



**OUR VOLATILE PLANET
GOLDSCHMIDT 2009**

Themes and Sessions

Theme 0: Plenary lectures

Coordinators:

Session 99a: Plenary Sessions

Convenors:

Keynote:

Theme 1: Nebular Processes, Planet Formation and Comparative Planetology

Coordinators: *Mark Rehkamper & Andy Davis*

Team Members: *John Chambers, Nicolas Dauphas, Larry Nittler, Maria Schönbachler, Qin-Zhu Yin, Brigitte Zanda & Jutta Zipfel*

Session 01a: Solar system material - sources and composition

Convenors: *Nicolas Dauphas, Laurent Remusat & Henner Busemann*

Keynote: *Kevin D. McKeegan*

The study of meteorites, interplanetary dust particles, and samples returned by the Genesis and Stardust spacecrafts in the past several years has tremendously improved our understanding of the formation of the solar system. This progress was made feasible in part by developments in mass spectrometry and imaging techniques. Important questions related to the formation of the Sun can now be investigated with unprecedented power. What is the composition of the Sun? Did a supernova explosion or passing AGB-star trigger the collapse of the molecular cloud core that made our solar system? How did stellar nucleosynthesis control cosmic abundances? How did organic material form and get mixed with refractory inclusions in meteorites? The aim of this multidisciplinary session is to discuss the initial conditions of the solar system. We welcome contributions from all fields relevant to this theme, including observations and modeling of young stellar objects as well as laboratory studies of presolar grains, organic matter, solar wind and cometary material.

Session 01b: From dust to planetesimals – Solar System processes and their timescales

Convenors: *Qin-Zhu Yin & Brigitte Zanda*

Keynote: *Fred Ciesla*

The earliest stage of planet formation, from dust to planetesimals (known as Stage I in the standard model) remains poorly understood. Planetesimal formation is difficult to constrain. The physics of grain growth in the solar nebula from micron-sized particles to kilometer-sized bodies is not well understood. Condensation, evaporation, and melting processes that generated refractory inclusions and chondrules may all be associated with physical changes that marked the initiation of grain growth. Chondrites, as the host of these components and the most pristine meteorites of our solar system, must have witnessed the initiation of planet formation and contain clues to their volatile element depletion and metal/silicate fractionation. These samples allow us to view inside our own protoplanetary disk from 4567 up to ~4562 Ma ago and study these processes in the laboratory in detail. However, this wealth of information must be placed in a broader context. The session invites contributions from a theoretical perspective, as well as observations from protoplanetary disks (e.g. Spitzer) and meteoritics. We encourage interdisciplinary dialog between isotope cosmochemistry, meteoritics, astrophysics, and observational astronomy of star and planet formation.

Session 01c: From planetesimals to planets: impacts, growth and differentiation

Convenors: *Maria Schönbachler & Mark Rehkamper*

Keynote: *David O'Brien*

For this session, we seek contributions that provide new insights into the formation and early differentiation of planets and asteroids as well as their modification by impact processes. Contributions from diverse fields are welcome, as we wish to foster a discussion between scientists that use stable or radiogenic isotope systems, trace element data or partitioning experiments to study the formation and evolution of planets with those that employ dynamical simulations, thermal modeling or astronomical observations.

Session 01d: Planetary geochemistry

Convenors: *Jutta Zipfel & Larry Nittler*

Keynote: *Jeff Taylor*

Our knowledge about terrestrial planets, moons and large asteroids is mainly shaped by the study of meteorites and space missions. Recent orbital and lander missions to Mars and the Messenger flyby of Mercury are improving our knowledge about the surface compositions of these planets. While meteorites mostly provide data for the interior of planetary bodies, mission data focus on their surfaces. Geochemical and petrological studies of both are needed in order to constrain the full extent of the origin and chemical evolution of a planetary body, such as Mars. This session is devoted to studies that give evidence for I) bulk planetary properties II) surface composition, and the chemical evolution of terrestrial planets and moons with a major focus on Mars.

Session 01e: Lunar Geochemistry and Chronology: a sample and remote sensing data perspective

Convenors: *Vera Assis Fernandes, Amy Gaffney & Katie Joy*

Keynote: *Tomoko Arai*

Lunar geochemistry and chronology have been revitalized in recent years by Clementine, Lunar Prospector and SMART-1 missions, the current Kaguya and Chang'e-1, and future (Chandrayaan-1 and LRO) global data obtained from orbit; samples that represent previously unsampled/uninvestigated compositional domains (e.g. meteorites); and new and improved analytical techniques that allow analyses of the smaller Apollo and Luna Samples. The aim of this session is to further explore the synergies between the different data sets for the evolving understanding of the formation and early differentiation of the Moon, lunar mantle and crust evolution, and lunar (and Earth) impact history.

Session 01f: Current and Future Life Detection Missions in the Solar System

Convenors: *Zita Martins & Mark A. Sephton*

Keynote: *Pascale Ehrenfreund*

The Phoenix mission successfully landed on Mars on May 2008 and since then it is investigating the habitability potential of the Martian ice-rich soil. Although Phoenix is not searching for life, it is able to determine whether Mars could have supported microbial life. Mars Science Laboratory (MSL) will be NASA's next rover mission to the Red planet. It will analyze the Martian soil for organic compounds essential for life, with the goal of identifying habitable environments. Following in the footsteps of the Viking landers, the future ESA's ExoMars mission will look directly for signs of life. However, prior to this it is necessary to identify geologically suitable Martian regions where it can be demonstrated that liquid water existed or still exists, and where organic compounds remnants of life may be preserved over long periods of time. In this session we invite contributions on the detection of extant and extinct life in planetary bodies of our Solar System. In particular, we welcome papers that discuss detection methods of biosignatures, as well as the latest mission instrumentation designed for in-situ life detection.

Session 01g: Siderophile and chalcophile elements: from chondrites to planetary processes

Convenors: *Olivier Alard, Anders Meibom & Astrid Holzheid*

Keynote: *Alex CORGNE*

The physical and geochemical properties and isotopic systems of siderophile and chalcophile elements offer great potential for investigating processes in the solar nebula as well as the evolution of asteroids and planets. These include, for example, the identification of presolar isotopic anomalies, nebula condensation, planetary-planetoids differentiation (timescales of core segregation, mantle melting and crust formation) and

the distribution and destruction of geochemical heterogeneity in the Earth's mantle. In an effort to bring together cosmochemists, geochemists and experimental petrologists, we broadly invite contributions that utilizes the siderophile and calcophile elements to address these and related problems. This session aims to be transversal to theme 1, 2, 3 and 4.

Theme 2: Earth, The Early Years: Building a Habitable Planet

Coordinators: *T. Mark Harrison & Charles Lineweaver*

Team Members: *Bill Bottke, Rick Carlson, Erik Galimov, Jun Korenaga & Kevin Zahnle*

Session 02a: Building Habitable Planets

Convenors: *Charles Lineweaver, Dimitar Sasalov, Stephen Mojzsis, Cin-Ty Lee, Nader Haghighipour & Lisa Kaltenegger*

Keynote: *Geoff Blake & Diana Valencia*

This session is planned to address such questions as: How does varying mass and composition of 'terrestrial' planets affect their habitability? How much planetary resurfacing is required to maintain the chemical disequilibrium that life needs? What is the mode of resurfacing of super Earths? Are stagnant lids incompatible with life?

Session 02e: Peering into the Cradle of Life: Processes and Habitats on the Archean Earth

Convenors: *Paul Mason, Crisogono Vasconcelos, Euan Nisbet & Sylvie Derenne*

Keynote: *Mark van Zuilen*

The key physical and chemical conditions at the surface of the Archean Earth when life and associated ecosystems emerged remain poorly constrained and the timing and mechanisms of formation and development of the earliest continents, oceans and atmosphere are unclear. This session invites contributions that use experimental or theoretical data to build models that describe the Archean environment that formed the habitat of early life. Research areas to be covered will include tectonic, sedimentary and biogeochemical processes. Particular attention will be given to the style and nature of early volcanism, hydrothermal circulation through the Archean oceanic crust, the temperature and composition of the Archean oceans, evolution of the Archean atmosphere, microbial habitats and metabolic activity of microorganisms in volcanic and sedimentary settings and the development of more robust chemical and isotopic biomarkers. The session will be (co) sponsored by the Archean Environment research networking program of the European Science Foundation.

