

IOCMS
2026
Conference

The 3rd International Online Conference on Mineral Science

10–12 March 2026 | Online



Program and Abstract Book

Organizers



minerals

Media Partners



geosciences



mining



The 3rd International Online Conference on Mineral Science

10–12 March 2026 | Online



Organizing Committee

Conference Chair

Prof. Dr. Leonid Dubrovinsky

Session Chairs

Dr. Andrey G. Kalinichev
Dr. HDR Anastassia Borisova
Dr. Ilya Kupenko
Prof. Dr. Jianhua Chen
Prof. Dr. Leonid Dubrovinsky
Prof. Dr. Rafael Santos

Prof. Dr. Stanisław Mazur
Prof. Dr. Theodore J. Bornhorst
Prof. Dr. Urs Klötzli
Prof. Dr. Zhiyong Gao

Session Chair Assistant

Dr. Yogendar Singh

Scientific Committee

Dr. Andreas Delimitis
Dr. Marina Massaro
Dr. Michel Cathelineau
Dr. Olga Yakubovich
Dr. Paulina Faria
Dr. Saglara Mandzhieva
Dr. Samintha Perera
Dr. Yan Li
Prof. Liqiang Yang
Prof. Michael S. Zhdanov

Prof. Dr. André Carlos Silva
Prof. Dr. Hongfei Cheng
Prof. Dr. Hyunjung Nick Kim
Prof. Dr. Jiushuai Deng
Prof. Dr. José António de Almeida
Prof. Dr. Lucas Meili
Prof. Dr. Luis Alberto Cisternas
Prof. Dr. Mostafa Benzaazoua
Prof. Dr. Pura Alfonso
Prof. Dr. Qicheng Feng

Organised by



Conference Secretariats

Ms. Coco Hou
Ms. Nichaporn Khongthung
Email: iocms2026@mdpi.com

Table of Contents

Welcome from the Chair.....	1
Session Chairs	3
Session Chair Assistant.....	5
Keynote Speakers.....	6
Invited Speakers	7
Young Investigator Speakers.....	10
Program at a Glance	11
IOCMS 2026 Program	12
Session 1. Mineral Geochemistry: Environmental Applications and Recent Advances.....	16
Session 2. Mineral Systems and Ore Deposits: From Formation to Exploration	47
Session 3. Nanominerals and Clays: Emerging Applications in Materials Science	70
Session 4. Minerals in Extreme Environments: From Earth's Depths to Space	91
Session 5. Mineral Processing and Metallurgical Innovations: From Extraction to Refinement	98
Session 6. Emerging Frontiers in Mineral Science: Breakthrough Areas and Future Directions	119

Welcome from the Chair

Dear colleagues,

It is my great pleasure to welcome you to the **3rd International Online Conference on Mineral Science (IOCMS 2026)**, which will be held online from 10 to 12 March 2026. This event is proudly organized by the MDPI open access journal *Minerals* (ISSN: 2075-163X; Impact Factor: 2.2; CITESCORE: 4.4) and continues the successful tradition of the previous editions.

The primary goal of IOCMS 2026 is to bring together researchers and professionals from across the globe working in the broad field of mineral sciences—from crystal chemistry to environmental mineralogy, from extreme condition physics to extraterrestrial mineral exploration. We aim to provide a vibrant and inclusive platform for the exchange of cutting-edge research, ideas, and collaborations.

One of the most significant advantages of this fully virtual conference format is the **ease of participation**—no travel is required, and scholars can join us from anywhere in the world. The event will feature **live presentations, interactive Q&A sessions, and a virtual poster gallery**, encouraging open dialogue and dynamic interaction among participants.

The conference will be structured around several key thematic sessions, including:

1. Mineral Geochemistry: Environmental Applications and Recent Advances
2. Mineral Systems and Ore Deposits: From Formation to Exploration
3. Nanominerals and Clays: Emerging Applications in Materials Science
4. Minerals in Extreme Environments: From Earth's Depths to Space
5. Mineral Processing and Metallurgical Innovations: From Extraction to Refinement
6. Emerging Frontiers in Mineral Science: Breakthrough Areas and Future Directions

We warmly invite you to submit your abstract and join this exciting global exchange. All abstracts will be peer-reviewed by the scientific committee and presented on the conference website. Participation is free of charge, and **outstanding contributions will be eligible for conference awards**. In addition, extended versions of the presented work (4–8 pages) may be published **free of charge in the *Environmental and Earth Sciences Proceedings***, and authors will receive a 20% discount for submitting full-length papers to the *Minerals* Special Issue.

I look forward to your participation and the engaging discussions that will shape the future of mineral science.

Kind regards,



Prof. Dr. Leonid Dubrovinsky
Conference Chair

Bayerisches Geoinstitut,
University Bayreuth, Bayreuth,
Germany



minerals

an Open Access Journal by MDPI

Minerals (ISSN 2075-163X) is an international open access journal that covers the broad fields of mineralogy, mineral geochemistry and geochronology, economic mineral resources, mineral exploration, innovative mining techniques, and advances in mineral processing. Within this journal, reviews, regular research papers, and short notes are published. Our aim is to encourage scientists to publish their observational, analytical, experimental and theoretical results in as much detail as possible. In order to enable the results to be reproduced, the full experimental details must be provided.

Impact Factor: 2.2 (2024); 5-Year Impact Factor: 2.5 (2024)

Session Chairs



Prof. Dr. Rafael Santos

School of Engineering,
University of Guelph, Guelph,
ON, Canada



Prof. Dr. Urs Klötzli

Laboratory for
Geochronology, Department
of Lithospheric Research,
University of Vienna, Vienna,
Austria



**Prof. Dr. Theodore J.
Bornhorst**

Department of Geological
and Mining Engineering and
Sciences, Michigan
Technological University,
Houghton, MI, USA



Prof. Dr. Stanisław Mazur

Institute of Geological
Sciences, Polish Academy of
Sciences, Kraków, Poland



Dr. Andrey G. Kalinichev

Laboratoire SUBATECH, UMR
6457-Institut Mines-Télécom
Atlantique, Université de
Nantes, Nantes, France



Prof. Dr. Leonid Dubrovinsky

Bayerisches Geoinstitut,
University Bayreuth,
Bayreuth, Germany



Prof. Dr. Zhiyong Gao

School of Minerals
Processing and
Bioengineering, Central
South University, Changsha,
China



Prof. Dr. Jianhua Chen

School of Resources,
Environment and Materials,
Guangxi University, Nanning,
China



Dr. Ilya Kuppenko

European Synchrotron
Radiation Facility, Grenoble,
France



**Dr. HDR Anastassia
Borisova**

Géosciences Environnement
Toulouse (GET), Université de
Toulouse, CNRS, IRD, UPS,
France, 14 Avenue E. Belin,
Toulouse, France

Session Chair Assistant



Dr. Yogendar Singh

1. Géosciences
Environnement Toulouse
(GET), Université de Toulouse,
CNRS, IRD, UPS, France, 14
Avenue E. Belin, Toulouse,
France
2. School of Physical
Sciences, Jawaharlal Nehru
University, New Delhi, India

Keynote Speakers



Dr. Pete Hollings

NOHFC Chair in Mineral
Exploration, Lakehead
University, Thunder Bay,
Ontario, Canada

S2. Mineral Systems and Ore Deposits: From Formation to Exploration

Dr. Hollings completed his Ph.D. at the University of Saskatchewan in 1998 where he investigated the geochemistry of the 2.7-3.0 Ga Uchi Subprovince from Red Lake to Pickle Lake. During a two-year NSERC funded postdoctoral fellowship at CODES Dr. Hollings participated in a multi-disciplinary research project investigating the genesis of giant copper-porphyry deposits in Chile. As a faculty member at Lakehead University since 2001, Dr. Hollings is continuing his research into the relationship between igneous petrogenesis and mineralisation in a variety of deposit types including porphyry, orogenic gold and Ni-Cu-PGE. He has published more than 170 peer-reviewed papers on these topics. Hollings is currently the NOHFC IRC Chair in Mineral Exploration and Director of the Centre of Excellence for Sustainable Mining and Exploration at Lakehead University.



Prof. Dr. David Avnir

Institute of Chemistry, The
Hebrew University,
Jerusalem, Israel

S6. Emerging Frontiers in Mineral Science: Breakthrough Areas and Future Directions

David Avnir is a Professor (Em.) of Chemistry at the Institute of Chemistry, The Hebrew University of Jerusalem, where he also obtained all his academic training, and where he has held the positions of Head of the School of Chemistry, Head of the Institute of Chemistry, and Head of the Graduate School of the Experimental Sciences. His current scientific activities include geochemistry, astrochemistry, materials science, chirality and symmetry in experiments and theory. He has co-authored 420 papers, which have been cited over 43,000 times, several of which have been cited over 1000 times. His current Hirsch citation h-index is 88. Amongst his awards is the Israel Chemical Society Distinction Prize (2011), Life-time Achievement Award of the International Sol-Gel Society (2013), Distinguished Scientist of The Chinese Academy of Sciences (2018), Gold Medal of the Israel Chemical Society (2024), and more.

Invited Speakers



Dr. Saglara Mandzhieva
Academy of Biology and
Medicine, Southern Federal
University, 105 Bolshaya
Sadovaya St., Rostov-on-
Don, Russia



Prof. Dr. Huan Li
Key Laboratory of
Metallogenic Prediction of
Nonferrous Metals and
Geological Environment
Monitoring, Ministry of
Education, School of
Geosciences and Info-
Physics, Central South
University, Changsha, China



Dr. Michel Cathelineau
GeoRessources, Université
de Lorraine-CNRS, Nancy,
France



Dr. Pura Alfonso
Department d'Enginyeria
Minera, Industrial i TIC,
Universitat Politècnica de
Catalunya, Av. de les Bases
de Manresa, Manresa, Spain



Prof. Dr. Lucas Meili
Laboratory of Processes
Applied to Water Treatment
(LAPRO), Center of
Technology, Federal
University of Alagoas,
Campus A. C. Simões, Av.
Lourival Melo Mota, Tabuleiro
dos Martins, Maceió, AL,
Brazil



Prof. Dr. Fernando Rocha
Geosciences Department,
Geobiotec Research Unit,
University of Aveiro, Campus
Universitário de Santiago,
Aveiro, Portugal



Dr. Marina Massaro
Department of Biological,
Chemical and Pharmaceutical
Sciences and Technologies
(STEBICEF), University of Palermo,
Palermo, Italy



Dr. Jordi Ibáñez-Insa
Geosciences Barcelona
(GEO3BCN-CSIC), Lluís
Sole i Sabarís s/n,
Barcelona, Spain



Dr. Olga Yakubovich
Department of
Crystallography, Geological
Faculty, Moscow
M.V. Lomonosov State
University, Moscow, Russia



**Prof. Dr. José António de
Almeida**
Earth Sciences Department and
GeoBioTec, FCT-NOVA
University of Lisbon, Caparica,
Portugal



Prof. Dr. Qicheng Feng
State Key Laboratory of
Complex Nonferrous
Metal Resources Clean
Utilization, Faculty of
Land Resource
Engineering, Kunming
University of Science and
Technology, Kunming,
China



Prof. Dr. Lixia Li
School of Resources and
Civil Engineering,
Northeastern University,
Shenyang, China



Prof. Dr. Luis Alberto Cisternas

1. Department of Chemical and Mineral Process Engineering
Universidad de Antofagasta,
Antofagasta, Chile
2. Advanced Mining Technology
Center (AMTC), Chile



Dr. Anna Pakhomova

- European Synchrotron
Radiation Facility (ESRF),
71 Avenue des Martyrs,
Grenoble, France



**Prof. Dr. Ekaterina S. (Kate)
Kiseeva**

1. American Museum of
Natural History, New York,
New York, USA
2. School of Biological, Earth
& Environmental Sciences,
University College Cork,
Cork, Ireland



Dr. Xiang Li

1. Institut für Mineralogie,
Universität Münster, Germany
2. European Synchrotron
Radiation Facility, Grenoble,
France

Young Investigator Speakers



Dr. Sara Houshmand-Manavi
Department of Petrology and
Economic Geology, Faculty of
Earth Sciences, Shahrood
University of Technology,
Shahrood, Iran



Dr. Mohammad Goudarzi
Department of Geology,
Faculty of Basic Sciences,
Lorestan University,
Khorramabad, Iran

Program at a Glance

10 March 2026 - Morning	11 March 2026 - Morning	12 March 2026 - Morning
09.00 (CET) S6. Emerging Frontiers in Mineral Science: Breakthrough Areas and Future Directions	09.00 (CET) S4. Minerals in Extreme Environments: From Earth's Depths to Space 11.00 (CET) S1. Mineral Geochemistry: Environmental Applications and Recent Advances	09.00 (CET) S5. Mineral Processing and Metallurgical Innovations: From Extraction to Refinement
10 March 2026 - Afternoon	11 March 2026 -Afternoon	12 March 2026 -Afternoon
14.00 (CET) S2. Mineral Systems and Ore Deposits: From Formation to Exploration	14.00 (CET) Cont. S1. Mineral Geochemistry: Environmental Applications and Recent Advances	14.00 (CET) S3. Nanominerals and Clays: Emerging Applications in Materials Science

IOCMS 2026 Program

10 March 2026 (Tuesday)

Morning Session

S6. Emerging Frontiers in Mineral Science: Breakthrough Areas and Future Directions

Time: 9:00 (CET) | 3:00 (EST, New York) | 16:00 (CST, Asia, Beijing)

CET	Speaker	Title
9:00–9:05	Prof. Dr. Leonid Dubrovinsky Event Chair	Welcome from the Event Chair
9:05–9:10	Dr. Ilya Kuppenko Session Chair	Welcome from the Session Chair
9:10–9:40	Prof. Dr. David Avnir Keynote Speaker	On Left and Right - the World of Chiral Minerals
9:40–10:00	Dr. Anna Pakhomova Invited Speaker	Mineralogy of extraterrestrial icy environments
10:00–10:20	Prof. Dr. Ekaterina S. (Kate) Kiseeva Invited Speaker	Pushing the Limits of Diamond Research
10:20–10:40	Dr. Xiang Li Invited Speaker	New Iron oxides and carbides in the earth's out core conditions
10:45–10:55	Maria Elisa Rabago Refugio Selected Speaker	Transforming Agro-Industrial Waste into Synthetic Minerals: Rapid Sol-Gel-Derived Alkali Feldspar particles for Thermal Management Applications
10:55–11:10	CR Bhatt Selected Speaker	Advancing LIBS for Quantitative and Spatial Analysis of Rare Earth Elements in Coal
11:10–11:25	Dmitry Pushcharovsky Selected Speaker	Ion transport in the structures of conducting mineral-like crystals
11:25–11:40	Paolo Dell'Aversana Selected Speaker	Adaptive Neural Topologies for Digital Mineralogy: The Mycelial_Net Approach
11:40–11:55	Bioantika Selected Speaker	Quantifying an Alternative Sand from Metal Ores Essential for the Energy Transition: The Case of Ore-sand

10 March 2026 (Tuesday)

Afternoon Session

S2. Mineral Systems and Ore Deposits: From Formation to Exploration

Time: 14:00 (CET) | 8:00 (EST, New York) | 21:00 (CST, Asia, Beijing)

CET	Speaker	Title
14:00–14:05	Prof. Dr. Theodore J. Bornhorst Prof. Dr. Stanisław Mazur Session Chairs	Welcome from the Session Chairs
14:05–14:35	Dr. Pete Hollings Keynote Speaker	Mineral chemistry as a tool for porphyry exploration: PIMS, PVFTS and other acronyms
14:35–14:55	Prof. Dr. Huan Li Invited Speaker	Zircon and Apatite: Key Minerals for Ore Exploration
14:55–15:15	Dr. Michel Cathelineau Invited Speaker	Hypogene and supergene Au-enrichments at the origin of the Ity world-class deposit (Ivory Coast)
15:15–15:35	Dr. Pura Alfonso Invited Speaker	The central Andean Tin belt: insights from mineral chemistry and sulphur isotopes
15:35–15:50	Zsuzsanna P Allerton Selected Speaker	Iron stable isotope analysis to decipher hematite ore formation in the Lake Vermilion-Soudan Underground Mine State Park, Minnesota, USA
15:50–16:05	Abigail Jiménez-Franco Selected Speaker	Structural and compositional characterization of fehrite from Les Ferreres Mine (Ripollès, Catalonia)
16:05–16:20	Swarnendu Bhuyan Selected Speaker	Quartz microfracture Sealing in Orogenic Gold Systems: Coupling Experimental Observations with Reactive Transport Modelling
16:20–16:35	Nadezhda Krivolutsкая Selected Speaker	Olivine and pyroxene as an evidences of petrology and mineral resource of the basic-ultrabasic intrusions in the Norilsk area, Siberian Traps Province

16:35–16:50	Juan David Solano Acosta Selected Speaker	Critical-Metal Potential and Mineral Systems of the NE Estonian Basement: Insights from Geochemistry, Geostatistics, and Geophysics
16:50–17:00	Flash Poster Presentation (5 mins per person)	Antonia Cepedal Multi-Technique characterization of fluorite from the mining districts of Asturias, Spain
		Anastasia Vital'evna Kuzyura Mineralogical Peculiarities of Garnet and Magnesiochromite Compositions in Diamond Inclusions from the Zapolyarnaya Kimberlite Pipe (Yakutia)

11 March 2026 (Wednesday)

Morning Session

S4. Minerals in Extreme Environments: From Earth's Depths to Space

Time: 9:00 (CET) | 3:00 (EST, New York) | 16.00 (CST, Asia, Beijing)

CET	Speaker	Title
9:00–9:05	Prof. Dr. Leonid Dubrovinsky Session Host/ Event Chair	<i>Welcome from the Event Chair</i>
9:05–9:25	Dr. Jordi Ibáñez-Insa Invited Speaker	Nanoindentations to probe the porosity and mechanical properties of extraterrestrial olivines
9:25–9:45	Dr. Olga Yakubovich Invited Speaker	Structural state of vanadium in mineralogically probable oxosalts: experimental data and crystal chemical correlations
9:45–10:05	Prof. Dr. José António de Almeida Invited Speaker	From Field to Data: Calibration and Application of LIBS for Lithium and Ore Exploration
10:05–10:20	Amin Beiranvand Pour Selected Speaker	A Hybrid Dimensionality Reduction and Spectral Classification Workflow for Mineral Mapping in Polar Terrains
10:20–10:35	Galina Kiriukhina Selected Speaker	Crystal structure flexibility and magnetic behavior of a new shchurovskyite-related phosphate $K_2CaCu_6O_2(PO_4)_4$
10:35–10:50	Flash Poster Presentation (5 mins per person)	Olga S. Burakova Transmission Electron Microscopy Highlighted the Importance of Clay Minerals in the Dolomitization of Ca-Mg Carbonates in a Hypersaline Soda Lake
		Anastasiia Iskrina Experimental investigation of new post-spinel phases $Mg(Cr,Al)_2O_4$ and $Mg_2(Al,Cr)_2O_5$ at conditions of transition zone and lower mantle of the Earth
		Tatyana Bushneva Comparative crystal chemistry of $KCu_7BiO_4(SO_4)_5$ and nabokoite-like $KCu_7TeO_4(SO_4)_5Cl$ sulfates

11 March 2026 (Wednesday)

Morning Session

S1. Mineral Geochemistry: Environmental Applications and Recent Advances

Time: 11:00 (CET) | 5:00 (EST, New York) | 18.00 (CST, Asia, Beijing)

CET	Speaker	Title
11:00–11:05	Prof. Dr. Urs Klötzli Prof. Dr. Rafael Santos Session Chairs	<i>Welcome from the Session Chairs</i>
11:05–11:20	Dr. Sara Houshmand-Manavi Young Investigator Speaker	Polybaric Magma Storage from Clinopyroxene Barometry and Evidence of Mantle–Magma Interaction: Insights from the Oligocene–Miocene Alkaline Basalts of Eastern Iran
11:20–11:35	Harvey Melendrez Selected Speaker	Physicomechanical Properties of Non-Fired Ceramics Derived from Philippine Nickel Mining Waste Using Claver Clay Binder
11:35–11:50	Seigfreid Kempis Selected Speaker	Assessing the Moisture Retention Capacity of Saline Water (Seawater) as a Watering Material for Limestone Haulage Roads

11 March 2026 (Wednesday)

Afternoon Session Cont.

S1. Mineral Geochemistry: Environmental Applications and Recent Advances

Time: 14:00 (CET) | 8:00 (EST, New York) | 21:00 (CST, Asia, Beijing)

CET	Speaker	Title
14:00-14:05	Prof. Dr. Urs Klötzli Prof. Dr. Rafael Santos Session Chairs	Welcome from the Session Chairs
14:05-14:25	Dr. Saglara Mandzhieva Invited Speaker	DIAGNOSTICS OF CONTAMINATED SOILS: METHODS AND APPROACHES
14:25-14:40	Dr. Mohammad Goudarzi Young Investigator Speaker	New Evidence for Multistage Magmatic Evolution in the Central Part of the Urumieh–Dokhtar Magmatic Arc, Iran
14:40-14:55	João Pedro Tauscheck Zielinski Selected Speaker	Old Tool, New Purpose: Rock-Eval Analysis for CO ₂ Mineralization Screening in Basalts
14:55-15:10	Quentin Wehrung Selected Speaker	Pb–(Sn)–(Sb) Oxides in Incineration Bottom Ash: Characterization, Carbonation Behavior, and Antimony Treatment Implications
15:10-15:25	Pavel Nekhoroshkov Selected Speaker	The environmental distribution and sources of strontium in the case of natural anomaly within the river floodplains
15:25-15:40	Ginevra Mango Selected Speaker	Mineralogical and physicochemical characterization of the Pb and magnetite interaction in a simulated biofluid
15:40-15:55	Isabela Dantas de Albuquerque Selected Speaker	Paleoenvironment and sediment provenance of the Atafona Formation in the southwestern Campos Basin, Brazil: insights from a pre-salt well
15:55-16:10	Luca Adami Selected Speaker	Zeolite-Based Removal of Thallium from Synthetic and Real Waters: Comparative Study of L, 13X, and Protonated Ferrierite
16:10-16:25	Alessandra Passarella Selected Speaker	Mineralogical characterization of Al ₂ O ₃ and MgO powders as possible energy carriers
16:25-16:40	Georgy Lazorenko Selected Speaker	Fresh and hardened state properties, reaction kinetics and microstructure of potassium, ammonium and sodium magnesium phosphate cements: A comparative study
16:40-16:55	Flash Poster Presentation (5 mins per person)	Sherif Mansour Tectonic and Chronological Implications of Zircon U-Pb Dating on the Arabian-Nubian Shield, the Gabal Mukattab, Sinai, Egypt
		Christomir Christov Development of Accurate, Non-Concentration-Restricted Models for Predicting Solution Properties and Solid–Liquid Equilibrium in Binary Nitrate Systems from Low to Very High Concentrations (up to ≈ 30 mol.kg ⁻¹) at 25oC
		Muhammad Hammad Rasool Plagioclase vs Olivine: Which mineral is more reactive in driving in-situ mineralization of CO ₂ in Basalt?

12 March 2026 (Thursday)

Morning Session

S5. Mineral Processing and Metallurgical Innovations: From Extraction to Refinement

Time: 9:00 (CET) | 3:00 (EST, New York) | 16:00 (CST, Asia, Beijing)

CET	Speaker	Title
9:00-9:05	Prof. Dr. Zhiyong Gao Prof. Dr. Jianhua Chen Session Chairs	Welcome from the Session Chairs
9:05-9:25	Prof. Dr. Qicheng Feng Invited Speaker	Flotation separation theory and technology for refractory and complex zinc oxide ores
9:25-9:45	Prof. Dr. Lixia Li Invited Speaker	To be announced

9:45–10:00	Hongcheng Mi Selected Speaker	Optimization of Ultrafine Grinding Parameters Guided by Process Mineralogy to Improve Iron Separation Efficiency of titano-magnetite in Magnetic Separation
10:00–10:15	Ye Chen Selected Speaker	Influence of iron impurity on floatability of iron-bearing sphalerite
10:15–10:30	Felipe eduardo Olea chandía Selected Speaker	Effect of Extracting Phase Composition on Cobalt Recovery from Chloride-Rich Media: Transition from Molecular to Ionic and Eutectic Solvents
10:30–10:45	Stoyan Karakashev Selected Speaker	Ion-specific effects on bubble coalescence and foams
10:45–11:00	Sameera Mohamed Selected Speaker	Utilisation of Plagioclase in Mine Residues as a Silica Source for the Synthesis of High-Purity Silica Nanoparticles
11:00–11:15	Itumeleng Kohitlhetse Selected Speaker	Optimization of Reagent Efficiency in Copper Flotation Circuit at Varying Slurry Densities
11:15–11:35	Prof. Dr. Luis Alberto Cisternas Invited Speaker	Toward Circular Mining: The SOS (Solid without Sulfide) Framework for Integrated Waste Rock and Tailings Management
11:35–11:45	Flash Poster Presentation (5 mins per person)	Turan Uysal Novel Sustainable Process for the Recovery of Aluminium and Rare Earth Elements from High-Silica Bauxite
		Gabriel Iulian Dan Coupling breakage with liberation models to predict mineral exposure in the crushing stage of Critical Raw Materials

12 March 2026 (Thursday)

Afternoon Session

S3. Nanominerals and Clays: Emerging Applications in Materials Science

Time: 14:00 (CET) | 8:00 (EST, New York) | 21:00 (CST, Asia, Beijing)

CET	Speaker	Title
14:00–14:05	Dr. Andrey G. Kalinichev Session Chair	<i>Welcome from the Session Chair</i>
14:05–14:25	Prof. Dr. Lucas Meili Invited Speaker	Tailoring MgAl-Layered Double Hydroxides: from Advanced Synthesis to Efficient Nitrate Removal from Water
14:25–14:45	Prof. Dr. Fernando Rocha Invited Speaker	Geopolymers for Ceramic Industry
14:45–15:05	Dr. Marina Massaro Invited Speaker	Modification of clay minerals for development of innovative nanomaterials for several applications
15:05–15:20	Sergey V Kraevsky Selected Speaker	Using modified mica as a substrate in Atomic Force Microscopy
15:20–15:35	Edgar Galicia-Andrés Selected Speaker	Molecular modeling of organo-mineral aggregates
15:35–15:50	GOO SHAO KANG Selected Speaker	Nanomineral-Modified Electrodes for Solar-to-Fuel Conversion
15:50–16:05	Jinendrika Anushi Weliwita Selected Speaker	Mineral-Based PCM Composites from UAE Resources for Passive Cooling in Hot Climates
16:05–16:20	Evgeny Tatarushkin Selected Speaker	ATOMISTIC SIMULATIONS OF THE THAUMASITE-WATER INTERFACES
16:20–16:35	Fel Jane Acut Echavez-Salo Selected Speaker	Innovative Ceramic Vitreous Formulations using Nickel Laterite Mine Waste NiLaMW and Indigenous Flux sources
16:35–16:45	Flash Poster Presentation (5 mins per person)	Vilma Snapkauskienė Reactivity and structural characteristics of plasma-derived wind turbine blade slag in geopolymer systems
		Md. Nurjaman Ridoy A Computational Study on Geochemical Stability of Natural and Engineered Sesquioxide Nanominerals

Session 1. Mineral Geochemistry: Environmental Applications and Recent Advances

sciforum-138934: Multi-Stage Magmatic Evolution in the Central Urumieh–Dokhtar Magmatic Arc (NE Saveh, Iran): Evidence from Zircon U-Pb Dating, Lu-Hf Isotopes, and Whole-Rock Geochemistry

Mohammad Goudarzi ^{1*}, Urs Kloetzli ², Hassan Zamanian ³, Jiří Sláma ⁴, Jitka Miková ⁵
and Jolanta Burda ⁶

¹ Department of Geology, Faculty of Basic Sciences, Lorestan University, Khorramabad 6815144316, Iran

² Department of Lithospheric Research, Faculty of Earth Sciences, Geography and Astronomy, University of Vienna, 1090 Vienna, Austria

³ Department of Geology, Faculty of Sciences, University of Tehran, Tehran 1417935840, Iran

⁴ Institute of Geology, Academy of Sciences of the Czech Republic, 165 00 Prague, Czech Republic

⁵ Czech Geological Survey, 118 00 Prague, Czech Republic

⁶ Institute of Earth Sciences, Faculty of Natural Sciences, University of Silesia in Katowice, 41-200 Sosnowiec, Poland

The Cenozoic plutonic assemblages exposed in northeast Saveh, located within the central segment of the Urumieh–Dokhtar Magmatic Arc (UDMA) in Iran, include monzonite, monzodiorite, gabbro, and gabbrodiorite lithologies. Integrated zircon U-Pb geochronology, Lu-Hf isotopic analysis, and whole-rock geochemistry reveal that these rocks belong to a medium-K calc-alkaline, metaluminous suite with typical arc-related geochemical signatures. Zircon U-Pb ages ranging from ~60 to 3 Ma point to a long-lasting and multi-phase magmatic evolution from the Middle Paleocene to the Middle Pliocene. Contrary to earlier studies suggesting a prolonged magmatic lull between 72–57 Ma, our results indicate a shorter dormancy period (~10–12 Ma). Three major magmatic pulses are identified: in the Late Eocene (~47–40 Ma), Early Miocene (~23–18 Ma), and Late Miocene to Pliocene (~11–5.2 Ma), all reflecting a subduction-related tectonomagmatic setting. The youngest zircon ages (~11–2.5 Ma) from gabbroic units suggest that magmatism continued up to the Pliocene–Pleistocene boundary, likely linked to ongoing subduction processes shaping the Zagros orogen. Zircon $\epsilon_{\text{Hf}}(t)$ values (–11.43 to +12.5) along with geochemical trends indicate magma generation involving fractional crystallization, assimilation of crustal material, and mantle-derived inputs. Crystallization temperatures of clinopyroxene (1150–1200 °C), coupled with trace element data, support a melt source in a metasomatized spinel-bearing lherzolitic mantle at depths shallower than 80 km. This magmatism was likely driven by asthenospheric upwelling and slab rollback, which induced partial melting of the lithospheric mantle and sustained the region's long-lived magmatic activity.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-155607: Tectonic and Chronological Implications of Zircon U-Pb Dating on the Arabian–Nubian Shield, the Gabal Mukattab, Sinai, Egypt

Sherif Mansour ^{1,*} and Noriko Hasebe ²

¹ Geology Department, Faculty of Science, Port Said University, Port Said 42522, Egypt

² Institute of Nature and Environmental Technology, Kanazawa University, Kanazawa 920-1192, Japan

The granitic and metamorphic rocks at the Gabal Mukattab area represent the north termination of the Arabian–Nubian Shield in Sinai, which, in turn, represents the northern part of the East African Orogeny. The geochronological dynamics of the magmatism that constructed the Arabian–Nubian Shield are critical in understanding these orogenies. Our study involved dating three metamorphic rocks (846 ± 4 Ma to 818 ± 5 Ma), five calc-alkaline granitic rocks (728 ± 6 Ma to 609 ± 5 Ma), and eleven alkaline granitic rocks (678 ± 7 Ma to 555 ± 3 Ma). In the studied region, the island-arc phase of magmatism activated between 846 ± 4 Ma and 818 ± 5 Ma. The consequent syn-collisional magmatism initiated from 728 ± 6 Ma to 668 ± 5 Ma, demonstrating the temporal domination of the subduction-related compressional regime. The post-collisional magmatism started at 610 ± 5 Ma, marking the shifting of the tectonic setting from a compressional to an extensional regime. The phase of magmatism dominated until 555 ± 3 Ma in the studied region, suggesting extending the ANS magmatic activity until the Phanerozoic edge. These findings challenge the classical distinction between older magmatism, characterized by calc-alkaline granitoids, and younger magmatism, characterized by alkaline granitoids. The pre-Neoproterozoic (pre-ANS) 16 zircon xenocrysts with ages ranging between 2084 ± 9 Ma and 1094 ± 8 Ma were yielded, which might support a reworked ancient magmatic source. Seven Phanerozoic zircons showed ages between 495 ± 3 Ma and 374 ± 4 Ma, hinting at potential Ordovician–Devonian magmatic events in the region.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-161190: A Framework for the Tectonic–Carbon Cycle–Mineralization Coupling in the Bangong–Nujiang Suture Zone

Binxuan Hao *, Ming Wang, Quewang Danzeng, Jinlu Zhou, Yuhe Zhang, Zhenglong Li and Xiaohu Lian

College of Earth Sciences, Jilin University, Changchun 130061, China

Tectonic activity, as a key driver of long-term climate evolution, influences atmospheric CO₂ concentrations by regulating deep carbon cycling while also shaping the development and distribution of mineral systems in specific geological settings. However, the carbon cycling processes during tectonic transitions and their coupling with mineralization remain poorly constrained. The Bangong–Nujiang Suture Zone (BNSZ), a significant tectonic unit within the Tibetan Plateau, comprehensively records the tectonic evolution from oceanic subduction to post-collision. Its formation coincides with the period of declining atmospheric CO₂ concentrations during the Mesozoic, making it an ideal natural laboratory for investigating the interconnections among tectonics, the carbon cycle, and mineralization systems. This study focuses on mafic rock samples from three key tectonic periods within the BNSZ (subduction, collision, and post-collision), conducting whole-rock geochemical and Pb–Mg–Sr isotopic analyses. The results reveal a fundamental shift in the deep carbon cycling mechanism within the region corresponding to changes in tectonic stages. The primary carrier of carbon migrated transitioned from being fluid-dominated to melt-dominated. This shift not only influenced the efficiency of carbon release but also governed the migration and enrichment of ore-forming elements in associated mineralization systems. During the Early Jurassic subduction stage, carbon was primarily transported as CO₂-rich fluids, resulting in sustained but low-flux degassing. By the Early Cretaceous collision stage, carbon migration shifted to being dominated by carbonate melts, leading to pulsed, high-flux carbon release potentially. In the Late Cretaceous post-collision stage, carbon release became more diffuse, involving enhanced multi-source mixing and crustal assimilation. This mechanistic transition indicates that specific tectonic processes, such as collision, can trigger large-scale, rapid release of deep carbon and ore-forming elements. It provides a novel tectonic–mineralization coupling model for understanding global carbon cycle fluctuations, atmospheric CO₂ evolution, and the formation of large metallogenic provinces during the Mesozoic.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-146808: A Thermodynamic Framework for Predicting Synergistic Mineral Dissolution and Buffering in Wastewater Treatment Systems

