

IMA 2022 – Sessions Abstracts Summary

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Advances in mineral data resources and infrastructure

Conveners: *Anirudh Prabhu, Shaunna Morrison, Xiaogang Ma, Daniel Hummer*

Minerals are key components in understanding the complex geologic history of Earth and other planetary bodies. Geologists have, therefore, been collecting mineral samples and compiling data about these samples for centuries. These data have been used to improve our understanding of geologic processes, mineralizing environments (paragenesis), planetary evolution, and changes in Earth's mineralogy through deep time.

This session welcomes presentations highlighting all aspects of advances made in developing, improving or maintaining mineral data resources. This may include, collecting, compiling and integrating data from various resources, building an infrastructure to access and use mineral data, or curating and maintaining mineral databases for various applications.

Session Name: Biomineralogy, biogeochemical cycles, environmental mineralogy
Sessions codes: OL02, OL25

Biomineralization and biogeochemical cycle of C, P, and S in sediments

Conveners:

Prof. Xiancai Lu, Nanjing University, xcljun@nju.edu.cn

Prof. Maria Dittrich, University of Toronto, m.dittrich@utoronto.ca

Dr. Xin Zhang, Pacific Northwest National Laboratory, xin.zhang@pnnl.gov

Dr. Huan Liu, Nanjing University, liuhuan@nju.edu.cn

Biomineralization is an important biogeochemical process in the lake and marine sediments, controlling the geochemical cycle of major elements such as C, P, and S and trace metals. Microbial activities play key roles in driving mineral precipitation, transformation, and element cycling. This session aims to provide an interdisciplinary platform to share new findings in the mineralogy, geochemistry, geobiology, and microbiology of sediments. This will enhance our understanding of the roles of sediments as geological sinks of carbon and phosphorus. The topics would be covered in this session, but are not limited to: 1) Biomineralization in lacustrine and/or marine sediments; 2) Evolution of nano mineral phases in sediments; 3) Microbe-regulated biogeochemical behavior of C, P, S and their environmental consequence; 4) Fate of trace metals in the biomineralization and transformation of nano minerals; 5) New approaches in mimic experiments, geochemical modelling, and molecular simulations to reveal mineralization and biogeochemical processes in sediments.

Biominerals and environmental mineralogy

Conveners:

Giovanni De Giudici, Kareen Hudson-Edwards, Juraj Maizlan, Kevin Rosso

Biominerals in recent decades have received growing interest from a large interdisciplinary scientific community. Biominerals play a pivotal role in biogeochemical cycle of elements in the geological record. Thus, understanding biomineralization processes in many different environments allows us to have a deep knowledge of natural risk, of changes related to anthropic activities, and of the possible resilience of the environment to change. Moreover, investigating biominerals allows the development of technologies for environmental sustainability, and offers diverse and fairly numerous examples to devise useful biobased materials.

This session is intended to strengthen the collaborative interaction among environmental mineralogists and is open to the whole scientific community interested in biominerals, sustainability and related technology development. The session acknowledges studies on biominerals at the molecular scale, the interface between minerals and organisms, the kinetics of (bio)mineral growth, communities of microbial and other organisms that individually or collectively drive biomineral processes. Moreover, this session invites contributions on biobased-environmental-technologies such as wetland systems, water treatment and bio-metallurgy. Finally, investigations on biominerals relevant to health are also welcome.

Session Name: **Chromite, chromitites and their inclusions: from hot to cold and shallow to deep**
Session Code: **OL07**

Chromite, chromitites and their inclusions: from hot to cold and shallow to deep

Conveners:

Tomo Morishita, Kanazawa University

Pedro Waterton, University of Copenhagen

Mathieu Rospabe, IFREMER (from Feb. 2022)

Chromite is a minor phase in ultramafic to mafic rocks, but is the major host mineral for chromium in these rocks. Chromite is one of the earliest crystallizing minerals from primitive melts and a refractory phase in mantle rocks after partial melting. Chromitite, a unique rock composed mainly of chromite, is a minor rock type found in rocks derived from mantle to lower crust, and layered mafic-ultramafic intrusions formed throughout Earth history. Chromite and chromitites are nearly ubiquitous, despite their low concentrations in the crust and mantle, but their origin and evolutionary history remain enigmatic. Determining the formation ages of chromitite and chromitite-bearing rocks is still a challenge. Melt, fluid, and mineral inclusions in chromite, including apparently ultra-high pressure minerals, platinum-group minerals, sulfides, zircon and other oxides, may also provide insights into the evolution of their mantle or magmatic hosts. In addition, a wide variety of chromian minerals and hydrothermal chromite/chromitite have been reported from rocks associated with chromite-bearing mafic-ultramafic rocks. The solubility of chromium in the melts/fluids as a function of pressure-temperature conditions, oxygen fugacity, pH and minor solute elements is an essential parameter to fully understand the mobility of chromium in diverse environments. We invite multidisciplinary contributions on chromian minerals and related topics from nature to the laboratory, including petrological and geochemical observations, and results from modeling/simulations.

Data-driven mineralogy research

Conveners:

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Session Description:

Observational, experimental, and numerical investigations have significantly advanced our understanding of mineralogy and related disciplines. Meanwhile, a large amount of mineralogical data (e.g., physics, chemistry, and images) has been collected and accumulated over the years. With the development of new data science theories and techniques, novel information hidden in such mineralogical data can be revealed. This can participate in enhancing our understanding of the mechanisms driving the Earth system and its environment. This session invites researchers with a broad range of expertise interested in investigating mineralogy and its application through compositional data analysis, machine learning, graphical analysis, database construction, and cyberinfrastructure development.

Session Name: **Diamond mineralogy and carbon in solar system**

Sessions Code: **OL41, OL53, OL64**

Carbon in the Solar System

Organic molecules are ubiquitous throughout our Solar System and may have been partially inherited, formed early in the protosolar nebula or synthesized later in a given planetary body. Studying organics may provide important insights into (i) the conditions of formation of the Solar System (e.g.: temperature limit for presolar organics to resist to their incorporation in the solar nebula); (ii) organic synthesis through abiotic and biotic pathways; and (iii) the history of early life on Earth and perhaps elsewhere. Identifying the formation mechanisms of such ancient organics remains challenging, mostly because of the chemical transformations they experienced since their formation.

This session welcomes contributions dedicated to better constrain the mechanisms of synthesis and transformations of organic materials found in various objects of the Solar System, with a particular emphasis on small bodies and the early Earth and Mars. The presented works can be based on analytical data obtained on natural samples, experimental work, or numerical codes.

Carbonates in Deep Earth

Conveners:

Daniel R Hummer

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Stefan Farsang

Department of Earth Sciences, University of Geneva, Switzerland (stefan.farsang@unige.ch)

Carbonate minerals play a crucial role in regulating the climate and habitability of our planet. Most carbon sinks to deep Earth via the subduction of carbonates. In the high-pressure and high-temperature environments of subduction zones, carbonates can devolatilize, dissolve in aqueous fluids, melt, or incorporate into carbon-bearing mantle phases. Any liberated CO₂ can be brought back to the surface in magmas and melts, completing the deep carbon cycle. To model these deep Earth processes, it is important to understand the high-pressure and high-temperature behaviour of carbonate minerals and carbonate-bearing melts, as well as their interaction with coexisting phases. Efforts such as the Deep Carbon Observatory have brought the properties and behaviour of carbonates at extreme conditions into better focus. This session welcomes both modelling and experimental results, especially from early career scientists, on the structure, properties, and behaviors of carbonate-bearing phases in the deep Earth.

New insights into diamond mineralogy, geochemistry and petrology

Co-conveners:

Fabrizio Nestola¹, Davide Novella¹, Sonja Aulbach²

¹ Department of Geosciences, University of Padova, Italy

² Department of Geosciences, Goethe-Universität Frankfurt, Germany

Diamond is a unique mineral that has formed in Earth's mantle over a great depth (between 120/130 and even 1000 km depth) and time interval (dating as far back as about 3.5 Gy). As such, accurate knowledge of diamond mineralogy, geochemistry and petrology can yield unique insights into the formation of our planet and its evolution over geological time. In this session, we invite contributions from all disciplines related to diamond research including, but not limited to, state-of-the-art analyses on natural diamonds and associated minerals and rocks, studies on synthetic diamonds, experimental constraints on conditions and processes of diamond formation/destruction as well as theoretical investigations of diamond properties.