Theme 3: The Deep Earth: Formation, Evolution and Dynamics

Coordinators: *Janne Blichert-Toft & Jun Korenaga*

Team Members: *Jacqueline Dixon, Manuel Moreira, Christine Thomas & Jim Van Orman*

Session 03a: Structure and evolution of chemical heterogeneities in the Earth's mantle

Convenors: *Al Hofmann & Paul Tackley*

Keynote: *Sebastian Rost*

The origin, preservation and evolution of isotopic heterogeneities in the terrestrial mantle remain fundamental questions on the efficiency of mixing and therefore structure of the mantle system. Seismic tomography provides a view of the large-scale structure within the mantle today, while geochemical analyses show evidence of all scales of heterogeneities, ranging from global down to microscopic. Numerical simulations of mantle convection investigate the chemical and physical evolution of the mantle over its lifetime, employing constraints imposed by processes of magmatic differentiation and convective homogenization. Some of the open questions in this context are: What is the present-day state of mantle heterogeneity and how has it evolved through time? Do the compositions of mantle melts adequately reflect the heterogeneity of mantle-source compositions, or are they primarily controlled by mixing processes in magma chambers? What is the role of "layered" as opposed to "whole-mantle" convection? Are there physically distinct geochemical reservoirs in the mantle, or are the heterogeneities chaotically distributed throughout the mantle? What are the dimensions of such heterogeneities? Is the concept of distinct

geochemical “reservoirs” and geochemical “end-member” compositions appropriate for describing the geochemistry of the mantle? We invite contributions that provide new insights into the nature of the terrestrial mantle and particularly those that integrate one or more of the subdisciplines of geochemistry, fluid dynamics, seismology and petrology.

Session 03b: Origins of hotspots and flood basalts

Convenors: *Nick Arndt & Cinzia Farnatani*

Keynote: *Godfrey Fitton*

The aim of this session is to provide a coherent view of thermal and thermochemical instabilities in the deep mantle and their evolution during mantle upwelling, and the petrological and tectonic processes that result in the formation and emplacement of magmas in oceanic islands and continental intraplate settings.

Understanding these processes requires contributions from petrologists, geochemists, tectonicians and geophysicists. We invite contributions discussing the dynamics of the source regions of plumes and their mineralogical and chemical compositions, the melting processes and their control on magma compositions, the extent to which melting anomalies reflect excess fertility in the mantle rather than excess mantle temperatures, and finally, the interaction between magma and wall rocks during passage to the surface.

Session 03c: Deep volatile cycles in terrestrial planets

Convenors: *Marc Hirschmann & Bernard Marty*

Keynote: *Hans Keppler & Manuel Moreira*

The storage of volatile elements in deep planetary reservoirs and the cycling between these reservoirs and the surface is central to understanding the formation and evolution of terrestrial planets. The storage of these elements has a considerable effect on the physical properties of planetary interiors and transfers of these elements between deep and surface reservoirs exert strong control on environmental conditions of terrestrial planets, such as pressure, temperature, and the occurrence of liquid water. This session welcomes all contributions that address the origins, fluxes, and processes affecting storage and transfer in deep planetary interiors of elements that are or were once volatile at planetary surface conditions.

Session 03d: Structure and chemical interactions at the core-mantle boundary

Convenors: *Mike Kendall & Jennifer Jackson*

Keynote: *John Brodholt*

The core-mantle region is arguably the site of the most significant boundary in the Earth. It separates the rocky mantle from the liquid iron-rich core and serves as boundary condition for convection on both sides. Understanding the structure, dynamics and material properties of this region is important for understanding a host of problems including: the evolution of the early Earth, its geodetic behaviour, properties of the magnetic field, mass exchange between the core and mantle, and hidden geochemical reservoirs. In this session we invite contributions from a range of disciplines that address these issues including geochemistry, geodynamic modeling, seismic studies, mineral physics, geodetic observations and geomagnetism.

Session 03e: Physics and chemistry of the core

Convenors: *James Badro & Stephane Labrosse*

Keynote: *Michael Walter*

The core, that represents a third of Earth's mass, is site to many important processes, like the geodynamo, which is fueled by the thermal and chemical evolution of the core in interaction with the mantle. Studying this evolution provides a link between the present state of the Earth and the processes of its formation and differentiation. The last decade has seen many exciting discoveries and lively debates about the chemical and physical properties of Earth's core. The time is ripe for mineral physicists, experimental petrologists, geochemists, seismologists and geodynamicists to re-examine the fundamental issues concerning the core under the new light of recent observational, experimental, and computational results. The aim of this multidisciplinary session is to present our current understanding of the formation, evolution, composition and structure of Earth's core. The session will accept contributions from a broad range of disciplines, focusing especially on experimental and theoretical mineral physics, experimental petrology, and geochemistry. The

following themes are especially welcome: (i) how and when did the core form, at what depth, and what were the various equilibrium processes it went through, (ii) what does the mantle tell us about the core, and what does the core tell us about the formation of the Earth and its early history, (iii) how has the core subsequently evolved and started to crystallize, (iv) how can mineral physics and petrology address the composition of the core, and what is the influence of light elements on the physical properties of iron, (v) what is the structure of the inner core, and what is the origin of its seismic anisotropy.

Session 03f: High Pressure Mineral Physics - a Key to Earth Structure: Symposium in honor of Ronald Cohen

Convenors: *Gerd Steinle-Neumann & Lars Stixrude*

Keynote: *G. David Price*

Characterizing structure-property relations of mineral phases of the Earth's interior over a wide range of pressure and temperature provides the key to understanding the physical state and evolution of the interior of our planet. Over the past two decades experimental work has been supplemented by quantum mechanical based electronic structure computations that provide reliable predictions of material properties, from magnetic structure, to phase transitions, and to high temperature elastic properties. This session is organized to honor one of the pioneers of computational mineral physics, Ronald Cohen, who has been awarded the Dana Medal of the American Mineralogical Society for his work. To celebrate his contributions to computational mineral physics we invite submissions from both computational and experimental mineral physics, especially experimental work that has confirmed - or challenged - computational predictions, or were guided by such results.

Theme 4: Mantle to Crust: Ocean Ridge and Intraplate Volcanism

Coordinators: *Steven L. Goldstein & Francis Albarède*

Team Members: *Wolfgang Bach, Cornelia Class, Hedy Edmonds, Cinzia Farnatani, Peter Michael & Alberto Saal*

Session 04a: Integrated Studies of Mid-Ocean Ridge and Intraplate Magmatism: From Top to Bottom

Convenors: *Peter Michael & Alberto Saal*

Keynote: *Rajdeep Dasgupta & Erik Hauri*

The study of Mid-Ocean Ridge (MOR) and intraplate magmatism has been rapidly evolving due to the growing body of geochemical and geophysical data, as well as recent advances in numerical modeling. Those studies have provided new insight into 1) the length scales and origins of geochemical variability in the mantle sources, 2) the timing and mechanics of melting and melt segregation processes, 3) the physical-chemical interaction of basalt with the upper mantle and the oceanic lithosphere, 4) the effect that melt supply and magma chambers have on obscuring the mantle chemical heterogeneity recorded in both MORB and OIB and 5) the interaction between the magmatic and hydrothermal systems. The studies of volatile elements are of particular importance, because volatiles influence mantle melting, magma differentiation and degassing, and their abundances, isotopic composition and spatial distribution provide important constraints on models of mantle convection, mantle heterogeneity and crustal recycling. The purpose of this session is to bring together scientist from different fields to present new data and models that significantly improve our understanding of both mid-ocean ridge and ocean island systems, and provide an opportunity to integrate results and refine our state of knowledge of MOR and OIB magma evolution. We welcome abstracts presenting new geochemical, petrological observations of MORB, OIB, the oceanic crust and abyssal peridotites (including melt inclusions and phenocrysts studies), as well as seismological observation and numerical models that will help the interpretation of Mid-Ocean and intraplate magmatism.