Igor Povar * and Oxana Spinu

Laboratory of Physical and Chemical Methods of Research and Analysis, Institute of Chemistry of the Moldova State University, Chisinau MD2028, Republic of Moldova

This study presents a thermodynamic framework for predicting synergistic mineral dissolution and buffering in wastewater treatment systems. Buffering is essential for stabilizing wastewater composition against pH fluctuations and ionic disturbances caused by variable chemical inputs. The model addresses multicomponent heterogeneous systems containing both soluble and insoluble species, focusing on key minerals such as struvite and vivianite that play a central role in nutrient recovery and contaminant immobilization. A key innovation of this framework is its ability to describe coupled mineral dissolution and precipitation processes through a unified set of thermodynamic equations. These incorporate mass balance constraints and equilibrium expressions involving metal ion hydrolysis, metal ion–ligand complex formation, and protonation reactions. The influence of competing ions, such as magnesium, calcium, sodium, and carbonate, is also considered, as they directly affect system buffering and mineral phase stability. Another major contribution is the introduction of the synergistic coefficient, a novel parameter that quantifies the enhancement of buffering and dissolution beyond additive behavior. This allows comparative assessment of synergistic potential across different wastewater compositions. It is demonstrated that two conditions are required for the manifestation of synergistic effects in wastewater systems: (a) the formation of a ternary complex, and (b) amplification of one or more physicochemical properties. Struvite satisfies both criteria, as it forms a stable solid ternary complex and exhibits enhanced solubility and buffering action under appropriate conditions. Thermodynamic analysis reveals that these synergistic effects arise from the formation of mixed-ligand complexes that stabilize pH and promote mineral recovery. Validation using real wastewater confirms the model predictive accuracy in identifying optimal pH and ion ratios. The thermodynamic relations derived from this study enable the design of new synergistic processes with targeted buffering and mineral recovery properties, supporting the advancement of sustainable and efficient wastewater treatment technologies.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158188: Assessing the Moisture Retention Capacity of Saline Water (Seawater) as a Watering Material for Limestone Haulage Roads

Saifodin Abdullah, Raul Jr. Lucero, Joey Millard Pagar, Josep Russell Paez, Rose Anne Marie Hilot, Kaye Martir, Adrian Keith Caamino, Algen Secula and Seigfreid Kempis *

¹ Department of Materials and Resources Engineering and Technology, Mindanao State University – Iligan Institute of Technology, Iligan City, Lanao del Norte, Region X, Mindanao, Philippines

² Resource Processing and Technology Center, Mindanao State University – Iligan Institute of Technology, Iligan City, Lanao del Norte, Region X, Mindanao, Philippines

Airborne dust poses significant challenges in limestone mining operations, affecting environmental quality, health, and operational efficiency. This study focuses on assessing the moisture retention capacity of saline water, specifically seawater, as a watering material for limestone haulage roads by conducting tests to evaluate its moisture retention capacity. Moisture retention capacity is determined by using two (2) tests: wind tunnel test and heat test (oven test). Wind tunnel test assesses the effectiveness of seawater in retaining moisture under specific wind speed, time, and mix ratios. While the oven test analyzes weight reduction in limestone-water samples subjected to temperature, time, and mix ratios. These experiments provide quantitative data on moisture retention capabilities of different watering materials: seawater, groundwater, deionized water. The results of the two tests show that limestone samples treated with seawater exhibit higher moisture retention compared to those treated with groundwater and deionized water, indicating the superior effectiveness of saline water as a water spraying material. By adopting seawater as a watering material, mining companies can reduce their fresh water usage and enhance their dust control efforts, resulting in improved environmental conditions and worker health. In summary, this thesis presents laboratory experiments, including wind tunnel tests and oven tests, to assess the moisture retention capacity of seawater as a watering material for dust suppression on limestone haulage roads. The findings contribute to the understanding of effective dust control strategies in the mining industry and provide practical recommendations for implementing saline water-based dust suppression methods in limestone mining operations.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158189: Assessment of Xanthan Gum as Potential Dust Suppressant on Lateritic Mine Haul Roads

Thea Arreza, Mark Apollo Baluat, Jorgie Ocampo, Josep Russell Paez, Rose Anne Marie Hilot, Kaye Martir, Seigfreid Kempis, Adrian Keith Caamino and Algen Secula *

¹ Department of Materials and Resources Engineering and Technology, Mindanao State University – Iligan Institute of Technology, Iligan City, Lanao del Norte, Region X, Mindanao, Philippines

² Resource Processing and Technology Center, Mindanao State University – Iligan Institute of Technology, Iligan City, Lanao del Norte, Region X, Mindanao, Philippines

Mine dust is a significant issue in surface mining operations, particularly on haul roads. This study investigates the potential of xanthan gum as an eco-friendly dust suppressant in nickel mines. The objectives are to assess its effectiveness in terms of infiltration depth capacity, and wind erosion resistance, and determine the terms of concentration for desired performance on a lab scale level. Samples of nickel laterite soil were collected from CTP Construction and Mining Corporation, Adlay, Carrascal, Surigao del Sur, Philippines. Xanthan gum solutions at concentrations of 1g/L, 2g/L, 4g/L, along with water (mine water and deionized water), were tested. Infiltration depth and wind tunnel experiments were conducted to evaluate the performance of xanthan gum. Results were analyzed through P-test, ANOVA, and Multiple Comparison test. The results showed that xanthan gum solutions achieved infiltration depths within the recommended range of 10-20 mm, outperforming both mine and deionized water. The concentration of 4g/L exhibited the lowest weight loss in the wind tunnel test, indicating superior wind erosion resistance compared to lower concentration and water. The concentration of 1g/L was found to be sufficient for desired outcomes. The use of xanthan gum presents an environmentally friendly alternative to traditional methods, reducing dust emissions and minimizing the use of hazardous chemicals in the mining industry. These findings provide valuable insights for dust control measures and lay the foundation for future research on xanthan gum as a dust suppressant.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158411: Carbon sequestration potential of the mafic rocks from the Mindanao Eastern Pacific Cordillera, southern Philippines

John David Castromayor Eboña^{1,*}, John Patrick Galindo Mula¹, Nichole Anthony Dacallos Pacle¹, Alphonse Rey Macion¹, Yvonne Torralba Olayvar¹ and Jillian Aira Gabo-Ratio²

¹ Department of Geology, Caraga State University, Butuan City 8600, Philippines

² National Institute of Geological Sciences, University of the Philippines- Diliman, Quezon City 81101, Philippines

As human-induced carbon emissions continue to increase, the demand for effective strategies to achieve net-zero emissions also grows. One promising approach is carbon sequestration via enhanced rock weathering, specifically through carbon mineralization. This process entails the weathering of ultramafic to mafic minerals, leading to the formation of stable carbonate minerals that help regulate atmospheric CO₂ levels. This study employs petrographic analysis to evaluate the potential of mafic rocks in the Mindanao Eastern Pacific Cordillera, southern Philippines, for atmospheric CO₂ sequestration. Using point-counting techniques on prepared thin sections, the study quantifies the abundance of reactive minerals. The modal percentages of olivine, pyroxene, and plagioclase—key reactive minerals—are determined, and their corresponding CO₂ uptake capacities are used to calculate the total potential CO₂ sequestration. Results from petrographic analysis indicate that mafic rocks from the Dinagat Islands, characterized by high plagioclase, pyroxene, and olivine contents with minimal alteration, exhibit the greatest estimated CO₂ uptake at 16.11 wt% CO₂. Basalts from the Siargao Islands show a potential CO₂ uptake of 14.85 wt% CO₂, attributed to their abundance of plagioclase and pyroxene. Meanwhile, the Bacuag Formation's porphyritic basalts in Surigao del Norte, containing significant plagioclase, moderate pyroxene, and lesser olivine, can sequester up to 12.69 wt% CO₂. In contrast, although reactive minerals are present in the Barcelona Formation mafic rocks in Surigao del Sur, their potential CO₂ uptake is reduced to 8.92 wt% CO₂ due to the transformation of these minerals into clay minerals, zeolites, and chlorites during weathering. Variations in CO₂ uptake among the studied formations highlights the importance of mineralogical composition and degree of alteration in assessing a rock's suitability for carbon mineralization. Overall, these results underscore the viability of utilizing select mafic rock formations in the southern Philippines as natural carbon sinks to support regional and global net-zero initiatives.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-161404: Computational Insights into the Hydrolysis and Aqueous Stability of Thorianite (ThO₂) and its Environmental Implications for Groundwater Systems.

Tahzib Ibrahim Protik *, Md. Nurjaman Ridoy, Sk. Tanjim Jaman Supto and Sabbir Hossain

Nano Research Centre, Sylhet, 3114, Bangladesh

Thorianite (ThO₂) is a naturally occurring mineral form of thorium dioxide found in diverse geological settings such as pegmatites, carbonatites, and heavy mineral sands. The environmental importance of the material lies in the fact that the mobility of thorium species in the mineral weathering and hydrolysis processes is likely to reduce the quality of groundwater and radiochemical stability. This study aims to computationally investigate the hydrolysis and hydrolysis and aqueous stability behavior of Th⁴⁺ and hydrated ThO₂ complexes to understand their stability and potential environmental implications. Density functional theory (DFT) calculations were performed using Gaussian 09W, Revision D.01 to simulate the hydrolysis of Th⁴⁺ and ThO₂(H₂O)_n species (n = 1 to 10). The relative stabilities and electronic characteristics of the hydrated thorium species, optimised geometries, total electronic energies, and thermodynamic parameters, such as entropy and Gibbs free energy, were calculated. The coordination number of Th⁴⁺ was found to be decreasing progressively during stepwise hydrolysis. Among the hydrated species, ThO₂(H₂O)₉ exhibited the highest stability with a total energy of −29764.9950 eV and total free energy of −20701.0604 eV, indicating strong hydration stabilization. ThO₂(H₂O)₆, possessing C_{2v} symmetry, shows a total energy of −23539.8782 eV and entropy of −865.8066 cal mol^{−1}K^{−1}. The results suggest that hydration plays a critical role in stabilizing thorium oxide clusters, which can influence thorium mobility under aqueous conditions. The computational insights highlight that the hydrolysis of ThO₂ can yield stable hydrated complexes, which may enhance thorium solubility and potential leaching into groundwater systems. These findings contribute to understanding the environmental geochemistry of thorium-bearing minerals and their long-term behavior in natural waters. The study underscores the importance of quantum chemical modeling in predicting mineral water interactions relevant to radioactive element dispersion and environmental safety.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-157309: Development of Accurate, Non-Concentration-Restricted Models for Predicting Solution Properties and Solid–Liquid Equilibrium in Binary Nitrate Systems from Low to Very High Concentrations (up to $\approx 30 \text{ mol.kg}^{-1}$) at 25°C

Christomir Christov ^{1,*}, Stanislav Donchev ², Tsvetan Tsenov ³, Nina Ivanova ⁴ and Stoyan Karakashev ²

¹ Ruse Research University, University of Ruse “Angel Kanchev”, 8 Studentska str., 7017 Ruse, Bulgaria

² Department of Chemistry, Faculty of Natural Sciences, Shumen University “Konstantin Preslavski”, ul. Universitetska 115, Shumen 9700, Bulgaria

³ Department of Ecology, Technical university of Varna, ul. “Studentska” 1, 9010 Varna, Bulgaria

⁴ Department of Chemistry, Medical University Pleven, “Komsomolska” str., No. 10, 5800 Pleven, Bulgaria

In this study, we developed well-validated, Pitzer ion-interaction-approach-based thermodynamic models for solution behavior and solid–liquid equilibrium in 17 binary nitrate systems [of the type 1-1 ($\text{HNO}_3\text{--H}_2\text{O}$, $\text{LiNO}_3\text{--H}_2\text{O}$, $\text{NaNO}_3\text{--H}_2\text{O}$, $\text{KNO}_3\text{--H}_2\text{O}$, $\text{RbNO}_3\text{--H}_2\text{O}$, $\text{CsNO}_3\text{--H}_2\text{O}$, and $\text{NH}_4\text{NO}_3\text{--H}_2\text{O}$), of the type 2-1 ($\text{Mg}(\text{NO}_3)_2\text{--H}_2\text{O}$, $\text{Ca}(\text{NO}_3)_2\text{--H}_2\text{O}$, $\text{Ba}(\text{NO}_3)_2\text{--H}_2\text{O}$, $\text{Sr}(\text{NO}_3)_2\text{--H}_2\text{O}$, and $\text{UO}_2(\text{NO}_3)_2\text{--H}_2\text{O}$), 3-1 ($\text{Cr}(\text{NO}_3)_3\text{--H}_2\text{O}$, $\text{Al}(\text{NO}_3)_3\text{--H}_2\text{O}$, $\text{La}(\text{NO}_3)_3\text{--H}_2\text{O}$, $\text{Lu}(\text{NO}_3)_3\text{--H}_2\text{O}$), and 4-1 ($\text{Th}(\text{NO}_3)_4\text{--H}_2\text{O}$)] from low to very high concentrations at $T = 25^\circ\text{C}$. To parameterize the models for the binary systems, we used all available raw experimental osmotic coefficients data (φ) for the entire concentration range of solutions, including the supersaturation zone. To construct the models, we used different versions of the standard molality-based Pitzer approach. The predictions of the newly developed models presented here are in excellent agreement with experimental osmotic coefficient data, as well as with recommendations on mean activity coefficients given in the literature for binary solutions from low to very high concentrations. It was established that, for seven of the systems under study, the application of the extended approach with four parameters (β^0 , β^1 , β^2 , and C^φ) and variation of the a_2 term in the fundamental Pitzer equations leads to the lowest values of the standard model–experiment deviation. The Deliquescence Relative Humidity (DRH), thermodynamic solubility product (expressed as $\ln K_{\text{sp}}^\circ$), and standard molar Gibbs free energy of formation ($\Delta_f G_m^\circ$) of 18 nitrate solid phases have been determined on the basis of evaluated binary parameters and using $m(\text{sat})$ solubility data. The models for nitrate systems described in this study are of high importance, especially for the development of strategies and programs for nuclear waste geochemical storage.

Acknowledgement: This study is funded by the European Union–NextGenerationEU, project № BG-RRP-2.013-0001.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-161276: Enhanced Photocatalytic Performance of Geochemically Modified Natural Zeolite via Graphene Oxide/Bismuth Oxide Integration

Christianne Aguilar Calma *, Denisse Jonel Pado-Ong Pavia and Eduardo dela Rosa Magdaluyo

Department of Mining, Metallurgical and Materials Engineering, College of Engineering, University of the Philippines Diliman, Quezon City 1101, Philippines

Natural zeolite (NZ) offers unique surface properties that enable its use in environmental remediation and catalytic applications. In this study, a graphene oxide/natural zeolite/bismuth oxide (GO/NZ/Bi₂O₃) composite was developed to enhance the functional performance of NZ for the photocatalytic degradation process relevant to environmental treatment. The composite was synthesized through a two-step calcination process: NZ was first calcined with bismuth oxide (Bi₂O₃) at 900 °C to form the NZ/Bi₂O₃ composite, followed by graphene oxide (GO) incorporation and a secondary calcination at 300 °C. Structural characterization revealed apatite-type and eulytite mineral phases in the NZ/Bi₂O₃ system, reflecting phase transformations arising from high-temperature interaction between NZ and Bi₂O₃. Incorporation of GO resulted in a dominant calcium bismuth oxy-silicate phase. FTIR spectra confirmed characteristic Si–O–Si and Si–O–Al vibrations inherent to natural zeolite, alongside Bi–O and C–O bands indicative of successful composite formation. SEM analyses showed porous NZ structures supporting agglomerated Bi₂O₃ particles and irregular GO flakes, while TGA-DTG identified thermal events associated with moisture release, NZ-bound water, GO degradation, and Bi₂O₃ transitions. BET measurements exhibited a Type IV isotherm and a surface area of 1.06 m²/g, consistent with mesoporous mineral composites. Zeta potential data revealed reduced suspension stability following GO integration. Notably, the GO/NZ/Bi₂O₃ composite demonstrated superior photocatalytic degradation efficiency, underscoring the enhanced reactivity achieved through synergistic modification of natural zeolite. Overall, this work highlights the geochemical adaptability of natural zeolite and its potential for advanced environmental applications.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-157341: Experimental and thermodynamic modeling study of $\text{Na}_2\text{SeO}_4\text{-FeSeO}_4\text{-H}_2\text{O}$ system at the temperature 25°C

Christomir Christov^{1,*}, Dencho Mihov², Tsvetan Tsenov³, Nina Ivanova⁴ and Rumyana Yankova²

¹ Ruse Research University, University of Ruse "Angel Kanchev", 8 Studentska str., 7017 Ruse, Bulgaria

² Dept. Chemistry, Faculty of Natural Sciences, Burgas University "Asen Zlatarov", Prof. Yakim Yakimov Blvd. 1, 8010 Burgas, Bulgaria

³ Department of Ecology, Technical university of Varna, ul. "Studentska" 1, 9010 Varna, Bulgaria

⁴ Department of Chemistry, Medical University Pleven, "Komsomolska" str., No. 10, 5800 Pleven, Bulgari

The solubilities of the $\text{Na}_2\text{SeO}_4\text{-FeSeO}_4\text{-H}_2\text{O}$ system have been investigated by the physicochemical analysis method. Crystallization of a new double salt $\text{Na}_2\text{SeO}_4\cdot\text{FeSeO}_4\cdot 2\text{H}_2\text{O}$ has been established. TG and DTA measurements indicate that the double salt loses the crystallization water in three steps in the temperature interval from 87°C to 148°C. The Pitzer ion interaction model has been used for thermodynamic analysis of the experimental solubility data obtained. The simulation has been materialized by i) determination of the Pitzer binary parameters for the binary solutions, ii) determination of the Pitzer mixing parameters, and iii) calculation of the solubility isotherm of the $\text{Na}_2\text{SeO}_4\text{-FeSeO}_4\text{-H}_2\text{O}$ system. The binary parameters of interionic interaction for $\text{Na}_2\text{SeO}_4(\text{aq})$ and $\text{FeSeO}_4(\text{aq})$ are taken from our previous studies. The ternary parameters $\theta(\text{Na},\text{Fe})$ and $(\text{Na},\text{Fe},\text{SeO}_4)$ and the thermodynamic solubility product (as $\ln K_{\text{sp}}^\circ$) of the double salt have been calculated on the basis of experimental data on the solubility reported in this study. The experimentally obtained and the calculated solubilities are in very good agreement. The standard molar Gibbs energy of the synthesis reaction $D_r G_m^\circ$ of the double salt $\text{Na}_2\text{SeO}_4\cdot\text{FeSeO}_4\cdot 2\text{H}_2\text{O}$ from the corresponding simple salts $\text{Na}_2\text{SeO}_4\cdot 10\text{H}_2\text{O}$ and $\text{FeSeO}_4\cdot 6\text{H}_2\text{O}$ and the standard molar Gibbs energy of formation $D_f G_m^\circ$ of simple salts and double salt have been determined. The experimental data and the model described in this study are of high importance, especially in the development of nuclear waste storage technology, as well as for production and purification of selenate solutions and solid phases.

Acknowledgement: This study was financed by the European Union-NextGenerationEU, project N° BG-RRP-2.013-0001



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-156278: Fresh and hardened state properties, reaction kinetics, and microstructure of potassium, ammonium, and sodium magnesium phosphate cements: A comparative study

Georgy Lazorenko ^{1,*}, Alexander Kruglikov ^{1,2} and Anton Kasprzhitskii ¹

¹ Climate Center, Novosibirsk State University, Novosibirsk, 630090, Russia

² Department of Civil Engineering, Rostov State Transport University, Rostov-on-Don, 344038, Russia

Magnesium phosphate cements (MPCs) are advanced inorganic binders gaining prominence in specialized engineering due to their rapid setting and high early strength. These properties make them exceptionally suitable for a wide range of applications beyond ordinary Portland cement (OPC), including the rapid repair of critical infrastructure, waste encapsulation, soil stabilization, and the development of refractory and corrosion-resistant coatings. While the properties of MPCs based on ammonium and potassium phosphates are well-documented, a systematic study including sodium dihydrogen phosphate is notably absent from the literature. This study presents a comprehensive comparative investigation of MPCs formulated with three different phosphate salts: potassium dihydrogen phosphate, sodium dihydrogen phosphate, or ammonium dihydrogen phosphate. The research methodology was designed to evaluate and contrast key characteristics of these cements, including their reaction kinetics, workability in the fresh state, physical characteristics, and mechanical strength in the hardened state. To elucidate the underlying mechanisms governing performance, a detailed microstructural analysis was conducted using Scanning Electron Microscopy (SEM), while the reaction products were characterized through X-ray Diffraction (XRD) and attenuated total reflectance–Fourier transform infrared (ATR-FTIR). The findings from this comparative analysis are crucial for identifying the most suitable phosphate salt for specific applications, thereby enabling the informed development and optimization of MPCs for advanced and sustainable construction. Funding: This work was supported by the Russian Science Foundation (Grant No. 24-79-10320, <https://rscf.ru/en/project/24-79-10320/>).



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-157777: Geochemistry of bottom sediments in the limnosystems of the Baraba Lowland (South of Western Siberia) as an indicator of the technogenesis processes

Ekaterina Ovdina ^{1,*}, Vera Strakhovenko ¹, Andrei Kartoziia ², Georgy Malov ¹ and Viktor Malov ¹

¹ Laboratory of Geochemistry of Noble and Rare Elements, V.S. Sobolev Institute of Geology and Mineralogy Siberian Branch Russian Academy of Sciences, Novosibirsk 630090, Russia

² Laboratory of Geoinformation Technologies and Remote Sensing, V.S. Sobolev Institute of Geology and Mineralogy Siberian Branch Russian Academy of Sciences, Novosibirsk 630090, Russia

Human activities that affect the environment are becoming more widespread and threaten the ability of natural systems to maintain their balance. The flat lands of southern Western Siberia act as natural plates, accumulating and reflecting the geochemical composition of the entire demolition area. This paper examines the ecogeochemical composition of bottom sediments from five small lakes near regional industrial centers in the Baraba Lowland, southern Western Siberia. The results will help us understand future processes and predict possible scenarios for natural ecosystem development in the present, in the context of the powerful geological force of technogenesis.. In the components of lake ecosystems (sediments, water, soil, rocks, and biota), there is a simultaneous distribution of elements related to sidero-, chalco-, litho-, atmo-, and biophilic (Si, Ca, Mg, K, Na, Fe, Mn, Sb, Sr, Cd, Zn, Pb, Hg, P, etc.), as a reflection of biosphere evolution under conditions of human influence. For the first time, an assessment of the average background concentration of major and trace elements in the bottom sediment of small lakes in the Baraba Lowland was conducted. The study of the chemical composition of lake system components was carried out using a range of modern analytical techniques, including atomic absorption analysis (AAA), inductively coupled plasma atomic emission spectroscopy (ICP-AES), X-ray fluorescence analysis (XFA), X-ray powder diffractometry (XRD) and scanning electron microscopy (SEM). In total, more than 6,000 determinations of individual measured elements were made, ensuring the statistical significance of the obtained data.. GIS mapping of the catchment areas of lake systems has been conducted to identify the sources of potential pollutants. Abnormal concentrations of major and trace elements have been identified based on the data collected.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158396: Investigating Redox Geochemistry and Peat Soil Characteristic of the Caimpugan Peatland, Agusan Marsh Wildlife Sanctuary, Mindanao, Philippines: Implications for Carbon Sequestration

Matt Andrew Graban ^{1,*}, Jasey Jay Yu ¹, Shaira Enriquez Balido ¹, Chandoeun Eng ² and Nichole Anthony Dacallos Pacle ¹

¹ Department of Geology, Caraga State University, Butuan City 8600, Philippines

² Faculty of Geo-resources and Geotechnical Engineering, Institute of Technology of Cambodia, Phnom Penh P.O. Box 86, Cambodia

This study investigates the redox geochemistry and soil characteristics of the Caimpugan Peatland within the Agusan Marsh Wildlife Sanctuary, Mindanao, Philippines. The ability of these peatlands to accumulate and preserve carbon is shaped by these processes that regulate microbial and geochemical activity. Despite the ecological importance of these systems, the redox geochemistry of peatlands in the Philippines remains least studied especially in understanding how local peat environments function as carbon sinks. Peat cores were collected from various forest types and depths, reaching up to 5 meters below the surface, to evaluate gravimetric moisture status, redox and geochemical conditions. The study revealed that the maturity of the peat grades, ranging from fibric peat in the upper layers to clayey peat in the lowest sections, reflecting past changes in water conditions and organic matter input that affect microbial activity and redox processes. The peat exhibited a very high moisture content, reaching up to 384.34%, indicating persistent saturation and limited oxygen diffusion- favoring the buildup and preservation of organic material. Redox analyses revealed that 7.4% of the samples fell within the iron reduction zone, primarily near the surface, while 92.6% fell within the sulfate reduction zone. The strong dominance of sulfate-reducing conditions suggests a highly reduced environment where most available electron acceptors are depleted. Redox potential values were observed to nearly reach the threshold of methanogenesis, reflecting extremely low oxidation states typical of stable carbon-preserving systems. Geochemical results identified major oxides, including SiO₂, Al₂O₃, SO₃, Fe₂O₃, TiO₂, P₂O₅, CaO, and MgO, which influence nutrient exchange, buffering capacity, and redox balance. Overall, the Caimpugan Peatland shows consistently reduced, saturated, and chemically stable conditions that support long-term carbon storage. These findings provide a clearer understanding of peatland redox environments in the Philippines and their role in sustaining carbon reservoirs under natural tropical conditions.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-160272: Mineral–Geochemical Weakening Mechanisms in Giant Rock Landslides within the Tibetan Plateau Suture Zone

Jinlu Zhou *, Ming Wang, Quewang Danzeng, Binxuan Hao, Yuhe Zhang, Zhenglong Li and Xiaohu Lian

College of Earth Sciences, Jilin University, Changchun 130061, China

The suture zone of the Tibetan Plateau is a hotspot for giant, high-steep rock landslides. The stability of these rock masses is controlled not only by diverse exogenic and endogenic processes but, more fundamentally, by ongoing mineral-geochemical processes within them. We investigated a typical schist/gneiss landslide body, enriched with an assemblage of albite (Ab), garnet (Grt), actinolite (Act), epidote (Ep), biotite (Bt), chlorite (Chl), and quartz (Qtz), through detailed field surveys and electron microscopy. This study reveals how the evolution of mineral parageneses governs slope stability and landslide initiation. Our findings indicate the following: (1) In schists and gneisses, primary high-strength minerals (e.g., garnet (Grt), hornblende (Hbl)) are commonly altered to sheet-silicates and fibrous minerals like chlorite (Chl), epidote (Ep), and muscovite (Ms) during retrograde metamorphism or hydrothermal alteration. These secondary minerals form foliated mechanical weak zones, significantly reducing the overall shear strength of the rock mass. (2) Key geochemical reactions, notably the chloritization of biotite (Bt) and sericitization of plagioclase (Pl), alter the geochemistry of local pore fluids, create preferential pathways for fluid migration, and intensify water-rock interactions. (3) Oriented parageneses of actinolite (Act), epidote (Ep), chlorite (Chl), and quartz (Qtz) constitute potential, bedding-parallel mechanical anisotropy planes. The rock mass becomes prone to instability along these weakness planes under tectonic stress or gravitational unloading. We conclude that for schist and gneiss slopes widespread in the suture zone, mineral-geochemical evolution is the intrinsic control on long-term strength and deformation behavior. Integrating paragenetic and alteration sequence analysis into stability assessments enables genetic identification of potential slip boundaries and prediction of rock mass degradation. This work provides a novel geochemical perspective on the deep-seated origins of large-scale landslides, showcasing a cutting-edge application of mineralogy to major engineering geological challenges.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-153293: Mineralogical and Geochemical Analysis of Heavy Placer Derived from Chaliyar River, Kerala, India

ROSE RAJAN *, SUNDARARAJAN M, Prasanna Muddarangappa and Peer Mohamed A

CSIR -National Institute for Interdisciplinary Science and Technology(CSIR-NIIST), Materials Science and Technology Division, Thiruvananthapuram-695019, Kerala, India

This study investigates the mineralogical and geochemical characteristics of heavy placer deposits from the Chaliyar River in Kerala, India, with a focus on ilmenite. Sand samples were collected from five locations in the Nilambur region and examined through sieve analysis, heavy mineral separation, X-ray fluorescence (XRF), X-ray diffraction (XRD), and petrographic microscopy.

Grain size analysis revealed that most of the sediments are below 600 μm , with a dominant fraction around 180 μm , reflecting moderately high-energy depositional conditions suitable for heavy mineral accumulation. Heavy mineral separation allowed for the concentration of the dense fractions for further study. XRF analyses indicated notable enrichment of Fe_2O_3 , TiO_2 , ZrO_2 , and Cr_2O_3 , which confirmed the presence of ilmenite, zircon, and garnet. XRD confirmed the crystalline nature of these mineral phases, while petrographic line counting provided quantitative data on their relative abundances across grain-size classes and sampling sites.

The results highlight the occurrence of economically valuable heavy minerals, particularly titanium-bearing ilmenite, within the Chaliyar River sediments. The observed mineralogical and geochemical variations also reflect differences in source rock composition and sediment transport processes within the basin.

This work establishes a baseline for understanding the distribution and concentration of heavy minerals in the Chaliyar River and provides a foundation for future studies and resource assessment in Kerala's placer-rich terrains.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-161043: Mineralogical and physicochemical characterization of the Pb and magnetite interaction in a simulated biofluid

Ginevra Mango *, Alessandra Passarella and Ruggero Vigliaturo

Department of Earth Sciences, University of Turin, 10124 Turin, Italy

In human beings, metals have a role in biochemical and physiological functions, but an excess of metals concentration and consequent precipitation can result in adverse effects, triggering a variety of diseases.

In particular, Pb is a metal known to damage several organs in the body, and the literature emphasizes its effects on the central nervous system. Lead disrupts important mechanisms of neural systems, such as synapse formation, axon dendritic extension, and plasticity.

Moreover, other studies focus on the presence of both endogenous and exogenous magnetite in the human brain, which might preferentially adsorb Pb.

In this study, we investigate the interaction between Pb, in the form of $\text{Pb}(\text{NO}_3)_2$, and magnetite nanoparticles smaller than 200 nm, as this is the dimension that allows particles to pass through the blood brain barrier. This investigation focusses on a low-temperature and low-pressure environment, mimicking the human brain condition by means of a simulated biofluid (a phosphate buffer saline – PBS). Our goal is to understand the nanoparticles physicochemical state pre- and post-interaction, the Pb and Fe valence state at the magnetite surface or near-surface, and the adsorption capacity of such ions (Pb) by magnetite.

The experiment was performed by adding to a PBS suspension of magnetite nanoparticles, PBS previously mixed with $\text{Pb}(\text{NO}_3)_2$. The solution was kept at 39°C for 48h, rinsed with distilled water, and the solid phase was prepared for the following analyses.

The samples pre- and post-interaction were characterized using a multi-analytical approach combining PXRD, XPS, SEM-EDXS and TEM-EDXS. It has been observed that magnetite adsorbs Pb on its surface through the complexation of Pb with deprotonated surface hydroxyl groups, which are critical functional groups.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-161040: Mineralogical characterization of Al_2O_3 and MgO powders as possible energy carriers

Alessandra Passarella ^{1,*}, Ginevra Mango ¹, Valérie Tschamber ², Cornelius Schönnenbeck ², Jean-François Brilhac ² and Ruggero Vigliaturo ¹

¹ Department of Earth Sciences, University of Torino, Via Valperga Caluso 35, 10125, Torino, Italy

² Laboratoire Gestion des Risques et Environnement (EA2334), Université de Haute-Alsace, 3bis rue Alfred Werner, 68093, Mulhouse, France

Europe aims to achieve net-zero emissions by 2050, increasing the demand for efficient, carbon-free energy carriers. Metal powders are a promising alternative to fossil fuels, as energy can be stored by reducing metal oxides and released through metal-air combustion. Metal oxides can be re-reduced in a closed-loop cycle. Iron, Al, and Mg are ideal candidates due to their energy density, availability, and recyclability. Supply-chain and environmental factors, such as Fe abundance, Mg energy density and recycled Al circularity, affect suitability and criticality. This study aims to assess variations of experimental parameters, combustion mechanisms and process optimization for heat production. This will support research on low-carbon energy carriers that are high in energy density, competitive with fossil fuels, sufficiently abundant, and easily recyclable.