Crystallography and application of carbonates: new crystal structures and reactivities

Convener

Bjoern Winkler (Institute of Geosciences, Goethe University Frankfurt,
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Carbonates are ubiquitous in nature, as they are the major reservoir of carbon in the biosphere, hydrosphere, in soils and in the Earth's crust. Conventional carbonates are characterized by nearly planar trigonal $[\text{CO}_3]^{2-}$ groups where C-sp² hybrid orbitals are formed between a central carbon atom and each of the three surrounding oxygen atoms. A decade ago, the family of carbonates was extended by the discovery of carbonates with tetrahedrally-coordinated carbon, where a central carbon atom forms C-sp³ hybrid orbitals to four surrounding oxygen atoms. Also, inorganic pyrocarbonate salts with C_2O_5 groups have now been synthesized. This session is dedicated to discuss the role of conventional and novel carbonates, their formation, crystallography, and physical properties, and their reactions with other minerals, e.g. in the context of nuclear waste repositories or subducting slabs"

The minerals and the fluids of the ocean worlds

Co-conveners

Julie Castillo-Rogez, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, United States
Bruno Reynard, Laboratoire de Géologie de Lyon, Ecole Normale Supérieure de Lyon, Lyon, France
Olivier Bollengier, Laboratoire de Planetologie et Géodynamique, University of Nantes, France
Jihua Hao, School of Earth and Space Sciences, University of Science and Technology of China, Hefei, Anhui, China

Spacecraft observations at icy bodies across the solar system and beyond have revealed systematic evidence of salts, brines, and carbon compounds. Data on phase behavior, thermophysical properties, and thermodynamics of these materials are needed in order to improve the fidelity of interior models and prepare for future missions (e.g., JUICE, Clipper). The results from recent observations at icy moons and dwarf planets (e.g., Saturn's moons, Ceres, and Pluto and Charon) call for a more accurate description of the mineralogy expected in these bodies that accounts for the diverse volatile and rock chemistry predicted by accretion models.

This session invites papers that advance the state of understanding the physical and chemical properties of ices, salts, hydrates, brines and fluids at the conditions relevant for large icy moons, dwarf planets, and large ocean worlds. We welcome contributions in theoretical and experimental research in these areas, and insights expected from future missions.

The Role of Fluids in Earth and Planetary Processes

The session is related to the study of fluids and melts on Earth and other bodies in the solar system for reconstruction of magma evolution, metamorphism, ore formation, sedimentary basin evolution, subduction processes, origin of life, etc.

Fluids in Earth and planetary systems represents one of the most dynamic research areas in the earth and planetary sciences. Understanding the properties and distribution of fluids allows researchers to better understand complex processes associated with mineral-melt-fluid processes, including precipitation, dissolution and mineral transformation by a variety of chemical reactions. Earth scientists use various approaches to study fluids in Earth and planetary systems. The most powerful are experimental mineralogy and geochemistry and the study of fluid and melt inclusions in minerals. The latter are unique sources of information concerning the composition and properties of fluids present at the time of mineral formation. Composition, physical and thermodynamic properties of fluids and their mass and energy transport capabilities are important to a variety of geochemical and geophysical processes, including the origin of mineral deposits, magma crystallization, metamorphism and metasomatism, geophysical properties of rocks and minerals, and the origin of life itself. Thus, this session topic is relevant to the General Meeting of the IMA because the study of fluids in geological processes is an active research topic in the global mineralogical community. Many laboratories and individual researchers focus their studies on experiments in fluid systems, while others study fluid evolution based on mineral compositions and the occurrence of fluid and melt inclusions in minerals. The proposed session is expected to generate a high level of interest owing to the importance of fluids in a broad range of geologic processes in Earth and planetary systems.

Names of potential organizers/session chairs of the session:

1. Robert J. Bodnar, Professor, Fluids Research Laboratory, Department of Geosciences, Virginia Tech, Blacksburg, VA USA
2. Pavel Plechov, Professor, Fersman's Mineralogical Museum of Russian Academy of Sciences, Russia
3. Sergey Smirnov, Professor, IMA Council Member, Institute of Geology and Mineralogy Siberian Branch of Russian Academy of Sciences

Names of prospective invited speakers.

Alex Sobolev

Ilya Veksler

Maxim Portnyagin

Jake Hanley

Matt Steele-MacInnis

Martin Appold

Sabina Strmic-Palinkas

Gulcan Bozkaya

John Mavrogenes

Andreas Audétat

Maria Luce Frezzotti

Michael Zolensky

Relationship to other potential sessions/fields. Expected impact and attendance.

The topic of the proposed session is related to the sessions dedicated to ore-deposit formation, mineral crystallization from aqueous fluids and melts, thermodynamics of magmatic and hydrothermal processes, gemology, water in the mantle, subduction processes, the search for extraterrestrial water and life, and others. The number of abstract submissions and attendance at this session is expected to be significant. As an example, a session on "Fluids and Melts" organized by Robert J. Bodnar for the Goldschmidt Conference in Montreal, Canada, in 2012, had the largest number presentations of all sessions at the conference and included three days of oral and poster presentations.

Scientific journals that may be asked/willing to publish selected contributions from the session.

Chemical Geology

Lithos

Geochimica et Cosmochimica Acta

Contributions to Mineralogy and Petrology

Minerals

American Mineralogist

Session Name: Formation, transformation, and biogeochemical processes of mineral nanocrystals in Earth's surface environment

Session Code: OL06

Formation, transformation, and biogeochemical processes of mineral nanocrystals in Earth's surface environment

Conveners:

Juan Liu (Peking University, China), Xin Zhang (Pacific Northwest National Laboratory, USA), Keisuke Fukushi (Kanazawa University, Japan)

Mineral nanocrystals are ubiquitous on Earth and exhibit a diversity of physical and chemical properties that are dependent on particle size and shape. In the past two decades, numerous studies have been conducted to investigate how mineral nanocrystals influence the Earth system, which significantly broaden and enrich our understanding on the role of minerals in the biogeochemical processes that shape Earth's surface environment. However, there are still big gaps in our knowledge of the distinct properties and behavior of mineral nanocrystals in the complex Earth system, mostly due to lacks of systematic size-resolved thermodynamic data and analytical tools for minerals at the nanoscale. Like the rock and water cycles of Earth, the cycle of mineral nanocrystals, i.e. the cycle among minerals nanocrystals, their precursors, and the Earth components that they participate, is important for us to understand how Earth works as a whole system. The objective of this session is to provide a platform for interdisciplinary researchers from mineralogy, biogeochemistry, geomicrobiology, computational chemistry and material sciences to share their understanding the unique structures, properties, reactivities, and transformation of mineral nanocrystals in Earth's surface environment, to encourage discussion and interdisciplinary collaboration on a variety of biogeochemical processes involving mineral nanocrystals, as well as to facilitate exchanging ideas about advanced analytical and computational methods for studying properties and interfacial reactions of mineral nanocrystals. The topics that would be covered in this session are, but are not limited to:

- Nucleation and crystallization of mineral nanocrystals
- Size-dependent properties of mineral nanocrystals
- Molecular mechanism and pathway of transformation of metastable mineral nanocrystals
- Biomineralization
- Microbially mediated dissolution/precipitation of mineral nanocrystals
- Interactions at the interface between microorganisms and mineral nanocrystals
- In situ microscopic and spectroscopic techniques applied to interfacial processes of mineral nanocrystals
- Computational modeling and simulation on crystallization, dissolution, and transformation of mineral nanocrystals

Session Name: Gemstones from the deep: A Celebration of the career of George E. Harlow
Session Code: OL14

Gemstones from the deep: A Celebration of the career of George E. Harlow

Conveners:

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Earth processes continuously form thousands of minerals; however, relatively a few numbers of them fall into the precious and gemstones categories. Gemstones are highly prized for their rarity and immense beauty, but their values are not limited to their monetary worth. Some gemstones such as jadeite jades, ruby corundums, and diamonds, have fascinated all geological sciences realms, from mineralogy to tectonics. Diamond is the best mantle gemstone to decipher the volatile global cycle and the oxidation state of the deep mantle. Jadeite jade marks the location of exhumed paleo subduction zones and provides geochemical properties of H₂O-rich slab-derived aqueous fluid responsible for the mantle wedge serpentinization. Ruby, the rarer corundum, exclusively forms during continental collision and is brought to the surface by deep erosion of thick orogenic belts.

This session is largely a celebration of George Harlow's outstanding career and contributions. It aims to attract the latest data and concepts regarding any natural gemstones and gemstone-related earth processes. We encourage contributions from the broad field of mineralogy, petrology, geochemistry, tectonics, and geoarchaeology, ranging from local to global scale to reflect George's multidisciplinary research contributions in mineralogy and solid-earth processes. We also welcome contributions exploring new directions with novel or interdisciplinary techniques regarding related topics.

Keynote speakers:

Barbara Dutrow (LSU)

George Harlow (AMNH)

Samuel Angiboust (ENS Lyon)

Potential contributors:

Vlad Shatsky, Roberto Compagnoni, Tadao Nishiyama, Alberto Vitale Brovarone, Horst Marshall, Philippe Agard, Olivier Vidal, Matthias Konrad-Schmolke, Ralf Halama

Session Name: Haiüy 200 Years On: What News In Gem Research?

Sessions Code: OL39, OL51, OL54

Haiüy 200 Years On: What News In Gem Research?

Chairmen: Isabella Pignatelli

Lee A. Groat

Gaston Giuliani

The interest in gems crosses history, from antiquity to the present, because they continue to fascinate for their beauty, colours and rarity. Nowadays, one wants to understand the link between their structure and composition (in particular the presence of chromophores) with their geological conditions of formation. These conditions also affect the gems' habit, typology of defects and texture, which became growth marks useful to reconstruct the physico-chemical parameters in each gem deposit. This results in unique and sought-after samples with great scientific interest, such as rubies or tourmaline with trapiche textures.