Session 04c: Hydrothermal processes at mid-ocean ridges: temporal and spatial variability and impacts on biogeochemical cycling between mantle, crust, and ocean

Convenors: *Hedy Edmonds, Julie Bryce, Marvin Lilley, Adelle Delacour & Marguerite Godard*

Keynote: *Andrea Koschinsky*

The numerous hydrothermal systems discovered along mid-ocean ridges during the last decades have underscored the importance of seawater circulation and alteration processes in crustal and

mantle-dominated lithosphere as means of mass and energy transfers in oceanic accretion zones. Hydration of the cooling lithosphere results in a series of strongly interconnected thermal, chemical, and biological processes within and upon the seafloor, which contribute significantly to biogeochemical budgets throughout the Earth-ocean system. Throughout her career, Karen Von Damm provided many insights into these significant processes by studying temporal and spatial variations in mid-oceanic ridge hydrothermal systems. In celebration of her legacy, we encourage contributions from all who seek to shed light upon the geological, geochemical and biological processes active at mid-oceanic ridge spreading centers.

Session 04d: Magma generation and evolution and global tectonics - A symposium in honor of Peter J. Wyllie for his life-long contributions to understanding how the Earth works and in celebration of the 50th Golden Anniversary of Journal of Petrology

Convenors: *Yaoling Niu, Marjorie Wilson, Ed Stolper & Hans Keppler*

Keynote: *Marc Hirschmann & Max Schmidt*

Magma generation and its evolution from mantle through crust are among the most important processes that have led to chemical differentiation of our planet throughout its history. Our current understanding of magma generation processes owes much to experimental petrology, including the more than 300 original research contributions by Peter Wyllie and his co-authors. Peter correctly recognised early on the significance of volatiles in magma genesis in all tectonic settings. Remarkably, when plate tectonics theory was still in its infancy, he effectively brought that theory to a generation of students worldwide through his book "The Dynamic Earth", which lucidly explained why volcanoes occur where they do. Memorably, Peter is the author of the very first paper in Journal of Petrology [Wyllie, P.J. & Tuttle, O.F. (1960). The system CaO-CO₂-H₂O and the origin of carbonatites. Journal of Petrology 1, 1-46]. This symposium honors Peter's lifetime contribution to petrology, aiming to bring together scientists from many parts of the world to discuss their new research on magma generation and differentiation processes. Topics include experimental petrology, igneous geochemistry and modeling, with emphasis on the use of petrology and geochemistry as a means to understanding how our planet works.

Theme 5: Continental Crust Formation, Tectonics and Orogeny

Coordinators: *Peter Clift & Sue Kay*

Team Members: *Samuel Bowring, Adam Goss, Chris Hawkesworth, Tony Kemp, Steve Parman, Gerhard Woerner & Guochun Zhao*

Session 05a: The Growth of Continental Crust: timing and rates

Convenors: *Craig Storey & Samuel Bowring*

Keynote: *Stein Jacobsen*

A long standing debate persists over the growth of continental crust during Earth evolution. One end-member is the steady-state hypothesis which assumes that a volume of crust, approximately equal to present day volume, was formed early in Earth history and has subsequently been maintained by recycling and new additions. Another end-member hypothesis suggests more gradual growth, either smoothly or episodically over all of Earth history. New approaches and discoveries are re-invigorating this debate and include extinct radionuclides (e.g. ¹⁴²Nd) and long-lived radiogenic isotope systems (e.g. Sm-Nd and Lu-Hf). In this session we invite contributions that aim to address this fundamental question through the integration of geology, geochemistry, and isotopic methods.

Session 05b: Crust coming of age: from accretion to craton

Convenors: *Qiang Wang, Bill Griffin & Michael Brown*

Keynote: *Cin-Ty Lee*

This session addresses the issue of the progressive stabilization of the continental crust during the Hadean and Archean Eons of Earth history. The session offers the opportunity to synthesize data from a wide variety of specialties and sources to identify the process by which stable cratons or supercratons emerged during the Mesoarchean-to-Neoproterozoic periods, including the processes that led to formation of the depleted continental lithosphere mantle by the beginning of the Proterozoic Eon. The session will bring together

information from field-, laboratory- and modeling-based studies and will integrate data from metamorphism, magmatism, geochemistry, deformation, tectonics, geochronology and metallogeny. Contributions that address the petrologic, geochemical and geochronological record of processes that are involved in the generation, modification and stabilization of the continental crust and lithosphere are particularly welcome, including those that assess the record of differentiation and thermal events, mineralization through time, and secular change in tectonic processes.

Session 05c: Crustal differentiation: What happens in the upper and lower crust?

Convenors: *Sue Kay, Gerhard Woerner & Guochun Zhao*

Keynote:

Invited Talks : Robert Kay (Cornell), Stephan Sobolev (GFZ Potsdam) Continental crust is characterised by the strongest thermal gradient along the geotherm and thus processes of crustal formation and differentiation are strongly temperature dependent. Magmatic and metamorphic processes in the lower crust cannot be separated, particularly at active margins since both are involved to the growth, differentiation and modification of crustal rocks. Thermal contrast between intruding mantle magmas and surrounding crustal rocks are low, which determines the rates and volumes of exchange between these reservoirs. With changing thermal and compositional state crustal rocks and magmas may advectively ascent into the upper crust. Hot crustal rocks may melt to form large intrusive complexes. Partially mantle-derived magmas tend to accumulate in the colder upper crustal environment where they differentiate at higher rates due to stronger thermal contrasts. These are the main processes - in combination with contrasting styles of tectonic transport at deep and shallow crustal level - that are driving or controlling the style and composition of crustal growth from mantle melts as well as internal crustal differentiation. This session seeks to attract contributions from the fields of igneous, metamorphic and experimental petrology as well as modelling that address - with in this scope, processes of crustal growth and crustal differentiation.

Session 05d: What is the evidence for geochemical and mass transfer between mantle and crust and back?

Convenors: *Mihai Ducea & Julian Pearce*

Keynote: *Mary Reid*

Crustal growth can be represented as a box model in which material is transferred in both directions between mantle and crustal reservoirs. Understanding the rates and mechanisms of mass transfer between these reservoirs, and their changes with time, is a minimum requirement for developing a quantitative model of crustal growth. This session focuses on the evidence for these rates and mechanisms. In terms of crustal inputs, we are particularly interested in evidence for the magnitudes and compositions of crustal additions through mantle plume and volcanic arc activity. In terms of outputs, we are particularly interested in geochemical and geophysical evidence for crustal delamination and for the return of crustal materials to the deep mantle via subduction zones. We also encourage contributors to address some of the controversies in crustal growth, which might include the following. What is the role of adakitic and boninitic magmas in crustal growth? Which contributed more to crustal growth: – plumes or subduction? If crustal growth is episodic, what caused the episodicity? How and when does continental crust delaminate and what is the fate of delamination products? What do OIBs tell us about crust-to-mantle transfer and its evolution with time? What fraction of subducted crustal material is returned to the mantle? We look forward to a lively discussion of these and other issues.

Session 05e: What are the effects of crustal growth, recycling and weathering on the oceans, atmosphere, and biosphere?