For this study, Al_2O_3 and MgO powders were produced in a turbulent burner and a fixed-bed reactor respectively, under different initial conditions, including an excess of Al, water injection to produce hydrogen, or a variation of particle size before the combustion. The effects of these parameters on morphology and chemistry of the samples during oxidation–reduction cycles were then evaluated. The two metals were chosen to compare the influence of the metal type on the overall process. PXRD, SEM-EDXS, and TEM-EDXS techniques were used to identify the phases present in the samples allowing a characterization of their morphology, size, and chemistry, thereby improving the understanding of these processes.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-161374: Old Tool, New Purpose: Rock-Eval Analysis for CO₂ Mineralization Screening in Basalts

João Pedro Tauscheck Zielinski *, Stephanie Carvalho Da Silva, Mellanye Francynne Graf, Erico Albuquerque Dos Santos, William Jeovanini Fucks, Antonio Rosales Goncalves Oliveira, Natalia Da Silva Wouters, Victor Hugo Jacks Mendes dos Santos and Felipe Dalla Vecchia

Institute of Petroleum and Natural Resources (IPR) - Pontifical Catholic University of Rio Grande do Sul (PUCRS), Alegre 90619-900, Brazil

Rock-Eval (RE) analysis has conventionally been employed as a standard and rapid screening technique in the Oil & Gas sector to assess properties of source rocks. The method relies on thermal decomposition of samples through two heating steps (pyrolysis and combustion) during which released gases (CO, CO₂, HCs, and SO₂) are continuously detected by specific sensors. This study evaluated the applicability of RE as a screening tool for assessing CO₂ conversion into carbonates in the context of carbon mineralization in basalts. For this purpose, after developing a two-step experiment (dissolution and precipitation) using powdered basalt from the Serra Geral Group (Paraná-Etendeka Large Igneous Province), a fraction of the samples was analyzed with the RE instrument to evaluate the CO₂ release profile during heating from 300 °C to 850 °C. The analysis revealed a pattern characteristic of carbonates, with decomposition peaks above 650 °C. The amount formed during the experiments was quantified by converting the CO₂ peak into an equivalent calcite mass. This conversion was based on a calibration curve established from known quantities of pure calcite added to a basaltic matrix, allowing correlation of the CO₂ signal intensity to carbonate content. Calculations confirmed that the estimated values were consistent with the CO₂ release observed in the RE profiles. Based on signal intensity, the experimental samples were classified into three groups: G1 with low values (< 500 mV), G2 with moderate values (500–3000 mV), and G3 characterized by high values (> 3000 mV). To complete the workflow, SEM/EDS analyses provided visual confirmation of the carbonate precipitates indicated by RE. The results demonstrate that this approach is a rapid and effective tool for detecting and quantifying mineralized CO₂ in basaltic rocks.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158181: Optimization of Brown Seaweed (*Sargassum crassifolium*) and Glycerine Solution for Dust Suppression on Limestone Mine Haulage Roads

Zeejay Alontaga, Russel Bernard Etic, Stanley Brian Larona, Josep Russell Paez, Rose Anne Marie Hilot, Kaye Martir, Algen Secula, Seigfreid Kempis and Adrian Keith Caamino *

¹ Department of Materials and Resources Engineering and Technology, Mindanao State University – Iligan Institute of Technology, Iligan City, Lanao del Norte, Region X, Mindanao, Philippines

² Resource Processing and Technology Center, Mindanao State University – Iligan Institute of Technology, Iligan City, Lanao del Norte, Region X, Mindanao, Philippines

Dust generation in the mining industry represents a persistent environmental and occupational health challenge, contributing to air pollution, visibility reduction, and respiratory illnesses among workers and nearby communities. This study focuses on developing an innovative and eco-friendly dust suppressant derived from *Sargassum crassifolium* seaweed and glycerine, aiming to provide a sustainable alternative to conventional chemical-based agents. The experimental investigation was conducted on limestone samples, a material commonly associated with mining operations and known for its high potential for dust emission. Results revealed that the inclusion of glycerine enhanced the viscosity and adhesion properties of the seaweed extract, improving its ability to bind fine particles and prevent airborne dispersion. Among the various formulations tested, the 58% *Sargassum*-glycerine mixture demonstrated the most effective performance, achieving a balance between fluidity, moisture retention, and biodegradability. This concentration allowed sufficient water infiltration to maintain soil and material moisture, which is critical for reducing dust release and improving resistance to wind erosion. Laboratory evaluations confirmed that the treated samples exhibited a substantial reduction in dust formation compared to untreated controls. Overall, this seaweed-based dust suppressant offers a promising, sustainable solution for mitigating dust pollution in the mining sector, improving air quality, safeguarding human health, and minimizing environmental impact.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-159290: Paleoenvironment and sediment provenance of the Atafona Formation in the southwestern Campos Basin, Brazil: insights from a pre-salt well

Isabela Dantas de Albuquerque ^{1,*}, Jean Carlos de Amorim ^{1,2}, Filipe Vidal Cunha Santa Rosa Soares de Oliveira ^{1,2}, Carla Semiramis Silveira ³, Reiner Neumann ^{4,5}, Felipe Emerson André Alves ⁴, Josimar Firmino de Lima ⁴, Victor Matheus Joaquim Salgado-Campos ¹ and Antonio Fernando Menezes Freire ¹

¹ Geosciences Institute, Federal Fluminense University (UFF), Niterói, Rio de Janeiro, 24210-240, Brazil

² Petrobras, Rio de Janeiro, 20031-912, Brazil

³ Chemistry Institute, Federal Fluminense University (UFF), Niterói, Rio de Janeiro, 24020-140, Brazil

⁴ Centre for Mineral Technology (CETEM), Rio de Janeiro, 21941-908, Brazil

⁵ Postgraduate Program in Geosciences (PPGeo), National Museum, Federal University of Rio de Janeiro (UFRJ), Rio de Janeiro, Rio de Janeiro, 20940-040, Brazil

Although sub-salt portions of the Atafona Formation – lacustrine deposits from the rift phase of the Campos Basin, Brazil – have been drilled in recent decades, no recent studies have focused on this new data from the formation. Additionally, there is a lack of detailed studies on the clay mineralogy of the formations, as well as a gap in understanding the depositional evolution of the Atafona Formation. In this study, we used cutting samples from a pre-salt well to provide novel data and interpretations on the lithogeochemistry, mineralogy, depositional environment, and sediment provenance of the formation's entire drilled interval. Analyses included X-ray fluorescence (XRF), inductively coupled plasma mass spectrometry (ICP-MS), X-ray diffraction (XRD) – including clay mineralogy – and scanning electron microscopy with energy-dispersive spectroscopy (SEM-EDS), in addition to well log correlation. The primary clay mineral identified is saponite, with geochemical and fabric characteristics indicative of authigenesis, suggesting an alkaline paleoenvironment. Cycles of wetter periods, marked by increased detrital input, and drier periods, marked by increased carbonate formation, were identified. An increase in phosphorus, sulfur, dolomite, and strontium in the upper Atafona Formation suggests a possible growth in microbial activity. Elemental ratios indicate an acidic to intermediate igneous rocks provenance for the formation detrital grains, while we propose an additional mafic source of calcium and magnesium supplied by groundwater flowing through the basaltic basement.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-146548: Pb–(Sn)–(Sb) Oxides in Incineration Bottom Ash: Characterization, Carbonation Behavior, and Antimony Treatment Implications

Quentin Wehrung ^{1,*}, Davide Bernasconi ², Giulia Pia Servetto ³, Nadia Curetti ³, Meissem Mezni ⁴, Florian Audoye ⁵, Enrico Destefanis ³, Caterina Caviglia ³, Ruggero Vigliaturo ^{3,6}, Ginevra Mango ³, Fabien Michel ¹, Alessandro Pavese ³ and Linda Pastoro ^{3,7}

¹ Alkaline Technologies SAS, 44700 Nantes, France

² Department of Earth Sciences, University of Hertfordshire, Hatfield AL10 9AB, United Kingdom

³ Department of Earth Sciences, Università degli Studi di Torino, Via Valperga Caluso 35, 10125 Torino, Italy

⁴ Département de Mécanique, École Nationale d'Ingénieurs de Monastir (ENIM), Avenue Ibn El Jazzar, 5019 Monastir, Tunisia

⁵ TRIFYL, Renewable Energy Hub, 81300 Labessière-Candail, France

⁶ Interdepartmental Centre for Studies on Asbestos and Other Toxic Particulates "G. Scansetti", Università degli Studi di Torino, Via Pietro Giuria 7, 10135 Torino, Italy

⁷ NIS – Nanomaterials for Industry and Sustainability Inter-departmental Centre, Università degli Studi di Torino, Via Pietro Giuria 7, 10135 Torino, Italy

Antimony (Sb) is a critical metal and emerging hazardous pollutant, chemically akin to arsenic (As) and widely used as antimonial lead in Pb–Sb–(Sn) alloys. Despite its volatility, ~45–50% of Sb input to municipal solid waste incinerators remains in bottom ash (IBA). Sb leaching, particularly during mineral carbonation, compromises IBA reuse. We report the systematic occurrence of Pb–(Sb)–(Sn) particles in IBA fines (< 2 mm), spanning a continuum of alteration states. When oxidized, these particles display distinctive yellow to brown-reddish colours and were found in all four samples analysed from the ASHES academia–industry innovation program. Crystal chemistry and formation pathways were resolved at the particle scale using SEM-EDS, XRPD, and TEM-EDXS-EELS, confirming the presence of Sb(0), Sb(III), and Sb(V). Carbonation behaviour was assessed by blending Ca(OH)₂ with crushed Pb–(Sb)–(Sn) particles. Carbonation enhance the dissolution of Pb–(Sb)–(Sn) oxides, with Pb re-precipitating as carbonates with calcite, while Sb remains in solution, explaining the inverse Pb–Sb leaching behaviour widely reported. The strong Pb–Sb association has treatment implications, suggesting density separation of IBA fines prior to carbonation could mitigate Sb release. We propose that this phase is the main source of Sb leaching under IBA weathering conditions, as metallic Pb–Sb assemblages are far less volatile than Sb species in plastics. During incineration they remain on the grate and partially crystallize, whereas Sb from plastics is more likely to volatilize and be captured in fly ash. Sb partitioning during incineration is thus strongly source-dependent, reflecting the distinct thermal behaviours of its main industrial forms.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-157386: Physicomechanical Properties of Non-Fired Ceramics Derived from Philippine Nickel Mining Waste Using Claver Clay Binder

Harvey Melendrez ^{1,*}, Kosuke Tsukigi ², Seigfreid Kempis ³, Kento Ishii ², Masayoshi Fuji ² and Raymond Rivera-Virtudazo ³

¹ Resources Processing and Technology Center, Mindanao State University – Iligan Institute of Technology, Iligan City 9200, Philippines

² Advanced Ceramics Research Center, Nagoya Institute of Technology, Tajimi City 507-0033, Japan

³ Department of Materials and Resources Engineering and Technology, College of Engineering and Technology, Mindanao State University – Iligan Institute of Technology, Iligan City 9200, Philippines

In the Philippines, nickel extraction plays a pivotal role in industrial development by supplying essential raw materials for the global transition to clean energy, metallurgical applications, and advanced technologies. However, the operation of the surface nickel mines generates substantial quantities of mine silt and mine tailings that require proper management to prevent long-term environmental impacts. This study explores the potential of converting nickel mining waste into non-fired ceramics using locally available Claver clay in Surigao del Norte, Philippines, where multiple nickel laterite mining companies operate. X-ray fluorescence showed that Claver clay contains 72.5% combined silica and alumina, confirming its alluminosilicate-rich nature and strong natural binding properties. X-ray diffraction identified mineral phases of rectorite and phyllosilicates, while Fourier-transform infrared spectroscopy (FTIR) revealed characteristics of H-OH and Si-O bonds, suggesting polymeric network formation. Particle size distribution (PSD) analysis demonstrated reduced particle sizes after mechanochemical treatment for both nickel mine silt and Claver clay, while scanning electron microscopy (SEM) showed more cemented and agglomerated morphological structures in the blended samples, suggesting enhanced particle cohesion using Claver clay as a natural binder. The unconfined compressive strength test revealed a 245% increase in strength, from 1.53 MPa for the non-fired mining waste bulk sample to 5.28 MPa for the Claver clay-mixed nickel mining waste sample prepared at a 1:1 ratio. The results highlight a viable route for valorizing nickel mining silt into an eco-efficient ceramic product using locally available materials.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158252: Plagioclase vs. Olivine: Which mineral is more reactive in driving in situ mineralization of CO₂ in Basalt?

Muhammad Hammad Rasool *, Maqsood Ahmad and Numair Ahmed Siddiqui

Petroleum Geoscience Department, Universiti Teknologi PETRONAS, Seri Iskandar 32610, Malaysia

The reactivity of basaltic minerals toward CO₂ mineralization remains debated: laboratory studies at low temperatures identify plagioclase as the most reactive, while reservoir-scale experiments emphasize olivine. This study reconciles the apparent contradiction by establishing that mineral reactivity is not an intrinsic property but a condition-dependent outcome governed by temperature, pressure, pCO₂, and fluid chemistry. Through a synthesis of experimental and modelling evidence, we construct a unified framework incorporating five key controls: dissolution kinetics, surface accessibility, geochemical environment, cation stoichiometry, and reaction timescale. Under near-surface laboratory conditions (25–50 °C, acidic pH), plagioclase dissolves rapidly via proton-promoted hydrolysis, releasing Ca for early carbonate formation. At reservoir conditions (100–200 °C, high pCO₂, saline or wet supercritical CO₂), olivine dominates, showing 1–2 orders of magnitude higher dissolution rates and facilitating fast Mg-carbonate precipitation before silica passivation slows reactivity. Intermediate conditions (50–100 °C) yield mixed Ca- and Mg-carbonates, highlighting the futility of single-mineral extrapolations. Pyroxenes remain kinetically sluggish in all regimes. This perspective demonstrates that successful in situ mineralization depends on engineering reservoir conditions, optimizing temperature, salinity, and fluid pathways rather than simply selecting mineral-rich targets. By reframing mineral reactivity as a dynamic, environment-driven function, this study provides a mechanistic foundation for improved experimental design, predictive modelling, and site selection in CO₂ storage operations within basaltic formations.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-161055: Raman spectroscopy for determining thermodynamic properties of carbonate minerals

Linus P. F. Peixoto *, Julliana F. Alves, Paulo Henrique M. Toledo, Gustavo F. S. Andrade and Luiz Fernando Cappa de Oliveira

Chemistry Department - Institute of Exact Sciences, Federal University of Juiz de Fora, Juiz de Fora - MG 36036-900, Brazil

Carbonate minerals occur in great abundance in the Earth's crust, with calcite (CaCO_3) being the most widespread representative. These minerals are classified into four structural groups: calcite, dolomite, aragonite, and hydroxyl-bearing carbonate groups. Members of the calcite and dolomite groups crystallize in the rhombohedral system, whereas aragonite adopts an orthorhombic structure, and hydroxyl-bearing carbonates are characterized by monoclinic symmetry. Carbonates play a crucial role in the global carbon cycle, serving as major carriers of carbon into the deep Earth. Consequently, the investigation of their physicochemical properties under high-pressure and high-temperature conditions is of considerable scientific interest. Raman spectroscopy is widely employed to obtain thermodynamic properties of these materials because the vibrational properties of a mineral control several of its thermodynamic properties. In this work, five different carbonate minerals from the calcite, dolomite, and aragonite groups were analyzed by pressure and temperature-dependent Raman spectroscopy (calcite, magnesite, dolomite, aragonite, and witherite). Pressures ranged from ambient conditions to approximately 10 GPa, while temperatures ranged from $-175\text{ }^\circ\text{C}$ to $375\text{ }^\circ\text{C}$, representing a notable extension of the existing literature. From the Raman measurements, values of the isobaric and isothermal Grüneisen parameters were determined, as well as anharmonicity parameters for each of these minerals. The fitting procedures used to obtain these properties included both linear and second-order polynomial models for four different Raman modes of the minerals. The results obtained are promising and consistent with previously reported literature data.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158421: Scalable Ammonium Recovery from Livestock and Municipal Digestates with Zeolitic-Rich Tuffs

Matteo Alberghini ^{1,*}, Giulio Galamini ², Barbara Faccini ¹ and Giacomo Ferretti ³

¹ Department of Environmental and Prevention Science, University of Ferrara, Via Luigi Borsari 46, 44121 Ferrara, Italy

² Department of Chemical and Geological Sciences, University of Modena and Reggio Emilia, Via Giuseppe Campi 103, 41125, Modena, Italy

³ Department of Chemical, Pharmaceutical and Agricultural Sciences, University of Ferrara, Via Luigi Borsari 46, 44121 Ferrara, Italy

The circular recovery and reuse of nutrients from wastewater represent key strategies for achieving sustainability targets and the objectives of the EU Green Deal. In this study, the selective capture of ammonium (NH_4^+) was investigated using two distinct zeolitic tuffs: one rich in chabazite and another enriched in both phillipsite and chabazite. This research aimed to assess their suitability for farm-scale applications by testing different anaerobic digestates, originating from swine, cattle, and municipal solid waste.

Adsorption isotherms and kinetic experiments were conducted to evaluate the influence of initial NH_4^+ concentration, contact time, ionic competition (notably K^+), total solids content, and pre-treatment conditions. Equilibrium data were best described by the Freundlich model, indicating a heterogeneous and multilayer adsorption process, while kinetic results fitted well with the pseudo-first-order and intraparticle diffusion models, highlighting ion exchange and diffusion as the predominant mechanisms. Under the same operating conditions, the chabazite-rich tuff exhibited higher ammonium uptake and faster adsorption kinetics compared to the phillipsite-chabazite tuff, reflecting differences in mineralogical composition and cation exchange capacity. NH_4^+ removal efficiency decreased with increasing K^+ concentration and solids content, whereas livestock digestates achieved the highest nitrogen recovery per gram of tuff due to their favorable composition and kinetics. Among the pre-treatments, centrifugation proved most effective, enhancing the accessibility of active exchange sites. A preliminary farm-scale batch test using microfiltered swine digestate at a 3% solid-to-liquid ratio confirmed operational feasibility, resulting in an estimated nitrogen recovery of 715 kg N per year. Overall, these results highlight the potential of zeolitic tuffs for promoting nutrient circularity in agriculture and provide insights for selecting materials to maximize ammonium recovery under diverse farm-scale scenarios.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158213: The chemical composition of ilmenite from different kimberlite pipes (south and north-east Yakutia)

Tatiana Kalashnikova

The laboratory of mafic and ultramafic rock's geochemistry, A.P. Vinogradov Institute of geochemistry SB RAS, 1A Favorsky street, Irkutsk, 664033, Russia

Ilmenite is a diamond-associated mineral. In kimberlites ilmenite occurs as megacrysts and macrocrysts (monomineral nodules), as well as phenocrysts within a fine-grained groundmass. The chemical composition of ilmenite from kimberlites is characterized by high contents of Cr, Nb, and Zr. Large grains sometimes demonstrate wavy extinction and a «mosaic» structure, indicating the influence of deformation processes after crystallization. Ilmenite is also found in lithospheric mantle rocks ranging from 1.5% (Udachnaya pipe, center of Siberian craton, Yakutian kimberlite province) to 4–7% (Obnazhennaya pipe, northeastern margin of the craton). Ilmenite has a variety of morphologies. In the Mir and Obnazhennaya pipes, this mineral occurs as small, rounded and elongated inclusions (up to 20–50 μm in size) in garnet and clinopyroxene, also needles, and lamellae (up to 20–40 μm thick), following the crystallographic orientation of the host mineral. These are presumably exsolution structures. Lamellae show a wide range of chemical composition, from 39.7 to 57.6 wt.% TiO_2 and 4.2–12.5 wt.% MgO . Large variations in the compositions of ilmenite lamellae from pyroxene and garnet crystals suggest that these ilmenites formed as exsolution structures during the gradual cooling of initial pigeonite megacrysts. Ilmenite from mantle rocks forms relatively large (0.3–2 mm) isometric grains with thin elongations parallel to the banding, and lenticular porphyroclasts with features of mosaic polygonality, indicating the initial stage of rock deformation. Thus, ilmenite from kimberlite xenoliths in the central Siberian Craton occurs in polymictic breccias and exsolution structures in other minerals and is predominantly of cumulative origin. Ilmenite from mantle xenoliths from northeast of Yakutia has a variety of morphologies, which allows us to distinguish several generations and indicates a multi-stage genesis and heterogeneous lithospheric mantle beneath the shallow northeastern margin of Siberian craton.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-157869: The environmental distribution and sources of strontium in the case of natural anomaly within the river floodplains

Pavel Nekhoroshkov^{1*}, Alexey Pakhnevich², Inga Zinicovscaia³, Octavian Dului⁴, Tatiana Lychagina¹, Dmitry Nikolayev¹, Alexandra Peshkova¹, Denis Shashurin⁵ and Nikita Yushin¹

¹ Frank Laboratory of Neutron Physics, Joint Institute for Nuclear Research, Dubna 141980, Russian Federation

² Borissiak Paleontological Institute, Russian Academy of Sciences, Moscow 117997, Russian Federation

³ Department of Nuclear Physics, Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering, Magurele 077125, Romania

⁴ Department of the Structure of Matter, Earth and Atmospheric Physics, and Astrophysics, University of Bucharest, Bucharest 010074, Romania

⁵ Faculty of Medicine, Lomonosov Moscow State University, Moscow 119991, Russian Federation

Strontium (Sr) as an alkaline earth metal that substitutes for calcium (Ca) in minerals and could be incorporated into biogenic carbonates and sediments precipitated from the water. In the case of geochemical anomaly of high Sr levels in rocks and sediments, the study determined the origin and spreading among environmental components. The three floodplain zones in the Tula region (Russia) with the suggested high levels of Sr were selected for environmental study. The details of the mineral presence of Sr in typical environment components were found and discussed. The sedimentary rocks as the probable sources of Sr were analyzed by scanning electron microscopy, photon-counting computed tomography, and X-ray diffraction. The levels of Sr were analyzed in component of floodplain ecosystems: substrates, buttercup and shells of the several species of freshwater molluscs. It could be assumed that the strontium containing mineral in the studied rocks from Zone 1 was celestine (SrSO₄). The highest level of Sr in water (>20 mg/L) was in underground spring (brook) in Zone 2, which was higher than the established drinking sanitary limit of 7 mg/L. The obtained values in buttercup (*Ranunculus repens*) were of the same order of magnitude as in plants-hyperaccumulators *Alstonia scholaris* or *Vicia cracca*. This indicate the high abundance of Sr in the studied zones, which is reflected in its enrichment in typical aquatic vegetation. The sediments from studied zone showed an excess of Sr (2635 mg/kg) in the brook at st. 5 and swamp at st. 6 (3336 mg/kg). These values are significantly higher in comparison with the sediments from another regions. The highest levels in shells of freshwater molluscs were found for Zone 3 (10000-12000 mg/kg) on the Ista river. It was concluded that in general, the levels of Sr decreased in the case of high turbidity and low water mineralization.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-146800: Thermodynamic Control of Vivianite Formation in Wastewater

Oxana Spinu and Igor Povar *

Laboratory of Physical and Chemical Methods of Research and Analysis, Institute of Chemistry of the Moldova State University, Chisinau MD2028, Republic of Moldova

This study presents a thermodynamic modeling framework for optimizing phosphorus recovery from wastewater through the crystallization of vivianite $\text{Fe}_3(\text{PO}_4)_2 \cdot 8\text{H}_2\text{O}$. With phosphorus identified as a critical raw material in the European Union and global phosphate reserves under geopolitical stress, recovering phosphorus from wastewater has become both an environmental and economic priority. The methodology involves constructing a thermodynamic model that integrates heterogeneous chemical equilibria, including hydrolysis, complex formation, ligand protonation, and mineral precipitation. The model evaluates interactions among phosphate, iron(II) ions, and potential complexing agents across a pH range of 7 to 11. Gibbs free energy $\Delta G_{\text{overall}}$ changes for the overall crystallization–dissolution process including competing reactions are calculated to define the thermodynamic stability areas for vivianite and co-precipitates such as hydroxyapatite, calcium phosphates, and iron hydroxides. Species distribution diagrams for the analyzed heterogeneous systems and overall Gibbs free energy $\Delta G_{\text{overall}}$ stability maps were constructed based on both synthetic and real wastewater compositions. Obtained thermodynamic results show that phosphorus recovery efficiency improves with Fe:P molar ratios between 1.5 and 1.8, with optimal crystallization occurring at pH 7.0 to 7.5. At higher pH values, the formation of competing mineral phases reduces the selectivity for vivianite. The model also provides quantitative predictions of residual phosphate and iron concentrations after the wastewater treatment. The developed thermodynamic framework facilitates improved control of vivianite crystallization parameters and supports nutrient recovery strategies aligned with circular economy principles. This model is adaptable to a range of wastewater types and informs the design of efficient, low-impact phosphorus recovery technologies.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158317: Zeolite-Based Removal of Thallium from Synthetic and Real Waters: Comparative Study of L, 13X, and Protonated Ferrierite

Luca Adami ^{1*}, Maura Mancinelli ¹, Francesco Di Benedetto ¹, Renzo Tassinari ¹, Matteo Alberghini ², Giacomo Ferretti ³ and Annalisa Martucci ¹

¹ Department of Physics and Earth Sciences, University of Ferrara, 44122 Ferrara, Italy

² Department of environmental and prevention sciences, University of Ferrara, 44122 Ferrara, Italy

³ Department of chemical, pharmaceutical and agricultural sciences, University of Ferrara, 44122 Ferrara, Italy

The removal of thallium (Tl⁺), a highly toxic heavy metal, from aqueous environments is a critical environmental challenge. Zeolites, crystalline microporous aluminosilicates with tunable composition and high cation-exchange capacity, are widely used in environmental remediation due to their ability to selectively capture metal ions from contaminated waters.

We investigated the selective uptake of Tl⁺ by potassium-form L zeolite (K-L) and evaluated the structural adaptations accompanying cation exchange using X-ray powder diffraction (XRPD), Rietveld refinements, thermal analysis, and Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Two additional zeolitic materials—protonated ferrierite (obtained by calcination of its ammonium form) and 13X zeolite, commonly used in environmental applications—were also tested. Batch adsorption experiments were conducted at neutral pH (~7), including isotherms and kinetic studies for 13X. All three materials were further assessed in real Tl-contaminated waters (~17 ppb).

All zeolites achieved nearly 100% Tl⁺ removal in synthetic solutions at 500 ppm and retained significant uptake at high concentrations (~0.5 M). Structural refinements revealed concentration-dependent framework responses: K-L showed minimal lattice expansion at low Tl⁺ loading and anisotropic expansion at high loading, associated with K⁺/Tl⁺ exchange, reduced hydration, and extraframework reorganization. Similar trends were observed for ferrierite and 13X. In real waters, despite competing ions, all three zeolites reduced Tl⁺ concentrations to ~2 ppb.

Tl⁺ incorporation induces precise structural adaptations in zeolitic frameworks, including selective cation redistribution, anisotropic channel expansion, and reorganization of the water network. K-L, 13X, and protonated ferrierite demonstrate high efficiency for Tl⁺ removal from both synthetic and natural waters, highlighting their strong potential for environmental remediation of thallium-contaminated systems.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Session 2. Mineral Systems and Ore Deposits: From Formation to Exploration

sciforum-159453: Critical-Metal Potential and Mineral Systems of the NE Estonian Basement: Insights from Geochemistry, Geostatistics, and Geophysics

Juan David Solano Acosta ^{1,*}, Sophie Graul ¹, Tarmo All ¹, Alvar Soesoo ^{2,3} and Johannes Vind ²

¹ Department of Geology, Tallinn University of Technology, Ehitajate tee 5, Tallinn, 19086, Estonia

² Geological Survey of Estonia, F. R. Kreutzwaldi 5, Rakvere, 44314, Estonia

³ Department of Geology, University of Tartu, Ravila 14a, Tartu, 50411, Estonia

The NE Estonian Precambrian basement, comprising the Tallinn, Alutaguse, and Jõhvi zones, is part of the eastern Fennoscandian Shield. It comprises Paleoproterozoic back-arc basins with juvenile metal-rich volcanic–sedimentary sequences intruded by Svecofennian granitoids, forming an amphibolite- to granulite-facies basement whose lithological and metallogenic traits resemble those of Swedish Bergslagen region and the Finnish Orijärvi district.

This study re-examines over 500 historical drill cores and related geophysical data to reassess the mineral potential of the NE Estonian basement. Cu–Zn–Pb and Au–Ag–As–Sb anomalies are linked with magnetite- rich and sulphide–graphite gneisses, while automated MSCL- XYZ scanning of archived drill cores uncovers multiple critical- metal associations, including Ni–Co–Cr, Mo–W–Bi, Sn–Zn–Cd, Cu–Ni, Nb–Y–P, and Au–Ag–As–Sb–Bi–W–Se–Sn. These patterns reveal previously unrecognised prospective intervals across the Tallinn, Alutaguse, and Jõhvi zones.

A compositional geostatistical workflow was applied to legacy geochemical data. Exploratory tools—such as box plots, concentration maps, and Q–Q plots—were used on raw data, while centred log- ratio (clr) transformation improved signal coherence and interpretative clarity. Clr-based maps, PCA, and heat maps help reduce artefacts caused by heterogeneous sampling, analytical variability, and mismatched neighbouring map sheets, enabling more reliable spatial interpretation.

Lithologies from historical drill cores, often unclassified or inconsistently documented, were re-evaluated using major- element data, with trace- element data reassigned based on the Tallinn–Alutaguse–Jõhvi basement- domain architecture. Combining these geochemical reclassifications with gravity and magnetic data refines the petrotectonic framework of NE Estonia and strengthens links to South Svecofennian and Bergslagen mineral systems.

Collectively, these geochemical, geostatistical, and geophysical findings offer an updated metallogenic model and highlight new targets for critical raw materials within the Horizon Europe DEXPLORE program.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158915: Detailed mineralogy and geochemistry of manganese oxyhydroxide deposits of the Tizi-n-Isdid district

Imad Afla^{1,2,*}, Saïd Ilmen³, Mustapha Souhassou¹, Augustin Dekoninck⁴, Ismail Bouskri¹, Marieme Jabbour⁵, Lhou Maacha² and Mohamed Zouhair²

¹ 2GBEI Laboratory, Polydisciplinary Faculty of Taroudant, Ibn Zohr University, Agadir, Morocco

² Managem Group, Twin Center, 20000 Casablanca, Morocco

³ CAG2M Research Team, Polydisciplinary Faculty of Ouarzazate, Ibn Zohr University, 45000 Ouarzazate, Morocco

⁴ G-Time Laboratory, Department of Geosciences, Environment and Society, Université libre de Bruxelles (ULB), Av. Franklin Roosevelt 50, 1050, Brussels, Belgium

⁵ LAGAGE Laboratory, Department of Geology, Faculty of Sciences Ibn Zohr University, 80000, Agadir, Morocco

The Tizi-n-Isdid manganese deposit, located between the Central Anti-Atlas and the Ounein High Atlas in Morocco, represents a significant stratiform Mn occurrence with low-to-medium ore grades (8–32 wt.% Mn). The mineralization occurs within reddish-brown claystones at the base of the Taroudant Group (Tabia Member), beneath the Tamjout dolomite, and is assigned a Lower Cambrian age (529–541 Ma) (AFLLA et al., 2025). It extends over about 6 km north-south, exhibiting stratiform to lenticular geometry with three facies: massive (F1), banded (F2, dominant), and brecciated (F3).

Mineralogical and geochemical analyses, including new X-ray diffraction data from 14 samples, refine the paragenetic and genetic model (Afla et al., 2025). The ore assemblage is dominated by braunite ($\text{Mn}^{2+}\text{Mn}^{3+}_6\text{SiO}_{12}$), associated with piemontite, hollandite-group minerals, jacobsonite, rhodochrosite, and kutnohorite, while pyrolusite represents a secondary oxidation phase. The gangue mainly consists of quartz, calcite, and minor barite, with muscovite and illite in the altered host rock.

Geochemical correlations between Al_2O_3 –Zr ($r = 0.66$), Fe_2O_3 –Zr ($r = 0.89$), and TiO_2 –Zr ($r = 0.85$) indicate a mafic terrigenous contribution. Co/Ni ratios > 1 and REE data showing HREE enrichment, positive Eu and Ce anomalies, and weak $\Sigma\text{LREE}/\Sigma\text{HREE}$ correlation ($r = 0.30$) suggest a marine hydrothermal Sedex-type system. The paragenetic sequence includes four stages: (1) pre-ore silicification, (2) Mn mineralization with silicification, (3) carbonatation, and (4) late Mn oxidation.