The unique geological conditions of formation of each gem deposit means that compositions can be used in many cases to determine their geographic origin. However, challenges remain with this approach.

In this session, we honour the career of Professor Gaston Giuliani, a pioneer and leader in mineralogy and geology, on the occasion of his retirement. Since the 1990s Professor Giuliani has been a leader in the application of science to the study of gems, combining mineralogical and geochemical data with observations made in the field.

Session Name: Mineral Classification: Archetypes, Species, and Natural Kinds

Session Code: OL20

Mineral Classification: Archetypes, Species, and Natural Kinds

Proposer: Carol Cleland Cleland@colorado.edu

Scientific disciplines carve the domains of phenomena that they investigate systematically into categories. These categories play important roles in scientific reasoning (prediction and explanation) about the domain of phenomena concerned. For example, the International Mineralogical Association's Commission on New Minerals, Nomenclature and Classification (IMA-CNMNC) recognizes more than 5700 different mineral species based on unique combinations of major element chemistry and crystal structure. Knowing that a mineral is diamond, for example, allows one to predict that it is extremely hard and an exceptionally good thermal conductor. Classification systems that are highly successful and fruitful for purposes of scientific reasoning are viewed as "carving nature at its joints"; their categories are dubbed "natural" (as opposed to, artificial or human) kinds by philosophers because they are judged to reflect real divisions in nature.

This proposed IMA 2022 session explores the scientific utility and fruitfulness of mineral classification systems by focusing on both the IMA-CNMNC standard mineral classification protocols and two recently proposed complementary approaches to mineral classification. On the one hand, Hawthorne et al. (2021) introduce the concept of a "mineral archetype," which defines a mineral as a pure form characterized by four intrinsic properties: "its name, its end-member formula and Z , its space group, and the bond topology of the end-member structure" [1]. Like the IMA system, the archetype concept of minerals classifies solid materials in terms of timeless (chemical and structural) properties, independently of their etiology (origin and evolution). In contrast with both the IMA system and the mineral archetype system, Hazen and colleagues have attempted to identify "historically" (in the sense of their origin and evolution) informative mineral categories [2,3]. Minerals are characterized by suites of diagnostic characteristics, including trace and minor elements, isotopes, fluid and solid inclusions, morphologies, optical properties, and other information-rich physical and chemical attributes, all coupled to that mineral's formation in the context of planetary evolution.

The mineral pyrite provides a useful example of the contrasts among these classification approaches. Archetype *pyrite* is pure FeS_2 with the ideal cubic ($Pa\bar{3}$; $Z = 4$) pyrite structure. The IMA-approved mineral species is similar to the archetype, but it embraces a range of major natural specimens that typically deviate from the idealized archetype. For example, the compositions of natural pyrite often include partial substitution of As for S and Co/Ni for Fe. By contrast, Hazen and colleagues suggest that "pyrite" encompasses 20 or more distinct natural kinds, each with a diagnostic combination of trace and minor elements, morphologies, paragenetic contexts (both abiotic and biotic), and other attributes associated with different formational histories [4,5].

This session will consider varied approaches to mineral classification, with a focus on several key questions:

- (1) To what extent are these and other approaches to classification mutually consistent? To what extent are they contradictory?

- (2) Are there phases that are currently IMA-approved species that do not have analogous archetype or natural kind equivalents? Are there natural solids that should be classified but are not currently recognized by the IMA-CNMNC? Is that a problem?
- (3) Is it valid to apply the concept of natural kinds to minerals [3,6]?
- (4) To what extent do these classification systems play central roles in the articulation and development of scientifically fruitful theories?

References:

- [1] Hawthorne et al. (2021) *Min. Mag.*, **85**, 125-131.
- [2] Hazen (2019) *Am. Min.*, **104**, 810-816.
- [3] Cleland et al. (2020) *Proc. Natl. Acad. Sci.*, **118**, e2015370118.
- [4] Gregory et al. (2019) *Econ. Geol.*, **114**, 771-786.
- [5] Hazen & Morrison (2021) On the paragenetic modes of minerals. *Am. Min.*, **106**, *in press*.
- [6] Santana (2019) *Foundations of Chem.*, **21**, 333-343.

Session Format: The proposed session will begin with a discussion of the history of mineralogical classification systems, leading to the IMA-CNMNC system in place today, alternative approaches, and the roles of natural kinds in scientific reasoning. Five talks will be followed by a discussion of the session questions. All talks will be 15 minutes long, including 3 minutes for questions. The session will end with a 40-minute panel discussion among members of the audience and the speakers.

Tentative lineup:

Chair and Moderator:

Sergey Krivovichev (committed)

Proposed Speakers:

1. Mike Rumsey (committed but may need to be remote), History of the Development of mineralogical classification systems and nomenclature.
2. Carol Cleland (committed), Natural kind taxonomies: their nature, varieties, and roles in scientific reasoning.
3. Frank Hawthorne (thinking about it), Defining mineral species in terms of archetypes; we will find a replacement if necessary).
4. Robert Hazen (committed), An evolutionary system of mineral taxonomy based on mineral natural kinds.
5. Carlos Santana (committed), Mineralogy doesn't need a natural kind-based taxonomy of mineral kinds.

Spectroscopic methods applied to mineralogy

Conveners: Jannick Ingrin, Yan Yang, Giovanni B. Andreozzi, Barbara L. Dutrow, Melanie Kaliwoda

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Spectroscopic methods are a cornerstone of mineral studies. These methods have the capability to acquire information at multiple scales, from atoms to molecules, to chemical bonds, and to elucidate crystal structures, physical properties and more. This session addresses all aspects of the geosciences that focuses on the investigation of mineralogical issues using the wide array of spectroscopic approaches. Such approaches include, but are not limited to, UV/Vis, IR, Raman, XAS, Mössbauer, EPR, NMR, MS, LIBS, Brillouin as well as synchrotron-based spectroscopies and in-situ or remote sensing spectroscopies. Contributions from investigations that involve other spectroscopic methods are also encouraged. Spectroscopic research from all aspects of mineral sciences will be considered, including studies focused on sedimentary, metamorphic, plutonic, and deep Earth minerals, as well as applications to environmental issues, cultural heritage, gemology, soil science, planetary materials, meteorites, and more.

Spectroscopy of Earth materials from the crust to core

Conveners:

Jin Zhang (Department of Earth and Planetary Sciences, University of New Mexico);

Xin Zhong (Institute of Geological Sciences, Freie Universität Berlin)

Jennifer Jackson (Division of Geological and Planetary Sciences, California Institute of technology)

Andrey Korsakov (Sobolev Institute of Geology and Mineralogy, Siberian Branch of the Russian Academy of Sciences)

Understanding the composition, structure and evolution of the solid Earth requires a comprehensive characterization of the physical properties of its constituting materials formed at different pressure, temperature and chemical environments. Recent developments in spectroscopy, including but not limited to Brillouin, infrared, Raman, Mössbauer and stimulated light scattering techniques, allows Earth scientists to perform laboratory investigations on the various structural properties under a wide range of conditions from the shallow crust to the deep core. This session provides a platform for the presentation of the experimental data, such as elasticity, melting temperature, viscosity, electrical and thermal conductivity, collected using various spectroscopy techniques. In particular, we encourage multi-disciplinary studies combining the laboratory measurements with first-principle calculations, field and geophysical observations, and/or numerical simulations to promote technical and theoretical breakthroughs as well as novel understandings of different geological processes at micro and macroscopic scales (e.g. metamorphic rock deformation, subduction zone geodynamics, fluid storage and transport).

Interaction between fluids and minerals

Studying mineral-fluid interactions is fundamental for the understanding of many processes in Earth sciences such as geology, hydrogeology, petrology (magmatic / metamorphic), geochemistry, paleoenvironmental reconstructions, more recently paleoaltimetric reconstructions to cite few them. These studies allow to better constrain the connections between the different envelopes of the terrestrial globe ; atmosphere, hydrosphere, lithosphere and deep Earth (mantle). This session invites researchers working on the analysis and tracing of fluids in terrestrial materials through the study of fluid inclusions, hydroxylated minerals, hydrothermal systems, etc. We focus on innovative contributions presenting new methodological developments centered on the direct analysis of fluids in minerals.

Mineral-fluid interactions at Earth's surface: Thermodynamics, kinetics and isotopes

Conveners: Anna L. Harrison, Vasileios Mavromatis (*Geosciences Environnement Toulouse (GET), CNRS, UMR5563, 14 Avenue Edouard Belin, 31400, Toulouse, France*)

Mineral formation and dissolution processes in Earth's surface and shallow subsurface environments control the cycling of elements such as nutrients and carbon. The formation of secondary phases, particularly of carbonates, act as archives of the environmental conditions that occurred at the time of their formation. These natural dissolution-precipitation processes can also be engineered for environmental remediation such as the storage of CO₂ in carbonate phases for climate change mitigation. Understanding the processes controlling element cycles, robust interpretation of paleo-proxies, and engineering of mineral reactivity all require knowledge of the thermodynamics and kinetics of mineral-fluid interactions. Additional insights into the controls of mineral-fluid interactions can be provided by the stable isotope fractionation between minerals and fluids, provided that the mechanisms controlling isotope fractionation are adequately understood. In this session we invite contributions that study mineral-fluid interactions including aspects such as thermodynamics, kinetics, and isotope fractionation in the lab or field. Insights from modeling at various scales are also welcome.