Convenors: *Peter Clift & John Eiler*

Keynote: *Christian France-Lanord*

Growth and destruction of continental crust has important consequences for the development of the atmosphere, hydrosphere and biosphere. As the continents were constructed and the relative volume of the ocean basins shrank relative sealevel must have risen, reducing continental erosion rates, as continental freeboard stabilized. As the crust has been reworked by orogeny this must have influenced global sealevel

via relative enlargement of the ocean basins and increased weathering rates as silicate rocks were exposed and eroded. Exhumation and weathering of the Himalaya has been linked to long-term Cenozoic global cooling, while the burial of large volumes of organic carbon in the submarine fans associated with orogeny would be expected to also drive long term climate change. The chemistry of the oceans, mostly notably the Sr and Os isotope compositions, are controlled by the riverine flux from the continents, in turn linked to crustal reworking. The reworking of continental crust in continental collision zones delivers much of the eroded "excess" crust to the oceans where it is susceptible to subduction and loss back to the upper mantle. In this session we invite contributions from researchers examining the interactions between Earth surface processes and the recycling of continental crust. We particular focus on the feedbacks between the two systems and how these have varied over long periods of Earth history.

Session 05f: Two billion seconds of life applied to four billion years of Earth history: A session to celebrate the achievements of Jan D. Kramers

Convenors: *Thomas Nägler, Balz Kamber & Igor M Villa*

Keynote: *Chris Hawkesworth*

From the earliest Earth to the Quaternary, using analytical innovations and theoretical modelling, Jan D. Kramers has pushed forward the limits of isotope geochemical knowledge. His contributions to understanding terrestrial geology have emphasized the role of cycling of elements through reservoirs and have recognized the importance of isolation / storage vs. erosion / recycling of continental crust. This session aims to celebrate Jan Kramers's achievements and approach to geochemistry with contributions to the themes that relate to his work. The session will be organized to reflect the evolution of Earth from its accretion all the way to the Anthropocene. Themes include, but not exclusively: early crustal growth, hidden and not-so-hidden reservoirs, geochemical models of the Earth including plumbotectonics, crust-mantle evolution (especially southern Africa), Late Archean rise of oxygen, Quaternary climatology, and hominin dating. A thread common to all these topics is the use of problem-oriented mass spectrometric innovation.

Session 05g: Scales and rates of mass transfer in metamorphic belts

Convenors: *Martin Engi, Roberto Compagnoni & Alfons Berger*

Keynote: *Randy Parrish*

The range of spatial-temporal scales, over which metamorphic transformations occur, is still poorly known. Progress towards documenting these scales and how they change along typical P-T-D-t paths experienced by metamorphic rocks requires efforts from various disciplines. Insight gained from field and experimental studies, and from numerical modeling need to be combined; the role of fluids has to be critically evaluated. This session seeks to bring together those working to understand the extent of micro- and mesoscopic mass transfer involved in metamorphic transformations with those aiming to quantify the rates and duration of these processes. For instance, microchemical measurements and in situ dating are increasingly combined with (quantitative or semiquantitative, 2- or 3-D) textural information to understand rock-forming processes. Studies integrating geochemical, petrological, and structural aspects of the record visible, at μm - to km-scale, are particularly invited.

Session 05h: Kinetics of metamorphic and igneous processes

Convenors: *Thomas Müller, Fred Gaidies & Fidel Costa*

Keynote: *Sumit Chakraborty*

Conditions and processes that lead to the formation of a rock may be recorded in multiple ways and on different scales. Mineral compositions and phase assemblages were usually interpreted based on equilibrium thermodynamics to obtain estimates for the conditions during rock or magma evolution. Process information was largely derived by empirical comparison of observed reaction microstructures and textures. More recently, sophisticated micro-analytical tools allow detecting compositional variations and textural features on decreasing scales and in three dimensions. The combination of new analytical and theoretical tools allows quantifying the temporal evolution of igneous and metamorphic systems with unprecedented high resolution. This session aims at the kinetics of mineral reactions and its influence on igneous and metamorphic crystallization. In particular, it focuses on the rates and timescales of chemical evolution and texture

formation in various geological settings. Contributions based on field observations, experimental investigations, theoretical as well as numerical studies are welcome.

Theme 6: Recycling: Subduction, The Mantle Wedge and Arc Volcanism

Coordinators: *Simon Turner & Janet Hergt*

Team Members: *Jon Davidson, Monica Handler, Katie Kelley, Tracy Rushmer & Doug Wiens*

Session 06a: Volatiles in subduction zone magmas, from the slab to the surface

Convenors: *Katherine Kelley & Roberto Moretti*

Keynote: *Paul Wallace*

Volatiles play a central role at subduction zones, influencing processes as varied as mantle melting, element transport, crystallization, magma migration and degassing. The impact and inter-relationships of volatile elements and species (e.g., H₂O, CO₂, S species, Cl, F, etc.) in subduction zone slab, mantle, and magmatic systems are essential components of this complex tectonic setting, and this session aims to present a comprehensive portrait of the current state of volatile studies at all levels through the subduction zone. This session welcomes all contributions from theory, models, experiments and measurements about the volatile cycle from the slab to the surface, including slab devolatilization, volatile fluxes and geochemical budgets, volatile solubility and physico-chemical properties of melts and HT fluids, melting and metasomatic processes, and pre- to syn-eruptive magma conditions as recorded by melt inclusions and phase equilibria.

Session 06b: Experimental constraints on conditions of melting beneath arcs

Convenors: *Tracy Rushmer & Carmen Sanchez-Valle*

Keynote: *Jim Brophy & Craig Manning*

Melting within the subduction zone environment, whether triggered by dehydration of the slab, magma generation at the base of the arc, or direct melting of the slab itself is the fundamental mechanism by which we grow and evolve continental crust. This session invites contributions to those working on obtaining experimental data and/or theoretical calculations which constrain chemical compositions and thermodynamic properties of melts and fluids at conditions relevant to arc magma genesis. Topics to be addressed include melt-solid phase relations, partial melting in arc environments, high pressure fluids and their role in arc system processes and application of data sets to field observations.

Session 06c: Novel tracers of slab components and new insights into the evolution of arc magmas

Convenors: *Monica Handler & Adam Kent*

Keynote: *Tim Elliott*

Our understanding of crustal and fluid recycling and magmatic evolution at subduction zones is being revolutionised through the application of increasingly diverse non-traditional geochemical tracers, ranging for example, from light elements (e.g. Li, Be, B, N) to chalcophile elements (e.g. Re, PGE), halogen and transition metal stable isotopes to U-series isotopes. This session seeks contributions that utilise non-traditional and novel geochemical tracers to investigate subduction zone processes, including timescales and mechanisms, from deep recycling through to high-level magmatic processes. Contributions that integrate several approaches or highlight novel applications of abundance or isotopic systems are particularly encouraged.

Session 06d: From Fiji to western Pacific arcs and beyond - a session in honour of Jim Gill

Convenors: *Erin Todd*

Keynote: *Simon Turner*

The aim of this session is to highlight current research that stems from two topical areas identified with the career of Jim Gill: the geochemistry of arc and backarc magmas; and the application of U-series to magmagenesis in all tectonic environments. Now 28 years after publication of his authoritative "Orogenic Andesites and Plate Tectonics," his legacy among contemporary subduction-zone themes is extensive. Suggested topics include (but are not limited to): 1) What is the composition of slab-derived fluids and melts released during subduction? 2) What is the effect of these fluids and melts on mantle melting? 3) What are

the effects of water and fO₂ on the differentiation of arc magmas? 4) What temporal and spatial geochemical trends are characteristic and fundamental to magma formation in arcs and back-arcs? 5) What is the time scale of igneous processes as inferred from U-series disequilibria? We particularly encourage submissions by Gill's students, peers, and collaborators.

Session 06e: Seismic, Geodynamic, and Mineralogical constraints on arc and backarc processes

Convenors: *Doug Wiens, Carmen Sanchez-Valle & Peter Ulmer*

Keynote: *Peter van Keken*

Geodynamic models allow study of many important processes in subduction zones, including mantle flow patterns, magma production processes, and the cycling of material including volatiles through the system. Seismic observations provide important constraints on these models, but require experimental and computational results relating seismic observations to physical properties. In this interdisciplinary session, topics will include seismic studies of arc seismic structure and anisotropy, geodynamic models of arc processes, and theoretical and laboratory constraints on the relationship of seismic velocities, attenuation, and anisotropy to mantle temperature, mineralogy, deformation, and melt and volatile content.