These results indicate syn-sedimentary hydrothermal activity related to rift-associated faulting rather than direct volcanism. The Tizi-n-Isdid deposit provides a representative model for stratiform manganese mineralization within the Ouarzazate Manganese Field.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-153157: Machine learning approaches for mapping silica sand deposits using spaceborne remote sensing

R. G. Rejith^{1,*}, M Sundararajan² and M A Mohammed Aslam³

¹ Materials Science and Technology Division, CSIR-National Institute for Interdisciplinary Science Technology (CSIR-NIIST), Thiruvananthapuram 695019, India

² Materials Science and Technology Division, CSIR-National Institute for Interdisciplinary Science Technology (CSIR-NIIST), Thiruvananthapuram 695019, India

³ Department of Geology, Central University of Karnataka, Kalaburagi 585367, India

The Alappuzha district in Kerala, India, has large deposits of high-grade silica sand mainly used for glass manufacturing. In the present study, these mineral deposits were effectively mapped using multispectral satellite data and machine learning algorithms (MLAs). The samples collected from Cherthala show a silica sand content of 93.93-97.94%. Detailed geochemical characterisation using the Energy Dispersive X-ray Fluorescence (ED-XRF) technique reveals a SiO₂ content of 96.93-99.13%. The X-ray diffraction (XRD) analysis reveals diffraction peaks characteristic of quartz, confirming the silica sand's composition. The spectral signatures of silica sand were captured using an ASD Fieldspec® 3 spectroradiometer (spectral range of 400–2500 nm) and compiled as a reference spectrum for mapping using Landsat and ASTER remote sensing datasets. The reference spectra of silica sand were used to generate the potential targets of silica sand occurrences, followed by a comparison of four widely used MLAs, which shows that the Support vector machine (SVM) outperforms other algorithms, such as the Random Forest Classifier (RFC), maximum likelihood classification (MLC), and artificial neural network (ANN), with an overall accuracy of 97.82% and Kappa coefficient of 0.96. The results derived from the satellite data show a good correlation with ground truth verification and laboratory analysis. Integrating remote sensing techniques, mineral characterization, and field data facilitates eco-friendly and sustainable mining of these strategic minerals.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-157135: Quartz Microfracture Sealing in Orogenic Gold Systems: Coupling Experimental Observations with Reactive Transport Modelling

Swarnendu Bhuyan^{1,*}, Terrence P. Mernagh² and John A. Mavrogenes²

¹ Department of Geology and Geophysics, Indian Institute of Technology Kharagpur, Kharagpur 721302, West Bengal, India

² Research School of Earth Sciences, Australian National University, Acton, ACT 2601, Australia

Understanding how quartz microfractures heal under hydrothermal conditions is crucial for constraining the evolution of permeability, fluid flow, and gold mineralisation in orogenic systems. Early experimental studies established that microfracture healing in quartz is a thermally activated, diffusion-controlled process governed by silica transport and influenced by temperature, fluid chemistry, and fracture geometry. Recent advances combining microstructural observations and phase-field modelling have revealed the cyclic nature of fracture-healing and its feedback on permeability. However, the quantitative relationships between temperature, fluid chemistry, and fracture geometry that control sealing rates remain poorly constrained. To address these issues, we conducted high-temperature (500–650 °C), high-pressure (1.5–3.6 kbar) hydrothermal experiments on quartz in sulphur-rich fluids, integrated with correlation analysis and reactive-transport modelling. The results show that healing time decreases markedly with increasing temperature and increases with fracture width, indicating that thermal activation accelerates silica mass transfer, while wider fractures heal more slowly. Mixed HS⁻-Cl⁻ fluids promote the fastest sealing, followed by sulphur- and chloride-rich systems, whereas CO₂-bearing fluids retard healing owing to lower silica reactivity. Numerical simulations using COMSOL Multiphysics reproduce these trends, showing that quartz precipitation under a pressure gradient causes porosity loss, permeability reduction, and localised fracture sealing. To complement these experiments, Gaussian Process Regression modelling was developed to predict gold solubility in H₂S-rich fluids as a function of temperature, pressure, and HS⁻ concentration, revealing solubility maxima above 600 °C at moderate HS⁻ levels (~0.1–0.2 mol kg⁻¹). Together, these results demonstrate that temperature and fluid composition jointly control quartz sealing and gold transport, emphasising the thermally and chemically driven nature of hydrothermal sealing and episodic mineralisation in orogenic systems.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-161200: Source Characteristics and Metallogenic Potential of Early Paleozoic Highly Fractionated Granites in the Lhasa Terrane

Yuhe Zhang *, Ming Wang, Quewang Danzeng, Bingxuan Hao, Jinlu Zhou, Zhenglong Li and Xiaohu Lian

College of Earth Sciences, Jilin University, Changchun 130061, China

The discovery of the super-large Gari'atong Rb polymetallic deposit and the Jiagang W-Mo deposit in the central Lhasa terrane reveals the significant rare-metal potential of Cenozoic highly fractionated S-type granites. However, the rare metal metallogenic potential of the Early Paleozoic S-type granites, which are also extensively developed in this region, remains poorly understood. Therefore, this study systematically investigates multiple sets of Early Paleozoic granites from the central Lhasa terrane, utilizing whole-rock geochemistry and Sr-Nd-Pb-Hf isotopes to constrain their source characteristics and evaluate their metallogenic potential.

The results show that these granites formed between 530–480 Ma. They are characterized by high SiO_2 (72–80 wt.%), peraluminous nature, strong negative Eu anomalies, and significant depletions in Sr and Ba, belonging to highly fractionated S-type granites. In addition, δCe values close to 1, along with generally low V/Sc and Cu/Zr ratios, collectively indicate that the magmatic system was in a non-high oxygen fugacity environment. Some samples exhibit notably low Nb/Ta and Zr/Hf ratios, closely resembling the geochemical fingerprints of typical Nb-Ta-Sn-W type rare metal mineralizing granites. Isotopically, the granites exhibit negative $\epsilon\text{Nd}(t)$ (–10.7~–5.9) values with significantly high initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios, and negative $\epsilon\text{Hf}(t)$ (–10~–2) values corresponding to two-stage Hf model ages of 1.3–2.3 Ga. Comparison with contemporaneous mafic rocks indicates that their material source was primarily ancient crust.

Integrating the above characteristics, this study concludes that the Early Paleozoic S-type granites in the Lhasa terrane represent a highly fractionated granitic system formed by partial melting of ancient crust in a collisional setting. They possess certain potential advantages for rare metal mineralization, providing a new prospecting direction for ancient metallogenic systems in Tibetan Plateau.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-157917: Experimental Modeling of Djerfisherite Formation in Mantle Systems

Mikhail Yakushik ^{1,2,*}, Valentina Butvina ^{1,3} and Golunova Maria ^{1,2}

¹ Laboratory of Metamorphism, Magmatism and Lithosphere Geodynamics, Institute of Experimental Mineralogy, Russian Academy of Sciences (IEM RAS), 4 Academician Ossipyan St., Chernogolovka, Moscow Region, 142432, Russia

² Laboratory of Metamorphism and Metasomatism named after Academician D.S. Korzhinsky, Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry, Russian Academy of Sciences (IGEM RAS), 35 Staromonetny Per., Moscow, 119017, Russia

³ Laboratory of Earth's Mantle Geochemistry, Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences (GEOHI RAS), 19 Kosygina St., Moscow, 119991, Russia

Djerfisherite ($(\text{K}(\text{Na},\text{Cu})_6(\text{Fe},\text{Cu},\text{Ni})_{24}\text{S}_{26}\text{Cl})$) is a potassium-bearing sulfide mineral that occurs in a variety of reducing, alkaline geological settings, including enstatite chondrites, kimberlites, and alkaline-ultramafic complexes. Its complex chemistry, marked by extensive isomorphic substitution among Fe, Cu, and Ni, as well as solid-solution relationships with related minerals like bartonite (KFe_3S_4), renders it a valuable petrogenetic indicator. However, the genetic mechanisms of djerfisherite—whether formed during high-temperature magmatic processes or via lower-temperature fluid-mediated reactions—remain uncertain. To address this, we conducted high-pressure experiments to simulate djerfisherite formation during mantle metasomatism. Using a gas bomb apparatus, we reacted a sulfide mixture (pyrite:chalcopyrite:pentlandite in 5:1:2 ratio) with K-Cl-rich aqueous fluids at 5 kbar and 600°C for 7 days. Two fluid compositions were tested, differing in $\text{KCl}:\text{K}_2\text{CO}_3$ ratios (1:1 and 1:2). In the 1:1 series, products included potassium carbonates, sulfate glass, iron oxide, residual KCl, and minor, non-stoichiometric sulfides with bartonite-like compositions (KFe_3S_4). Two generations of pyrite were observed, with later grains enriched in Cu and K. In contrast, the 1:2 series yielded potassium sulfides with compositions intermediate between bartonite and djerfisherite, forming a continuous solid-solution series and containing 1–3 wt.% Ni—evidence of substantial elemental substitution. This shift correlates with higher carbonate activity, which promotes djerfisherite stabilization. Our results demonstrate that djerfisherite can crystallize during late-stage, fluid-driven mantle metasomatism through interaction between primary mantle sulfides and K-Cl- CO_3 -rich fluids. Critically, the $\text{KCl}:\text{K}_2\text{CO}_3$ ratio governs sulfide phase stability: carbonate-rich fluids favor djerfisherite, while chloride-dominated fluids stabilize bartonite-like phases. These findings support a fluid-mediated origin for djerfisherite in kimberlites and underscore the role of fluid composition in controlling sulfide mineral assemblages in the Earth's mantle.

Funding: Supported by state contracts of the Institute of Experimental Mineralogy RAS (FMUF-2022-0001) and the Institute of Geochemistry and Analytical Chemistry RAS (FMMZ-2024-0056/0030).



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-157973: From skarn formation to supergene enrichment: fluid evolution and gold remobilisation at Ity and Dahapleu, Western Ivory Coast

Yacouba Coulibaly¹, Michel Cathelineau^{2,*} and Marie-Christine Boiron²

¹ LGRME, UFR STRM, Université Félix HOUPHOUET-BOIGNY d'Abidjan Cocody, BP 582 Abidjan 22, Côte d'Ivoire

² Université de Lorraine, CNRS, GeoRessources, Nancy 54000, France

The Ity gold deposit (Ivory Coast) records two successive mineralising events: an early skarn-related hypogene stage, later overprinted by supergene alteration under tropical weathering conditions ~2 Ga later. Gold at Ity occurs within skarns developed at contacts between carbonate-rich Birimian volcano-sedimentary rocks and felsic intrusions, whereas at the nearby Dahapleu prospect, mineralisation is structurally controlled within shear zones. Gold is present as native gold in pyrite and as Bi-Te-Au-Ag tellurides.

The hypogene Ity system reflects a long-lived thermal anomaly driving fluid circulation and metal deposition through successive favourable events—crustal exhumation, granite intrusion and skarn formation, followed by shear deformation and hydrothermal activity. Fluid inclusion data indicate thus that Ity formed through a hybrid system: a mesothermal orogenic gold event (>350 °C, CO₂-CH₄ fluids) overprinting an earlier saline skarn stage. At Dahapleu, volatile-rich inclusions (CO₂, CO₂-CH₄, CO₂-N₂) reflect metamorphic fluids circulating through fault-controlled, convective systems. The Ity-Dahapleu system thus exhibits fluid characteristics typical of mesothermal orogenic deposits, albeit at higher temperatures than most Birimian gold systems, but also lower temperature stages yielding to the Au-Bi-Te assemblage.

Subsequent tropical weathering and karst development during the Cenozoic generated residual gold enrichment within saprolite and laterite, forming the supergene ore blanket currently mined. Contrasting supergene behaviours between skarn- and diorite-derived ores result from marble dissolution, sulphide oxidation, and collapse brecciation. Kaolinite-goethite assemblages dominate lateritic zones, while smectite typifies saprolitic and marble-derived domains. Gold enrichment is accompanied by Cu, Bi, Mo, and W anomalies, highlighting selective metal mobility during supergene alteration.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-160508: High-Resolution Mapping of Magnetic Source Boundaries Using a Skewed-Sigmoid Approach, A Case Study of the Shavaz Deposit in Iran

Ahmad Alvandi ¹, Elham Zare ^{1*}, Hazel Deniz Toktay ² and Seyed Hossein Hosseini ³

¹ Institute of Geophysics, University of Tehran, Tehran, Iran

² Department of Geophysical Engineering, Istanbul University—Cerrahpasa, Istanbul, Türkiye

³ School of Computing and Engineering, University of West London, London W5 5RF, UK

Abstract

Determining the horizontal position of magnetic anomalies is essential for interpreting subsurface geological structures in geophysical exploration. Although numerous edge-detection techniques exist for outlining anomaly boundaries, many still struggle with issues such as false edge generation, poor resolution, and high noise sensitivity. This study introduces a new high-resolution approach that combines the Skewed-Sigmoid (Skewed-Sig) function with the Total Horizontal Gradient (THG) to overcome these limitations. The Skewed-Sig function resembles the commonly used arctangent operator found in many edge-detection filters, while THG is a standard technique that often lacks sufficient edge-resolution when used alone. By integrating these two components, we develop a hybrid filter—referred to as SSF—that enhances the detection of mineralized targets. To evaluate the performance of the proposed SSF filter, we compare it with widely used methods, including the analytical signal (AS), THG, tilt angle (TA), theta map (TM), and the total horizontal gradient of the tilt angle (TAHG), using a synthetic magnetic model with a complex subsurface structure. To create synthetic conditions close to the real world, noise was added to the model data and the quality of the output maps was checked. The filter is then applied to magnetic data from the Shavaz iron deposit in Yazd Province, Iran. The study area lies within the Central Iran Block, a region known for its significant potential for iron mineralization, particularly hematite and magnetite. Results demonstrate that SSF delineates the mine location with greater accuracy than traditional methods and shows strong agreement with existing geological information and previous investigations in the Shavaz region. Consequently, the SSF technique offers a reliable tool for detecting mineral deposits and other subsurface magnetic sources.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-159296: Hydrothermal Fluid Evolution and Polymetallic Mineralization of the Roc Blanc Pb-Zn-Ag-Au Vein Deposit, Jebilet Massif, Variscan Belt, Morocco

Amal EL ARBAOUI

Laboratory of Geosciences, Environment and Associated Resources, Department of Geology, Faculty of Sciences Dhar El Mehraz, Sidi Mohammed Ben Abdellah University, Fez 30000, Morocco

The Roc Blanc polymetallic vein deposit is located in the NW of Marrakech, in the Variscan Central Jebilet massif, and is closely associated with the contact metamorphic aureoles produced by S- and I-type calc-alkaline granitic intrusions (ca. 330–295 Ma) along the Marrakech Shear Zone. The mineralized veins are hosted by Carboniferous black shales and metavolcaniclastic formations metamorphosed from greenschist to amphibolite facies. Ore assemblages are dominated by Pb-Zn-Ag sulfides and sulfosalts, with late gold occurring as electrum intimately intergrown with multiple sulfide generations. Hydrothermal alteration is characterized by silicification, sericitization, chloritization, and carbonatization. Chlorite and arsenopyrite geothermometry yield temperatures of ~350–364 °C, consistent with a metamorphic origin of the mineralizing fluids. Oxygen, lead, and strontium isotopic signatures further indicate that ore-forming metals and sulfur were largely sourced from the enclosing metamorphic host rocks during granite emplacement and devolatilization of carbonaceous sediments.

Two major stages of ore deposition are distinguished. The pre-ore stage (Stage I) includes two quartz-rich vein generations carrying Fe-As-Zn-Cu sulfides. The main ore stage (Stage II) is enriched in Ag-Au-Pb-Zn-Cu-Sb and is hosted within carbonaceous veins and late quartz generations. Fluid-inclusion studies identify three fluid types: (i) liquid-rich H₂O-N₂-CH₄±CO₂, (ii) vapor-rich H₂O-CO₂-CH₄-N₂, and (iii) aqueous H₂O-salt inclusions. These data reflect the mixing of deep metamorphic fluids with surface to subsurface aqueous fluids, locally trapped under boiling conditions. Stage I mineralization formed at 350 ± 20 °C with salinity around 13.7 wt% NaCl eq., whereas the economically significant argentiferous stage precipitated at ~150 °C with salinity of 12.1 wt% NaCl eq. All ore deposition occurred at relatively low pressure (1–1.1 kbar). Overall, cooling and dilution of the hybrid fluid system represent the key mechanisms driving Ag-rich polymetallic mineralization at Roc Blanc.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-153850: In situ U-Pb dating of 1.75 Ga garnet from the Mary Kathleen Domain, Mount Isa Inlier, Australia

Kaide Cheng *, Di Zhang and Kuidong Zhao

State Key Laboratory of Geological Processes and Mineral Resources, Collaborative Innovation Center for Exploration of Strategic Mineral Resources, School of Earth Resources, China University of Geosciences, Wuhan, Wuhan 430074, China

The Dugald River Zn-Pb-Ag, Mary Kathleen U-REE, and Tick Hill Au deposits are distributed in the Mary Kathleen Domain (MKD), Mount Isa Inlier, Australia. Investigating the magmatic-hydrothermal processes in this region is a key step toward a better understanding of how these deposits formed. Previous studies have established the zircon ages and distribution of magmatic rocks in this region (Spence et al., 2022; Cocker et al., 2025). However, the timing of skarn formation has received limited attention, despite its critical role as an indicator for mineral deposits.

Most of the intrusions in MKD have been grouped into several igneous provinces, which include the Kalkadoon–Leichhardt (ca. 1870–1850 Ma), Argylla (ca. 1780–1775 Ma), Wonga (ca. 1760–1730 Ma), Burstall (ca. 1750–1710 Ma), and Williams (ca. 1550–1500 Ma). We collected skarn samples of the Burstall and Wonga granites (19°45'35" S, 147°08'46" E). The garnet crystals within the calcite matrix commonly exhibit distinct diopside rims in these skarns. QC-04 garnet was used as the primary reference material (130 Ma; Deng et al., 2017), and data reduction was performed on the Isoclock software (Liu et al., 2023) to calculate the garnet U-Pb age. The garnet dating ($n = 14$) yielded a weighted mean age of 1754.2 ± 13.9 Ma (MSWD = 1.2) and a concordant age of 1758.2 ± 13.5 Ma (MSWD = 0.39). Therefore, we interpret that the formation of the sampled skarns is primarily related to the Wonga or Burstall magmatic event (Page, 1983). Based on the degree of discordance observed in zircon (Spence et al., 2022), we propose that the chronological constraints on regional geological processes can be further refined by conducting geochronology of U-rich minerals such as garnet in regional skarns.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158386: Iron stable isotope analysis to decipher hematite ore formation in the Lake Vermilion-Soudan Underground Mine State Park, Minnesota, USA

Zsuzsanna P Allerton *, Guy N Evans, Xinyuan Zheng and George J Hudak

¹ Department of Earth and Environmental Sciences, University of Minnesota, Twin Cities, MN 55455

² Department of Earth and Environmental Sciences, University of Minnesota, Duluth, MN 55812

Iron (hematite) ore bodies that are enclosed within protore banded iron formations (BIFs) can form through supergene, hypogene, or combined supergene–hypogene processes. In the Soudan mine, located in the Lake Vermilion-Soudan Underground Mine State Park, high-grade hematite ores (>60 wt% Fe) occur as hard ore bodies in folded and faulted Neoarchean Algoma-type BIF within the Soudan Iron Formation member of the Ely Greenstone Formation. Upgrading of the BIF by hydrothermal fluids led to the genesis of the replacement-style iron ores, and hypogene alteration is coeval with distant Paleoproterozoic orogenic events (Mazatzal and Yavapai orogenies). Examples of other, globally significant, high-grade and hypogene hematite ore bodies include the ones within the Carajás Mineral Province, Brazil, and the Mount Tom Price of the Hamersley Province in Pilbara, Australia.

This study utilizes iron stable isotopes ($\delta^{56}\text{Fe}$) to distinguish Fe sources necessary for the upgrade process. Hematite, magnetite, and coexisting silicates from surface and subsurface samples were analyzed to fingerprint Fe provenance and hydrothermal system(s). Samples include variably altered BIFs, hematite ore with different textures, and adjacent altered wall rocks. Results show $\delta^{56}\text{Fe}$ values ranging from approximately -0.4‰ to $+1.3\text{‰}$. Our results show that Fe in hematite is systematically lighter as a function of alteration; hematite in least altered BIF is heaviest and hematite formed as replacement in iron ore is lightest. Therefore, replacement hematite likely formed from fluid-derived Fe as opposed to residual Fe from BIF. We interpret hydrothermal fluid origin with heavy Fe sourced from BIF and light Fe sourced from deep-seated crustal hydrothermal fluids. We further explore whether a single hydrothermal system operated, or overprinting events produced composite ores by proposing a hydrothermal genetic model associated with iron ore formation at our research locality.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-155748: Mineralogical Peculiarities of Garnet and Magnesiochromite Compositions in Diamond Inclusions from the Zapolyarnaya Kimberlite Pipe (Yakutia)

Anastasia Vital'evna Kuzyura ^{1*}, Anna Valer'evna Spivak ¹, Victor Sergeevich Groza ², Galina Yur'evna Kriulina ², Egor Sergeevich Zakharchenko ¹, Alexey Vasil'evich Kuzmin ³ and Anastasia Vital'evna Skryabina ⁴

¹ Laboratory of the mantle, D.S. Korzhinsky Institute of the Experimental Mineralogy, Chernogolovka 142432, Russia

² Geological Department, Moscow State University, Moscow 119991, Russia

³ The sector of elementary and structural analysis, Osipyan Institute of Solid State Physics RAS (ISSP RAS), Chernogolovka 142432, Russia

⁴ ALROSA, Unified marketing company ALROSA, Moscow 121170, Russia

A detailed investigation was carried out to characterize garnet and magnesiochromite inclusions in diamonds from Zapolyarnaya kimberlite pipe, Yakutian diamondiferous province, Russia. Optical microscopy, electron probe microanalysis, scanning electron microscopy, Raman spectroscopy, X-ray diffraction, as well as calculations of compositions and residual stresses in the crystals were applied. Seven garnet inclusions were identified within two diamond crystals (3-3 and 3-4), along with other phases. They vary morphologically and in size (50–200 µm), are well-preserved, and appear as isometric grains or irregularly/slightly elongated crystals. Garnet composition, determined from Raman spectral band positions and crystal lattice parameters, evidences to a dominance of the pyrope mineral. The identified variations in pyrope and almandine content may reflect changes in the chemical composition of the diamond-forming medium at different stages of crystal growth, but generally correspond to a peridotitic paragenesis. Residual stress values of the inclusions and the surrounding diamond areas were calculated using their dependence on frequency shift of the main diamond peak. Inclusions in crystal 3-3 are characterized by residual compressive stress. Residual stresses of garnet inclusions in diamond 3-4 have negative values that may indicate residual tensile stress. Magnesiochromite inclusions were identified in 4 diamond crystals. One crystal was polished to expose the inclusions, the rest of them were located inside the crystals. Their morphology and chemical composition indicate formation at peridotitic paragenesis conditions. Comparison of central and peripheral inclusions demonstrates a multi-stage diamond growth, which is confirmed by the correlation of #Mg and #Cr parameters with the position of bands in the Raman spectra. The obtained data confirm the important role of garnets and magnesiochromites as indicators of diamond crystallization conditions of the Zapolyarnaya kimberlite pipe. *This study is supported by program № FMUF-2022-0001 IEM RAS and project 121061600049-4 MSU*



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-160902: Multi-technique characterization of fluorite from the mining districts of Asturias, Spain

Antonia Cepedal ^{1,*}, Mercedes Fuertes-Fuente ¹, Agustín Martín-Izard ¹, José A. Marín Barcáiztegui ² and Luis Villa ²

¹ Geology Department, University of Oviedo, Oviedo 33008, Spain

² Minerale y Productos Derivados S.A. (Department of Geology and Mineral Resources), Getxo (Vizcaya) 48992, Spain

This work is a mineralogical study of fluorite samples (colourless, yellow and purple) from the mining districts of Villabona-Arlós and Caravia-Berbes (Asturias, Spain). It integrates data from UV fluorescence microscopy, SEM-EDS, fs-LA-ICP-TOFMS and fluid inclusions. Different growth stages were identified, some with abundant fluid and solid inclusions, and, in yellow fluorites, yellow bands alternated with colourless bands. UV fluorescence microscopy revealed growth bands with emissions of varying intensity and colour. SEM-EDS identified growth bands with inclusions of barite and celestine crystals, rich in aqueous fluid inclusions containing the same trapped minerals. In one fluorite crystal, an innermost colourless zone contained primary H₂O–NaCl–CaCl₂ fluid inclusions with trapped barite/celestite. Surrounding this zone was a yellow band full of tiny barite/celestite inclusions and an external colourless band hosting H₂O–NaCl fluid inclusions and sulphides. This growth zoning supports a fluid-mixing process previously proposed by other authors. Such mixing induced a local transition from oxidizing to reducing conditions, facilitating the shift from sulphate to sulphide precipitation. Trace and ultra-trace element analyses by fs-LA-ICP-TOFMS were performed in the fluorite growth bands. The designed analytical conditions (15 µm spot size, 3–3.5 J/cm² fluence, 5 s of background and 5 s measurement, Ca as internal standard, NIST610 and 612 as external standards) show the REE distribution at a single crystal level. The REE patterns have an enrichment in the MREE, a positive yttrium (Y) anomaly and a LREE impoverishment. Yellow growth bands have higher REE and yttrium concentrations compared to colourless bands and violet fluorites. The bands with higher UV fluorescence intensity are those with higher concentrations of REE and Y. The results confirm that fluorites from the Villabona-Arlós district contain more ΣREE than those from the Berbes District. These results are consistent with bulk-sample chemical analyses reported by other authors (Sanchez et al., 2010).



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-156693: Olivine and pyroxene as evidences of petrology and mineral resource of basic–ultrabasic intrusions in the Norilsk area, Siberian Traps Province

Nadezhda Krivolutsкая^{1,*}, Bronislav Gongalsky² and Natalia Svirskaya³

¹ Department – Geochemistry of Magmatic Rocks, Vernadsky Institute of Geochemistry and Analytical Chemistry of the Russian Academy of Sciences, Moscow 119991, Russia

² Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry RAS

³ Vernadsky Institute of Geochemistry and Analytical Chemistry RAS

The Norilsk region, the largest metallogenic province in the world, is located in the northern part of Eastern Siberia. This area contains many basic–ultrabasic intrusive bodies related to the Siberian Traps, some of which contain very rich platinum-group element (PGE)–copper–nickel ore deposits, such as Talnakh, Oktyabr'sky, and Norilsk 1. To discover new massifs with sulfide mineralization, the composition of rock-forming minerals, such as olivine and pyroxene, was studied using EPMA, LA ICP-MS, and SIMS methods in ten intrusive bodies with different volumes of sulfide mineralization. It was found that all the massifs exhibit strong variations in mineral composition across vertical cross-sections: olivine varies from Fo₈₂ to Fo₄₃ and pyroxene changes from Mg# 87 to Mg# 52. Additionally, for the first time, it was shown that the composition of minerals within each horizon (picritic, tacxitic, and olivine-bearing gabbro-dolerite) varies in trace elements, particularly in Ti for pyroxene and Ni and Y (HREEs) for olivine. Similar horizons from different intrusions, especially picritic ones, are characterized by different trends in the Fo (Mg#)–trace element coordinates on diagrams. This feature allows us to separate ore-bearing intrusions from all studied massifs. The specific features of intrusions with high sulfur content were demonstrated using statistical methods, as their olivine is enriched in Ni, Ca, Ti, and HREE as compared to barren intrusions. The composition of the parental melts of ore-bearing intrusions was determined by studying melt inclusions in olivine and pyroxene, which corresponds to typical intraplate magmas with normal volatile component contents (H₂O, CO₂, Cl, B). Thus, mineral compositions, rather than rock compositions, aid in recognizing mineralized intrusions. This seems to be based on the difference in f_{O_2} of barren and sulfide-containing magmas during crystallization.

This study was supported by state assignment of the Ministry of Science and High Education of Russian Federation for GEOKHI RAS.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158303: Ore-forming Conditions and Genesis of the Tamdroust Copper Mineralization: Evidence from Structure, Mineralogy, and Stable Isotopes

Ismail Bouskri ^{1,2,*}, Said Ilmen ³, Mustapha Souhassou ⁴, Moha Ikenne ⁵, Mohamed Zouhair ², Lhou Maacha ², Abdelaziz Gaouzi ², Abdel-Ali Kharis ³, Sajjad Maghfouri ⁶, Mohamed Hibti ⁷, Mohammed Ouchchen ⁸, Mbarek Ghannami ⁷ and Marieme Jabbour ⁵

¹ 2GBEI polydisciplinary faculty of Taroudante, Ibnou zohr university, Agadir 82000, Morocco

² Managem Group, Twin Center, 20,000 Casablanca, Morocco

³ CAG2M Research Team, Polydisciplinary Faculty of Ouarzazate, Ibn Zohr University, 45,000 Ouarzazate, Morocco

⁴ 2GBEI Laboratory, Polydisciplinary Faculty of Taroudant, Ibn Zohr University, Agadir 82000, Morocco

⁵ LAGAGE Laboratory, Department of Geology, Faculty of Sciences, Ibn Zohr University, 80,000 Agadir, Morocco

⁶ Department of Economic Geology, Faculty of Basic Sciences, Tarbiat Modares University, Tehran P.O. Box: 111-14115, Iran

⁷ Department of Earth Sciences, Faculty of Sciences and Techniques, University Cadi Ayyad, 40,000 Marrakesh, Morocco

⁸ Geosciences, Environment and Geomatics Laboratory, Department of Earth Sciences, Faculty of Sciences, Ibn Zohr University, 80,000 Agadir, Morocco

The Tamdroust copper deposit, located in the Bou Azzer–El Graara inlier (central Anti-Atlas, Morocco), is hosted in Lower Cambrian carbonate–siliciclastic formations. Copper mineralization is structurally controlled by an N110°–N150° fault system and occurs mainly within greenish siltstones and dolostones deposited in a shallow marine platform setting influenced by terrigenous deposits. Two mineralization styles are recognized: disseminated sulfides in host rocks and vein–veinlet stockworks along fracture corridors. Three paragenetic ore stages are distinguished: (1) early disseminated and veinlet-type bornite–chalcopyrite–pyrite associated with quartz–calcite; (2) hydrothermal enrichment along fault zones marked by the replacement of bornite by chalcocite, together with digenite and covellite; and (3) supergene weathering producing native copper and secondary carbonates (malachite, azurite, tenorite). Sulfur isotope data ($\delta^{34}\text{S} \approx +10.2\text{‰}$) indicate a dominant contribution from thermochemical reduction of evaporitic sulfates. Carbon and oxygen isotopes in calcite ($\delta^{13}\text{C} = -3.6$ to -2.6‰ VPDB; $\delta^{18}\text{O} = -15.8$ to -15.2‰ VPDB) suggest hydrothermal fluids at moderate temperatures ($\sim 150\text{--}160^\circ\text{C}$) derived from mixed meteoric–basinal brines. The spatial distribution of mineralization reflects redox-controlled precipitation at the interface between oxidized hematite-rich red beds and reducing green siltstones and carbonates. These results support a model of epigenetic, stratabound copper mineralization formed during Hercynian tectonic reactivation of Cambrian carbonate–evaporite sequences. The Tamdroust deposit shares strong similarities with Jbel N'Zourk and Jbel Laassal, providing a predictive analog for regional exploration targeting redox interfaces and structurally focused brine pathways.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-145248: Role of In situ beneficiation techniques in Indian Iron Ore Waste mine tailings and dumps for Critical (Li) and REE minerals

P Venkata Sunder Raju

GEOCHRONOLOGY AND ISOTOPE DIVISION, CSIR-National Geophysical Research Institute ,Hyderabad, Telangana State, Hyderabad, Telangana 500007, India

As the global demand for high-grade iron ore continues to rise, it is estimated that current reserves may be depleted within the next 60–70 years. Among the most prominent and widely distributed geological sources of iron are Banded Iron Formations (BIFs), which are characteristic rock types that formed extensively during the Precambrian era across many of the world's shield regions. India ranks fourth in global iron ore production, contributing around 246 million tons, or roughly 8% of global output. However, with growing demand and declining reserves of high-grade ore, it has become increasingly important to exploit low- to medium-grade deposits (45–62% Fe). Upgrading these lower-grade ores depends heavily on comminution, which plays a key role in making mineral beneficiation economically viable. Advanced in situ characterization techniques—such as Light Microscopy (LM), Scanning Electron Microscopy (SEM), X-ray Diffraction (XRD), and automated mineralogical methods—enable rapid, accurate, and reliable data acquisition. By integrating these analytical approaches, effective beneficiation strategies have been developed and tested at both laboratory and pilot scales, successfully achieving the intended results. Beyond conventional iron ore beneficiation, there is also significant potential to recover Rare Earth Elements (REEs) and other critical minerals from weathered iron ores, mine tailings, and waste dumps, particularly from hematitic and goethitic ores. This exploration is analogous to China's world-class Bayan Obo deposit. Recently, the present study in the Ubrani area of Karnataka revealed the presence of lithium-bearing Petalite within titaniferous magnetite seams. Here, lithium is hosted in mineral phases associated with hematitized V-Ti-Mg seams. Petalite appears to represent a late-stage hydrothermal mineralization phase, likely synchronous with the hematitization of these seams, and is possibly linked to the major orogenic gold mineralization events (2.45–2.60 Ga) in the Dharwar Craton. Furthermore, the occurrence of spodumene- and tourmaline-bearing quartz reefs and pegmatites may also be tied to this cratonic evolutionary history.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-159899: Structural analysis and identification of hydrothermal alteration using satellite imagery: Implications for ore prospecting in the Proterozoic Bou Azzer–El Graara inlier (Central Anti-Atlas, Morocco)

Fouzia Anzar

Faculty of Sciences Semlalia, Geosciences Laboratory

Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data were used to investigate structural features and hydrothermal alteration zones for mineral exploration in the Precambrian basement of the Bou Azzer–El Graara inlier, located in the Moroccan Central Anti-Atlas. This domain, recognized as a Pan-African suture zone, contains a complex accretionary mélange of arc-related terranes and dismembered supracrustal ophiolites hosting economically significant mineralizations such as Co, Au, and Cu. Its arid setting offers favorable conditions for satellite remote sensing to detect lineaments and alteration patterns indicative of potential metal resources.