Mineral-Fluid Reactions in Sustainable Mineral Processing and Extractive Metallurgy towards a Carbon Neutral Future

Theme: The dynamical world of minerals

Proposer: Fang Xia (Murdoch University, Australia)

Minerals are essential sources of metals for the development of renewable energy technologies that are highly demand as we move towards a carbon neutral future. The processing of minerals containing the required technologically important metals (e.g., Li, Ni, Cu, Co, V, In, Ge, and the rare earth elements, REEs) and the extraction of these metals from ore minerals are important steps for the target applications. These steps involve the reactions between ore minerals and fluids, such as the dissolution of minerals into aqueous solutions and the precipitation of new minerals on mineral grain surface from supersaturated solutions. Sustainable mineral processing and extractive metallurgy calls for the development of energy efficient processes with minimum environmental impact. To achieve this goal, it is vital to have a deep knowledge of the mineral-fluid reactions that are taking place in mineral processing and extractive metallurgy, as well as in mine closure processes. Especially, the controls on the rate limiting steps and the acceleration of reaction rate by enhancing mineral reactivity and permeability are important topics for today's mineral scientists and engineers. Hence, this session invites mechanistic, microstructural, and kinetic investigations on mineral-fluid reactions that are responsible for minerals leaching, including stirred tank reactor leaching, high pressure leaching, and the environmentally more friendly heap leaching and in situ leaching processes, and reactions responsible for mineral flotation, acid mine drainage minimization and the capture and long-term storage of atmospheric carbon dioxide gas by mineral carbonation reactions.

Alteration minerals.

Alteration minerals develop at various temperature ranging from ambient to several hundreds of Celcius degrees, through circulation of various fluids : water, hydrogen, methan, H₂S... They form in various geological processes such as continental weathering and hydrothermalism. The mineralogical diversity of alteration minerals covers clays, sulphates, silica minerals, and many others. Their formation and preservation through geological times witness the conditions prevalent at this place and time. Hence, their study contributes to the reconstruction of paleoenvironments, paleoclimates, and more widely, late fluid circulations cycles. This session on alteration minerals welcomes contributions focussed on both Earth and Mars, whatever the techniques involved in their investigation.

Melts and glasses from laboratory to planetary interiors

The major transport vectors for heat and mass inside the Earth's mantle are the silicate melts and aqueous fluids. Chemical reactions, ionic diffusion, heat exchange, mass displacements are all favoured by the presence of these agents across the Earth's crust and mantle reservoirs. The liquid state is also prevalent in the outer core where it ensures chemical and thermodynamical exchanges between the base of the mantle and the top of the inner solid core.

But the molten state is also one of the most difficult to study. In parallel to various high-temperature and high-pressure experiments and calculations that address melts directly, studies of glass analogues remain a valuable alternative easily accessible in the laboratory. The purpose of this session is to offer a melting pot for discussion around melts and glasses from various perspectives, both computational and experimental: mineralogy, thermodynamics, geochemistry, geodynamics, seismology, planetology, etc.

Session Name: **Mineralization and mineralizing environments: Exploring mineral paragenesis**

Sessions Code: **OL50, OL57**

Mineralization and mineralizing environments: Exploring mineral paragenesis

Conveners: Morrison, Hazen

Abstract: Mineral speciation, composition, and characteristics are the direct result of the physical and chemical conditions of their formational environments. These conditions are unique to certain time periods of Earth and planetary evolution, to select planetary bodies and regions, and/or to specific geologic or biologic processes. As a result, minerals and their embedded information offer a view into mineralizing environments across space and time – a powerful tool for understanding the processes, events, and materials that govern our complex evolving planetary systems.

This session welcomes contributions related to mineral paragenesis/modes of formation, mineralizing environments, early earth environments, minerals and mineralizing systems on other planetary bodies, mineral and geochemical biosignatures, environmental signatures in minerals, mineral evolution, mineral ecology, and changes in mineralization and mode of mineralization through deep time.

Session Name: **Mineralogy and gemology in Cultural Heritage**

Session Code: **OL27**

Mineralogy and gemology in Cultural Heritage

Theme: Physics and chemistry of minerals

Gems and pigments are important parts of Cultural Heritage artifacts. The in-depth characterization of these peculiar geomaterials involves pluridisciplinary approaches integrating mineralogy, geochemistry, optics, ion-matter interactions and social sciences to improve our knowledge on ancient technologies of production, tracing of the material sources and conservation strategies. This session is dedicated to recent advances in the applications of mineral sciences in the different fields of heritage science. It will present novel analytical techniques as well as integrated studies of gemstones, biominerals, pigments as well as ceramics and glasses from different cultural heritage contexts.

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Mineralogy and Museums

Proposer: Mike Rumsey (M.Rumsey@nhm.ac.uk)

Conveners : Mike Rumsey, Christiano Ferraris

The mineralogical collections preserved in museums and academic institutions worldwide underpin and preserve many facets of current scientific research across a surprising number of disciplines. They allow us to revisit, re-analyse and re-interpret our knowledge of the mineral kingdom using our ever-improving technological equipment alongside new scientific hypotheses.

This session looks to bring together all academic aspects of collections-based mineralogy including active research and collections history, alongside new processes, and developments relevant to the creation, growth, management, or exhibition of all mineralogical collections - minerals, rocks, ores, gems or meteorites.

Specialised topics might include: Type specimens, studies only possible due to the historic preservation of collections, general studies performed on museum specimens, studies that have initiated the growth or creation of new collections, entirely new collections, museums and institutions, new and novel exhibitions, exhibition development, collections storage, collections organisation, general collections management, sampling policies, access and research policies, collections databasing, new methods and developments in collections accessibility, new methods and developments for interpreting mineral collections, history of specific collections, general history of mineralogical collections, crystal models, 'fake' mineral specimens, general historical mineralogy, new collections facilities and equipment, hazard management in collections, collections salvage, the conservation, preservation and preparation of mineralogical specimens, ethical considerations within mineralogical collections, iconic specimens, legal and cultural considerations relevant to the management of mineral collections, curatorship, digitisation, collections management systems (databases), data portals and data aggregators, public outreach and the private collector-public museum interface.

The important role of UHP and UHT rocks deciphering the evolution of the lithosphere: Metamorphism at extreme conditions

Conveners

Hans-Peter Schertl (Institute of Geology, Mineralogy and Geophysics, Ruhr-University Bochum, Germany), Samuel Angiboust (Département des Sciences de la Terre, École normale supérieure de Lyon, France)

Considered to represent “exotic” and generally unattainable PT-environments as recently as 35 years ago, ultrahigh-pressure (UHP) and ultrahigh-temperature (UHT) metamorphic rocks are now considered to be common and widespread. UHP-metamorphism describes equilibration at depths corresponding to PT-conditions attaining the coesite stability field, whereas UHT conditions refer to recrystallization temperatures > 900°C. A dramatic increase in current research on UHP- and UHT-metamorphism reflects their significance in deciphering lithosphere evolution, and thus about 35 years later we now have completely different views on processes such as mantle dynamics, crustal tectonics and fluid-rock interaction during subduction, collision and exhumation, crust-mantle interaction in subduction zones, geochemical recycling, etc. A completely new field of research has also developed as a result of new discoveries of UHP minerals and assemblages in ophiolitic bodies in Tibet (Luobusa) and the Polar Urals (Ray-Iz). Recent studies document that not only UHP but also UHT terranes (for instance in Inner Mongolia) can reach a lateral extent of hundreds of kilometers, which can be the result of common large-scale regional phenomena. It is intriguing to note that in SE Spain and in the Rif Belt in NW Africa, UHP mineral inclusions of microdiamond and coesite have been discovered in garnet and kyanite of UHT granulites.

Many of these new findings triggered further experimental studies and modeling, and intensified future research should allow a better understanding of processes such as the subduction of oceanic and continental lithosphere, recycling of surface carbon and fluids to mantle depths, and later ascent towards the Earth’s surface.

Mineralogy and petrology of the upper mantle: Where we come from and where we are going

Conveners

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The nature and evolution of the Earth’s lithospheric mantle is largely constrained from the studies of natural samples as xenoliths in mantle-derived melts or in orogenic peridotite massifs and ophiolites. Partial melting, recycling in subduction zones or related to delamination processes, as well as mantle metasomatic processes, are responsible for the very heterogeneous nature of the Earth upper mantle. Deciphering the interaction of lithosphere with asthenosphere and deeper mantle is critical to understanding the mantle secular evolution and to propose relevant models reconciling findings from petrological, mineralogical, petrophysical and geochemical approaches. Then those models based on natural samples are coupled with experiments and geophysical data, in order to better understand, scales and amplitudes of upper mantle heterogeneities as well as their dynamic role. Therefore the session’s focus primarily on results from natural sample studies but experimental and numerical modelling are more than welcome as they are essential research corollary. Multidisciplinary contributions are strongly encouraged.