Session 06f: Chemical/isotopic composition and evolution of slab components with progressive subduction:

1) From seafloor down to forearc depths, including subduction channel processes,

2) From forearc to subarc depths and beyond

Convenors: *Thomas Pettke, Carl Spandler, Ivan Savov & Timm John*

Keynote: *Marco Scambelluri*

Subduction recycles crustal components through convergent plate magmatism and back into the deep mantle. This session focuses on the quantification of chemical and isotopic compositions of subduction zone inputs, the progressive metamorphic processing of slab materials, the characteristics of fluids/melts released from the slab, their interaction with the mantle wedge, and inputs to the deep mantle. These data provide direct constraints on key aspects of arc magmatism and deep mantle refertilization, in both modern and ancient environments, with relevance extending to OIB and other intra-plate magma types. This platform shall foster an integrated discussion on metamorphic processes in subducted slabs and document their chemical/isotopic relevance on Earth's mantle dynamics. We solicit contributions from field-based, experimental and numerical geochemistry/petrology, geophysics, and research potentially related to subduction zone inputs / outputs. Sub-session 1 convened by IS & TJ. Sub-session 2 convened by TP & CS. One common, prominent poster session.

Theme 7: Evolution of Earth's Surface Environment

Coordinators: *Tim Lyons & Sasha Turchyn*

Team Members: *Ariel Anbar, Galen Halverson, Hugh Jenkyns, Lee Kump, Gordon Love & Isabel Montanez*

Session 07a: Oxygen over Earth History: The Great Oxidation Event, Oxidation of the Proterozoic Ocean-Atmosphere, and the Terminal Proterozoic Transition

Convenors: *Galen Halverson, David Fike & Ariel Anbar*

Keynote: *Jochen Brocks & Simon Poulton*

This session focuses on the application of geological, geochemical, and geobiological approaches to constrain the rises (and falls) of atmospheric oxygen and the evolution of ocean redox over Earth history. The session will be divided into three parts: (A) The Great Oxidation Event; (B) Oxidation of the Proterozoic Ocean-Atmosphere; and (C) the Terminal Proterozoic Transition. Specific approaches may include biomarkers, paleontology, mass-dependent or mass-independent S isotopes, light (e.g., C, N), or heavy stable isotopes (e.g., Fe, U), and trace metal abundances. Preference will be given to those submissions involving new analytical techniques or multi-disciplinary approaches. Modeling- and theoretically-based submissions are also encouraged.

Session 07b: Terrestrial records/analogs of modern and ancient climate change

Convenors: *Matt Lachniet, Neil Tabor & Joe Werne*

Keynote: *Ian Fairchild*

The Earth's climate system leaves tantalizing clues of its past behavior in near-surface terrestrial environmental records. Recent advances in process- and proxy-based understanding of the physical and geochemical signatures of past climates and environments has permitted increasingly-detailed investigation of climate on timescales ranging from

Session 07c: Records of ocean anoxia and their impact on life, climate, and ocean chemistry

Convenors: *Gordon Love, Hugh Jenkyns & Tanya Goldberg*

Keynote: *Derek Vance*

The recognition of carbon and other elemental cycles as principal drivers of environmental evolution over geological timescales is based on detailed sedimentary records generated and interpreted by geologists, geochemists and computational modellers over decades of research. Not until relatively late in our planet's history, around 700-600 million years ago, did oxygen reach and then exceed the critical threshold required to establish and support basic animal life. The long-term burial of organic matter and iron sulfide minerals in sedimentary rocks are key processes controlling the maintenance of high levels of oxygen in the atmosphere since the late Neoproterozoic. Episodes of widespread deposition of organic-rich sediments on shelves and basins whose bottom waters were at least periodically anoxic/euxinic have been recognized throughout the Phanerozoic Eon and termed Oceanic Anoxic Events (OAEs). We seek exciting research contributions documenting and analyzing biogeochemical records of environmental and biological change through any of the Phanerozoic OAEs. Such contributions may describe fundamental shifts in: ocean redox structure, global climate and sea-surface temperature, primary production rates and microbial marine community structure, atmospheric pO₂ and pCO₂ estimates, as well as sedimentary organic-carbon/metal sulfide burial and preservation.

Session 07d: Geochemistry of extinction and radiation events

Convenors: *Lee Kump, Jonathan Payne & Tim Lyons*

Keynote: *Paul Wignall*

Because ecosystems depend fundamentally on the transfer of nutrient elements from the physical environment to organisms (and among organisms), it is perhaps not surprising that all of the major extinction and radiation events in the paleontological record are associated with short- or long-term changes in global (bio)geochemical cycles. Advances have occurred over the past several decades in the stratigraphic resolution of paleobiological and geochemical data and of the range of geochemical proxies available. Nevertheless, numerous questions remain regarding the general mechanisms linking environmental change to biological response and the ways in which these mechanisms have combined to produce observed extinction and radiation events in the fossil record. We welcome contributions to this session that address the geochemical causes and consequences of extinction and radiation events from a geochemical or paleobiological perspective. Observational and theoretical studies are encouraged.

Session 07e: Reconstructing Paleo-Atmospheric pCO₂ & Its Role in Long-Term, Extreme and Abrupt Global Climate Change through Earth History

Convenors: *Isabel Montanez & Mark Pagani*

Keynote: *Foster Gavin*

The link between rising atmospheric carbon dioxide and predictions of a warmer future are broadly recognized, but we still lack critical information that allows us to predict the rates and magnitudes of CO₂-forced climate trends, regional perturbations, and ecological responses that form the basis of social policies. Establishing a historical correspondence of CO₂ concentration to Earth's climate state over a spectrum of geologic conditions, refining our knowledge of specific climatic events in relationship to CO₂, as well as establishing the primary factors forcing the evolution of CO₂, provides the potential to understand the nature of climate sensitivity to CO₂ and the importance of associated feedbacks over time. In this session, we welcome abstracts that address the potential and limitations of established CO₂ proxy techniques as well as those proxies being refined and/or developed, and papers that establish CO₂ records over all time scales,

and relate scenarios of climate change to modeled or reconstructed alterations of the carbon cycle.

Session 07f: Cenozoic climate change: bridging model- and data-based approaches to reconstructing Cenozoic temperature and ocean/atmosphere chemistry

Convenors: *Sasha Turchyn & Jim Zachos*

Keynote: *Jeffrey Kiehl & Stefan Schouten*

Reconstruction of ocean chemistry and climate over the Cenozoic allows for an intimate study of paleoclimate over timescales from thousands to millions of years. Access to well-preserved ocean sediments spanning all ocean basins, coupled with detailed knowledge of other climate and tectonic variables, yields high-resolution analysis addressing climatic changes through both model- and data-based approaches. Furthermore, the last 65 million years have witnessed dramatic shifts in temperature, ice volume, and ocean chemistry, as well as more transient perturbations to the carbon cycle, thus offering a rich field for scientific inquiry. Resolving the timing, nature, and causes of these climatic changes will help us better understand and interpret paleoceanographic variability earlier in Earth history. In this session we seek contributions from scientists exploring all aspects of Cenozoic climate change. We are particularly interested in work using novel paleoceanographic techniques, model-based approaches, and new interpretations of existing data to quantify aspects of ocean chemistry and climate.

Session 07g: Isotopic and Chemical Tracers in Archaeometry – New Approaches and Applications

Convenors: *Jorge Spangenberg & Martine Regert*

Keynote: *Richard P. Evershed*

Biogeochemistry and isotope geochemistry are fundamental tools used in the study of changes in past climates, environments and evolution of ancient societies. Recent results have uncovered many new aspects of early socio-economic settings, including food availability, preparation and consumption, procurement strategies, palaeodiet, trading routes and migrations of populations. This session aims to bring together researchers from (organic and inorganic) chemistry, isotope geochemistry and archaeometry in order to describe new developments in the study of materials and artefacts recovered from archeological sites. Emphasis will be given to new analytical techniques and results of multidisciplinary case studies using geochemical, isotopic, mineralogical, botanical, and zoological methods. This session also aims to integrate contributions discussing the processes that affect the composition of archaeological remains and comparisons with modern reference materials.