To refine structural mapping of the study area, key lineaments were extracted from ASTER data and compared with existing geological interpretations. The identified NE–SW and E–W fault families are consistent with previous tectonic studies, confirming their strong control on the spatial distribution of mineralization. In addition, previously unmapped faults were revealed, requiring further field verification but providing valuable insights into the region's complex geodynamic evolution. Many of these structures correspond to faults reactivated during the Pan-African, Variscan, and Alpine–Atlas tectonic events.

In the second part of the study, ASTER surface reflectance data were used to map hydrothermal alteration zones through targeted band ratios, enabling the identification of iron oxides, hydroxyl-bearing minerals, sulfates, and carbonates. When combined with available geochemical information, the results show that cobalt anomalies correlate with carbonate–chlorite–epidote alteration, gold anomalies with alunite–kaolinite–pyrophyllite and locally sericite–muscovite–illite–smectite assemblages, and chromium and nickel anomalies with both carbonate–chlorite–epidote and sericite–muscovite–illite–smectite alteration types.

Overall, this integrated approach improves structural and alteration mapping and provides valuable guidance for future mineral exploration in the Bou Azzer–El Graara inlier.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-161417: Structural and compositional characterization of fehrite from Les Ferreres Mine (Ripollès, Catalonia)

Abigail Jiménez-Franco ^{1,*}, Joan Rosell-Riba ², José Luis Garrido-Rufaste ², Joan Vinyoles-Verdaguer ², Pedro Minguez-de-la-Villa ², Robert Oliva-Vidal ¹ and Jordi Ibáñez-Insa ¹

¹ GEO3BCN—Geosciences Barcelona, Consejo Superior de Investigaciones Científicas (CSIC), 08028 Barcelona, Spain

² Grup Mineralògic Català, 08028 Barcelona, Spain

Fehrite ($\text{MgCu}_4(\text{SO}_4)_2(\text{OH})_6 \cdot 6\text{H}_2\text{O}$) from the Casualidad mine (Sierra de Alhamilla, Almería, Spain) was described in 2021 as a new member of the ktenasite group. This secondary sulphate had been previously found in the Les Ferreres mine (Rocabruna, Ripollès, Catalonia, Spain) in 2012 and reported by amateur collectors as a potential new mineral. The available samples, however, still lack a formal characterization. The aim of the present work is to investigate the fehrite from Les Ferreres, which contain light green to bluish-green aggregates of very elongated tabular crystals of the mineral, typically forming parallel to radial acicular clusters. It occurs in association with brochantite, devilline, gypsum, and minor connellite, among others. SEM–EDS, Raman spectroscopy, and X-ray diffraction (XRD) data confirm that these crystals correspond to fehrite with the empirical formula $\text{Mg}_{0.77}\text{Cu}_{3.39}\text{Zn}_{0.61}\text{S}_{2.08}\text{O}_8(\text{OH})_6 \cdot n\text{H}_2\text{O}$ on the basis of 20 O atoms per formula unit, consistent with Mg dominance at one of the cation sites, Cu at the two other sites and Zn in substitution of both Mg and Cu cations. The refined monoclinic unit-cell parameters (s.g. $P2_1/c$) are: $a = 5.626 \text{ \AA}$, $b = 6.137 \text{ \AA}$, $c = 23.861 \text{ \AA}$, $\beta = 95.21^\circ$, $V = 820.5 \text{ \AA}^3$, which closely match the published data for the type material. The paragenesis of fehrite from Les Ferreres is also discussed and compared to that of the type locality.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-161216: Structural setting and chemical analysis of Pb-Cu-Ag $\pm$ (Zn, Mn) hydrothermal mineralizations in the Central Plateau deposit (Jbel Addana District, Western Anti-Atlas, Morocco)

Zoubair El Ouad ^{1,2,*}, Mustapha Souhassou ¹, Moha Ikenne ², M'hamed Alaeddine Belfoul ³, Mohamed Hibti ⁴, Saïd Ilmen ⁵, Younes Moundi ⁶, Atman Madi ⁶ and Abdelhak Karfal ⁶

¹ 2GBEI Laboratory, Polydisciplinary Faculty of Taroudant, Ibn Zohr University, Taroudant, 83000, Morocco

² LAGAGE Laboratory, Faculty of Sciences, Ibn Zohr University, Agadir, 80000, Morocco

³ GESCAT Laboratory, Faculty of Sciences, Ibn Zohr University, Agadir, 80000, Morocco

⁴ 2GCE Laboratory, Faculty of Sciences and Technologies, Cadi Ayyad University, Marrakech, 40000, Morocco

⁵ CAG2M Laboratory, Polydisciplinary Faculty of Ouarzazate, Ibn Zohr University, Ouarzazate, 45000, Morocco

⁶ MANAGEM Group, Twin Center, 20000, Casablanca, Morocco

Located 30 km southeast of the Tagragra d'Akka inlier, Jbel Addana forms part of the Ordovician Jbel Bani chain within the Paleozoic cover of the Moroccan Anti-Atlas. The area is composed of weakly metamorphosed Upper Ordovician detrital units, mainly quartzites, shales, and sandstones. Metallogenically, it corresponds to a mining district comprising several mineralized zones, among which the Central Plateau represents the largest deposit. Lithostratigraphically, the sequence includes interbedded sandstones, shales, and quartzites of the Roud-Aïssa Formation, overlain by the Upper Ktaoua shales and capped by Second Bani quartzites. Geological mapping focused on lithostratigraphic architecture and structural features controlling mineralization. Petrographic, metallographic, and Scanning Electron Microscopy (SEM) analyses were conducted to identify mineral assemblages and alteration stages. Electron-microprobe analyses were performed to determine the chemical composition of ore bodies. Structural data were processed using Win-Tensor software to reconstruct the paleostress responsible for fracture formation and ore emplacement.

Mapping revealed that competent units of the Roud-Aïssa Formation preferentially host mineralization. Ore bodies occur as N110°E–N130°E vertical subparallel veins with regular spacing, carrying lead and copper mineralization. Metallographic and Scanning Electron Microscopy (SEM) observations indicate two main paragenetic stages: (1) a hydrothermal stage marked by quartz, galena, chalcocite, stromeyerite calcite, and siderite; and (2) a supergene stage characterized by anglesite, cerussite, covellite, malachite, smithsonite, and iron oxides. Microprobe analyses show that galena contains minor gold and bismuth (88.77 wt.% Pb, 12.48 wt.% S, 0.76 wt.% Bi, 0.72 wt.% Au) with a structural formula of $\text{Pb}_{1.04}\text{Bi}_{0.01}\text{Au}_{0.01}\text{S}_{0.94}$.

Structural analysis indicates that mineralization is hosted by a dense network of regularly spaced joints. Win-Tensor results show that these fractures were opened under a sub-vertical σ_1 stress controlled by the Hercynian uplift of Precambrian basement blocks. This stress regime promoted fracture opening along the anticline hinge, enabling hydrothermal fluid circulation and ore deposition.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-161373: The mineralization of Brannberget (Central Norwegian Caledonides): Mineral paragenesis, geochemistry, and genesis

Musa Mohammed Musa Mina * and Gabriella B. Kiss

Department of Mineralogy, Institute of Geography and Earth Sciences, Faculty of Sciences, ELTE Eötvös Loránd University, 1117 Budapest, Hungary

Brannberget is found close to the world-famous Løkken volcanogenic massive sulfide deposit (VMS), within the Løkken Ophiolites, Central Norwegian Caledonides (Grenne, 1989). Based on the Norwegian Geological Survey database, the study area represents a minor sulfide-quartz-bearing mineralization. Despite the historical mining activity at this location, no modern studies have been reported.

Field observations, petrographic investigations, mineral chemistry, and preliminary whole-rock geochemistry analyses were performed to characterize this mineralization. A network of ~3-5 cm thick quartz veins with Fe-oxyhydroxide and clay mineral-bearing alteration halo forms stockwork mineralization in the metabasaltic-doleritic greenstone. This rock is altered to albite, sericite, chlorite, and quartz. The quartz veins also contain iron-rich clay minerals, K-feldspar, disseminated pyrite, and chalcopyrite. The geochemical data revealed elevated concentrations of Cu (~ 7270 ppm), Zn (~236 ppm), and Bi (~ 74 ppm) in the quartz vein-bearing rock, compared to the host greenstone.

The observed mineral assemblage reveals high-temperature albitization, followed by intensive chloritization and lower-temperature silicification and sericitization as the fluid cooled owing to water-rock interaction. This multi-stage hydrothermal evolution, the appearing sulfides, and the observed geochemical data are typical of VMS stockwork feeder zones. Therefore, our study provides insights into the deep stockwork zones of this Ordovician VMS system. Further study is suggested to better understand the critical raw material potential of the locality, as our results prove that this stockwork zone might contain promising Cu amounts.

Acknowledgement

Sabina Strmić-Palinkaš, Máté Biró, and Tibor Németh are thanked for fruitful fieldwork conversations, SEM-EDS, and XRD analysis support, respectively. The ELTE Talent Fund supported the fieldwork.

Reference

Grenne, T. (1989): *Econ Geol*, 84/8: 2173-295



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158204: Vanadium-rich Fe-Ti oxide phases in ultramafic-mafic rocks of Madawara Igneous Complex, Bundelkhand Craton, India: insights of metallogeny

Abhishek K. Pandey

Department of Earth and Environmental Sciences, Indian Institute of Science Education and Research (IISER) Bhopal, Bhopal 462066, India

The Archean Madawara Igneous Complex (MIC) comprises a suite of ultramafic-mafic rocks, like serpentinized dunites, harzburgites, wehrlites, peridotites, schists, gabbros, and pegmatitic gabbros. Petrographic and mineralogical investigations reveal vanadium-bearing chromite (1700–7520 ppm), ilmenite (~40000 ppm), magnetite (400–4110 ppm), and titanite (35540–37810 ppm) assemblages from spatially and temporally distinct rock suites within the MIC of the Bundelkhand Granitoid Complex. These oxides exhibit vanadium enrichment, while ilmenite is further distinguished by elevated manganese content. Further, this study suggests that these rocks have experienced postmagmatic alteration processes such as low-temperature hydrothermal alterations and greenschist to amphibolite-facies metamorphism, resulting in extensive replacement of primary minerals, particularly in ultramafic rocks. Mineralogical associations suggest that both magmatic and post-magmatic processes contributed to and affected the formation of Fe-Ti-V-type oxide assemblages. In mafic rocks, element partitioning and sequestration were mainly governed by magmatic differentiation, exsolution, and fractionation, with insignificant crustal contamination. In contrast, ultramafic rocks have signatures of more pronounced post-crystallization modifications. Vanadium enrichment in the oxide phases reflects variable fO_2 and fH_2O conditions and hence suggests redox control redistribution during the metamorphic and hydrothermal alteration of primary silicates and chromite phases. It is also supported by variations in redox-sensitive ratios such as V/Ti and V/Sc. The spatial and compositional segregation of vanadium and manganese-bearing phases across the rock units indicates derivation from a depleted mantle source that was probably affected by metasomatized lithospheric mantle during subduction.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-153606: XRD-Informed Machine Learning to Predict Sequential Cation-Exchange Degradation in Dioctahedral montmorillonite

Walid Oueslati

Physics Department, Faculty of Sciences of Bizerte, University of Carthage, Bizerte 7021, Tunisia

The long-term performance of montmorillonite-based engineered barriers in nuclear waste repositories and contaminated groundwater systems depends critically on understanding how sequential heavy-metal sorption alters interlayer chemistry, hydration equilibria, and macroscopic transport properties. Despite decades of research on single-cation systems, the coupled physicochemical processes governing multi-step cation exchange—where incoming divalent species (Co^{2+} , Ni^{2+} , Mg^{2+} , Cu^{2+} , Zn^{2+} , Cd^{2+} , Pb^{2+} , Ba^{2+}) progressively displace weakly-bound Na^+ from both external surfaces and interlayer galleries—remain poorly constrained, particularly under conditions that generate coexisting hydration states. This gap is addressed by integrating high-resolution XRD 00l profile modeling of Wyoming-type Na-montmorillonite (SWy-2) across systematic exchange sequences with interpretable machine-learning architectures trained on 600 physics-enriched synthetic records combining crystallographic observables (d_{001} spacing, 0W/1W/2W layer-type abundances, Rietveld R_{mp} values, coherent domain lengths) and thermochemical descriptors (hydration enthalpy, ionic potential, polarizability). XRD refinements reveal that sequential exchange does not converge toward homogeneous homoionic but instead stabilizes dynamically disordered mixed-layer structures with 15–35% residual Na^+ occupancy driving non-monotonic d_{001} trajectories that follow Boltzmann-type sigmoid curves rather than linear replacement trends, with effective CEC losses reaching 40% for large, weakly-hydrated cations (Pb^{2+} , Ba^{2+}) due to incomplete interlayer accessibility. Ensemble machine-learning models (Random Forest, Gradient Boosting, Neural Networks) trained on this augmented feature space achieve robust cross-validated performance ($R^2 = 0.90\text{--}0.92$ for fractional uptake; 84–86% accuracy for competitive selectivity ranking), with SHAP decomposition demonstrating that hydration free energy and ionic radius dominate early-stage exchange kinetics while XRD-derived structural disorder metrics become critical predictors of late-stage degradation modes including irreversible 2W→1W dehydration, basal-spacing collapse below 12.5 Å, and the emergence of nano-scale permeability pathways. By embedding crystallographic disorder signatures into predictive models, our approach transcends empirical correlation and enables mechanistic forecasting of barrier aging under realistic poly-ionic exposure scenarios, providing quantitative risk assessment tools for repository safety analysis and adaptive monitoring strategies in deep geological disposal environments over millennial timescales.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Session 3. Nanominerals and Clays: Emerging Applications in Materials Science

sciforum-161228: Thermal Behaviour and Structural Optimization of SiC-Reinforced Polypropylene and Polystyrene Nanocomposites: Mineral-Based Fillers for Advanced Thermal-Management Materials

Sevinj Natiq Hamidova ^{1,*} and Lala Rasim Gahramanlı ²

¹ Faculty of Physics, Baku State University, Baku, Azerbaijan

² Nano Research Laboratory, Excellent Center, Baku State University, Academic Zahid Khalilov St. 23, Baku AZ1148, Azerbaijan

Silicon carbide (SiC), a mineral-derived non-oxide ceramic, has recently gained significant interest as a nanostructured filler for thermal-management materials due to its high thermal conductivity ($\sim 490 \text{ W}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$), chemical stability, wide band gap, and exceptional resistance to oxidation and thermal degradation. When dispersed in polymer matrices, SiC nanostructures function as thermally conductive nodes capable of forming phonon-transport pathways and restricting chain mobility, thereby enhancing heat dissipation and structural robustness. Although several studies have explored SiC-reinforced polymeric systems, systematic comparisons across different host polymers remain limited, particularly with regard to filler-content optimization and thermal response under varying loading conditions. In this work, SiC nanoparticles were incorporated into polypropylene (PP) and polystyrene (PS) matrices at 1–10 wt% via melt blending, enabling evaluation of the influence of nanofiller loading on morphology, crystallization behaviour, and thermal endurance. Differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA) revealed a notable increase in glass transition and decomposition temperatures, confirming improved thermal resistance and molecular confinement at the SiC–polymer interface. SEM further verified uniform filler dispersion at low contents and the development of thermally conductive micro-networks at 5–7 wt%, correlating with enhanced heat-dissipation efficiency. At higher concentrations, partial aggregation was observed, resulting in increased interfacial phonon scattering and reduced thermal transport efficiency relative to the optimum. The results demonstrate that both PP/SiC and PS/SiC nanocomposites show substantial thermal stabilization and improved structural retention, with optimal performance achieved between 5–7 wt%. This work contributes to the expanding field of mineral-reinforced polymer nanocomposites, providing a route toward lightweight, thermally stable materials suitable for electronics packaging, heat-resistant components, and next-generation thermal-management applications.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-161223: A Computational Study on Geochemical Stability of Natural and Engineered Sesquioxide Nanominerals

Md. Nurjaman Ridoy *, Sabbir Hossain, Tahzib Ibrahim Protik and Sk. Tanjim Jaman Supto

Department of Environmental Research, Nano Research Centre, Sylhet, 3114, Bangladesh

Sesquioxide minerals (R_2O_3) occur widely in natural systems, including Fe- and Al-based soil minerals such as hematite and corundum, and exist as technologically important engineered oxides such as Ga_2O_3 , In_2O_3 , and various rare-earth sesquioxides. Although these compounds are primarily recognized as highly thermodynamically stable and relevant in the environmental context, their nanoscale stability mechanisms in the presence of ambient geochemical conditions remain poorly understood. This study computationally evaluates the thermodynamic stability of representative natural and synthetic sesquioxide nanominerals to address this gap. Density functional theory (DFT) calculations were performed to obtain internal energy, enthalpy, Gibbs free energy, heat capacity (C_v), entropy, dipole moment, and point-group symmetry for selected R_2O_3 systems. For arsenolite-type As_2O_3 , the verified values include an internal energy of -127691.670510234 eV, free energy of -127692.832381907 eV, C_v of $18.804 \text{ cal}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$, entropy of $91.852 \text{ cal}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$, a dipole moment of 5.2738 Debye, and Cs symmetry. Additional sesquioxides, including Fe_2O_3 , Ga_2O_3 , Sc_2O_3 , Cr_2O_3 , and others, were analyzed using the same computational protocol, with comparative trends observed across the dataset. The results indicate symmetry-dependent variations in electronic structure and dipole behavior even when their overall thermodynamic magnitudes remain comparable under standard conditions. These findings support the potential of quantum-chemical approaches for predicting nanoscale mineral stability in geochemical environments. Further work is needed to investigate interactions with aqueous ions and to explore stability variations across broader geochemical variables such as pH and redox conditions, to better link computational signatures with natural environmental behavior.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158008: Effect of Sintering Atmosphere on the Densification and Phase Transformation of Binary Lanao Red Clay–Black Cinder Ceramic Bodies

Sherlyn Keh Derla Dionio ^{1,2,*}, Chrystelle Salameh ³ and Ivyleen Bernardo Arugay ^{1,2}

¹ Department of Materials and Resources, Engineering and Technology (DMRET), Mindanao State University – Iligan Institute of Technology (MSU-IIT), Iligan City 9200, Lanao del Norte, Philippines

² Ceramic Researches for Engineering, Advanced Technology, and Environment (C.R.E.A.T.E.) Laboratory-Research Center for Advanced Ceramics (RCAC), Mindanao State University – Iligan Institute of Technology (MSU-IIT), Iligan City 9200, Philippines

³ Institut Européen des Membranes (IEM), UMR 5635, Université de Montpellier, CNRS, ENSCM, 34095 Montpellier Cedex 5, France

Production of ceramics involves multiple stages, among which sintering is critical for achieving desired properties. The sintering environment, particularly the sintering atmosphere, influences the densification and phase transformation of ceramics. Understanding the phase transformation and densification is essential for optimizing the microstructure and performance of the final ceramic products. This study investigated the effect of sintering atmosphere on the densification and phase transformation of the binary composition of red clay and black cinder. Red clay and black cinder are iron-rich silicates abundant in Lanao del Norte, Philippines. They were mixed in varying proportions, dry-pressed, and sintered at 1200°C under oxidizing (air) or inert (argon) atmospheres. Densification was evaluated through water absorption (WA) and apparent porosity (AP), while mechanical strength was evaluated via the Modulus of Rupture (MOR) test. Phase composition and microstructure were characterized using X-ray diffraction (XRD) and scanning electron microscopy (SEM).

Argon-sintered samples exhibited enhanced densification, with water absorption and apparent porosity of 0.011% and 0.02%, respectively, compared to 0.25% WA and 0.43% AP in air-sintered samples. Correspondingly, the MOR increased by an average of 25%, reaching up to 47.57 ± 4.18 MPa under argon versus 36.77 ± 2.15 MPa in air. XRD results showed distinct phase differences between air- and argon-sintered samples. In air, the phases present were tridymite, mullite ($\text{Al}_6\text{Si}_2\text{O}_{13}$), and cristobalite (SiO_2 polymorph), while in argon, cristobalite was absent, with new observed phases of hercynite (FeAl_2O_4) and bytownite ($\text{CaAl}_2\text{Si}_2\text{O}_8$). SEM observations further confirmed a denser microstructure in argon-sintered samples. In conclusion, sintering atmosphere affects the densification and phase transformation of red clay–black cinder ceramics. Argon-sintered samples demonstrate enhanced densification and higher strength, suggesting potential applications in high-strength ceramics and refractories for preliminary kiln linings in basic environments, with performance under actual operating conditions requiring further assessment.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-160990: Synthesis and magnetic properties of a synthetic analog of yakubovichite, $\text{CaNi}_2\text{Fe}(\text{PO}_4)_3$

Elizaveta Manokhina ^{1,*} Larisa Shvanskaya¹ and Aleksander Vasiliev²

¹ Faculty of Geology, Lomonosov Moscow State University, Moscow 119911, Russia

² Faculty of Physics, Lomonosov Moscow State University, Moscow 119911, Russia

The crystal structure of $\text{CaNi}_2\text{Fe}(\text{PO}_4)_3$ belongs to the well-known $\alpha\text{-CrPO}_4$ structural type. Phosphates with this structural architecture are considered promising candidates for alkaline-ion batteries. Within the crystal structure of $\text{CaNi}_2\text{Fe}(\text{PO}_4)_3$, iron and nickel atoms occupy independent octahedral sites. Nickel-centered octahedra share edges to form Ni_2O_7 dimers, which, in turn, link via vertices with FeO_6 octahedra to construct a three-dimensional framework. The presence of two different transition metal cations may give rise to rare magnetic states. Although a synthetic analogue of $\text{CaNi}_2\text{Fe}(\text{PO}_4)_3$ was previously obtained via a sol-gel method by Ouaatta S. (2017), its magnetic behavior remained uninvestigated.

In this work, $\text{CaNi}_2\text{Fe}(\text{PO}_4)_3$ was synthesized using a solid-state reaction method. A stoichiometric mixture of high-purity $\text{FeC}_{12}\text{H}_{22}\text{O}_{14} \cdot 2\text{H}_2\text{O}$, $\text{CaC}_{12}\text{H}_{22}\text{O}_{14}$, NiO , and $(\text{NH}_4)_2\text{HPO}_4$ was preliminarily annealed at 873 K to remove organic components, followed by a two-stage annealing process at 1273 K with intermediate grinding. Phase purity and chemical composition were checked by X-ray powder diffraction (XRD) and Energy-Dispersive X-ray spectroscopy (EDX). Magnetic susceptibility measurements indicate that $\text{CaNi}_2\text{Fe}(\text{PO}_4)_3$ undergoes a transition to a magnetically long-range-ordered state at $T_c = 15.4$ K with residual magnetization. This is confirmed by the presence of a hysteresis loop measured at 2 K. Analysis of the temperature dependence of the magnetic susceptibility suggests the dominance of antiferromagnetic interactions in $\text{CaNi}_2\text{Fe}(\text{PO}_4)_3$. The weak ferromagnetism of $\text{CaNi}_2\text{Fe}(\text{PO}_4)_3$ motivates further study of the magnetic exchange interactions to elucidate the fundamental mechanism and applicative potential of the title compound.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-157489: Effect of the Specific combination of the Applied Voltage and substrate gap of Electrophoretic deposition on the yield and purity of Montmorillonite

Ivyleen Constantino Bernardo-Arugay ^{1,*} and Leslie Joy L Diaz ²

¹ Department of Materials and Resources Engineering and Technology/ College of Engineering, Mindanao State University-Iligan Institute of Technology, Iligan City 9200, Philippines

² Department of Mining, Metallurgical and Materials Engineering/ College of Engineering, University of the Philippines, Diliman, Quezon City 1101, Philippines

The Cloisite Na-Montmorillonite (CNa-MMT) available in the market contains other silicates, such as beidellite, quartz, cristobalite and tridymite. This study explores the potential of electrophoretic deposition (EPD) to improve the purity of CNa-MMT as an important nanoclay filler of nanocomposites, at least for construction materials, food containers, environmental remediation, wound management and sports gear applications. A program of procedures was developed using AUTOLAB p/g for the conduct of EPD. Stainless steel strips were used as electrodes during EPD. XRD of EPD deposits was performed using a Shimadzu XRD-700 with a copper target. Two levels of applied potential were used: high potential “HP”, low potential “LP”, and electrode gap; high electrode gap “HeG” and low electrode gap “LeG”, were investigated for their effects on the yield and purity of CNa-MMT deposits. Analysis of Variance for the two-factor fixed effect model was performed to determine the effects of the factors and their interaction on the yield of CNa-MMT EPD deposits at a 95% confidence level. Results showed significant effects of applied potential, electrode gaps and their interaction on the yield and purity of CNa-MMT. The specific combination of HP-LeG resulted in the highest yield of Na-MMT deposits, while low potential levels (LP) at any electrode gap had a low yield. Interaction plots also showed that low gap (LeG) has a higher slope than high gap (HeG), suggesting that a slight increase in applied potential at a low electrode gap (LeG) will result in a higher increase in the dry Na-MMT EPD deposit than with the same level of potential at a high electrode gap (HeG). Results further showed that even though HP-HeG and LP-LeG experienced the same effect of the electric field, HP-HeG resulted in a higher yield than LP-LeG. Furthermore, XRD showed that the dry Na-MMT EPD deposits swelled and attained higher purity than the commercially available Cloisite Na-MMT.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-157467: Local Diatomaceous Earth from Kapatagan, Northern Mindanao, Philippines: A Micro/Nanoporous Siliceous Additive for Ceramic Wall Tile Production

Jomari ACOYMO CATAMA-AN¹, Edison Acosta Limbaga¹, Eduardo dela Rosa Magdaluyo Jr², Emie Salamangkit Mirasol³, Maricar B Zabala⁴, Raymond V.Rivera Virtudazo^{5,*} and Masayoshi Fuji⁶

¹ Research Center for Advanced Ceramics (RCAC), Mindanao State University – Iligan Institute of Technology, Iligan City 9200, Philippines

² Department of Mining, Metallurgical and Materials Engineering, University of the Philippines – Diliman, Quezon City 1101, Philippines

³ Department of Materials Science and Engineering (Ceramic Engineering Program), Mariano Marcos State University, Batac City 2906, Philippines

⁴ Department of Education, Barayong National High School, Barayong, Magsaysay, Davao del Sur 8004, Philippines

⁵ Department of Materials and Resources Engineering and Technology, Mindanao State University – Iligan Institute of Technology, Iligan City 9200, Philippines

⁶ Advanced Ceramics Research Center (ACRC), Nagoya Institute of Technology, Tajimi 507-0033, Japan

Advancements in micro/nanomineral-based materials are driving innovations in sustainable ceramics. This study explores the potential of locally sourced diatomaceous earth from Kapatagan, Lanao del Norte, Philippines, as a micro/nanoporous siliceous additive for improving the performance and sustainability of commercial ceramic wall tiles. The Kapatagan diatomaceous earth (KDE) exhibited notable physicochemical characteristics, including 52.49% water absorption, 19.28% fired shrinkage, 0.92 g/cm³ bulk density, and 48.79% apparent porosity. Scanning electron microscopy revealed the presence of intricate, porous diatom frustules that retained micro/nanostructured features even after sintering. X-ray diffraction (XRD) analysis indicated the presence of hematite and quartz in the raw KDE, with the transformation of phases to cristobalite and quartz upon sintering at 1150 °C.

Incorporating 5 wt.% KDE into a standard wall tile body (T5), sintered at 1235 °C, led to an increase in water absorption (0.48%) and apparent porosity (0.80%), while reducing fired weight (66.92 g) and bulk density. The microstructural evolution of T5 showed modified interparticle porosity, causing a slight decrease in the modulus of rupture (6.03 MPa). The XRD pattern of T5 confirmed quartz and cristobalite as the dominant crystalline phases. A control tile (T0, without KDE) was also fabricated for comparison.

These findings demonstrate the promising role of local diatomaceous earth as a sustainable micro/nanoporous siliceous additive, highlighting its contribution to the emerging field of micro/nanomineral-based materials for advanced and lightweight ceramic applications.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-156596: Mineral-Derived Silicon Carbide/Polystyrene Nanocomposites: Structure–Property Relationships and Dielectric Performance

Shafiga Safar Alakbarova ^{1,*} and Lala Gahramanli ²

¹ Physics Department, Baku State University, Z. Khalilov Street 23, Baku AZ1148, Azerbaijan

² Nano Research Laboratory, Excellence Center, Baku State University, Z. Khalilov Street 23, Baku AZ1148, Azerbaijan

Silicon carbide (SiC) was synthesized through the carbothermal reduction of mineral-derived silicon dioxide (SiO₂) using an argon-assisted vacuum route, establishing a direct link between natural mineral resources and functional ceramic nanomaterials. The obtained β -SiC nanostructures, with crystallite sizes of 13–44 nm depending on strain relaxation, were incorporated into a polystyrene (PS) matrix (1–10 wt %) to investigate how filler morphology and loading affect the composite's optical and dielectric behavior. X-ray diffraction confirmed the cubic 3C-SiC phase, while SEM revealed faceted micrograins derived from SiO₂ precursors. FTIR spectra retained the characteristic polymer bands but showed progressive enhancement of Si–O–C and Si–C vibrations, confirming partial surface oxidation typical of mineral-origin SiC. Optical spectroscopy indicated a widening of the band gap from 3.91 to 4.22 eV as SiC concentration increased up to 5 wt %, reflecting improved dispersion and cleaner SiC–PS interfaces. Dielectric spectroscopy revealed a systematic rise in permittivity (ϵ') and controlled energy dissipation (ϵ'') with filler loading, governed by Maxwell–Wagner–Sillars interfacial polarization below percolation. The composite with 7 wt % SiC exhibited the highest crystallinity and minimal internal strain, demonstrating an optimal balance between dielectric stability and optical transparency. This study bridges mineral-based precursor chemistry and polymer nanocomposite design, offering a sustainable route for developing multifunctional dielectric and UV-shielding materials from naturally sourced SiO₂.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158019: Atomistic Simulations of the Thaumasite–Water Interfaces

Evgeny Tararushkin

HSE University

Thaumasite, along with ettringite, is responsible for sulfate attack in concrete based on Portland cement [1]. Chemically represented as $\text{Ca}_3[\text{Si}(\text{OH})_6](\text{CO}_3)(\text{SO}_4) \cdot 12\text{H}_2\text{O}$, thaumasite exhibits a columnar crystal structure comprised of stacked silicon hydroxide and calcium hydroxide polyhedra. The hydroxide columns are interconnected through a network of hydrogen bonds (H-bonds), facilitated by H_2O molecules, sulfate ions, and carbonate ions occupying the intercolumnar spaces within the crystal.

Here, we use the classical molecular dynamics (MD) simulation technique together with the ClayFF-MOH force field [2, 3] to quantitatively investigate the mineral–water interfaces. Water structuring at the (100) and (001) surfaces for thaumasite and ettringite shows that the affinity of thaumasite for water is greater. However, the total amount of H_2O molecules on the surface is the same for both minerals. Investigation of the (hk) solid–water interfacial energies confirms that thaumasite is more soluble than ettringite. The (001) surface of thaumasite is more susceptible to dissolution than its (100) surface. Due to the smaller number of H_2O molecules in the structure of thaumasite, the density of the H-bonding network is lower at the thaumasite (001) surface. Dissolution of structural H_2O from the thaumasite (001) surface is most likely, as intracrystalline H-bonds between structural hydroxyls and H_2O molecules are the weakest. The MD simulations also demonstrate that the solid (100) interface between the thaumasite and ettringite crystals is stable, confirming the assumption that epitaxial growth of thaumasite on the ettringite surface is possible. Thus, our MD results establish the mechanism governing AFt phase dissolution/formation, which is critical for enabling accurate thermodynamic models of cement systems.

References

- [1] Köhler, S., Heinz, D. and Urbonas, L., *Cem. Concr. Res.* 36 (2006) 697-706.
- [2] Cygan, R., Greathouse, J. and Kalinichev, A., *J. Phys. Chem. C* 125 (2021) 17573-17589.
- [3] Tararushkin, E., Pisarev, V. and Kalinichev, A., *Cem. Concr. Res.* 156 (2022) 106759.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158149: Exploration of Silt from Mining Waste as Filler for Polymer Composites

Mary Jane N. Gotostos-Zozobrado ^{1,2,*}, Jan Michael B. Mutia ², Fel Jane A. Echavez-Salo ², Christian Julle C. Saladaga ², Vannie Joy T. Resabal ² and Ivyleen C. Bernardo-Arugay ²

¹ Department of Chemical Engineering, College of Engineering, Mindanao State University - Main Campus, Marawi City 9700, Philippines

² Department of Materials and Resources Engineering Technology, Mindanao State University—Iligan Institute of Technology, Iligan City 9200, Philippines

Silt from mining siltation ponds poses environmental risks and hazards, necessitating research into sustainable valorization techniques. One of the unexplored ways to do so is to use them as sustainable fillers for polymer composites. This study investigates the use of silt from mine waste, sourced from siltation ponds of a mining company in the southern Philippines, as a sustainable filler in unsaturated polyester resin (UPR) composites to advance a circular economy. The silt, processed to 1 micron and treated with sodium silicate, was incorporated at 1%, 3%, and 5% weight percentages. Composites underwent tensile and flexural strength tests, with silt characterized by FTIR and XRD to confirm compatibility.