High pressure mineral phases in meteorites: trusty reporters of shock conditions?

Conveners:

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Within the last decade, in a variety of meteorites including ordinary chondrites, martian, lunar, and other achondrites, and terrestrial impactites identified many high-pressure (HP) minerals, yielding constraints on shock conditions and hence parameters such as the size of colliding bodies, impact velocity, etc. The HP minerals which have been experimentally synthesized in the lab may provide robust constraints on P conditions based on static experiments. In contrast, there still HP minerals like jadeite and its relatives (albitic jadeite, lingunite, tissintite, etc.) which offer a promising set of shock pressure constraints but establishing their occurrence is challenging. There has been much confusion in the literature over the identity of jadeite in several meteorites and impactites. Are optical and Raman microscopy sufficient to establish the composition and structure of jadeite and related phases? Once established, what are the pressure constraints that can be inferred from these minerals and from other HP polymorphs? We cannot always assign a certain stability field and therefore we may never be able to separate thermodynamic from kinetic factors in determining what composition and ordering state is preserved. Also, the experiments may prove exceedingly difficult if static experiments fail to return some possibly metastable phases and dynamic experiments fail to recover high-pressure phases without back-transformation. We invite contributions reporting textural, chemical, and structural data on HP minerals in shocked meteorites, terrestrial impactites, experimental samples as well as related theoretical and computational efforts.

Refractory minerals and materials

Guy Libourel

Refractories and phases that compose them are materials that are resistant to high temperature, used predominantly for elevated temperature materials processing (e.g., furnace linings, thermal protection system materials) and other high-tech applications in which thermomechanical properties are critical. These peculiar materials are also found in terrestrial or extraterrestrial settings, as for instance the refractory inclusions of primitive meteorites that are the oldest preserved solids of our Solar system. The present session will report on advances in the field concerning the discovery of new minerals or refractory materials, their modes of formation and synthesis, new methods of characterization, as well as the modeling approaches for describing their properties.

High-pressure oxide phases: Mineralogy, crystallography and implications for the deep Earth and other planetary interiors

Alan Woodland

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It has been 10 years since the discovery of Fe_4O_5 . Since then a surprisingly large variety of different Fe-oxides have been found to be stable at high pressures above about 10 GPa, some with particular properties, like Fe peroxide, (FeO_2) which can also incorporate hydrogen. Such “exotic” stoichiometries and crystal structures occur in other oxide systems as well, and the investigation of more complex solid solutions is well underway. In addition, even “traditional” oxide phases like $(\text{Mg,Fe})\text{O}$ are revealing important new secrets in terms of their crystal chemistry and polymorphism. The purpose of this session is to bring together researchers to discuss the most recent advances in our understanding of simple oxide systems at high pressures and what implications these findings have for the deep Earth as well as for the interior of larger exoplanets.

Planetary cores: chemistry and its consequences

Dr Jac van Driel, Dr Haiyang Luo and Prof Lidunka Vočadlo

Department of Earth Sciences, University College London, United Kingdom

The state and dynamics of Earth’s core controls a wide range of processes from the generation of Earth’s magnetic field to mantle convection. Furthermore, the evolution of planetary cores is thought to be a key component in establishing the habitability of planets more broadly.

A ‘true’ realisation of the state and evolution of any planetary core requires results from a wide range of scientific disciplines from geodynamics to mineralogy, seismology to mineral physics. Moreover, huge advances have been made in the understanding of other planetary bodies, such as Mars through the recent INSIGHT mission.

Fundamental to all properties of planetary cores, is chemistry, and in turn how variations in chemistry leads to changes in the high pressure-temperature behaviour of core materials. For example, the inclusion of light elements into predominately siderophile iron rich compositions, have been shown to alter properties such as seismic wave speeds as well as influence melting and crystallisation behaviour. Additionally, differing chemistries will likely control the kinematics solid state properties such as atomic diffusion, dislocation propagation, and grain growth.

This session explores fundamental properties of planetary cores, through the lens of chemical composition and the second order consequences that arise from its variability. Topics include, but are not restricted to, atomistic simulations, experimental mineralogy, microstructural analysis of minerals, geodynamics, and seismology.

Mineralogy at extreme conditions in Earth and other planets

Convenors:

Catherine McCammon, Paola Comodi, Bruno Reynard plus one convenor at the early career level

Sponsor: Sub-commission "Earth deep interior" of the CPM

Minerals play a critical role in how planets work. The way minerals respond to changes in pressure, temperature and composition determines properties and processes of deep planetary interiors, both within our own solar system and beyond. We invite contributions on all aspects of high-pressure mineralogy, both experimental and computational, that shed new light on our understanding of planetary structure, composition and processes, both in the past and the future.

Alteration mineralogy of Mars: insights from orbit, in situ robotic exploration, and meteorites

Erwin Dehouck (LGL-TPE, Lyon, France), Benjamin Bultel (University of Oslo, CEED, Norway), William Rapin (IRAP, Toulouse, France) Joseph Razzell Hollis (JPL, Pasadena, CA, USA)

Although it is a very dry place today, the surface of Mars displays ample evidence for past aqueous activity, including in the mineralogical record.

Several decades have passed since the first detection of alteration minerals on the surface of Mars from orbit. Orbital surveys have shown that alteration phases are widespread at the global scale, and their presence in ancient terrains highlights a rich history of early aqueous processes not yet fully understood. In situ missions have provided petrological and geochemical data allowing for the reconstruction of paleoenvironments at the local/regional scale. Together, orbital and in situ observations have revealed multiple complex and long-lived alteration scenarios for ancient Mars.

In the last decade, new instruments deployed on the surface of Mars, including the first X-ray diffractometer aboard the Curiosity rover (2012) and a suite of submillimeter analyzers (SuperCam, PIXL and SHERLOC) aboard the Perseverance rover (2021), have brought new ways to detect, identify and characterize the Martian alteration phases. A whole collection of alteration and primary minerals has been thus identified and used to apprehend the geological evolution of the planet. Our perception of the composition of the martian crust evolved from a simple basaltic planet to the detection of alkaline rocks. . In parallel, the study of Martian meteorites (including the first Noachian regolith breccia) as well as terrestrial analogs has helped to deepen our understanding of the alteration processes that have occurred on Mars.

In this session, we welcome all contributions that tackle the question of formation mechanisms of Martian alteration phases to explain their observed nature and diversity, or that explore their significance to past climates and habitability of the planet.

Primary mineralogy on Mars : insights from orbit, in situ robotic exploration and meteorites

Agnes Cousin (IRAP OMP Toulouse), Olivier Beyssac (IMPMC Paris) & Arya Udry (UN Las Vegas)

During the last decade, the igneous and sedimentary mineralogy and petrology of Mars has known a revolution thanks to several missions: in situ robotic exploration using cutting-edge instruments for mineralogy (NASA Curiosity and Perseverance rovers, CNSA Zhurong rover), new unique martian meteorites (regolith breccia NWA7034/7533, Tissint and many others) and ongoing high-resolution exploration from orbit (MRO/CRISM). Several missions for in situ mineralogical exploration are also scheduled for the coming years (rovers ESA ExoMars, JAXA MMX) with ultimately the return of Martian samples on Earth in the 2030s ! This session welcomes presentations from past/current/future missions and/or studies of meteorites on igneous and sedimentary processes on Mars. Experimental and instrumental contributions or the study of Martian analogs are welcome as well.

Martian mantle mineralogy

With the exception of the Moon, Mars is the only other planetary body for which we begin to have an integrated vision to its mineralogy. A range of space missions, including remote sensing from orbiters and local sensing from landers and rovers, provided and are still proving a wealth of information about composition and structure of the materials forming the planet. If more data have been acquired on minerals at the surface of the planet and, overall, on subsurface and crustal minerals, very recent seismological observations provided by the mission InSight allow now also to more pertinently address mantle mineralogy.

In this session we would like to make the point on current knowledge of Martian mineralogy, welcoming contributions addressing physical and chemical properties of minerals and rocks by direct and indirect measurements on Martian samples (space missions and Martian meteorites), the complementary laboratory measurements on analogues, as well as thermodynamic models, all across the variety of geological settings and thermodynamic conditions proper to Mars.