Session 07h: The cosmogenic toolbox: Dates and rates of Earth surface processes

Convenors: *Tibor Dunai, Susan Ivy-Ochs, Finlay Stuart, Florian Kober & Nat Lifton*

Keynote: *Darryl Granger*

Terrestrial cosmogenic nuclides (TCN) provide quantitative constraints on the evolution of Earth's surface. The last decade has seen an explosion in the use of the workhorse nuclides, ^{10}Be and ^{26}Al , to disciplines such as glacial chronology. This has gone hand-in-hand with the refinement of analysis/interpretation of hitherto less commonly-used isotopes, ^3He , ^{21}Ne and ^{36}Cl , and the development of new isotopes, e.g. ^{14}C and ^{53}Mn . The resultant range of quantitative constraints on Earth surface processes now extends well beyond the exposure age, versus steady state erosion rate, options. This session seeks to tap into these recent developments to provide a flavour of the new applications of TCN. Furthermore we solicit papers on methodological work at the foundations of the techniques, such as refinement of production rates, decay constants, and issues of scaling.

Session 07i: Rates and mechanisms of erosion and weathering processes: from experiments to models

Convenors: *François Chabaux, Susan Brantley, Yves Godderis & Mohammed Rafi Sayyed*

Keynote: *Niels Hovius*

The aim of this session is to bring together researchers from different scientific communities working on different aspects of erosion and weathering across a range of temporal and spatial scales. We seek investigators using the full range of experimental and modeling approaches to investigate geomorphologic,

geochemical and biological parameters and their coupling on the weathering and erosion processes, in natural as well as experimental environments. We especially encourage contributions focusing on how the rates of weathering and erosion processes and the coupling between soil production and sediment transport are influenced by climate variability, tectonic activity and human disturbance, and how paleo-records can help to recover variations of these parameters over geologic time. This session is open to the study of weathering/erosion systems from the past to the present day. It also includes studies on the geochemistry of intra-basaltic weathering horizons and sediments from the flood basalts as such thermally altered palaeosols are considered as analogues of the Martian surface.

Theme 8: Interfaces and Interfacial Processes from the Nano- to Continental Scale

Coordinators: *Stephan Kraemer & Patricia Maurice*

Team Members: *Gordon Brown, Ruben Kretzschmar, James Rustad, Kristina Straub & Art White*

Session 08a: Mineral/water interface chemistry: The legacy of Stumm and Schindler and what we have learned since

Convenors: *Gordon Brown & Janet Hering*

Keynote: *James Leckie*

Werner Stumm (1924-1999) (EAWAG, Swiss Federal Institute of Technology, ETH) and Paul W. Schindler (1927-2006) (Department of Inorganic Chemistry, University of Bern) left us a rich legacy of concepts (surface complexation modeling, surface coordination theory, surface ligand exchange, dissolution and corrosion mechanisms, surface catalyzed redox reactions, photocatalytic processes, rate laws for surface controlled reactions) and key experimental studies that laid the foundation for many of our modern views of mineral/water interface chemistry. This symposium will explore the Stumm-Schindler legacy through modern applications of surface complexation modeling at mineral/water interfaces and the applications of new experimental and theoretical methods to mineral/water interfaces and the sorption and dissolution processes that occur at these interfaces. It will also explore the use of these models in a particular focus of the symposium will be on what we have learned since the seminal studies of these two giants of mineral surface chemistry.

Session 08b: Stable isotope signatures in interfacial systems

Convenors: *James Rustad, Dave Sherman & Jay Black*

Keynote: *Abby Kavner & Laura Wasylenki*

Several recent studies have been concerned with the fractionation of stable isotopes by interfacial processes. Understanding interfacial processes is of great benefit to geochemists trying to understand the significance of isotopic signatures measured in ancient environments. Stable isotope signatures are, likewise, a potentially unique constraint on fundamental interfacial processes and reactivity. This session gathers together geochemists interested in both stable isotope fractionation and mineral water-interfaces.

Session 08c: Microbial cycling of iron minerals

Convenors: *Kristina Straub & Thilo Behrends*

Keynote: *Joel E. Kostka*

Microbially mediated redox and mineral transformations of ferric and ferrous iron play a pivotal role in the biogeochemical cycle of iron on Earth. This session is devoted to new findings on the contribution of prokaryotes to the global cycling of iron. Areas of special interest include I) rates, mechanisms and ecology of microbial iron oxidation or reduction, II) involvement of prokaryotes in changing the iron cycle during Earth's history, III) importance of prokaryotes for the supply of iron as nutrient for eukaryotes and IV) microbially controlled or induced iron mineral formations.

Session 08d: Biogeochemical processes at redox interfaces

Convenors: *Ruben Kretzschmar & Scott Fendorf*

Keynote: *Andreas Kappler*

Strongly fluctuating redox conditions or pronounced redox gradients occur in aquifers, lake sediments,

wetlands, and soils. Redox reactions and resulting transformations of minerals and natural organic matter have strong effects on the behavior and cycling of nutrients, potentially toxic trace elements, and organic pollutants in the environment. This symposium will highlight recent advances of the understanding of biogeochemical redox processes under fluctuating or spatially heterogeneous redox conditions. Interactions between microorganisms, minerals, organic matter and the speciation and mobility of trace elements and organic pollutants will be of special interest.

Session 08e: Environmental nanoparticles and nano-scale processes

Convenors: *Patricia Maurice & Frank von der Kammer*

Keynote: *Alain Manceau*

Nanoparticles (1 - 100 nm) and colloids (1 – 1000 nm) are ubiquitous in the environment and it seems evident that these natural nanoparticles play important roles in aquatic processes. Due to their high surface area to mass ratio they represent a relevant and in some systems the dominant provider of reactive surface sites. Nanoparticles contribute to soil genesis, element cycling, transport processes and influence the mobility, bioavailability and toxicity of contaminants and Moreover it has been observed that aquatic chemical reactions may be catalyzed by certain materials at certain particles sizes, which would mean that a “nano-effect” is not only existing for engineered particle systems but also for natural ones. We invite contributions which in particular address the occurrence, behavior and environmental roles of natural colloids and nanoparticles, including the nanoparticles formation, relocation, nanospecific reactions and analytical characterization of natural nanoparticles or nanostructured surfaces.

Session 08f: Bridging the gap between theory and the field in critical zone processes

Convenors: *Art White & Kate Maher*

Keynote: *Susan Brantley*

Significant recent research is focused on the critical zone, which defines the shallow segment of the earth's surface produced by chemical and physical weathering and subjected to the influences of biology, hydrology, climate and anthropogenic manipulation. This session will focus on how recent advances in our understanding of geochemical kinetic theory from experimental and modeling approaches can inform us about complex soil and regolith environments and vice versa. The session will explore how current and future developments in integrated field-oriented studies can be used to isolate controlling variables and further advance our understanding of fundamental geochemical theory and processes.

Session 08g: Structure and Reactivity of Organic Species at Mineral Surfaces

Convenors: *Owen Duckworth, Alan Stone & Stephan Kraemer*

Keynote: *Stephan Hug*

In this session, we seek to probe the fundamental environmental role of organics, including biomolecules (e.g., siderophores, enzymes, surfactants, low molecular mass organic acids, and exopolysaccharides) and xenobiotics (e.g., agrochemicals, pharmaceuticals, industrial chemicals, and other pollutants), at surfaces. Specific topics of interest are physical and chemical mechanisms of growth and dissolution (thermal or photochemical), surficial coordination of organics and metal-organic complexes, and chemical transformations of organics at surfaces. We particularly invite contributions that approach this topic at laboratory to field scale studies using wet chemical, isotope, spectroscopic, microscopic, mass spectrometric, and/or geomicrobiologic methods.