Tensile tests revealed the 5% filler composite with the highest Young's modulus (437.064 MPa) and toughness (361.473 J/m³), surpassing the UPR control (308.363 MPa and 322.866 J/m³). Flexural tests showed the 1% filler composite with the highest flexural modulus (1276.413 MPa) and maximum stress (58.716 MPa), while the 3% filler composite balanced stiffness (1061.621 MPa), strength (47.890 MPa), and toughness (617.153 J/m³). ANOVA confirmed significant differences in tensile ($p=0.019$) and flexural properties ($p=0.007$). Fracture analysis using a digital microscope indicated mixed brittle and ductile mechanisms, with rougher surfaces in higher filler composites suggesting improved energy dissipation. FTIR and XRD verified silt's suitability, with the presence of phyllosilicates detected in the sample. Future work should include SEM analysis of fractured surfaces to investigate microstructural interactions and a UTM with higher capacity to accurately assess compressive strength. These findings reveal that mine waste-derived silt can be used as a sustainable filler for enhancing UPR composite mechanical properties, supporting eco-friendly material development.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158172: From Local Resource to Advanced Material: Philippine Talakag Clay as an Emerging Additive for Ceramic Manufacturing

Grandeur Il Villarmia Paglinawan ^{1,*}, Lori-Ann Intong Cabalo ², Eduardo Jr. Magdaluyo ³, Julie Bourret ⁴ and Raymond V. Rivera Virtudazo ⁵

¹ Advanced Porous Ceramic Particles (APCerP) Laboratory, Research Center for Advanced Ceramics (RCAC), Mindanao State University – Iligan Institute of Technology, Iligan City 9200, Philippines

² Advanced Porous Ceramic Particles (APCerP) Laboratory, Research Center for Advanced Ceramics (RCAC), Mindanao State University – Iligan Institute of Technology, Iligan City 9200, Philippines

³ Department of Mining, Metallurgical and Materials Engineering, University of the Philippines – Diliman, Quezon City 1101, Philippines

⁴ Institut de Recherche sur les Céramiques (IRCER), UMR 7315 CNRS, Centre Européen de la Céramique, University of Limoges, Limoges 87000, France

⁵ Department of Materials and Resources Engineering and Technology, College of Engineering, Mindanao State University – Iligan Institute of Technology, Iligan City 9200, Philippines

Extrusion-based 3D printing is an emerging additive manufacturing (AM) technique that enables the layer-by-layer fabrication of complex ceramic structures from flow-optimized pastes. This study explores the potential of locally sourced Talakag clay obtained from Tikalaan, Talakag, Bukidnon, Philippines, as a sustainable material for ceramic additive manufacturing. The clay was blended with zeolite, silica, and feldspar to enhance printability and structural performance. The raw materials were physically processed through crushing, pulverizing, and sieving, followed by paste formulation containing 71% solids and 29% liquid. Carboxymethyl cellulose (CMC) was incorporated as a binder to improve viscosity control, homogeneity, and extrusion behavior. Printing trials using the DeltaWASP 2040 Clay printer revealed that the optimized paste extruded smoothly at 3–3.5 bar, producing continuous, dimensionally accurate, and structurally stable layers. Post-printing evaluations confirmed good surface smoothness, geometrical precision, and mechanical integrity. The presence of micro/nanomineral components in Talakag clay contributed to the enhanced rheological and cohesive properties of the paste, supporting its feasibility for 3D ceramic fabrication. The study demonstrates that locally available mineral resources can serve as cost-effective and eco-friendly raw materials for advanced ceramic technologies. Overall, Talakag clay and its composites exhibit strong potential for sustainable extrusion-based additive manufacturing, paving the way for future innovations in functional ceramic materials and green manufacturing within the context of micro/nanomineral-based materials science



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158371: Innovative Ceramic Vitreous Formulations using Nickel Laterite Mine Waste NiLaMW and Indigenous Flux sources

Fel Jane Acut Echavez-Salo ^{1,*} and Ivyleen Bernardo-Arugay ²

¹ Research Center for Advanced Ceramics, College of Engineering and Technology, Mindanao State University–Iligan Institute of Technology, Iligan City 9200, Philippines

² Department of Materials and Resources Engineering and Technology/ College of Engineering, Mindanao State University–Iligan Institute of Technology, Iligan City 9200, Philippines

Vitreous ceramics are highly impervious, exhibiting less than 1% water absorption and are commonly derived from triaxial mixtures of clays, fluxes, and fillers. In this study, nickel laterite mine waste (NiLaMW), a by-product of extraction of nickel ore and the idle silicate deposits in Lanao del Norte, specifically black cinder (a pyroclastic material) and diatomaceous earth, were utilized as alternative raw materials. The NiLaMW was used as a full replacement to clay while black cinder and diatomaceous earth were utilized as substitutes for feldspar in a typical ternary diagram for ceramic formulation. The thermal properties, morphologies and mineralogical compositions of these materials were characterized to assess their suitability for vitreous ceramics production. At least three ceramic formulations primarily based on NiLaMW were developed and their products were formed through slip casting method. Green wares were sintered at 1200°C. The physico-mechanical properties (linear shrinkage, water absorption, apparent porosity, bulk density and modulus of rupture “MOR”) of these NiLaMW-based formulations were compared against established standards for ceramic products such as ISO Standard 13006, PNS154-2005, and ICCTAS ESTD 1990. All materials except NiLaMW exhibited melting behavior at temperature below 1200°C which means that they can be used as a source of fluxes. The results demonstrated that all formulations were highly vitreous, with a very low average water absorption of less than 0.03% and a MOR ranging from 42.71MPa to 46.25MPa, thus presenting its potential for vitreous ceramic applications. These findings show that NiLaMW and locally available silicate deposits can be utilized as sustainable resources for ceramic production, offering cost-effective and eco-friendly solutions that benefit both industry and environment. Furthermore, this approach effectively repurposes waste derived from the mining industry and limits additional mining operations, thereby lowering the carbon footprint and aligning with circular economy principles as a sustainable alternative to conventional ceramic production.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-161159: Mineral-Based PCM Composites from UAE Resources for Passive Cooling in Hot Climates

Saleimah Ahmed Alyammahi ¹, Jinendrika Anushi Weliwita ^{2,*} and Raid Musallam ²

¹ Department of Mechanical Engineering Technology, Engineering Technology & Science division, Faculty of Engineering, Fujairah Campus, Higher Colleges of Technology, Abu Dhabi, P.O.Box 25026, UAE

² Department of Civil Engineering Technology, Engineering Technology & Science division, Faculty of engineering, Fujairah campus, Higher Colleges of Technology, Abu Dhabi, P.O.Box 25026, UAE

Passive thermal energy storage materials are increasingly recognized as cost-effective solutions for reducing cooling energy demand in regions with extreme heat. Organic phase change materials (PCMs), particularly paraffin wax, offer strong thermal buffering performance due to their high latent heat capacity. However, their inherently low thermal conductivity and limited structural stability reduce practical efficiency in passive cooling systems. This study aims to develop and evaluate mineral-enhanced organic PCM composites by incorporating UAE-derived minerals—specifically limestone, dolomite, silica sand, and gabbro fines—to improve heat transfer and mechanical integrity. Organic PCM composites will be prepared using paraffin wax blended with varying mineral loadings (5–25 wt%). Samples will be fabricated using simple casting techniques, and their thermal performance will be characterized through controlled hot-plate heating (≤ 90 °C), embedded thermocouple measurements, and cooling cycle experiments. Key evaluation parameters include melting and solidification behavior, heat absorption and release characteristics, thermal conductivity enhancement, and dimensional stability during repeated thermal cycling. It is anticipated that UAE minerals—particularly silica sand and dolomite—will significantly improve the thermal conductivity and stability of the PCM matrix. The expected outcomes will help identify safe, low-cost, and locally sourced mineral-PCM combinations suitable for passive cooling applications in building envelopes, rooftop thermal buffers, and compact thermal energy storage units. This proposed study demonstrates the potential of leveraging abundant UAE mineral resources to create sustainable, climate-adapted thermal energy storage materials for extreme desert environments.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158405: Molecular modeling of organo-mineral aggregates

Edgar Galicia-Andrés

Institute of Molecular Modeling and Simulation, Department of Material Sciences and Process Engineering, University of Natural Resources and Life Sciences, Vienna (BOKU), Muthgasse 18, 1190 Vienna, Austria

Soil microaggregates contain components of organic and inorganic nature. These components interact at the molecular scale forming a hierarchy of aggregates which can build up to reach landscape scales. Such aggregates provide soil with unique properties that depend on a wide range of factors such as the type of minerals and soil organic matter, their location, parent materials, weathering conditions and even human influence. Moreover, molecular interactions are responsible to provide stability to soil which has been discussed as key factor to the decrease of carbon sequestration.

In this regard, computer simulations offer the possibility to access molecular scales, serving as virtual microscopes, to characterize complex systems such as soil at realistic conditions without typical problems such as technical difficulties to measure samples, disturbing or destruction of the samples that ultimately lead to under/over-estimation of measurements. This makes simulation methods ideal to characterize soil samples and provide with molecular signatures that address to particular problems on adsorption of components to soil or even strategies to mitigate climate change.

In this work, we characterized organo-mineral aggregates with different organic composition by using molecular dynamic simulations. We observed that all aggregates exhibit unique responses which result in the development of the electric double layer. We characterize the electric double layer in terms of its charge density profiles and structural properties. By providing a deep understanding at the molecular level of specific organo-mineral aggregates, it could lead to an improvement tunnable to specific soils in several fields such as better design of pesticides, implementation of new strategies for carbon sequestration, efficient removal of pollutants such as toxic heavy metals and organic compounds.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158113: Nanomineral-Modified Electrodes for Solar-to-Fuel Conversion

Goo Shao Kang

Faculty of Chemical and energy engineering, University of Technology Malaysia, Skudai, Johor Bahru 81310, Malaysia

The escalating global energy demand necessitates innovative approaches to harness solar energy and convert it into sustainable chemical fuels. This research investigates the design and optimization of nanomineral-modified electrodes for enhanced photocatalytic hydrogen production through direct water splitting. Specifically, we employ layered nanoclays and transition metal oxides (titanium oxide, iron oxide, and tungsten oxide) as electrode modifiers to improve charge separation, reduce electron-hole recombination, and extend light absorption into the visible spectrum. The synergistic integration of nanomineral films with metal oxide photocatalysts addresses critical limitations in current solar-to-hydrogen systems, including poor charge carrier mobility and limited photocurrent generation.

Our methodology employs a multi-stage approach: synthesis of layered nanomineral films via sol-gel and hydrothermal techniques; controlled decoration of these nanomineral surfaces with metal oxide nanoparticles to establish heterostructures; systematic characterization using X-ray diffraction, scanning electron microscopy, and electrochemical impedance spectroscopy; and evaluation of photocatalytic performance in a custom-designed photoreactor under simulated solar radiation.

Preliminary results demonstrate that nanomineral-modified metal oxide electrodes exhibit significantly enhanced photocurrent density and hydrogen evolution rates compared to unmodified counterparts. This approach promises improved solar-to-hydrogen conversion efficiency by facilitating electron transfer, creating favorable band alignments, and increasing the reactive surface area for water oxidation. The outcomes will establish design principles for next-generation photoelectrochemical devices and contribute to scaling sustainable hydrogen production for energy applications.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158187: Natural Ilmenite-derived Heterostructures with Self-Reconstructing Interfaces for Efficient Oxygen Evolution

Zhijie Chen

Univeraity of New South Wales

Designing earth-abundant and durable catalysts for the oxygen evolution reaction (OER) is vital for sustainable energy conversion and carbon-neutral technologies. Herein, we present a modular design strategy to construct an efficient sulfide/oxide heterostructured electrocatalyst through a facile sulfidation treatment of natural ilmenite. The resulting catalyst integrates high intrinsic activity, good electrical conductivity, and long-term operational stability. Benefiting from the synergistic coupling between FeS₂ and TiO₂, it requires only an overpotential of 230 mV to achieve a current density of 10 mA cm⁻² and retains its performance over extended electrolysis in alkaline media, showing nearly 20-fold higher OER activity than pristine ilmenite at 300 mV. Comprehensive structural and electrochemical analyses reveal that the superior performance originates from an accelerated surface self-reconstruction process, where lattice-sulfur leaching promotes the in situ generation of FeOOH species that serve as the genuine active phase. Meanwhile, the residual FeS₂ modulates surface electronic structures, facilitating charge transfer and enhancing conductivity, while the TiO₂ scaffold maintains mechanical integrity and prevents corrosion. This synergistic interplay ensures efficient charge separation, fast reaction kinetics, and excellent durability. This work establishes a scalable and eco-friendly route to convert natural minerals into high-efficiency heterostructured catalysts, providing a sustainable materials platform for renewable-energy conversion and storage applications.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-161360: Physicochemical and ceramic properties of clay materials from Barangay Tikalaan and Barangay Libertad (Talakag, Bukidnon, Philippines) and their suitability for ceramic bodies

Lori-ann Intong Cabalo ^{1,2,3,*}, Seigfreid D. Kempis ^{2,3}, Adrian Keith R. Caamiño ^{2,3}, Leaniel C. Silva ^{2,3}, Algen Secula ^{2,3}, Liezl Jabile ^{1,2,3}, Raymond V. Rivera-Virtudazo ^{1,2,3}, Edison A Limbaga ^{1,2,3} and Rose Ann Marie Hilot ^{2,3}

¹ Ceramic Researches for Engineering, Advanced Technology, and Environment (C.R.E.A.T.E.) Laboratory- Research Center for Advanced Ceramics (RCAC), Mindanao State University – Iligan Institute of Technology (MSU-IIT), Iligan City 9200, Philippines

² Resources Processing and Technology Center – Research Institute for Engineering and Innovative Technology (RIEIT), Mindanao State University – Iligan Institute of Technology, Iligan City 9200, Philippines

³ Department of Materials and Resources, Engineering and Technology (DMRET), Mindanao State University – Iligan Institute of Technology (MSU-IIT), Iligan City 9200, Philippines

Clayey materials from two barangays in Talakag, Bukidnon, Philippines, were studied for potential ceramic stoneware products. Twelve site samples were collected and investigated through X-ray Fluorescence analysis to determine physical and firing properties at 1100°C. In terms of chemical oxide content, the studied clays are rich in SiO₂, Al₂O₃, TiO₂, and Fe₂O₃. Physicochemically, results show large particle size variations with medium to low plasticity. Particle size distribution reveals that the average particle size is lower than 425 microns. SiO₂ (24.62-46.54%) and Al₂O₃ (26.85% - 42.10%) are major chemical oxides, followed by TiO₂ (1.42% - 2.78%), Fe₂O₃ (0.531% - 25.46%), and alkali and alkali earth oxides in trace amounts. These results determine their behavior on firing at a specified temperature. The range of color was determined using a portable color meter and shows that a few specimens are predominantly from cream to light cream or are a white color after firing at 1100°C. The linear shrinkage values vary from 1.79% to 25.685, weight loss from 3.15% to 33.40%, and bulk density from 1.23 to 1.77 g/cm³. The water absorption ranges from 13 % to 40.15 % and the apparent porosity ranges from 37% to 62%. The evaluation of the studied clays based on their physicochemical and ceramic properties revealed that they are suitable for the manufacture of ceramic wares such as earthenware tiles and fired brick bodies.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158485: Reaction kinetics and material transport in chemically complex mineral-water environments at the nanoscale

Inna Kurganskaya

University of Bremen

Geochemical processes at the nanoscale constitute a rich microcosm of complex, intertwined reaction networks and molecular transport mechanisms. Crystalline and amorphous materials, water, ions, gases, and molecular entities altogether generate dynamic molecular ensembles that govern the essence of phase transformations, metamorphic and metasomatic reactions, as well as reactions in the setting of cements, pastes, and other manufactured materials, as well as silica-water reactions prerequisite to the origin of life. The current state-of-the-art theoretical description for these systems is still in its infancy. Thermodynamic and kinetic models rely on macroscopic laws and homogeneous mechanisms, where transport is often excluded from consideration. Reactive transport models, in turn, operate on large scales and employ simplistic kinetic models or thermodynamic solvers, thereby excluding the molecular complexity and heterogeneity of multi-phase systems at small scales. We discuss in this presentation hybrid approaches to modeling the behavior of complex geochemical systems at the nanoscale by employing methods from Molecular Dynamics[1], kinetic Monte Carlo[2], Cellular Automata, material transport, and other techniques under one conceptual theoretical framework. The research presented is relevant to the origin of life study, but also can be applied to other processes where complex heterogeneous systems cannot be understood by means of conventional modelling or experimental techniques.

[1] "Advances in Clayff Molecular Simulation of Layered and Nanoporous Materials and Their Aqueous Interfaces" (2021) Randall T. Cygan, Jeffery A. Greathouse, Andrey G. Kalinichev. *J. Phys. Chem. C*, 125, 32, 17573–17589.

[2] "Mineral Dissolution Kinetics: Pathways to Equilibrium" (2021) Inna Kurganskaya, Andreas Luttmann, *ACS Earth Space Chem.* 2021, 5, 7, 1657–1673



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-157909: Reactivity and structural characteristics of plasma-derived wind turbine blade slag in geopolymer systems

Vilma Snapkauskienė ^{1,*}, Regina Kalpokaitė-Dičkuvienė ², Arūnas Baltušnikas ² and Mindaugas Aikas ¹

¹ Plasma Processing Laboratory, Lithuanian Energy Institute, Breslaujos 3, LT-3035 Kaunas, Lithuania

² Laboratory of Materials Research and Testing, Lithuanian Energy Institute, Breslaujos 3, LT-3035 Kaunas, Lithuania

The waste management of wind turbine components is challenging, as they are composed of glass or carbon fibers embedded in highly durable polymer matrices. A potential method for recycling wind turbine blades involves their conversion into melted or vitrified slag using thermal plasma-based systems. However, the suitability of melted slag as the geopolymer binding material remains underexplored. Therefore, this study focused on the resistance of slag obtained after wind turbine blade vitrification to alkaline and acidic activation solutions, subsequently assessing the effectiveness of adding such specific waste for the synthesis of geopolymers.

The composition and microstructure of the slag and geopolymer were analyzed using X-ray diffraction, FTIR, and SEM-EDS analytical tools. The results revealed that the vitrified slag contains both amorphous and crystalline anorthite phases, with the content of the amorphous phase decreasing as the distance from the plasma reactor increases.

According to SEM-EDS and FTIR analysis, the leaching of calcium was observed in slag exposed to an acidic environment, although dissolution was also observed in an alkaline solution. The impact of as-derived vitrified slag on the microstructure and mechanical strength of geopolymer was investigated to evaluate its potential application in geopolymer materials.

The study demonstrates that plasma vitrification of wind turbine blade waste produces a partially amorphous slag with potential for geopolymer applications. The reactivity and microstructure of the resulting materials suggest that this slag can serve as a supplementary precursor in sustainable binder systems.

Acknowledgment

This research was carried out with the financial support of European Union Structural Funds for the project “Testing an R&D idea - The Potential of Waste in the Synthesis of Climate-Neutral Geopolymers (ANGeoS)”.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158422: The transcript of the key dissolution reactions at the barite-water interface: the insights from Kinetic Monte Carlo

Nikolay Trofimov *, Andreas Luttge and Inna Kurganskaya

University of Bremen, Bremen, Klagenfurter Str. 4, Germany

The kinetic processes at the solid-liquid interface are a significant scope of study in physical chemistry, chemical engineering, and environmental sciences. A deeper understanding of the nanoscale processes at the barite-water interface is particularly critical due to the potential use of barite in nuclear waste repositories. Barite can incorporate radioactive isotopes of Ra and Sr and also serve as an efficient neutron-shielding material. Additionally, barite is now commonly used as a weighting agent in drilling fluids in the oil and gas industry.

We employed Kinetic Monte Carlo simulations to investigate barite dissolution under far-from-equilibrium conditions at nano- to micrometre scales. Previously (Kurganskaya et al., 2022; Trofimov et al., 2025) we described the macroscopic features and behaviour of the barite-water system. As the next step, we collected the statistical data on the key reactions governing barite dissolution. We found that the reaction kinetics cannot be captured in terms of the single rate-limiting kinks. Instead, the dominant role is played by the self-reproducing functional groups of the kink sites. These groups react slowly and thereby control the overall dissolution kinetics.

To obtain more information on the system of study, we analysed the fast reactions occurring at the kink sites, which contribute most to the material flux. Interestingly, these sites also tend to form self-reproducing functional groups. We observed that their detachment dynamics are non-linear at the beginning of etch pit formation and become linear after some time (specific to each kink site or kink site group).

This demonstrated that the processes at mineral-water interfaces can be more complex than previously thought.

Kurganskaya, I., Trofimov, N., Luttge, A., 2022. Minerals
Trofimov, N., Luttge, A., Kurganskaya, I., 2025. ACS Omega



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158473: Using modified mica as a substrate in Atomic Force Microscopy

Sergey V Kraevsky, Anastasia A. Valueva and Alena V Kolesnichenko

Institute of Biomedical Chemistry

Atomic force microscopy (AFM) is a powerful tool for nanoscale surface characterization, and the choice of substrate plays a crucial role in experimental success. Mica (muscovite) is widely used as one of the most preferred AFM substrates, particularly in the study of biomolecules and nanomaterials. Freshly cleaved mica offers several advantages, including atomic smoothness, chemical inertness, and ease of surface preparation. The smooth surface of mica, which requires no complex polishing, provides a perfectly plain base for high-resolution imaging of individual molecules, such as DNA, proteins, and lipid bilayers. This property allows for accurate measurement of the topography and mechanical properties of samples without artifacts introduced by substrate roughness.

Biomacromolecules are typically stored in a salt buffer, which requires the substrate to be rinsed to remove these salts after sample deposition. Therefore, there are several methods available for modifying the mica surface to bind the target molecules. Here, we present three types of surface modifications of freshly cleaved mica for various AFM experiments that we use in our practice.

1) Mica surface modification with divalent metal ions. This modification compensates for the negative surface charge of mica, which is important when studying negatively charged biomolecules like DNA and RNA.

2) Binding of amino groups of APTES molecules to the mica surface. This is a universal method that allows for the active capture of various biomacromolecules from solution onto the surface.

3) Mica surface modification with active antibodies. With the A-protein, antibodies can be oriented with a specific epitope facing outward. This allows for the specific binding of viruses, bacteria, and their fragments.

The work was performed within the framework of the Program for Basic Research in the Russian Federation for a long-term period (2021-2030) (№122030100168-2).



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Session 4. Minerals in Extreme Environments: From Earth's Depths to Space

sciforum-157497: Astrobiomineralogy: A Systematic Review of Mineral–Microbe Interactions and Biosignatures in Extreme and Extraterrestrial Environments

Marina Corrêa Freitas

ICBS – International Center for Biomedical & Space Sciences, LIASTRA International Astronomy League, Rio de Janeiro, Brazil

Introduction

The study of mineral–microbe interactions under extreme conditions has become a cornerstone in understanding both the origins of life and its potential beyond Earth. Minerals play a crucial role as catalytic surfaces, nutrient sources, and preservers of biosignatures. The emerging field of **astrobiomineralogy** integrates geochemistry, microbiology, and space sciences to explore how such processes operate from Earth's deepest biosphere to Martian and icy moon environments.

Methods

Following PRISMA guidelines, this systematic review analyzed 180 peer-reviewed studies (2010–2025) retrieved from Scopus and Web of Science. Studies focusing on microbial colonization, biomineralization, and mineral biosignatures in extreme or simulated extraterrestrial conditions were included. Bibliometric and co-word analyses were conducted using VOSviewer.

Results

Results reveal convergent patterns between terrestrial extremophiles (e.g., cyanobacteria, *Deinococcus* spp.) and their mineral substrates, particularly sulfates, phyllosilicates, and iron oxides, mirroring assemblages detected on Mars and Europa. Laboratory simulations demonstrate that microbial films induce mineralogical transformations that can persist as biosignatures detectable by Raman and X-ray spectroscopy.

Conclusions

Astrobiomineralogy bridges the gap between mineral sciences and space biomedicine, elucidating how life–mineral systems respond to radiation, desiccation, and low gravity. The synthesis highlights new frontiers for planetary exploration, life detection strategies, and potential biotechnological applications of extremophilic mineral interactions in human spaceflight contexts.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-161389: Comparative crystal chemistry of $\text{KCu}_7\text{BiO}_4(\text{SO}_4)_5$ and nabokoite-like $\text{KCu}_7\text{TeO}_4(\text{SO}_4)_5\text{Cl}$ sulfates

Tatyana Bushneva * and Larisa Shvanskaya

Faculty of Geology, Lomonosov Moscow State University, 119991 Moscow, Russia

Mineralogy inspires the search for functional magnetic materials. Fumarolic copper oxysalts, with the Cu^{2+} spin-1/2 state, are prime candidates for quantum magnetism studies. Recent focus has been on minerals featuring a square kagome lattice of copper ions, such as nabokoite, $\text{KCu}_7\text{TeO}_4(\text{SO}_4)_5\text{Cl}$. Here we report a new compound structurally related to nabokoite.

Green plate crystals of $\text{KCu}_7\text{BiO}_4(\text{SO}_4)_5$ were synthesized via chemical vapor transport. A stoichiometric mixture of K_2SO_4 , CuSO_4 , CuO , and Bi_2O_3 was sealed in a fused silica ampoule with I_2 , evacuated, and heated in a 580–640 °C gradient for 30 days. Resulting crystals were characterized by scanning electron microscopy and single-crystal X-ray diffraction. The crystal structure of $\text{KCu}_7\text{BiO}_4(\text{SO}_4)_5$ was found to be tetragonal with the space group $P4/ncc$ and $a = 9.7731(1)$ Å and $c = 20.4094(6)$ Å, and $Z = 4$. $\text{KCu}_7\text{BiO}_4(\text{SO}_4)_5$ crystallizes in the same tetragonal space group as $\text{KCu}_7\text{TeO}_4(\text{SO}_4)_5\text{Cl}$ nabokoite. However, these compounds are not isostructural. The substitution of Te^{4+} by Bi^{3+} is accompanied by the absence of chloride ions, as is evident from a comparison of their formulas. The key structural difference lies in the arrangement of Cu-centered polyhedra within the kagome-like layers. In $\text{KCu}_7\text{BiO}_4(\text{SO}_4)_5$, the Cu–O layer is formed by CuO_6 octahedra and Cu_2O_5 square pyramids sharing trans-edges, creating four-membered windows. In contrast, analogous layers in nabokoite phases are built from CuO_6 octahedra and CuO_5Cl distorted octahedra, where the latter share common chlorine vertices. Furthermore, as seen in projection along the layers, the decorating Cu atoms in nabokoite-like phase are in mixed coordination and form CuO_4Cl pyramids that share a chlorine vertex with the polyhedra of the square kagome lattice. In our compound, the decorating Cu atoms are in CuO_4 square coordination and connect to the SKL exclusively via sulfate tetrahedra. $\text{KCu}_7\text{BiO}_4(\text{SO}_4)_5$ is promising for studying magnetic behavior.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-156107: A Hybrid Dimensionality Reduction and Spectral Classification Workflow for Mineral Mapping in Polar Terrains

Khurram Riaz, Amin Beiranvand Pour * and Aidy M. Muslim

Institute of Oceanography and Environment (INOS), Higher Institution Center of Excellence (HICoE) in Marine Science, Universiti Malaysia Terengganu (UMT), 21030 Kuala Nerus, Terengganu, Malaysia

Accurate identification of alteration minerals in remote polar regions remains a significant challenge due to limited field accessibility, extreme environmental conditions, and the inherent spectral complexity of exposed lithologies. Satellite-based multispectral remote sensing, particularly using the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), provides an efficient means of investigating surface mineralogy. However, ASTER data are often affected by spectral redundancy, sensor noise, and overlapping absorption features that reduce mineral classification accuracy. This study introduces a hybrid dimensionality reduction and spectral classification workflow integrating Minimum Noise Fraction (MNF), Independent Component Analysis (ICA), and Spectral Angle Mapper (SAM) algorithms to enhance lithological mapping in polar environments. The workflow was applied to ASTER imagery from South Victoria Land, Antarctica, where exposure of metamorphic and hydrothermally altered rocks offers an ideal setting for method evaluation. The MNF transform was first used to suppress noise and extract high-variance components, while ICA separated independent spectral sources representing unique mineralogical signatures. Subsequently, SAM classification calibrated with United States Geological Survey (USGS) reference spectra enabled precise identification of alteration minerals. The integrated MNF-ICA-SAM approach effectively discriminated key alteration minerals including alunite, kaolinite, jarosite, chalcedony, opal, and hematite, corresponding to diagnostic Al-OH, Fe-OH, and hydrous silica absorptions across the VNIR-SWIR spectrum. Comparative analyses demonstrate that the hybrid workflow significantly improves spectral separability and classification accuracy compared with single-method techniques. These results highlight the potential of integrated spectral processing as a robust, transferable, and data-driven framework for mineral mapping in polar terrains. The proposed methodology not only enhances the geological interpretability of ASTER imagery but also establishes a foundation for future integration with hyperspectral, UAV, and machine-learning-based systems in remote and data-limited environments.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-160126: Crystal chemistry and magnetic properties of mineral-like sulfates with copper square-kagome lattice

Larisa Shvanskaya ^{1,*}, Tatiana Bushneva ¹ and Alexander Vasiliev ²

¹ Faculty of Geology, Lomonosov Moscow State University, GSP-1, Leninskie Gory, Moscow, 119991, Russian Federation

² Faculty of Physics, Lomonosov Moscow State University, GSP-1, Leninskie Gory, Moscow, 119991, Russian Federation

The minerals elasmochloite, $\text{Na}_3\text{Cu}_6\text{BiO}_4(\text{SO}_4)_5$, nabokoite, $\text{KCu}_7\text{TeO}_4(\text{SO}_4)_5\text{Cl}$, and atlasovite, $\text{KCu}_6\text{FeBiO}_4\text{Cl}(\text{SO}_4)_5$, are rare fumarolic minerals. In their crystal structures, Cu-centered polyhedra connect via edges and vertices, forming Cu–O/Cl layers with a kagome square topology. Interest in compounds featuring such architectures has grown in recent years due to the potential for realizing a quantum spin liquid state.

Given the scarcity of these minerals, analogs of elasmochloite were synthesized using a chemical vapor transport method, which simulates the fumarol conditions. It was established that, in laboratory experiments, a polymorphic variety crystallizes with the analog of the mineral, $\text{Na}_3\text{Cu}_6\text{BiO}_4(\text{SO}_4)_5$. Interestingly, both polymorphs belong to the same sp. gr., $P2_1/n$, and have similar cell parameters. Single-crystal XRD analysis revealed that the key structural difference between the polymorphs lies in the degree of distortion and a different relative arrangement of the Cu–O layers alternating with Na–O 2D fragments. In the mineral's structure, the Cu–O layers lie parallel to the monoclinic axis, whereas in the synthetic compound, they are perpendicular to the monoclinic axis. The Na–O sublattice adapts to the copper-oxygen layers, forming unique structural motifs.

In an attempt to substitute sodium ions with larger potassium ions, a new sulfate, $\text{KCu}_7\text{BiO}_4(\text{SO}_4)_5$, was synthesized. In its crystal structure, the magnetic subsystem of the square kagome type is decorated with additional copper cations compared to the copper subsystem in elasmochloite. The crystal structure of $\text{KCu}_7\text{BiO}_4(\text{SO}_4)_5$ is related to that of nabokoite, with both crystallizing in the tetragonal space group $P4/ncc$. The structural difference arises from the substitution of Te^{4+} by Bi^{3+} , which is compensated by the absence of chlorine atoms in the new phase.

Magnetic susceptibility and heat capacity measurements indicate that both compounds are frustrated antiferromagnets with magnetic ordering transitions at 18 and 12 K for the Na- and K-sulfates, respectively.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-160582: Crystal structure flexibility and magnetic behavior of a new shchurovskyite-related phosphate $K_2CaCu_6O_2(PO_4)_4$

Galina Kiriukhina ^{1,2,*}, Olga Yakubovich ¹ and Larisa Shvanskaya ¹

¹ Faculty of Geology, Lomonosov Moscow State University, 119991 Moscow, Russia

² Korzhinskii Institute of Experimental Mineralogy RAS, 142432 Chernogolovka, Russia

The unique conditions of fumaroles give rise to an exceptional diversity of mineral species due to a combination of key factors: high temperatures, atmospheric pressure, gas transport of chemical components, and the unusual geochemical setting of active volcano exhalations. Using high-temperature synthesis, we obtained single crystals of a new copper phosphate $K_2CaCu_6O_2(PO_4)_4$, which represents a new morphotropic modification of the fumarolic arsenate shchurovskyite, $K_2CaCu_6O_2(AsO_4)_4$. The $K_2CaCu_6O_2(PO_4)_4$ crystal structure and chemical composition were studied by single-crystal X-ray diffraction and EDS spectroscopy.

In this work, six structurally related oxysalts were grouped into the shchurovskyite family with the general formula $A_2B[M_6O_2](TO_4)_4$, (A is K^+ or Rb^+ ; B is Ca^{2+} , Cu^{2+} , or K^+ ; T is P^{5+} or As^{5+} ; and M is Cu^{2+} , Cu^{2+} , or Al^{3+}). In their structures, two-periodic blocks composed of TO_4 tetrahedra and Cu^{2+} -centered polyhedra are interconnected into a heteropolyhedral framework with channels occupied by extra-framework cations. The geometric topology of the Cu-ion substructure is similar across the family. However, the anionic environment of the copper polyhedra systematically varies with symmetry changes, exhibiting a large diversity of Cu^{2+} coordination geometry. This structural flexibility arises from the Jahn–Teller effect of Cu^{2+} cations, resulting in structural rearrangement driven by temperature and compositional variations.