Session Name: Minerals and rocks under stress: a way to unravel geological processes

Sessions Code: OL52, OL55

Minerals and rocks under stress: a way to unravel geological processes

Mattia L. Mazzucchelli, Mainz Institute of Multiscale Modeling & Institute of Geosciences, Johannes Gutenberg University of Mainz, J.-J.-Becher-Weg 21, Mainz, 55128, Germany (mmazzucc@uni-mainz.de)

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The correct interpretation of geological and planetary processes requires the reconstruction of the stress conditions under which they take place. This information is often recorded in the mineralogy and microstructures of rocks that have been involved in such processes in the past and have subsequently become available to direct investigation. In the last decades, various experimental, analytical and computational techniques have become more and more accurate and accessible. They allow us to investigate with unprecedented detail the effect of stress on the properties and the microstructures of minerals, fluids and rocks (e.g. elastic response, defects, phase equilibria and transformations etc.) shedding light on the mechanisms that govern the processes that have originated them. A better constrain on stress distribution in natural systems is required to determine rock deformation mechanisms at the large scale and to interrogate the effect that differential stress might have on the stability of mineral assemblages.

In this session, we welcome contributions adopting a broad variety of experimental, analytical and numerical techniques to investigate the effect of stress on minerals, rocks and their physical properties from the microscopic to the macroscopic scale. The session targets, among other, current advances in elastic geobarometry, microstructure and electron microscopy.

Session Name: **Nanoscale contributions to terrestrial and extraterrestrial mineralogy**

Session Code: **OL44**

Nanoscale contributions to terrestrial and extraterrestrial mineralogy

Anne-Magali Seydoux-Guillaume (CNRS, LGL-TPE, France) and Lee White (Open University, UK)

Minerals record isotopic and structural evidence that tells us about the nature, intensity or duration of geological processes (including metamorphism, weathering, and deformation). For many systems, the size of minerals and features which preserve evidence of these processes require a challenging sub-micrometer approach. This is made possible by the improvement of new high spatial resolution analytical techniques including Transmission Electron Microscopy, Atom Probe Tomography, STXM, TKD, NanoSIMS, TOF-SIMS, and many others which make it possible to extract chemical, isotopic and structural information at close to atomic scale. This session aims to bring together researchers focusing on the development and integration of “nanoscale” analytical techniques in terrestrial and extraterrestrial minerals to solve major geological and planetary issues.

Session Name: New frontiers in the study of hazardous raw and man-processed minerals, characterization and methods for the mitigation of the environmental and health risks

Session Code: OL45, OL56

New frontiers in the study of hazardous raw and man-processed minerals, characterization and methods for the mitigation of the environmental and health risks

Proposers:

Alessandro F. Gualtieri (Università di Modena e Reggio Emilia, Italy)

Paolo Ballirano (La Sapienza Università di Roma, Italy)

Alessandro Pacella (La Sapienza Università di Roma, Italy)

Laurie Glossop (Glossp Consultancy, Australia)

Natural and man-processed materials like asbestos and asbestos containing materials, elongate mineral particles, crystalline silica, and many more as well as the soils and rocks containing them, may represent an environmental and health hazard. Due to natural causes (weathering and erosion) or anthropic factors (mining activity or activities related to landscape modification), such phases may be dispersed in the living environment, resulting in contamination of soil, water, air media. This process may take place directly in the site of natural occurrence or in the sites where such minerals are processed at industrial scale.

This session welcomes contributions aimed at the identification, characterization, bio-chemistry, assessment of toxicity and pathogenicity and methods for the mitigation of the environmental and health risks of raw and man-processed natural materials. Contributions dealing with hazard assessment strategies and geo-engineering mitigation procedures are strongly encouraged. The main goal is to provide a space to share experiences, new methodologies and knowledge, but also to identify critical issues and establish new international cooperation.

Session Name: New Minerals, Nomenclature, and Classification

Sessions Code: OL17, OL36, OL48

New Minerals, Nomenclature, and Classification

Chair: Frédéric Hatert

This session is organized by the IMA Commission on New Minerals, Nomenclature and Classification (CNMNC). All communications concerning the definition of new mineral species are welcome, as well as those dealing with the characterization of minerals by classical investigation techniques (crystal structure analysis, chemical analyses, spectroscopic techniques). The session also aims to discuss all topics related to mineral nomenclature and to mineral classification.

Mineral Classification: Archetypes, Species, and Natural Kinds

Proposer: Carol Cleland [Cleland@colorado.edu](mailto:CarolCleland@colorado.edu)

Scientific disciplines carve the domains of phenomena that they investigate systematically into categories. These categories play important roles in scientific reasoning (prediction and explanation) about the domain of phenomena concerned. For example, the International Mineralogical Association's Commission on New Minerals, Nomenclature and Classification (IMA-CNMNC) recognizes more than 5700 different mineral species based on unique combinations of major element chemistry and crystal structure. Knowing that a mineral is diamond, for example, allows one to predict that it is extremely hard and an exceptionally good thermal conductor. Classification systems that are highly successful and fruitful for purposes of scientific reasoning are viewed as "carving nature at its joints"; their categories are dubbed "natural" (as opposed to, artificial or human) kinds by philosophers because they are judged to reflect real divisions in nature.

This proposed IMA 2022 session explores the scientific utility and fruitfulness of mineral classification systems by focusing on both the IMA-CNMNC standard mineral classification protocols and two recently proposed complementary approaches to mineral classification. On the one hand, Hawthorne et al. (2021) introduce the concept of a "mineral archetype," which defines a mineral as a pure form characterized by four intrinsic properties: "its name, its end-member formula and Z, its space group, and the bond topology of the end-member structure" [1]. Like the IMA system, the archetype concept of minerals classifies solid materials in terms of timeless (chemical and structural) properties, independently of their etiology (origin and evolution). In contrast with both the IMA system and the mineral archetype system, Hazen and colleagues have attempted to identify "historically" (in the sense of their origin and evolution) informative mineral categories [2,3]. Minerals are characterized by suites of diagnostic characteristics, including trace and minor elements, isotopes, fluid and solid inclusions, morphologies, optical properties, and other information-rich physical and chemical attributes, all coupled to that mineral's formation in the context of planetary evolution.

The mineral pyrite provides a useful example of the contrasts among these classification approaches. Archetype *pyrite* is pure FeS₂ with the ideal cubic ($P\bar{a}3$; Z = 4) pyrite structure. The IMA-approved mineral species is similar to the archetype, but it embraces a range of major natural specimens that typically deviate from the idealized archetype. For example, the compositions of natural pyrite often include partial substitution of As for S and Co/Ni for Fe. By contrast, Hazen and colleagues suggest that "pyrite" encompasses 20 or more distinct natural kinds, each with a diagnostic combination of trace and minor elements, morphologies, paragenetic contexts (both abiotic and biotic), and other attributes associated with different formational histories [4,5].

This session will consider varied approaches to mineral classification, with a focus on several key questions:

- (1) To what extent are these and other approaches to classification mutually consistent? To what extent are they contradictory?
- (2) Are there phases that are currently IMA-approved species that do not have analogous archetype or natural kind equivalents? Are there natural solids that should be classified but are not currently recognized by the IMA-CNMNC? Is that a problem?
- (3) Is it valid to apply the concept of natural kinds to minerals [3,6]?
- (4) To what extent do these classification systems play central roles in the articulation and development of scientifically fruitful theories?

References:

- [1] Hawthorne et al. (2021) *Min. Mag.*, **85**, 125-131.
- [2] Hazen (2019) *Am. Min.*, **104**, 810-816.
- [3] Cleland et al. (2020) *Proc. Natl. Acad. Sci.*, **118**, e2015370118.
- [4] Gregory et al. (2019) *Econ. Geol.*, **114**, 771-786.
- [5] Hazen & Morrison (2021) On the paragenetic modes of minerals. *Am. Min.*, **106**, *in press*.
- [6] Santana (2019) *Foundations of Chem.*, **21**, 333-343.

Session Format: The proposed session will begin with a discussion of the history of mineralogical classification systems, leading to the IMA-CNMNC system in place today, alternative approaches, and the roles of natural kinds in scientific reasoning. Five talks will be followed by a discussion of the session questions. All talks will be 15 minutes long, including 3 minutes for questions. The session will end with a 40-minute panel discussion among members of the audience and the speakers.

Session Name: On the labyrinthine world of open-framework minerals: occurrence, crystal-chemistry, properties and utilization

Session Code: OL65

“On the labyrinthine world of open-framework minerals: occurrence, crystal-chemistry, properties and utilization”.

¹G. Diego Gatta, ¹Paolo Lotti, ²Georgia Cametti, ³David Bish

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Open-framework minerals are a class of microporous materials mainly represented by zeolites, feldspathoids, clathrates and minerals with heteropolyhedral frameworks. Many of these structures hold a variety of cations and molecules within the pores in their open framework. Interest has grown over the last few decades, and there has been an explosion of studies on their occurrence, synthesis routes and properties. Both natural and synthetic varieties exist, and they represent an intersection between mineralogy and material science. The aim of this session is to assemble contributions on the occurrence, crystal-chemistry, properties and utilization of natural open-framework compounds and their synthetic counterparts, revealing any potential petrological implications and emphasizing the connections between mineralogy and materials engineering.