Session 08h: The thermodynamics and kinetics of water-rock interaction. A celebration of the career of Jacques Schott

Convenors: *Eric Oelkers*

Keynote:

This session fills a current gap in the program; the lack of a session aimed at the acquisition of fundamental data for describing the equilibrium state and rates at the mineral fluid interface. The session will also provide a focus for this subject in conjunction with a proposed MSA/GS short course on the Thermodynamics and kinetics of water-mineral reactions to be held just before the Goldschmidt meeting in Davos. Finally this

session highlights the career of Jacques Schott at his official retirement. Though often soft spoken, he has been one of the most productive geochemists over the past generation; he is the number one publisher of papers in GCA and the number three publisher of papers in Chemical Geology over the past decade.

Theme 9: Earth's Resources I: Origin and Sustainable Exploitation of Oil/Water/Gas systems

Coordinators: *Barbara Sherwood Lollar & Mike Lewan*

Team Members: *Geoffrey Ellis, Steven Harris, Brian Horsfield, Johanna Lippmann-Pipke, Anna M. Martini, Lisa Mary Pratt & M. Cathryn Ryan*

Session 09a: Energy and the Environment: Fluid/rock interaction

Convenors: *Susan Stipp, Bruce Yardley & Yousif Kharaka*

Keynote: *Tor Austad & Sigurdur Gislason*

This session welcomes contributions about the interactions between fluids and solids – the geochemical processes, properties and behaviour in the water/gas/hydrocarbon/porous rock system. It includes topics such as migration of oil and gas; pore surface properties; wettability/surface tension controls on flow; reactivity of gases and solutions in porous solids; CO₂ sequestration in sedimentary formations; mineralisation of CO₂ in porous rocks; sources and sinks for non-hydrocarbon gases (H₂S, CO₂, N₂); modelling of geochemical or basin chemical evolution; isotopic studies of rocks; groundwater or fluids; diagenesis; and many other topics. Research can be fundamental or applied, experimental or theoretical.

Session 09b: Role of metals in understanding the origins of petroleum

Convenors: *Joseph Curiale & David Selby*

Keynote: *Mike Lewan*

Although the association of organics and metals has always been a topic of interest in organic geochemistry, most of the studies have focused on metallic ore deposits. This session will focus on how metals provide insights on the origins of petroleum. The session objectives are broadly defined, and topics will include age dating of crude oils and their time of generation, metal catalysis in hydrocarbon generation, metals serving as correlation parameters among oils and their source rocks, and petroleum metal sources from mantle fluids.

Session 09c: Thermal stability of petroleum in the Earth's subsurface

Convenors: *Simon George & Yongchun Tang*

Keynote: *Xianming Xiao*

Recent fluid-inclusion studies continue to show that petroleum exists in host rocks that have experienced prehnite-pumpellyite and amphibolite-grade metamorphism, which contradicts results from experimental studies on hydrocarbon thermal stability. Further, petroleum is known to exist in some very high temperature (>190°C) reservoirs, showing that the previous paradigm of oil destruction by 120-150°C is invalid. The start of oil-to-gas cracking likely depends on pressure, oil type, presence of catalysts and whether it is an open or closed system, but the precise controls remain poorly defined. This session is intended to bring together researchers working on this issue based on fluid inclusion, oil-cracking experiments, and natural gas exploration.

Session 09d: Shale gas, coalbed methane and novel sources of natural gas

Convenors: *Brian Horsfield & Anna M. Martini*

Keynote: *John Zumberge*

Unconventional natural gas deposits from coalbeds and shales are among the most rapidly expanding gas plays worldwide. These resources are self-sourced via thermogenic or microbial processes and often contain a mix of both. The gas occurs in both the free and dissolved states, and in many cases the majority of the gas is adsorbed within the organic-rich, low permeability matrix. While high energy costs and advances in fracturing and horizontal drilling technology have enabled these gas resources to become a lucrative reality, the complex processes essential to their formation is poorly constrained. This session will also examine "frontier" unconventional targets including gas hydrates on continental margins and in

permafrost regions. Our session seeks to emphasise the interplay of chemical, physical and biological processes acting at various scales of time and space in unconventional gas systems. We hope to attract contributions from geochemists, geologists, and geomicrobiologists to address fundamental issues pertinent to both exploration and production.

Session 09e: The role of sulfur in petroleum systems

Convenors: *Geoffrey Ellis & Zeev Aizenshtat*

Keynote:

Although geochemists have long recognized the importance that sulfur plays in every stage of petroleum generation and accumulation, there is an increasing need for a greater understanding of the role of sulfur in petroleum systems. New restrictions on sulfur content in diesel fuel and dwindling supplies of low-sulfur crude oil are just two examples of the importance of sulfur to the world's petroleum industry today. This session will cover the latest advances regarding the geochemistry of sulfur in petroleum systems including (but not limited to) such topics as: bacterial sulfate reduction (BSR), effect of sulfur content on kerogen and oil thermal stability, thermochemical sulfate reduction (TSR), kinetics of sulfur mediated reactions, identification and application of sulfur-compound biomarkers, and applications of sulfur stable-isotopes in petroleum geochemistry. This could include field, laboratory, and theoretical based studies and might encompass the sub-disciplines of organic and inorganic geochemistry, stable isotopes, as well as molecular and aqueous thermodynamic modeling. This session will potentially attract researchers working in the areas of petroleum systems modeling, reservoir characterization, and unconventional hydrocarbons (e.g., heavy oils) among others. Moreover, work in this area has important implications beyond those directly related to petroleum systems including impacts on economic geology (e.g., sulfide mineral deposits) and environmental geology.

Session 09f: Understanding hydrocarbon biodegradation: field and laboratory approaches

Convenors: *Steven Harris & Julia Foght*

Keynote: *Rainer Meckenstock*

Biodegradation of hydrocarbons in petroleum reservoirs is one of the main controls on the occurrence, composition and quality of natural gas and crude oil. The majority of the global petroleum inventory is biodegraded, which has severe implications for exploration and production. In addition, biodegradation is a primary mechanism for remediation of hydrocarbon-contaminated environments. This session will focus on the role of microorganisms in hydrocarbon biodegradation in the environment and the salient laboratory approaches and experimental tools used to understand the processes as they occur in the field. Furthermore, this discussion will comprise an assessment of the biotic and abiotic factors that influence the rate and extent of hydrocarbon metabolism by diverse microorganisms in a variety of habitats. Topics within this session may range from biodegradation of hydrocarbon pollutants to the role of microbes in enhancing energy recovery from fossil fuels. Other important topics include new and improved approaches to assess the mechanisms and effects of bioactivity, including but not limited to compositional characterization of hydrocarbons and polar non-hydrocarbons, isotopic signatures of organic and inorganic components, and modeling of microbial processes from the molecular to the basin scale. Given the nature of this theme, contributions representing a range of disciplines are encouraged to address these issues and advance our understanding of this critical field of research.

Session 09g: Future impacts on hydrogeological resource potential and quality: Global change and implications for the future of water resources in arid and semi-arid regions

Convenors: *Avner Vengosh, Wolfram Kloppmann & Micheal Edmonds*

Keynote: *Fred M. Phillips*

Multi-model predictions of the Intergovernmental Panel on Climate Change suggest a significant reduction in precipitation in arid and semi-arid zones, such as the southwestern USA, the Middle East, and Northern Africa. The rapid population growth in these areas has led to increasing pressure on these already stressed resources; a drier future will only exacerbate the water crisis in these regions. This session aims to explore the fate of groundwater resources in arid zones and to investigate future prospects of these diminishing

sources. This session will address scientific approaches to quantify the impacts to groundwater resources via field based, experimental, and modeling techniques to predict and guide future management of these resources, aiming to elucidate future trends in water quantity and quality. Topics may include: near-term and long-term impacts of climate change on water resources in water-scarce areas, shifting water uses due to urbanization, seawater intrusion, and land-use changes, sustainability of using fossil groundwater, impact of increasing hydrocarbon and metal resource extraction, desertification, and salinization.