Calculations based on the topology of the framework channels indicate the potential for K^+ -ion migration through the $K_2CaCu_6O_2(PO_4)_4$ structure. Magnetic susceptibility measurements show that $K_2CaCu_6O_2(PO_4)_4$ undergoes a transition into a long-range ordered state with a spontaneous magnetic moment at $T_C = 10$ K. The fit of the $\chi(T)$ curve yields a Weiss temperature of -97.8 K, indicating dominant antiferromagnetic interactions at high temperatures. Compared to its Rb-analog ($T_C = 25$ K), $K_2CaCu_6O_2(PO_4)_4$ exhibits a lower ordering temperature and signs of magnetic frustration.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158332: Transmission Electron Microscopy Highlighted the Importance of Clay Minerals in the Dolomitization of Ca-Mg Carbonates in a Hypersaline Soda Lake

Olga S. Burakova ^{1,2,*}, Lyubov V. Zaytseva ², Maria A. Sinetova ³ and Alexandra G. Markelova ³

¹ Winogradsky Institute of Microbiology, Federal Research Centre “Fundamentals of Biotechnology”, Russian Academy of Sciences, 117312 Moscow, Russia

² Borissiak Paleontological Institute, Russian Academy of Sciences, 117647 Moscow, Russia

³ Timiryazev Institute of Plant Physiology, Russian Academy of Sciences, 127276 Moscow, Russia

Modern dolomite stromatolites were previously described in the hypersaline Petukhovskoe Soda Lake (Southwestern Siberia, Russia). Exopolysaccharides (EPS) secreted by phototrophic communities have previously been shown to play a crucial role in their formation. In the current study, using transmission electron microscopy (TEM) with energy dispersive X-ray (EDX) spectral microanalysis, we demonstrate that clay minerals also play a significant role in the dolomitization of Ca-Mg carbonates in this lake. The lake is characterized by the development of phototrophic communities, whose huge biomass accumulates near the shoreline and gradually dries out, finally forming cavernous crusts that later become stromatolites. Three samples (S1, S2, and S3) were collected simultaneously in the littoral at different distances from the water and represent successive stages (from S1 to S3) of phototrophic biomass desiccation. TEM revealed ubiquitous clay minerals (consistent with montmorillonite composition) in all samples, which were represented by free clay particles, fine clay particles surrounding cell walls, and a completely interstitial clay-EPS matrix. Carbonate crystals of varying sizes were embedded in this matrix. IR spectroscopy indicates a transition from predominantly high-Mg calcite in S1 to a dolomite composition in S3. Consistently, TEM-EDX analysis of 130 points revealed a statistically significant decrease in the average Mg/Ca (atomic %) ratio in carbonate crystals from 4.8 ± 2.9 (S1) to 2.8 ± 1.2 (S2) and 1.3 ± 0.2 (S3), while the opposite trend was observed in the Mg/Si ratio: 0.7 ± 0.1 (S1), 1.1 ± 0.3 (S2), and 2.0 ± 1.2 (S3). These ratios in clays did not change significantly. The 3-5-fold excess of Mg over Ca at the analyzed points in carbonate crystals in S1 and S2 indicates that Mg may have originally been associated with clay minerals, which act as Mg donors for incorporation into the Ca-Mg carbonate crystal lattice. This research was funded by the Ministry of Science and Higher Education of the Russian Federation.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Session 5. Mineral Processing and Metallurgical Innovations: From Extraction to Refinement

sciforum-157183: Comparison of Applicability of Comminution Methods for Complex Rare Earth Ores: Product Characteristics, Grinding Energy Consumption and Magnetic Separation Performance

Siyou Li *, Lixia Li, Nan Li, Zhe Liu, Feifei Liu, Hongcheng Mi and Jiaqi Wang

School of Resources and Civil Engineering, Northeastern University, Shenyang, Liaoning 110819, China

This study aims to optimize the comminution process in light of the characteristics of fine embedded size and easy sliming of valuable minerals in complex rare earth ores, to achieve efficient grinding of the complex rare earth ore. Firstly, taking a rare earth ore from China as the research sample, the process mineralogy and crushing working index tests were conducted to explore the properties of the ore. Subsequently, crushing tests were conducted respectively using jaw crushers, double-roll crushers and high-pressure grinding rolls, and grinding tests were conducted using ball mills and rod mills. The particle size distribution, the liberation degree of gangue minerals and the microscopic morphology of different products were compared and analyzed. Finally, magnetic separation test was carried out, and the magnetic separation performance and energy consumption of different grinding products were compared and analyzed. The results show that HPGRs have higher crushing efficiency and produce more suitable particle size distribution of the product. Rod mills have the selective grinding effect on coarse-grained particles and the selective protection effect on fine-grained particles, which can effectively reduce mineral sliming formation and increase the recovery of the magnetic separation process under the similar concentrate grade. This research has certain guiding significance for solving the crushing and grinding problems of complex rare earth ores, and can provide a reference for the efficient development and utilization of this ore type.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158388: Comminution Studies of Difficult Grindable Iron Ores of South India-A Case Study on Low Grade Iron Ores of Sandur, Karnataka. India

Kavitha Ravikumar Ghodke * and Sharath Kumar P

Department of Mineral Processing, Post graduate center Nandihalli, Vijayanagaram Shree Krishnadevaraya University, Nandihalli 583119, India

The present study aims to study the Comminution characteristics of two difficult grindable low grade Iron ores of Sandur, Karnataka of South India. The two Iron Ore samples (Ore1, Ore 2) were collected from different mines of Sandur region of South India. The vast availability of low grade ores and rising global consumption of Iron and steel creating the demand to process the low grade ores of this area to meet the margins of steel industries, which in turn increases the attention on the comminution studies as they are difficult to grind due to their finer liberation size and high energy consumption rate. Thus, it is important to optimize the grinding circuit with accurate models; to predict industrial mill performance models requires experimentally determined breakage parameters, values of these being established by laboratory test.

An attempt is made to study the comminution characteristics of two ores by evaluating the energy consumption using Standard Bonds Work index test followed by comparative studies of performance of jaw and Roll crusher. The results revealed that the experimental and predicted values aligned well overall, suggesting the CEP model used for predicting crushing efficiency is reasonably accurate. Also, an attempt is made to Develop T-family curves using single particle breakage test by standard Drop Weight Test to evaluate the relationship between the impact energy – particle size distribution.

The findings provide valuable insights for optimizing crushing and grinding operations across different ore types.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158402: Comparison of Surface Properties and Flotation Performance of Products of SAG + Ball Mill and HPGR + Tower Mill

Feifei Liu ¹, Lixia Li ^{1,*}, Ziyi Wang ¹, Nan Li ¹, Jiaqi Wang ¹, Yueri Feng ¹, Qiang Zhang ^{2,3} and Bing Li ^{4,5}

¹ School of Resources and Civil Engineering, Northeastern University, Shenyang, Liaoning 110819, China

² Shenyang Shengshi Wuhuan Science and Technology Co., Ltd., Shenyang Liaoning Province, China 113122

³ Liaoning Provincial Engineering Research Center of Efficient Comminution and Separation, Shenyang 110027, China

⁴ Shenyang Shengshi Wuhuan Science and Technology Co., Ltd., Shenyang 110027, China

⁵ Liaoning Provincial Engineering Research Center of Efficient Comminution and Separation, Shenyang 110027, China

The modification of mineral surface properties during comminution plays an important role in determining subsequent flotation behavior. This study compares the surface characteristics and flotation performance of hematite ore products obtained from two comminution circuits: semi-autogenous grinding plus ball milling (SAG + BM) and high-pressure grinding rolls plus tower milling (HPGR + TM). SAG products with a P95 of 1 mm were collected from an operating concentrator and further ground in a laboratory ball mill, while run-of-mine ore was processed by HPGR to the same P95 and subsequently milled in a tower mill to an equivalent final fineness. Particle size distribution, microcrack development, and surface morphology were characterized using laser particle sizing, scanning electron microscopy (SEM), and atomic force microscopy (AFM), respectively. Surface roughness and specific surface area were quantified by root mean square (RMS) roughness Rq, power spectral density (PSD), and Brunauer–Emmett–Teller (BET) analyses.

Results indicate that HPGR + TM products exhibit a higher density of intra- and intergranular microcracks, increased surface roughness, and larger BET surface areas compared with SAG + BM products. Flotation tests show that the HPGR + TM circuit produced a concentrate with 64.62% TFe at a recovery of 85.06%, while the SAG + BM circuit achieved 61.71% TFe at 86.10% recovery. These correspond to a measurable improvement in concentrate grade of approximately 2.9 percentage points under the investigated conditions. The observed difference is associated with comminution-induced surface modification, which may improve particle hydrophobicity and bubble–particle attachment behavior.

Overall, the study highlights the coupling between comminution-induced surface characteristics and flotation response, emphasizing the importance of considering interactions between interconnected processes at the flowsheet level. Further statistical validation is required to fully quantify the observed performance difference and to support process-scale optimization.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158445: Coupling breakage with liberation models to predict mineral exposure in the crushing stage of Critical Raw Materials

Gabriel Iulian Dan *, Percy Rodrigo Escalante Salcedo, Pura Alfonso, Josep Oliva and Hernan Anticoi

Departament d'Enginyeria Minera, Industrial i TIC, Universitat Politècnica de Catalunya, Av. Bases de Manresa 61-63, 08242 Manresa, Spain

Predicting mineral liberation during comminution remains a key factor in optimizing the processing of Critical Raw Materials (CRM). This study presents a modelling system that couples a Roll crusher's breakage Model B with Gaudin's statistical liberation model to predict the liberation behavior of Cu, Zn and Pb sulfide ores. The main objective is to establish a predictive framework linking a roll crusher's operating parameters to crushing modelling, enhancing the understanding of the relationship between comminution and liberation, with the potential application to other types of materials.

The quartered Run-of-mine (ROM) material was characterized using Particle Size Distribution (PSD), X-ray diffraction (XRD), X-ray fluorescence (XRF), chemical analysis, and automated Mineral Liberation Analysis (MLA) to establish a quantitative mineralogical baseline. The ROM was split into two fractions: particles smaller and larger than 1250 μm . Liberation characteristics were evaluated for the undersize fraction, while the oversize material was subjected to comminution using a roll crusher. Comminution tests were conducted under controlled conditions, including compressive force, throughput, roll speed, and feed PSD. Models were calibrated with experimental data to simulate particle breakage using MATLAB® scripts, and MLA measurements of the crusher's product were used to validate model predictions by quantifying the resulting mineral liberation.

The ROM material showed that 55% of chalcopyrite, 36% of sphalerite and 40% of galena were liberated. Comminuted material showed a liberation degree of 42% of chalcopyrite, 33% of sphalerite and 31% of galena. Through the model verification, the results prove the potential of the induced liberation by roll crusher, reducing the volume of material which require further grinding in downstream comminution stages while maintaining comparable mineral liberation.

The proposed coupled modeling and validation framework could provide a foundation for predictive mineral processing techniques which target energy efficiency and improved recovery of critical raw materials.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-157075: Eco-Efficient Utilization of Calcite-Rich Phosphate Waste for Feed-Grade Phosphate Production and Integrated CO₂ Sequestration

Zouhir BALAGH *, Yassine Ait-Khouia, Mostafa BENZAAZOUA and Yassine Taha

Geology and Sustainable Mining Institute (GSMI), Mohammed VI Polytechnic University, Lot 660 Hay Moulay Rachid, Ben Guerir 43150, Morocco

Phosphate mining activities generate enormous quantities of calcite-rich residues whose management poses both environmental and economic challenges, largely due to their low reactivity and limited industrial value. In this work, a sustainable valorization route is proposed to transform this carbonate waste into feed-grade calcium phosphates while simultaneously capturing carbon dioxide in a stable mineral form. The process is based on a two-step chemical pathway integrating alkaline conversion and phosphate synthesis.

In the first stage, the calcite-dominant residue was subjected to an alkaline activation using sodium hydroxide (NaOH), leading to the in situ generation of calcium hydroxide [Ca(OH)₂] and sodium carbonate (Na₂CO₃). The reaction parameters were systematically optimized through a statistical design of experiments combining Plackett–Burman screening with a central composite design. Among the tested factors, NaOH concentration, solid-to-liquid ratio, and reaction time were identified as the most influential variables. The optimized conditions (7.95 mol L⁻¹ NaOH, 75 °C, S/L = 4.28 g per 50 mL, and 26 min) resulted in a conversion yield of 88%, confirming the spontaneous and exothermic character of the process ($\Delta G \approx -58$ kJ mol⁻¹; $\Delta H \approx -59$ kJ mol⁻¹). Sodium carbonate was recovered by crystallization from both the filtrate and washing effluents, achieving an average recovery of 86%, equivalent to the sequestration of approximately 0.33 t of CO₂ per tonne of calcite treated.

The second step involved the neutralization of the Ca(OH)₂-rich product with phosphoric acid, enabling the controlled precipitation of monocalcium phosphate (MCP) or dicalcium phosphate (DCP) depending on the targeted Ca/P molar ratio. X-ray diffraction (XRD), X-ray fluorescence (XRF), and scanning electron microscopy coupled with energy-dispersive spectroscopy (SEM-EDS) confirmed the formation of well-crystallized, pure calcium phosphates exhibiting high solubility in 2% citric acid (>90%), in accordance with international feed additive standards.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158453: Effect of Extracting Phase Composition on Cobalt Recovery from Chloride-Rich Media: Transition from Molecular to Ionic and Eutectic Solvents

Felipe eduardo Olea chandía ^{1,2,*}, Bernardo Bengui ¹, Constanza Banchieri ², Nicolas Schaeffer ¹, João A. P. Coutinho ¹, René Cabezas ³ and Esteban Quijada ²

¹ CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-1933 – Aveiro, Portugal

² Laboratory of Separation Processes Intensification (SPI), Department of Chemical and Bioprocess Engineering, University of Santiago de Chile, Av. Lib. Bdo. O'Higgins 3363, Estación Central, Santiago – Chile

³ Department of Environmental Chemistry, Faculty of Sciences, Catholic University of the Most Holy Conception, Concepción, Chile

Cobalt (Co) is an essential metal for sustainable technologies, including electric vehicles and energy storage systems. Its selective recovery from complex leachates remains a challenge due to the co-presence of nickel (Ni) and manganese (Mn). This work examines the influence of the extracting phase composition on the solvent extraction (SX) of Co from highly acidic chloride media (pH $\approx$ 0.86, 6–12 M LiCl) containing Ni and Mn. Trioctylphosphine oxide (TOPO) was used as the extractant, dissolved in three different media: dodecane, the ionic liquid (IL) 1-methyl-3-octylimidazolium bis(trifluoromethylsulfonyl)imide ([C₈mim][Tf₂N]), and the hydrophobic eutectic solvent (HES) TOPO:decanoic acid (1:1). The extraction of Co increased with LiCl concentration, consistent with the formation of anionic Co–chloride complexes, while Ni extraction remained negligible due to its high hydration energy. Slope analysis confirmed a 2:1 TOPO:Co stoichiometry for all systems, indicating a solvation-controlled extraction mechanism. Both the IL and the HES improved Co recovery compared with the molecular diluent, achieving high selectivity with minimal Mn co-extraction. Volatility tests showed severe solvent loss for dodecane, whereas [C₈mim][Tf₂N] and TOPO:decanoic acid exhibited excellent thermal stability (2% mass loss) and low water uptake (2%). These results highlight the potential of IL and HES as sustainable alternatives to conventional organic diluents. Among the systems studied, TOPO:decanoic acid (1:1) displayed the best balance of extraction efficiency, selectivity, and stability, representing a promising medium for Co recovery from chloride solutions.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-161282: Experimental and DEM Simulation Study on Grinding Behavior of Ceramic Balls in a Vertical Stirred Mill

Ningning Liao *, Ji Wu and Caibin Wu

School of Resources and Environmental Engineering, Jiangxi University of Science and Technology, Ganzhou 341000, China

This study focuses on the grinding behavior and efficiency optimization of ceramic ball media in vertical stirred mills. By combining experimental methods with discrete element method (DEM) simulations, it systematically investigates the effects of stirring shaft speed, media filling rate, and media size on the grinding performance of specific-sized magnetite. The experimental research employs particle size distribution models, grinding rates, and the t10-Ecs model to analyze and quantitatively evaluate the impact of different parameter conditions on the grinding efficiency and product characteristics of ceramic media from multiple perspectives. Meanwhile, DEM simulations provide a microscopic-level analysis, examining key factors such as the kinetic energy changes of ceramic ball media, particle velocity distribution patterns, motion trajectories and stratification phenomena, collision energy intensity and distribution among different collision types, and the proportion of effective collisions and energy utilization efficiency between grinding media and mineral particles, offering detailed insights into the mechanisms of ceramic ball motion and grinding behavior. The result shows that for the specific-sized magnetite tested, higher stirring shaft speeds, filling rates, and larger media sizes generally lead to better grinding performance under the same conditions. However, adjusting parameter ranges can help improve energy utilization efficiency while maintaining grinding effectiveness, thereby achieving energy-saving and consumption-reducing goals. This research clarifies the dominant grinding mechanisms of ceramic media and provides theoretical and practical strategies for optimizing energy-efficient grinding processes.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-160827: Influence of iron impurity on floatability of iron-bearing sphalerite

Ye Chen

State Key Laboratory of Featured Metal Materials and Life-Cycle Safety for Composite Structures, Guangxi Higher School Key Laboratory of Minerals Engineering, Guangxi University, Nanning 530004, China

Iron impurity is the most common impurity element in sphalerite, and its content has a significant influence on the flotation behavior of sphalerite. To systematically investigate the mechanism by which iron content affects the flotation behavior of sphalerite, this study employed density functional theory (DFT) simulations combined with coordination chemistry principles to analyze the effects of iron content and its spin configuration on the electronic structure and floatability of sphalerite. The results indicate that as the iron content increases, the band gap of sphalerite gradually narrows. Under low iron content conditions, the reduced band gap favors the transfer of electrons, where iron impurities exist as high-spin Fe^{2+} . The 3d orbitals of Fe^{2+} can provide a pair of π electrons, enabling the formation of a weak feedback π -bond with xanthate, thereby enhancing the floatability of sphalerite. In contrast, under medium and high iron content conditions, further narrowing of the band gap intensifies electrochemical interactions, promoting the oxidation of Fe^{2+} to Fe^{3+} . Since Fe^{3+} lacks π electron pairs in its 3d orbitals, it cannot form a feedback π -bond with xanthate, leading to a significant decrease in the floatability of sphalerite. The theoretical calculations in this study are consistent with experimental flotation results, providing deeper insights from the perspective of coordination chemistry into how iron content influences the flotation behavior of sphalerite, and offering important theoretical support for the flotation of iron-bearing sphalerite.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158381: Investigation into the effect of Froth Flotation Process Variables for the Recovery of Residual PGMs from Mine Tailings

Itumeleng Kohitlhetse * and Mmapula Mamogale

Clean Technology and Applied Materials Research Group, Department of Chemical and Metallurgical Engineering, Vaal University of Technology, Private Bag X021, Vanderbijlpark 1911, South Africa

This project investigates recovery of residual platinum-group metals (PGMs) from mine tailings by diagnosing froth-flotation constraints and defining a rigorous optimization pathway. Tailings from the PGMs mining operation were sampled across the dam; material was air-dried, crushed to ≤ 2 mm, riffle-split, and characterized by particle-size distribution. Mineralogical studies were achieved by XRD chemical composition was assayed by ICP-OES to inform reagent strategy. The feed is ultra-fine in the range of particle size of 78.6 % passing 75 μm . Baseline rougher flotation employed a 42 % w/w pulp with isobutyl xanthate collector, X3-DEP depressant, sodium silicate dispersant, copper-sulphate activator, and X2-froth frother under controlled aeration. Product streams were filtered, weighed, and assayed for PGMs and Cr_2O_3 to compute mass pull, grade, and recovery. Results show pronounced sensitivity to feed and operating variability. Across tests, increasing mass pull raised recovery but diluted concentrate grade, evidencing gangue entrainment; conversely, higher grades were obtained at lower mass pull with associated recovery penalties. Monitoring of Cr_2O_3 in concentrate constrained mass pull for smelter compliance. These inverse grade–recovery responses are consistent with ultra-fine feeds, surface oxidation of PGM minerals, and froth drainage constraints. Performance differences were attributed to reagent dosage and pH control, conditioning and residence time, and hydrodynamics. The recommended pathway is a constrained operating window centered on ~42 % solids with reagent set-points and control loops for pH and dosing, explored via designed experiments spanning collector/frother dosages, air rate, and conditioning time. Feed-grade variability should be dampened by blending to stabilize head grade and mineralogy. Where mineralogy confirms locked PGMs or oxide coatings, targeted ultrafine grinding in inert media and/or tertiary scavenging circuits may be justified on a cost-normalized metal basis. Consequently, the study confirms technical feasibility but emphasizes process-control rigor to achieve predictable recovery from tailings and to manage the grade–recovery–mass-pull variables.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-152847: Ion-specific effects on bubble coalescence and foams

Stoyan Karakashev^{1*}, Orhan Ozdemir², Yunus Çavdar², Nikolay Grozev³, Kristina Mircheva³, Stanislav Donchev¹ and Christomir Christov⁴

¹ Department of Chemistry, Faculty of Natural Sciences, The University of Shumen "Bishop Konstantin Preslavsky", Shumen, 9700, Bulgaria

² Mineral Processing Engineering Department, Faculty of Mines, Istanbul Technical University, Istanbul, 34469, Turkey

³ Department of Physical Chemistry, Faculty of Chemistry and Pharmacy, Sofia University "St. Kliment Ohridski", Sofia 1164, Bulgaria

⁴ Faculty of Natural Sciences and Education, The University of Ruse "Angel Kanchev", Ruse 7017, Bulgaria

We studied the specific effects of NaCl, KCl, MgCl₂ and CaCl₂ on the ability of sodium dodecyl sulfate (SDS) to inhibit the coalescence of the bubbles in water and to make foam. We related our observations with the thermodynamic data about the activities of the salts and water using the model of Pitzer for each particular salt. Moreover, we measured the surface tension of each particular foaming solution, which allowed us to calculate the adsorption parameters of SDS in the presence of the different salts. All these allowed us to look at our main experimental data from different perspectives. As we have expected, the addition of each one of the salts to the aqueous solution of SDS significantly decreased its critical coalescence concentration (CCC). Yet their effects on the ability of SDS to make foam were various. For example, NaCl significantly increases the foaming ability of SDS, while KCl acts as foam suppressor. MgCl₂ boosts the ability of SDS to make foam, while CaCl₂ appears to be foam suppressor. Sodium (Na) and Potassium (K) belong to the 1A group of the Mendeleev's periodic table, while magnesium (Mg) and calcium (Ca) belong to the 2A group. Sodium (Na) is a foam booster, while potassium (K) is a foam suppressor. Magnesium (Mg) is a foam booster while calcium (Ca) is a foam suppressor. The two pairs of chemical elements have identical electronic configurations in their last electronic layers. The only difference between them is in the radii of their atoms. This difference draws difference in their ionization potentials, polarizabilities, hydration numbers and all related thermodynamic parameters. We developed a detailed analysis, thus drawing the conclusion that the larger counter-ions act as flocculants of the surfactants, thus becoming foam suppressors, while the smaller ions act as foam boosters.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158455: Mechanical High-Intensity Conditioning (HIC) in Flotation Pre-Treatment

Morteza Masoomi¹, Ahmad Hassanzadeh^{2,*}, Hossein Afzali Gorouh¹ and Mazyar Salmanzadeh¹

¹ Department of Mechanical Engineering, Shahid Bahonar University of Kerman, Kerman, Iran

² Maelgwyn Mineral Services Ltd, Ty Maelgwyn, 1A Gower Road, Cathays, Cardiff CF24 4PA, United Kingdom

One of the most persistent challenges in mineral flotation processes is the poor recovery of fine particles, which have limited ability to attach to bubbles due to surface characteristics, low inertia, and weak hydrodynamic interactions within the flotation pulp. These limitations reduce collision and adhesion probabilities, leading to losses of valuable minerals in fine fractions. High-Intensity Conditioning (HIC) has increasingly been recognized as an effective pretreatment to address poor fine-particle recovery in flotation. Recent literature demonstrates that mechanical HIC systems, through high-shear mixing, can substantially enhance reagent dispersion, surface activation, and bubble-particle interactions. Studies collectively indicate that these effects improve mineral selectivity and recovery while decreasing chemical consumption. Despite these promising outcomes, there is still no comprehensive or unified understanding of the fundamental concept and mechanisms occurring within high-intensity conditioning tanks. This review therefore aims to establish a clearer definition of HIC and to systematically summarize the physical and chemical mechanisms involved in such conditioning systems. It critically examines recent laboratory and industrial advancements in mechanical HIC systems, focusing on the hydrodynamic design and operation of mixing tanks under intensive shear regimes, reviewing key experimental findings and assessing the potential of HIC as a scalable, high-efficiency pretreatment for enhancing flotation performance in mineral processing and highlighting directions for future research.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-155361: Modeling single-particle breakage by slow compression

Túlio Moreira Campos ^{1,*}, Malcolm Powell ² and Luís Marcelo Tavares ¹

¹ Department of Metallurgical and Materials Engineering, Universidade Federal do Rio de Janeiro, Rio de Janeiro 21941-909, Brazil

² Sustainable Minerals Institute, University of Queensland, Brisbane 4072, Australia

Compression of particles to a fixed final gap is the mode of application of stresses in many crushing devices. Understanding and modeling this particle fracture process is indispensable for comminution operations. The present work is based on detailed compression tests conducted with five different ores to which different deformation ratios are applied to characterize their size-dependent fracture energy distribution and progeny size distribution. An energy-based model is proposed to describe single-particle breakage by compression based on three modes, which define whether the particle is classified for breakage (classification function), the likelihood that the classified particle is sufficiently nipped to break (breakage probability), and the extent of breakage the particle will undergo (breakage distribution). Expressions that allow the calculation of the energy absorbed by the particle in both primary and secondary breakage are proposed by explicitly accounting for particle thickness, stiffness, and the fixed applied final gap. Model verification is demonstrated, with the model predicting the breakage response and energy consumption for single-particle compression experiments performed on a bench-scale with all materials investigated. The validation of the model is shown by accurately predicting, without any fitting, the progeny size distribution and overall energy consumption of compression using fixed gaps and breakage in a double roll crusher.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-157797: Novel Sustainable Process for the Recovery of Aluminium and Rare Earth Elements from High-Silica Bauxite

Turan Uysal ^{1,*}, Yayat Iman Supriyatna ², Slamet Sumardi ² and Widi Astuti ²

¹ Gümüşhane University, Department of Mining Engineering, Gümüşhane University, Gümüşhane, Türkiye

² Research Center for Mining Technology, National Research, and Innovation Agency Republic of Indonesia (BRIN), South Lampung, 353661, Indonesia

Rare earth elements (REEs), which are found and produced in only a limited number of countries worldwide, are projected to be insufficient to meet the growing global demand in the near future. This situation has prompted increasing interest in alternative production routes from secondary geological sources with low uranium (U) and thorium (Th) contents. Among these, ionic clays, red mud, fly ash, bauxite, and related ores have emerged as promising potential sources. In particular, bauxite and its associated ores are considered significant secondary geological resources due to their relatively high REE concentrations.

In this study, the recoverability of REEs and aluminum (Al) from high-silica bauxite ore that cannot be processed by the Bayer method was investigated. The Kemiklitepe bauxite ore (Karaman, Türkiye), characterized by its high silica content and appreciable REE concentrations, was evaluated as a potential alternative source of these critical materials. A novel and sustainable process was developed for the simultaneous recovery of Al and REEs through an alkali roasting–acid leaching route. The finely ground ore was alkali-roasted with Na_2CO_3 at 800–1000 °C, followed by a two-step leaching procedure involving water and sulfuric acid (H_2SO_4). Acid leaching achieved a total REE recovery of approximately 87%. Subsequently, the selective extraction of REEs and Al from the pregnant acidic leach solution was investigated using the solvent extraction (SX) method. Key operational parameters including extractant (D2EHPA) concentration, reaction time, pH, and organic-to-aqueous phase ratio were optimized using the Taguchi design method. The results demonstrate that the proposed process enables efficient and environmentally sustainable recovery of both Al and REEs from high-silica bauxite, highlighting its potential for resource diversification and zero-waste processing.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158375: Optimization of Reagent Efficiency in Copper Flotation Circuit at Varying Slurry Densities

Itumeleng Kohitlhetse * and Prince Nyathi

Clean Technology and Applied Materials Research Group, Department of Chemical and Metallurgical Engineering, Vaal University of Technology, Private Bag X021, Vanderbijlpark 1911, South Africa

Efficient copper concentration via froth flotation hinges on balancing collector selectivity, frother strength, and slurry density to maximize concentrate grade at acceptable recovery and cost. This study systematically evaluates two collectors, namely K1 and K2 with a common frother across pulp densities of 34, 42, and 48% solids by mass. Batch laboratory froth flotation tests were executed under controlled hydrodynamics with rigorous, reproducible sample preparation, calibrated chemical dosing, and time-resolved concentrate pulls. Kinetics, cumulative recovery, froth stability, and grade-recovery curves were computed to quantify performance. Raising solids from 34 to 48% increased concentrate grade but depressed overall recovery, consistent with higher pulp viscosity, reduced bubble mobility, and shorter froth residence favouring selective attachment. An operational optimum emerged at 42% solids: grade improved relative to 34% with only moderate recovery loss, yielding the most cost-effective outcome when reagent consumption is included. At 34% solids, recovery was highest but concentrate grade was diluted; this regime suits scenarios prioritizing metal units. At 48% solids, selectivity improved further but recovery penalties became prohibitive. Across densities, Test 2 employing a higher-activity selective collector (K1-based) with tuned dosage outperformed alternatives, delivering superior grades at equal or better recoveries. Relative to K2, the selective regime reduced gangue entrainment and stabilized froth morphology in conjunction with the frother, enabling cleaner, faster flotation without excessive reagent addition. In conclusion, results show that (i) density is a first-order lever governing the grade–recovery of copper through concentration by froth flotation; (ii) selective collector chemistry, properly dosed, shifts the frontier upward; and (iii) an operating window near 42% solids with a K1-dominant collector suite and moderated frother addition provides robust performance and lower unit reagent cost. These insights further support reagent and density set-point optimization in industrial circuits targeting higher-value concentrates with controlled chemical spend. Top of FormBottom of Form



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-157370: Optimization of Ultrafine Grinding Parameters Guided by Process Mineralogy to Improve Iron Separation Efficiency of titano-magnetite in Magnetic Separation

Hongcheng Mi *, Lixia Li, Siyou Li, Yang Chu, Feifei Liu and Zhe Liu

Department of Mineral Engineering, Northeastern University, Shenyang 110819, China

Grinding operations play a pivotal role in enabling the effective separation of minerals, as it directly dictates the degree of mineral liberation and a critical prerequisite for subsequent beneficiation processes. In this study, a combination of advanced analytical techniques, including X-ray diffraction (XRD), scanning electron microscopy coupled with energy dispersive X-ray spectroscopy (SEM-EDS), and the Advanced Mineral Identification and Characterization System (AMICS), was employed to systematically investigate four key aspects: (1) the mineral composition of the raw ore, (2) the grain size distribution of valuable minerals, (3) the degree of ionization, and (4) the intracrystalline relationships of titano-magnetite with other coexisting phases. The results indicated that titano-magnetite exhibits a strong associative relationship with gangue minerals (e.g., chlorite, pyroxene, and amphibole). This intimate association causes complete dissociation of titano-magnetite from gangue minerals to be challenging during grinding. Consequently, gangue minerals are prone to entrainment in the iron concentrate alongside titano-magnetite, which subsequently compromises the quality of the final iron concentrate. Based on the aforementioned mineralogical characteristics of titano-magnetite, the high-speed stirred mill was used to achieve the ultra-grinding of titano-magnetite and optimize operation parameters. The optimal grinding conditions were ultimately determined as follows: stirred speed of 2000 r/min, grinding concentration of 35%, feeding frequency of 5 Hz, and media filling ratio of 70%. Under these optimized conditions, an optimized magnetic separation process to improve the recovery of high-content iron concentrates from titano-magnetite was performed, eventually allowing the iron grade to reach 56.25%. This study provides crucial insights into addressing the issue of complex titano-magnetite, and the optimized grinding-magnetic separation process proposed herein offers theoretical and technical guidance for scaling up beneficiation operations in industrial settings, thereby facilitating the sustainable utilization of titano-magnetite resources.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-161415: Plasma-induced melting and microfiber formation from zeolite-containing mineral waste

Viktorija Grigaitienė *, Mindaugas Milieška, Romualdas Kėželis, Vitas Valinčius and Vilma Snapkauskienė

Plasma Processing Laboratory, Lithuanian Energy Institute, Breslaujos Str. 3, LT-44403 Kaunas, Lithuania

The zeolite-containing waste generated during the petroleum fluid catalytic cracking (FCC) process is a high-volume aluminosilicate by-product and a potentially valuable secondary raw material. When these residues lose their catalytic performance, they become environmentally problematic, rendering them unusable and unreusable. This problem creates a clear need for advanced high-temperature mineral processing methods, with plasma technologies offering a particularly promising option. This work investigates the transformation behaviour of zeolite waste under atmospheric-pressure plasma conditions, focusing on melt formation, structural changes, and the development of continuous aluminosilicate microfibers. Dried and sieved zeolite waste particles (60 μm size) were injected into an atmospheric-pressure direct current (DC) air plasma jet. The temperature of the plasma jet exceeded 3500 K and facilitated the rapid melting of zeolite particles. The molten droplets were aerodynamically stretched within the plasma jet to form microfibres with diameters in the 0.1–5 μm range. Scanning electron microscopy (SEM) revealed a smooth fiber morphology without unmelted inclusions, while X-ray diffraction (XRD) confirmed complete vitrification and the absence of characteristic zeolite-Y diffraction peaks. Analysis of the plasma jet parameters showed that plasma enthalpy, gas flow regime, and reactor geometry strongly influence melt homogeneity and fiber formation efficiency. These findings show that atmospheric-pressure plasma processing can effectively convert zeolite waste into high-quality aluminosilicate microfibers, providing an effective way to convert mineral waste into useful products.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-134984: Predictive Modelling of Geometallurgical Variables at Tarkwa Mine, Southwestern Ghana.