Ore mineralogy and trace elements

Conveners

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The general need for raw materials and ores steadily increases. Therefore, besides better understanding on the genesis of ore deposits, mineral intergrowth, as well as valuable by-products for a zero-waste policy, new methods for the exploration of ore minerals are relevant for both scientific and economic considerations. One major key for these aspects is the investigations of ore minerals and incorporated trace elements. In the last decades, analytical techniques (e.g., LA-ICP-MS, SIMS, EPMA, TEM, WDX element maps) have significantly advanced the study of ore minerals, from nano- and micro- towards deposit-scale, including measurements of lower concentrations of trace elements. In general, trace elements are particularly of interest as they can provide crucial information for ore formation and can act as exploration tools. This session therefore focuses particularly on ore minerals, including its role in mineral exploration, ore genesis, and mineral processing. We invite contributions applied to mineral geochemistry of different ore deposit types. We particularly welcome integrative studies using trace elements, isotope systematics and phase relationships to understand the genesis of ore minerals using different approaches ranging from field work, reflected-light microscopy towards sophisticated analytical methods such as LA-ICP-MS, SIMS, EPMA, TEM, WDX element maps.

Session Name: Precious metals and associated minerals: developments in their characterization
Session Code: OL63

Precious metals and associated minerals: developments in their characterization

The session is SGA sponsored and there is a limited number of travel grants available to SGA students who submit the abstract as senior author.



Jussi Liipo
President
Mineralogical Society of Finland

Precious metals, gold, silver, and the six platinum group elements including ruthenium, rhodium, palladium, osmium, iridium, and platinum are well-known to occur as discrete metallic alloys and as minerals, in which the precious metals are an essential component such as platinum group minerals (PGM). Precious metals may also occur in solid solution mainly in Ni± Cu± Fe sulfides. Characterization followed by beneficiation of these elements has many challenges for the applied mineralogist due to its trace concentrations, small grain sizes or nugget effects and multiple associations with different coexisting minerals, like sulfides, arsenides, oxides and silicates. Nowadays, PGM's are classified as critical raw materials for the European Union, while gold is stored in form of jewelry, bullion coins or bars as a hedge against inflation or other economic disruptions. Precious metals have become indispensable to modern life as many current and future industrial applications are dependent on them. This session aims to encourage the discussion about the important role of the precious elements by combining contributions from the full range modern investigation techniques. Results from advanced ore characterization, ore mineralogy, applied mineralogy or with any other topic related to precious metals are welcomed.

Projecting Mineral Elasticity Across Scales and Disciplines

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Minerals react to changes in the external physical conditions, such as temperature and stress, by elastic deformation. Fluctuations in stress and temperature can arise from a wide spectrum of processes. The propagation of seismic waves, for example, is controlled by the elastic properties of rocks. Seismic observations can therefore be integrated with mineral elasticity to infer the structure and composition of planetary interiors. Differences in the elastic relaxation between a mineral inclusion and the host phase can give rise to residual stresses that can be analyzed to reconstruct the pressure and temperature when the host–inclusion pair first formed. The disparate thermal expansion properties of mineral grains translate temperature fluctuations on the surfaces of Earth and other planets into thermal stresses within rocks that drive mechanical rock weathering. In addition to these natural examples, elastic properties are central to the application of minerals, or mineral-like materials, in construction and insulation materials, as optical and electronic components, and in other technologies. On the microscopic scale, the elastic properties reflect the atomic architecture of the crystal structure and can be affected by phase transitions and structural instabilities. As a consequence, domain structures of crystals often tend to minimize elastic strain energy. With this session, we aim at showcasing recent advances in the study of mineral and rock elasticity with applications spanning from earth and planetary sciences to modern-day technologies. We are looking forward to experimental, computational, and theoretical contributions to mineral elasticity from atomic to planetary scales.

Session Name: **Redox state and properties in mineralogy and geochemistry**
Session Code: **OL27**

Redox state and properties in mineralogy and geochemistry

Roberto Moretti (IPGP, Obs Guadeloupe), Daniel R. Neuville (IPGP-CNRS, Paris)

Understanding the redox conditions of geomaterials is extremely important for constraining and advancing our knowledge on the formation and evolution of the Earth. Redox state is one of the keys to understand planetary processes at work, from Earth oxygenation to the plethora of magmatic, metamorphic and sedimentary processes behind planetary evolution. Furthermore, redox plays a fundamental role in affecting the physical and chemical properties of geomaterials and its understanding allow bridging important gaps between material and Earth sciences.

Tools and techniques are continuously developed, refined and made accessible to determine redox properties of condensed mineral and amorphous phases, covering the widest possible range of pressure and temperature. These include partitioning experiments, Raman spectroscopy, X ray Absorption Spectroscopy, Mossbauer spectroscopy, EELS, the electron microprobe-based "flank method" and much more. Advances in experiments and theory furnish an increasing number of insights into the atomic structures and macroscopic properties of such phases at ambient and high pressures and temperatures. This continuous development in research and technology allows, for example, assessing the evolution of magmas and the processes that operate in different geodynamic settings, from spreading centres to subduction zones or to fully characterize processes and short- to long-time responses of the so-called critical zone at the interface between the geological and biological realms.

The objective of the session is to put mineralogy and geochemistry under the redox perspective and stimulate a general discussion of the redox links between atomic scale structures, macroscopic material properties, geodynamic and exogenous processes.

We then expect that different theoretical and experimental research fields will converge in this session under the redox perspective. Besides, we aim at showing the vitality in mineralogy and geochemistry of one of the major branches of Chemistry and highlight its role in deciphering the continuum of processes that characterize the dynamic evolution of Earth and its geochemical and mineralogical reservoirs.

Session Name: Serpentinites and beyond

Session Code: OL08, OL21

SERPENTINITES AND BEYOND: the back-and-forth journey of water into the mantle

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The interaction of the mantle rocks with the hydrosphere is perhaps one of the most critical reactions on our planet, that together with its counterpart reaction (deserpentinization) control many key bio-geo-dynamic processes. Hydration and dehydration reactions of ultramafic rocks are involved in the long-term geochemical volatile cycling associated with subduction zones but also are thought to exert a role on the mechanical instabilities accounting for short- to medium-term seismic cycles. Moreover, serpentinization is associated with the origin of life and the formation of energy sources for a deep biosphere. There remain, however, outstanding fundamental questions to fully determine (de)serpentinization processes. For example, how are microphysical and microchemical processes during (de)serpentinization coupled and how does the rheology and permeability of serpentinite systems change in space and time? Can serpentinization lead to a geochemical environment that can synthesize organic compounds?

In this session, we welcome contributions adopting a broad variety of natural observations, experimental, analytical and numerical techniques addressing outstanding geochemical and geodynamic questions around serpentine minerals, serpentinites, serpentinization and deserpentinization.

Iron serpentines in terrestrial and extra-terrestrial samples

Iron serpentines are found in extra-terrestrial and terrestrial samples, in both natural and anthropic environments. They are characterised by complex, modular structures where several cationic substitutions occur. During their formation, H₂ is generated as a consequence of iron oxidation in presence of water. For this reason, they are considered to have supported H₂-based microbial communities and contributed to fluxes of abiotic methane and other hydrocarbons in the Earth's crust. This leads to hypothesize a possible relationship between the Fe-serpentines and the conditions favorable for the evolution of organic matter in the Solar System, which made the life possible on the Earth.

Nowadays the formation conditions and stability fields of these minerals are still poorly understood, and a detailed crystallographic/cristallochemical characterization is often lacking. Several studies are carried out in the last years (using hydrothermal synthesis, electron diffraction microscopy, etc.) to know more about these interesting minerals.

Isabella Pignatelli

Session Name: Solar system materials - studies of landed, orbital, and returned mission samples and meteorites / Understanding planetary materials and processes via analog, simulated, and theoretical studies on Earth

Sessions Code: OL12, OL23, OL37, OL46

Ice in the solar system

Ices play a key role in the chemistry and physics of planet and star formation, whether by acting as a catalyst for chemical reactions or by forming grain coagulations. Thanks to recent missions (Cassini, Rosetta, New Horizons, etc.), our knowledge of planetary and interstellar ices has greatly improved. The aim of this session is to bring together latest advances from planetary community to review our knowledge and identify new challenges in the light of future missions. We encourage submissions from all areas of ice studies, including but not limited to experimental and/or theoretical studies of surface-ice chemistry, volatiles in ices and geology of icy bodies in the solar system.

Mineralogy, petrology, and geochemistry of C-type asteroid Ryugu and Solar-System small bodies

The JAXA's Hayabusa2 spacecraft explored C-type near-Earth asteroid (162173) Ryugu and successfully returned the first sample from C-type asteroid in December 2020. The amount of returned sample exceeds 5 grams, which is the largest ever from deep space. Detailed analysis of Ryugu samples, led by the Hayabusa2 project and JAXA, has been in progress since June 2021. The initial analysis phase by the project ends in June 2022, and the sample will be available to the community. This session will focus on new mineralogical, petrological, and geochemical findings from Ryugu samples, their comparison with the meteorite collection, and implication to origin and evolution of the asteroid and the Solar System. Contributions highlighting analysis of related pristine samples, sample science of Solar-System small bodies, and technical development for analysis of primitive extraterrestrial samples are also welcome.