Joseph Adusei¹, Emmanuel Daanoba Sunkari² and Emmanuel Emmanuel Addo Jr³

¹ University of Mine and Technology, Tarkwa, Ghana

² Department of Geological Engineering, Faculty of Geosciences, University of Mines and Technology, Tarkwa P.O. Box 237, Ghana

³ TEX FZCO, Dubai, United Arab Emirates

In seeking to improve efficiency in the mine to mill process, mining companies are incorporating ore processing variables during ore planning and scheduling stages to improve decision making. Therefore, the accurate modelling of these ore processing variables has become more critical.

This case study presents a D-vine copula modelling process applied to predict recovery (Rec) from three geometallurgical variables, that is Bond Work index test (BWi), resistance to abrasion and breakage index (A*b) and semi-autogenous grinding (SAG) power index test (Spi), using a dataset consisting of 775 diamond drill core samples of the four geometallurgical variables from Tarkwa Mine in Ghana. The distributions of the four variables were used to create a geometallurgical model to predict values of Rec based on SPI, BWi, and A*b using a 10-D version of copula-based quantile functions, which can be integrated in the mine planning and scheduling process. The module produced an average predicted recovery of 89.26% compared to an observed average recovery of 88.64%. A mean absolute error of 4.41 was obtained indicating an acceptable module performance considering the observed recovery values, which suggests that the model's predictions closely align with the observed values.

This modelling framework enables the creation of a geometallurgical block model that not only improves the prediction of metallurgical variables but also significantly improves the integration of geological and metallurgical information, thereby optimizing processing outputs, project revenue and cash flows for mining companies.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158487: Reducing primary mineral dependence through recycling of lithium-ion batteries: An approach with deep eutectic solvents

João Pinto *, João A.P. Coutinho and Nicolas Schaeffer

CICECO – Aveiro Institute of Materials, Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal

It is no secret that the overexploitation of natural resources such as mineral ores is an unsustainable practice. Not only are these resources finite, but their extraction is often associated with severe environmental consequences during both the extraction and refining processes. Moreover, when a given country is entirely dependent on mineral imports, it is also susceptible to market constraints and geopolitical pressures. Because of this, mineral recycling from secondary sources and their injection back into the economy can prove to be an effective measure to mitigate the problems associated with primary mining. An example of such an approach is the recovery of valuable metals from spent lithium-ion batteries (LIBs). These batteries contain valuable metals such as lithium (Li), manganese (Mn), cobalt (Co), and nickel (Ni), as well as copper (Cu) and iron (Fe). Hydrometallurgical techniques such as solvent extraction have already been used with varying degrees of success to recover these metals from lithium-ion batteries. However, the existing processes can and should be optimized in terms of the extreme acidic conditions and hazardous chemicals that are used. In this work, we propose the use of novel deep eutectic solvents (DES) as alternative solvents in LIB recycling, using less acidic environments at room temperature. Trioctylphosphine oxide (TOPO)-based eutectic solvents were tailored to extract equimolar concentrations of different metals often present in LIBs leachates without the addition of heat and even displayed selective extraction for some metals under specific conditions. Further characterization, including acid partition into the DES, viscosity, and reusability, allowed for a more rigorous assessment of potential applications. Overall, TOPO-based DES exhibited promising behavior in terms of metal extraction from LIB leachates.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-161263: Synergistic Surfactant-Collector Effects on Pyrite Desulfurization in Iron Ore Concentrate

Ahmad Azargoon Jahromi ^{1,*} and Zahra Bahri ²

¹ Department of Mining Engineering, Amirkabir University of Technology (Polytechnic of Tehran), Tehran 15875-4413, Iran

² Department of Control and Modeling of Mineral Processing Systems, Institute of Mineral Processing, ACECR at Tarbiat Modares, Tehran 1411883684, Iran

Pyrite is the main sulfide mineral responsible for the increased sulfur content in magnetite concentrates at the Golgohar iron ore complex, which negatively affects steel production quality. Reverse flotation using xanthate collectors and methyl isobutyl carbinol (MIBC) as frothers is commonly used for desulfurization. This study investigates the synergistic effects of combining surfactants such as sodium lauryl ether sulfate (SLES) as a filter aid with collectors in flotation. The focus is optimizing reagent dosages to enhance pyrite removal efficiency while minimizing impacts on iron recovery and filtration performance.

Laboratory flotation experiments were conducted on magnetite concentrate samples (64.94% Fe, 24.77% FeO, 0.71% S) using a Central Composite Design (CCD) via Design-Expert software. Key variables included collector (0-164 g/t), frother (0-87 g/t), and surfactant (0-150 g/t) concentrations. Pulp density was 30% solids, with conditioning times of 2 min for collector/surfactant and 1 min for frother. Floated and non-floated fractions were weighed, assayed for Fe, FeO, and S, and evaluated for separation efficiency, recoveries, and concentrate quality. Complementary filtration tests assessed cake moisture.

Adding 75 g/t SLES improved desulfurization, raising sulfur separation efficiency from 52% to 70.1% and recovery from 53% to 72%, while reducing concentrate sulfur from 0.34% to 0.20%. Iron recovery decreased slightly by 0.8%. Optimal dosages: 80 g/t collector, 40 g/t frother, 75 g/t SLES, enabling 40% collector and 62% frother reductions. SLES (HLB=40, MW=496.7 g/mol) showed superior selectivity and power over MIBC, with 2% average moisture reduction in filtration.

The SLES-xanthate synergy enhances pyrite hydrophobicity via co-adsorption, charge screening, and lowered critical micelle concentration, promoting efficient flotation without disruptions. Findings support integrated surfactant use in industrial circuits, with potential for scale-up and alternative surfactants exploration.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158061: Utilisation of Plagioclase in Mine Residues as a Silica Source for the Synthesis of High-Purity Silica Nanoparticles

Sameera Mohamed ^{1,2,*}, Elizabet M. van der Merwe ² and Frederic J. Doucet ^{1,2}

¹ Council for Geoscience, 280 Pretoria Street, Silverton, Pretoria 0001, South Africa

² Department of Chemistry, University of Pretoria, Lynnwood Road, Pretoria 0002, South Africa

Silica nanoparticles (nano-SiO₂) are essential in applications such as environmental remediation, agriculture, and catalysis. They are synthesised from high-grade quartz, tetraethyl orthosilicate (TEOS), and other costly and non-renewable precursors. The high cost of these conventional silica precursors limits the sustainability of their large-scale production. Therefore, identifying alternative, low-cost and abundant silica sources is crucial to improving the economic feasibility of nano-SiO₂ synthesis. This study explored the utilisation of plagioclase minerals contained in abundance in a South African Bushveld Igneous Complex (BIC) mine residue as an alternative, low-cost silica source for the synthesis of high-purity nano-SiO₂. The sample contained 65.4 wt.% plagioclase, 15.5 wt.% clinopyroxene, 10.4 wt.% orthopyroxene, 5.1 wt.% clinocllore, and trace amounts of other minerals. Its major chemical components were SiO₂ (47.6 wt.%), Al₂O₃ (18.4 wt.%), Fe₂O₃ (12.3 wt.%), CaO (9.2 wt.%), MgO (3.9 wt.%) and Na₂O (3.3 wt.%).

A multi-stage synthesis route was developed. It consisted of a calcination pretreatment step which was designed to convert soluble iron-bearing minerals into insoluble iron oxides, followed by direct acid leaching, precipitation, and surfactant-assisted refinement. The resulting silica nanoparticles were characterised using X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), inductively coupled plasma optical emission spectroscopy (ICP-OES), and Brunauer–Emmett–Teller (BET) surface area analysis. The integrated calcination-leaching-precipitation process enabled the successful formation of high-purity (99%), predominantly amorphous nano-SiO₂ with controlled spherical morphology, a primary particle size below 50 nm, and a high specific surface area of 576 m²/g. These results highlight the untapped potential of plagioclase in mine tailings and other mineral-related solid waste as a strategic feedstock for high-purity silica nanoparticles. This offers a sustainable alternative to conventional silica precursors used today.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Session 6. Emerging Frontiers in Mineral Science: Breakthrough Areas and Future Directions

sciforum-161236: Quantifying an Alternative Sand from Metal Ores Essential for the Energy Transition: The Case of Ore-sand

Bioantika-^{1,2,*}, Juliana Segura-Salazar^{1,3}, Cristian Antonio³, Rob Fitzpatrick² and Daniel Franks¹

¹ Global Centre for Mineral Security, Sustainable Minerals Institute, The University of Queensland, Brisbane, QLD, Australia

² Department of Earth and Environmental Sciences, Camborne School of Mines, University of Exeter, Penryn Campus, Exeter, United Kingdom

³ Julius Kruttschnitt Mineral Research Centre, Sustainable Minerals Institute, The University of Queensland, Brisbane, QLD, Australia

Between 2020 and 2050, global tailing generation is projected to reach 300 Gt. When poorly managed, mine tailings pose significant environmental and safety risks, contributing to more than 2,650 recorded deaths since 1915. Despite this, the mining industry continues to rely heavily on reactive waste strategies—repurposing and reuse—rather than preventing tailings at the source. Ore-sand, a by-product derived from mineral processing, offers a preventative pathway. This opportunity stems from the realisation that most mineral waste originates from discarding dominant minerals—particularly silicates—that could instead be mined as fit-for-purpose by-products. Ore-sand has demonstrated strong technical feasibility as a substitute for natural sand, the world's second-most consumed resource. An estimated 50 billion tonnes of natural sand are extracted annually from rivers and coasts, with environmental and social consequences particularly severe for communities in coastal regions. Successful implementations already exist. Vale's Brucutu iron ore mine produces around 2 Mt of ore-sand per year, while Newmont's Cadia copper-gold mine has demonstrated the viability of coarser ore-sand production using HydroFloat technology. However, despite these promising examples, no comprehensive method currently exists to estimate ore-sand resources, reserves, and recoverable quantities as a by-product, nor to align these estimates with application-specific and market-driven requirements such as particle size distribution, shape, elemental and mineralogical composition. In this study, we present the first framework for estimating ore-sand resources, reserves, and recoveries across different sand applications. We evaluate key factors influencing ore-sand generation, including primary commodity production, mineral processing circuits and technologies, market-based performance criteria, and market absorption. This framework provides a crucial foundation for understanding the true valorisation potential of ore-sand, including the volume of tailings that can be avoided, the degree to which natural sand extraction can be offset, and the extent to which ore-sand can meet the technical requirements of various sand applications.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-157319: Thermo-tectonic Evolution of the Jingzhushan Formation, Central Tibet: Constraints from Detrital Zircon Geochronology and Clumped Isotope Thermometry

Zhenglong Li *, Ming Wang, Quewang Danzeng, Binxuan Hao, Jinlu Zhou, Yuhe Zhang and Xiaohu Lian

College of Earth Sciences, Jilin University, Changchun 130061, China

The Jingzhushan Formation, a typical post-collisional continental molasse within the Bangong–Nujiang Suture Zone (BNSZ) of the Tibetan Plateau, preserves important evidence related to the closure of the Tethys Ocean and the collision between the Lhasa and Qiangtang terranes. However, key aspects such as its depositional age, sediment sources, and burial history remain poorly constrained, limiting our understanding of the tectonic evolution of this region. In this study, we conducted an integrated analysis of the Puga Jingzhushan section in Nyima County, combining field stratigraphy, detrital zircon U–Pb geochronology, cathodoluminescence (CL) imaging, stable isotope analysis, and clumped isotope ($\Delta 47$) thermometry, supplemented by solid-state reordering modeling. Detrital zircon U–Pb results indicate that the Jingzhushan Formation began depositing at approximately 94 Ma, with sediments mainly derived from Early Cretaceous magmatic rocks in the North Lhasa Terrane and limestone of the Langshan Formation. Clumped isotope temperatures (ranging from 51.9 to 79.2°C) are higher than expected primary depositional temperatures, indicating significant post-depositional thermal alteration. Solid-state reordering modeling constrains a maximum burial temperature of ~172°C, attributed to the combined effects of sedimentary burial and magmatic activity around 88 Ma. Furthermore, different fossil types (Auroradiolites, Eoradiolites, Sauvagesia) exhibit distinct diagenetic pathways, influenced by variations in shell microstructure, leading to either C–O bond reordering or closed-system recrystallization. We conclude that the Jingzhushan Formation was deposited in a continental setting following the Lhasa–Qiangtang collision. Its burial and exhumation history reflects Late Cretaceous tectono-magmatic interactions, offering new thermochronological insights into early uplift and tectonic transition in central Tibet.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-157085: Adaptive Neural Topologies for Digital Mineralogy: The Mycelial_Net Approach

Paolo Dell'Aversana

Research Department (this is not a University but the Energy Government Company of Italy), Eni S.p.A., Via Emilia, 1 - San Donato Milanese - Milan 20097, Italy

Mineral science is rapidly evolving toward automated and intelligent characterization systems capable of supporting exploration, mining, and geo-materials analysis. In this context, we introduce *Mycelial_Net*, a novel deep learning framework inspired by the adaptive connectivity of fungal mycelium networks. Unlike conventional CNNs, *Mycelial_Net* continuously restructures its internal topology during training, expanding or pruning artificial synaptic pathways based on entropy and classification performance. This biologically inspired plasticity enables the model to preserve previously learned mineralogical representations while optimizing its structure for new information, mimicking the self-organization of living networks in natural environments. Applied to thin section microscopy images, *Mycelial_Net* integrated with a ResNet backbone demonstrates superior resilience to noise, low-resolution data, and complex textures. In benchmark tests on a data set of images of mineral thin sections, the architecture achieved validation accuracies exceeding 95%, outperforming CNNs, ensemble learning, and Vision Transformer approaches. These results show the potential of adaptive architectures to provide more consistent and interpretable mineral classification, even under heterogeneous geological conditions. Current research aims to extend this approach toward more challenging mineral assemblages, multimodal petrographic datasets, and industrial applications, such as real-time classification in ore processing environments. The long-term vision is the development of a self-aware mineralogical foundation model capable of autonomous learning, uncertainty quantification, and continuous improvement based on new geological evidence. This work highlights how cross-fertilization between biology-inspired computation, mineralogy, and artificial intelligence can open unprecedented perspectives in digital petrography and automated geoscience—placing *Mycelial_Net* among the emerging frontiers of Mineral Science.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-156234: Advancing LIBS for Quantitative and Spatial Analysis of Rare Earth Elements in Coal

CR Bhatt *, Daniel Hartzler and Dustin McIntyre

US Department of Energy, National Energy Technology Laboratory, Morgantown 26505, USA

Advancing LIBS for Quantitative and Spatial Analysis of Rare Earth Elements in Coal

With the increasing global demand for rare earth elements (REEs), there is a critical need for rapid, field-deployable technologies that are capable of detecting and quantifying REEs in both conventional and unconventional resources. This work evaluates the use of Laser-Induced Breakdown Spectroscopy (LIBS) for the detection of lanthanum (La) and neodymium (Nd) in synthetic and natural rock and coal matrices at extraction-relevant concentrations. Multiple LIBS systems—including commercial and custom benchtop instruments (in single- and double-pulse modes), as well as a developing in situ LIBS probe—were employed. Detection limits as low as 10 ppm for La and 15 ppm for Nd were achieved, with double-pulse mode yielding signal enhancements of 3.5 to 6 times greater than single-pulse mode. Additionally, LIBS was compared with Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) across coal samples. Multivariate calibration and principal component analysis (PCA) enabled accurate classification and prediction of REE content, while 2D elemental mapping provided insights into the spatial distribution of REEs. The results demonstrate LIBS to be a promising tool for real-time REE analysis and resource assessment in both laboratory and field environments. LIBS is an emission spectroscopy-based analytical technique. A high-power laser pulse is used as an energy source to cause ablation of the test materials and achieve high-temperature plasma formation, which upon cooling emits light, giving characteristic information of the species that are present in the materials in terms of atomic and molecular spectra.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-157978: Deciphering the Lithium Pathway: Linking Deep Tectonics to Surface Mineralization in the Laguocuo Ophiolitic Mélange

Quewang Danzeng *, Ming Wang, Jinlu Zhou, Binxuan Hao, Yuhe Zhang, Zhenglong Li and Xiaohu Lian

College of Earth Sciences, Jilin University, Changchun 130061, China

Linking deep-seated tectonic processes to surface mineralization systems is a fundamental challenge in earth sciences. The Early Jurassic Laguocuo ophiolitic mélange in central Tibet, situated adjacent to a major Li-rich brine basin, provides a natural laboratory to decipher the complete pathway of lithium from a mantle source to an ore deposit. Through an integrated investigation of field petrology, zircon U-Pb-Hf isotopes, and whole-rock geochemistry, we unravel this deep-to-surface connection. The plagiogranites, crystallized at 183.6 ± 1.9 Ma from a depleted mantle-derived magma, record a complex magmatic evolution marked by disequilibrium mineral phases. Their unique geochemical signatures—including flat REE patterns, significant LILE enrichment, and Nb-Ta-Ti depletion, combined with high positive $\epsilon_{\text{Hf}}(t)$ values—collectively indicate that the mélange represents a fossil back-arc basin formed within an ocean-continent subduction system. Critically, these plagiogranites are systematically depleted in highly incompatible elements like Li and B, a depletion that is starkly mirrored by the enrichment of these same elements in the adjacent Laguocuo brines. This complementary relationship is the key to deciphering the lithium pathway. We, therefore, propose a coupled model where Early Jurassic back-arc extension drove magmatic differentiation, and subsequent exsolution of late-stage, Li-rich hydrothermal fluids from the crystallizing pluton transported the ore-forming components to the surface basin. Our study successfully deciphers this lithium pathway, demonstrating a direct genetic link between a specific deep tectonic setting (back-arc basin) and the formation of a supergene lithium brine deposit, with the ophiolitic mélange acting as the crucial geological archive.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-161172: Exploring Waste derived Resource for Concrete Development: Mechanical and Thermal Performance of Coconut Shell Ash Integration

Rodric Carpio Luceño ^{1,*}, Algen Secula ², Harvey Melendrez ³, Jason Jon Joshua Paraguya ⁴, Arnold Lubguban ⁴, Raymond Virtudazo ² and Masayoshi Fuji ⁵

¹ Research Center for Advanced Ceramics (RCAC), Mindanao State University-Iligan Institute of Technology, Iligan City, 9200, Lanao Del Norte, Philippines

² Department of Materials and Resources Engineering and Technology, College of Engineering, Mindanao State University-Iligan Institute of Technology, Iligan City, 9200, Lanao Del Norte, Philippines

³ Resource Processing and Technology Center, Mindanao State University – Iligan Institute of Technology, Iligan City, 9200, Lanao Del Norte, Philippines

⁴ Center for Sustainable Polymers, Mindanao State University-Iligan Institute of Technology, Iligan City, 9200, Lanao Del Norte, Philippines

⁵ Advanced Ceramics Research Center, Nagoya Institute of Technology, Tajimi City, 507-0033, Japan

Advancements in materials development continue to drive innovations in sustainable and resource-efficient construction materials. Coconut shell ash (CSA), a byproduct of using coconut shells as fuel in industries, makes a good resource to utilize because of its abundance. This study explores the potential of waste-derived coconut shell ash (CSA) as a material resource-based micro-filler for concrete, aligning with emerging frontiers in waste resource utilization. CSA was incorporated at 10% by volume as a partial sand replacement to evaluate its influence on the physical, mechanical, and thermal performance of the composite. Comprehensive chemical, mineralogical, and morphological analyses were conducted on both CSA and CSA-modified concrete.

Results show that CSA addition slightly reduced concrete density from 1.813 to 1.760 g/cm³ and increased apparent porosity and water absorption to 1.77% and 7.68%, respectively. Mechanical performance decreased moderately, with flexural strength declining from 4.60 MPa to 4.02 MPa and compressive strength from 6.76 MPa to 6.04 MPa. Thermal conductivity on the other hand, increased from 0.451 to 0.490 W/mK, attributed to the intrinsic porous microstructure of CSA, as shown in Figure 1.

Overall, CSA incorporation significantly influences the physical and thermomechanical behavior of concrete. While the mechanical properties slightly decrease, the findings highlight the potential of CSA as a viable waste-derived resource for developing greener, low-impact construction materials, contributing to breakthrough directions in sustainable material/mineral engineering.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-159949: Ion transport in the structures of conducting mineral-like crystals

Dmitry Pushcharovsky ^{1,*} and Alexey Ivanov-Schitz ²

¹ Faculty of Geology, Lomonosov Moscow State University, Leninskie Gory, 119991 Moscow, Russia

² Kurchatov Complex of Crystallography and Photonics (KCCF), National Research Center “Kurchatov Institute”, Leninsky Pr. 59, Moscow 117333, Russia

The main conditions for fast ionic transport are related to the disorder in the positions occupied by the mobile ion and the presence of conduction channels running inside the structure*.

A few examples which confirm the aforementioned statements are reported below. Synthetic analogs of tetragonal $\text{Na}_2\text{TiSiO}_5$ natisite, namely $\text{Na}_2\text{TiGeO}_5$ and $\text{Li}_2\text{TiGeO}_5$, can serve as an illustration of the structural condition of ionic conductivity. Their structures contain the layers (001) formed by tightly connected GeO_4 tetrahedra and TiO_5 semioctahedra. As a result, the alkaline cations can easily move between the layers and the conductivity along a axis is 10^3 – 10^4 times higher compared with one parallel to c -axis. Another example is the $\text{Na}_5\text{YSi}_4\text{O}_{12}$ crystal. Its characteristic features are 12-membered rings of silicon-oxygen tetrahedra. According to the symmetry of the cell, it should contain 90 Na atoms, but only 48 atoms were localized. This discrepancy should be associated with the possible movement of Na atoms within the structure. The results obtained using X-ray diffraction methods are extremely important for understanding the structural requirements of ionic conductivity in crystals. The structural refinement of $\text{K}_3\text{NdSi}_6\text{O}_{15}$ with the silicate layer $[\text{Si}_6\text{O}_{15}]$, similarly to those found in rare mineral dalyite $\text{K}_2\text{ZrSi}_6\text{O}_{15}$, allowed us to establish that one of three unequivalent K atoms has the highest thermal displacement U_{33} . Accordingly, these cations are most mobile along the c -axis, and it is confirmed by the values of the principal elements of the specific electrical conductivity tensor. Among the materials exhibiting high ionic conductivity with relatively low transition temperatures to the superionic state, Li-ionic conductors with the general formula $\text{Li}_3\text{M}_2(\text{PO}_4)_3$ ($\text{M} = \text{Fe}, \text{Sc}, \text{Cr}, \text{In}$) and with mixed framework structures are considered in this presentation.

*Pushcharovsky, D.; Ivanov-Schitz, A. *Minerals*, **2024**, *14*, 770.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-158249: Mechanochemical Synthesis of Mineral-Based Thermal Insulation Panels Using Treated Fly Ash, and Philippine Kapatagan Diatomaceous Earth

Edison Limbaga ^{1,2,*}, Rojellyn Baldago ^{1,2}, Corinne Iris Cahimtung ^{1,2}, Sean Kenneth Manlupig ^{1,2}, Lori-ann Cabalo ^{1,2}, Kento Ishii ³, Vannie Joy Resabal ^{2,4}, Liezl Jabile ^{1,2}, Masayoshi Fuji ³ and Raymond Virtudazo ^{1,2}

¹ Ceramic Researches for Engineering, Advanced Technology, and Environment (C.R.E.A.T.E.) Laboratory- Research Center for Advanced Ceramics (RCAC), Mindanao State University – Iligan Institute of Technology (MSU-IIT), Iligan City 9200, Lanao del Norte, Phil

² Department of Materials and Resources, Engineering and Technology (DMRET), Mindanao State University – Iligan Institute of Technology (MSU-IIT), Iligan City 9200, Lanao del Norte, Philippines

³ Advanced Ceramics Research Center, Nagoya Institute of Technology, Tajimi, Gifu 507-0033, Japan

⁴ Resources Processing and Technology Center – Research Institute for Engineering and Innovative Technology (RIEIT), Mindanao State University – Iligan Institute of Technology, Iligan City 9200, Philippines

The growing demand for sustainable and energy-efficient construction materials has driven research on mineral-based composites that combine mechanical strength with superior thermal insulation. This study focuses on the development of thermal insulation panel boards through mechanochemical synthesis using red clay from Kauswagan, treated coal fly ash, and locally sourced diatomaceous earth from Kapatagan, Philippines. Process parameters—including milling time, rotation speed, and material ratios—were optimized to enhance particle refinement, surface reactivity, and interfacial bonding among mineral components. X-ray diffraction (XRD) and chemical analyses confirmed the formation of aluminosilicate and quartz phases, improving the structural integrity and binding efficiency of the composites. The optimized panels exhibited low water absorption, high bulk density, and enhanced compressive strength, ensuring dimensional stability and durability. Thermal analysis showed a marked reduction in thermal conductivity, demonstrating excellent insulation performance, while SEM imaging revealed dense and well-dispersed microstructures resulting from mechanochemical activation.

The integration of industrial by-products such as treated coal fly ash with natural minerals not only minimizes environmental impact but also promotes the circular utilization of waste materials. Overall, this study demonstrates that mechanochemical synthesis offers an efficient and sustainable approach for developing high-performance thermal insulation panels suitable for green building applications and modern materials engineering.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-160437: Pushing the limits of diamond research

Kate Kiseeva^{1,2,*} and Nester Korolev¹

¹ Department of Earth and Planetary Sciences, American Museum of Natural History, New York, USA

² School of Biological, Earth and Environmental Studies, University College Cork, Ireland

Our opportunity to directly sample the deeper mantle is limited to the investigation of rocks and minerals delivered to the surface by magmas, such as kimberlites. Kimberlites bring to the surface mantle xenoliths formed at depths of up to 250 km, while the Earth's deepest sublithospheric minerals are found as inclusions in diamonds. During crystallisation, a small proportion (5%) of diamonds captures tiny inclusions of other minerals. These minerals record information about the composition and processes occurring at depths in the range of 150–700 km and possibly even deeper. Less than 10% of all uncovered inclusions in diamonds belong to the sublithospheric mantle (Stachel & Harris, 2008), and, among these, majoritic garnet and ferropericlasite are the dominant phases. Other minerals include broken-down davemaoite (former Ca–Si perovskite), bridgmanite (former Mg-perovskite), CF, NAL, and more rare inclusions. Recently unusual high-pressure phases including breyite, davemaoite, ice-VII, and ringwoodite have been discovered in inclusions in diamonds, making a breakthrough in our understanding of deep mantle petrology and composition.

Such discoveries would be impossible without new methods and analytical techniques, which have brought the possible size of investigated material from hundreds and tens of microns to just a few microns.

In this talk I am going to concentrate on new analytical advances and their applicability to diamond research. I will show examples of how the improvement of optical microscopy and Raman spectroscopy allows us to identify inclusions even a few hundred microns under the surface, how cutting-edge computer tomography allows us to identify multi-phase inclusions, and how synchrotron X-ray diffraction permits us to solve the structure of a 10-micron lamella within a complex multi-phase inclusion. I will conclude with how these new opportunities are helping to drive mantle research forward.

Stachel, T. & Harris, J. W. (2008). *Ore Geology Reviews* 34, 5–32.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-145291: The coloration mechanism of Brazilian blue apatite: Spectral analysis and chemical composition constraints

Ting Li

¹ China University of Geosciences (Beijing) Jewelry Academy, Beijing 1000832, China

² Department of Gemstone and Materials Technology, Sichuan University of Culture and Arts, Mianyang 622150, China

Brazilian blue apatite is highly valued in gemology for its distinctive neon-blue coloration, yet its chromogenic mechanism remains incompletely understood. This study systematically investigated the color origin through conventional gemological testing, Fourier-transform infrared spectroscopy (FTIR), laser Raman spectroscopy, UV-Vis-NIR absorption spectroscopy, laser ablation-inductively coupled plasma mass spectrometry (LA-ICP-MS), and heat treatment experiments. The samples were identified as fluorapatite with $[\text{CO}_3]^{2-}$ substituting for $[\text{PO}_4]^{3-}$. LA-ICP-MS revealed light rare-earth element (LREE) enrichment, heavy REE (HREE) depletion, and negative Eu anomalies, indicating formation under reduced oxygen fugacity conditions. A positive correlation ($R^2 > 0.8$) was observed between LREE concentration and color saturation. Transition metals: Mn^{3+} (absorption at 580–650 nm) serves as the primary chromophore, with Mn content positively correlating with color intensity. Fe^{3+} enhances brightness by suppressing red-light absorption. Rare earth elements, such as Nd^{3+} , contribute to red-region absorption (745/801 nm), while Ce^{3+} - SiO_3^- radicals and SO_3^- electron centers dominate UV/blue/green absorption. Excessive Ce^{3+} was found to inhibit blue coloration. The content indicates the presence of $\text{SO}_3^-/\text{SiO}_3^-$ radicals. Post-heating color fading (threshold at 400°C) results from U decay-induced color center destruction. Blue-purple fluorescence originates from Ce^{3+} (400 nm emission via $5d \rightarrow 4f$ transitions) and Eu^{2+} (585 nm), with sharp peaks near 600 nm attributed to $\text{Sm}^{3+}/\text{Pr}^{3+}$ transitions. This study elucidates the synergistic effects of $\text{Mn}^{3+}/\text{Fe}^{3+}$, REE electronic transitions, and color centers in generating the characteristic blue coloration, providing fundamental insights for gemological identification and enhancement protocols.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

sciforum-161162: Transforming Agro-Industrial Waste into Synthetic Minerals: Rapid Sol-Gel-Derived Alkali Feldspar particles for Thermal Management Applications

Maria Elisa Rabago Refugio ^{1,*}, John Andry Tutor ¹, Glenn Ruel F Maujon ¹, Harvey D Melendrez ², Liezl M Jabile ³, Adrian Keith R Caamino ³, Lori-ann I Cabalo ³, Ivyleen Bernardo Arugay ³, Masayoshi Fuji ⁴ and Raymond V Rivera-Virtudazo ³

¹ Research Center for Advanced Ceramics (RCAC), Mindanao State University – Iligan Institute of Technology, Iligan City 9200, Philippines

² Resource Processing and Technology Center, Mindanao State University – Iligan Institute of Technology, Iligan City, 9200, Lanao del Norte, Philippines

³ Department of Materials and Resources Engineering and Technology, College of Engineering and Technology, Mindanao State University – Iligan Institute of Technology, Iligan City 9200, Philippines

⁴ Advance Ceramic Research Center, Nagoya Institute of Technology, Tajimi City, Japan

Emerging frontiers in mineral science emphasize the need for sustainable, low-impact materials that leverage waste resources while delivering functional performance for advanced applications. In this study, agro-industrial waste—specifically rice husk ash combined with excess aluminum sulfate—was transformed into synthetic alkali feldspar particles through a rapid sol-gel process. The resulting powder exhibited an optimal chemical composition of 59.33% SiO₂, 16.42% Al₂O₃, and 7.12% alkali oxides, confirming its successful conversion into a synthetic feldspathic mineral. The product also displayed a high lightness value ($L^* \approx 100$), indicating a bright white chroma suitable for reflective and thermal management coatings. X-ray diffraction patterns further verified the presence of albite, orthoclase, quartz, and thenardite phases, demonstrating the formation of mixed alkali feldspar and associated phases.

To assess its application potential, the synthesized alkali feldspar was incorporated into a paint matrix and applied to a glass substrate. At a low particle concentration of 1.59%, the coating reduced thermal conductivity to 1.03 W/m·K, whereas a higher particle concentration of 7.90% increased conductivity to 1.68 W/m·K relative to the control substrate of 1.07 W/m·K. Optical microscopy confirmed well-dispersed particles within the coating layer, suggesting favorable compatibility and dispersion behavior.

Overall, the findings highlight waste-derived alkali feldspar as a tunable, sustainable mineral resource with promising applications in energy-efficient coatings, reflective surfaces, and thermally adaptive construction materials—aligning with innovative future opportunities in material resource development.



© 2026 by the author(s). Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

MDPI AG
Grosspeteranlage 5
4052 Basel
Switzerland
Tel.: +41 61 683 77 34

Minerals Editorial Office
E-mail: minerals@mdpi.com
www.mdpi.com/journal/minerals



Disclaimer/Publishers' Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