Mission minerals: Exploring our solar system's mineralogy through remote-sensing, landed, and sample-return missions

Conveners: Shaunna Morrison (MSL, RRUFF), Dante Lauretta (OSIRIS-REx), Kerstin Lehnert (AstromatDB, EarthChem), Larry Nittler (Hayabusa2, MESSENGER)

Information on the mineral inventory across our solar system is rapidly expanding due to the far-reaching and powerful remote-sensing, landed, and sample-return missions. Many of these spacecrafts contain instrument payloads capable of detecting mineral species, including XRF, XRD, Raman, IR, and NIR. Further, returned samples can be explored with a suite of laboratory instruments, increasing our understanding of the chemical and textural features of astromaterials at an unprecedented level of detail and precision. The detection and classification of minerals and mineralizing systems on the diverse bodies in our solar system is shaping our understanding of planetary evolution, the diverse geologic and geochemical processes across our solar system, and the search of life beyond Earth.

This session welcomes contributions related to mineralogy and/or mineralizing environments and processes on other planetary bodies, geologic and geochemical history of planetary materials and systems, spacecraft instrumentation and observations, laboratory studies in preparation for returned samples, and field studies and advances in flight-ready mineral detection instrumentation.

Minerals under extraterrestrial conditions

Conveners: Mara Murri (Department of Earth and Environmental Sciences, University of Milano-Bicocca, Italy), Anna Barbaro (Department of Earth and Environmental Sciences, University of Pavia, Italy)

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The investigation of planetary bodies has been under continuous development especially with the advent of sample return missions and last-generation remote-sensing techniques. In particular, the study of extraterrestrial minerals is fundamental for shedding light on the origin and evolution of the Solar System bodies. Remote-sensing techniques together with laboratory studies on meteorites, micrometeorites, interstellar grains as well as experiments on planetary analogues and analyses of sample return materials allow us to better understand and constrain the processes involved in shaping Solar System bodies. Planetary materials and in turn their constituent minerals are subject to space weathering processes such as meteoroid bombardment and solar wind irradiation. These processes cause the alteration of mineral chemistry and structure, and they also contribute to the excavation of planetary surfaces which can generate new meteoritic materials and can sample portions of the impact target.

In this session we will bring together all the different aspects of planetary mineralogy to enjoy this fascinating mineral science world and to promote fruitful discussions and synergic collaborations. We invite and welcome contributions from the broad field of mineral investigation on extraterrestrial materials and analogues. Contributions that cover characterization of minerals under extraterrestrial conditions, study of planetary bodies and meteorites as well as in-situ experiments to remote-sensing data are encouraged.

Progress in Mineralogy inspired by planetary science discoveries

Conveners:

Luca Bindi (University of Florence, Italy) Oliver Tschauner (University of Las Vegas, USA)

The exploration of extreme environments in space, planets and moons is yielding an ever increasing number of previously unknown minerals. Some of them have been previously synthesised, some were entirely unknown. In either case their properties and composition reflect the complexity of natural environments and open new avenues for understanding the history of the early solar system, the formation and the evolution of planets and moons. What are the new directions in mineralogy with respect to the planetary sciences? How does mineralogy add to the success of the recent return missions and complement the latest progresses in the study of extraterrestrial materials? The session will be open to contributions, analytical, experimental, computational, which address these questions.

Session Name: **Symmetry breaking in minerals**

Sessions Code: **OL18, OL22**

Symmetry breaking in minerals

Convenors:

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Symmetry is one of the fundamental characteristics of a mineral. But the symmetry of minerals can be broken or reduced by many different processes. Structural phase transitions in minerals give rise to many important phenomena including magnetism and ferro-electricity (symmetry breaking by ordering of magnetic moments and electric polarisation respectively). Cation ordering can break symmetry and be used as a geothermometer or geospeedometer. The symmetry of minerals can also be broken without phase transitions, for example by surface relaxations or the application of deviatoric stress, and can give rise to useful chemical and physical properties.

On the 100th anniversary of the discovery of ferro-electricity we invite contributions on all aspects of symmetry breaking in minerals at all scales, the methods to detect it including diffraction and spectroscopies, and the consequences of symmetry breaking and how it can be used.

Session Name: **Theoretical and Computational Mineral Physics**

Session Code: **OL19**

Theoretical and Computational Mineral Physics

Conveners: Jun Tsuchiya (GRC, Ehime University), Razvan Caracas (IPGP), Sebastian Ritterbex (GRC, Ehime University), Bijaya B. Karki (Louisiana State University)

Knowledge of crystallographic, chemical and physical properties of minerals is required to advance our understanding of the structure and dynamics of the Earth and planetary interiors. In the past decade, this has largely progressed based not only on experimental studies but also on theoretical and computational studies within the applications of various techniques, from first principles to empirical, from static calculations to molecular dynamics, and from atomistic to multi-scale models. This session will bring together the latest contributions related to computational studies of a wide range of mineral properties, including but not limited to structure, phase equilibria, thermodynamics, elasticity, diffusion, conductivity, transport properties, viscosity, etc. The scope of this session covers all studies of crystalline and amorphous materials within a broad range of compositions relevant in mineralogy. Through our presentations and discussions, we hope to create new paths for breakthroughs in future research directions within the field of computational mineralogy.

Session Name: **Unravelling low-temperature mineralogy from atomic-scale approaches**

Session Code: **OL61**

Unravelling low-temperature mineralogy from atomic-scale approaches

Conveners:

Julie Aupart (GET, Université Toulouse 3, France)

Marc Blanchard (GET, Université Toulouse 3, France) Encarnación Ruiz Agudo (Universidad de Granada, Spain)

Low-temperature mineralogy and geochemistry provide insight into the processes occurring at the Earth's surface, such as biomineralisation, weathering, diagenesis, or the transport of contaminants. In particular, an in-depth understanding of these large-scale processes can be achieved by studying the underlying atomic-scale mechanisms involved, both with analytical and computational techniques.

This session aims to highlight recent advances in the understanding of low-temperature mineralogy from an atomic or molecular level perspective, *i.e.* through microscopy and spectroscopy investigations as well as computer simulations. This includes studies on proxies such as stable isotopes and trace elements, chemical impurities in minerals, crystal defects, crystal zonations, processes at the mineral-fluid interface such as dissolution-recrystallisation, crystal nucleation and growth, adsorption. These contributions may pertain to contexts such as chemical weathering, soil evolution, sedimentary processes and diagenesis, contaminant transport and remediation, biomineralisation, and biogeochemical cycles in the Critical Zone. Presentations based on the development or application of new or advanced analytical and theoretical methods are welcome.

Related themes:

- Environmental mineralogy, biomineralogy
- The dynamical world of minerals

Session Name: Volatiles in planetary interiors

Sessions Code: OL03, OL11

Deep Earth water in the mantle and core

Convenors: Toru Inoue (Hiroshima University, Japan), Paola Comodi (Università di Perugia, Italia), Daniel R. Neuville (Université de Paris, France), Jun Tsuchiya (Ehime University, Japan)

Water is the most abundant volatile component in the Earth, and it has been transported into the Earth interiors by subducting slab during the Earth history. High pressure experimental and computational works have been clarified that various hydrous minerals, such as dense hydrous magnesium silicate (DHMS), were stable under high pressure and high temperature conditions corresponding to the Earth interiors. In addition, it is clarified that nominally anhydrous minerals under high pressure can accommodate significant amount of water in the crystal structures. Actually, some high pressure hydrous minerals such as hydrous ringwoodite were discovered in diamond inclusion, and the Earth interiors would be hydrous condition at least locally. The dehydration melting phenomena and the behavior of the generated hydrous magma also should have an important role for the Earth evolution. In this session, we welcome the various topic corresponding to the subject of “deep Earth water in the mantle and core”.

Suggested invited speaker: Eiji Ohtani (Tohoku University, Japan)

principal convenor

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Planetary Interiors

Volatiles Storage in Planetary Interiors

Most of the volatiles-rich minerals are typical of superficial layers of telluric planets (Earth, Mars), however, the atomic structures of minerals found in deep planetary interiors are never perfect and can incorporate significant amount of various volatiles elements (H, C, S, Halogens, noble gases or highly siderophile elements). The presence of these elements in the lattice of deep minerals in telluric planets can impact many large-scale properties such as viscosity, *electrical and thermic conductivity*, ionic diffusion, melt percolation or melting temperature. For example, for the Earth, water *derived-species* are recurrently proposed as key geodynamic components. Despite major progresses in experimental technics at extreme conditions, spacial detection, numeric geodynamic models, and the calculation capability, many unknowns remain on the capacity of minerals to store volatiles elements. This session aims to bring together studies investigating any aspect of volatiles storage in planetary interiors (e.g., Earth, Mars, Venus). We welcome contributions including, but not limited to: 1) experimental and theoretical investigation; 2) quantification of the transport, fluxes and cycles; 3) advances in quantitative measurement techniques; or 4) data report on observables. Submissions from students and early career researchers are especially encouraged.

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