Session 09h: Reactive transport processes in groundwater systems

Convenors: *Adam Foster & Brian Katz*

Keynote: *olivier Atteia*

There are a myriad of processes that can influence the movement of chemical constituents in aqueous systems and have the potential to profoundly alter the geochemistry of the environment. Accurate predictions of the ultimate fate of any molecule in natural systems involve an accurate description of these interrelated reactions as they occur on a molecular level and affected by biogeochemical conditions. This symposium will address issues related to aqueous geochemistry including the complex interplay of organic and inorganic compounds with biotic and abiotic phases in the environment. Subject matter will include research on the reactive processes that affect the movement of chemical constituents in surface waters and aquifer systems and the interactions between these two systems, including phenomena that influence the speciation, transport, and fate of compounds in pristine as well as contaminated environments. Studies advancing our understanding of a variety of aqueous geochemical reactions are welcomed.

Theme 10: Earth's Resources II: Origin and Sustainable Exploitation of Fluids and Ore Deposits

Coordinators: *Chris Heinrich & Katy Evans*

Team Members: *Cornel de Ronde, Bernhard Dold, Hiroshi Ohmoto, Urs Schaltegger & Gordon Southam*

The following eight sessions will investigate the geochemical processes contributing to the formation, localisation and preservation of ore deposits, and explore our future requirements of mineral resources on a global scale. Global geochemical processes have changed through Earth's history, and the feedbacks between the evolution of lithosphere dynamics and the composition of ocean and atmosphere have controlled the formation and preservation of distinct mineral deposits since the Archean to the present. Session topics focus on processes over a large range of scales, from the plate dynamics giving rise to large mineralized provinces, through the modelling of ore-forming hydrothermal systems including the duration of contributing processes, down to nano-scale microbial activity in nature and in experimental laboratory studies of mineral - fluid interactions.

Session 10a: Natural resources and future technological development

Convenors: *Kristín Vala Ragnarsdóttir*

Keynote:

Today's technology relies on many mineral resources that now are becoming scarce. This session aims to bring together geochemists and engineers, physicists and chemists in order to discuss which materials need to be abandoned in technological development due to their scarcity and which replacement possibilities exist. Can we rely on aluminium and silicon for future technology? Where can we obtain necessary data to complete material-cycle analysis for all metals? How can we close the material cycles?

Session 10b: Redox evolution of the Earth and its influence on ore mineralization

Convenors: *Hiroshi Ohmoto & Mark Barley*

Keynote: *Mark Barley*

This session intends to bring together astrobiologists, petrologists and geochemists to exchange recent ideas concerning: (1) the redox evolution of the mantle, crust, atmosphere and oceans through geologic time, and (2) its effects on: (a) the evolution of the biosphere and (b) geochemical cycles and ore formation of redox-sensitive elements (e.g., S, C, Fe, Mn, Mo, Cu, Sn, W, Au, Ag, U, Cr, REEs).

Session 10c: Biogeochemical cycling: Linking the biosphere to mineral deposits

Convenors: *Gordon Southam*

Keynote: *James Saunders*

The near surface distribution and contribution of the biosphere to low temperature geochemical processes has important implications for the geochemistry, distribution and mineralogy of metals in the environment, with implications for the exploration & formation of ore deposits, and for the bioremediation of contaminated systems.

Session 10d: Experimental Studies and Numerical Modelling of Hydrothermal Ore Formation

Convenors: *Katy Evans & Gleb Pokrovski*

Keynote: *Terry Seward*

Prediction and understanding of hydrothermal ore-forming processes require constant improvements to experimental datasets upon which conceptual and numerical models are based, but they also depend on suitable algorithms for numerical models to enable simulating geological reality. Areas of rapid advance include the thermodynamics and hydrodynamics of multiphase fluid-melt-mineral systems, the geochemical behaviour of trace elements, and the coupling between deformation and reactive fluid flow. This session welcomes experimental, theoretical, and analytical contributions that deal with quantitative aspects of the chemistry and physics of ore-related fluid phases and fluid-rock interactions that result in metal mobilization, transport and precipitation as hydrothermal ore deposits.

Session 10e: Large-Scale Tectonic Controls on Fertility of Magmatic Suites for Ore Genesis

Convenors: *Jim Mungall & Steve Barnes*

Keynote:

This session will focus on the petrogenetic processes that dictate the potential for a magma to become the progenitor of an ore deposit, rather than on the ore deposits themselves. All deposit types - whether magmatic or hydrothermal in origin - whose main fluxes of economic elements are derived from magmas constitute suitable topics. Examples include the conditions required to generate U-rich S-type granites in collisional zones, the origins of the magma parental to the numerous deposit types found in the Bushveld complex, or the optimal conditions for the formation of Au-rich magmas in volcanic arcs.

Session 10f: Seafloor Hydrothermal Systems Associated with Volcanic Arcs

Convenors: *Cornel de Ronde & Richard Arculus*

Keynote: *Bob Embley*

This session will include all aspects of submarine hydrothermal systems related to volcanic arcs and back-arc settings, including: (1) the petrology, volcanology and geochemistry of volcanoes known to host hydrothermal systems, (2) the geophysics of submarine hydrothermal systems, particularly with respect to delineating subseafloor hydrology and magma bodies, (3) the distribution of vent fields and associated alteration zonation and mineralization, and (4) the composition of vent fluids and their impact on active ore formation and the global oceans.

Session 10g: Resolving Timescales of Magma Degassing and Ore Formation

Convenors: *Urs Schaltegger & Thomas Driesner*

Keynote: *Lukas Baumgartner*

Time scales relevant to ore formation in magmatic systems are likely to vary from as short as decades to millions of years, and even shorter periods are involved with volcanic degassing and eruption. Precise geochronology has substantially developed in the last years, delivering more precise and accurate age data. Numerical modeling predicts the various time scales and rates of the various processes involved. However, attempts to link the two complementary approaches have been sparse. This session invites contributions from both fields in order to identify synergies and strategies that may lead to a better constrained understanding of the time-scales of ore-forming magmatic and magmatic-hydrothermal processes.

Session 10h: Fluids, Melts and Wall Rocks: Processes of Metal Enrichment in Magmatic-Hydrothermal Ore Deposits

Convenors: *Adam Simon, Sarah Penniston-Dorland & Jacob Hanley*

Keynote:

This session focuses on field, geochemical, experimental and theoretical evidence for the integrated role played by fluids, melts and wall rocks in concentrating metals in magmatic-hydrothermal systems ranging from layered mafic intrusions to porphyry Cu-, Mo-, Au- systems. The session will address mineral-scale to magma-chamber scale processes, including (i) the relative importance of magmatic vs. hydrothermal events in PGE and chromite ore formation (ii) the influence of metal and sulfur content of ore-forming magmas and fluids, and the role of oxygen and sulfur fugacity; and (iii) the transport dynamics of melts and fluids at the intrusion scale. Contributions related to the application of novel analytical or experimental approaches in quantifying ore-forming processes are encouraged.

Theme 11: Climate Change: Processes and Records

Coordinators: *Jess Adkins & Gerald Haug*

Team Members: *Mark Cane, Larry Edwards, Valérie Masson-Delmotte & Daniel Sigman*

Session 11a: The history of ENSO and ITCZ variability, from the Holocene to the Pliocene

Convenors: *Gerald Haug & Ralf Tiedemann*

Keynote: *Christina Ravelo*

The behavior of ENSO during the past is thought to have experienced significant changes since the Pliocene possibly related to coupled ocean-atmosphere dynamics of the ITCZ and controlled by different processes on different time-scales. The paleo-migrations of the ITCZ, the exact nature of these changes and their underlying causes are not well understood. To constrain such changes, this session welcomes contributions addressing past changes in Pliocene to Holocene ITCZ and ENSO variability from seasonal to million year timescales. We also encourage contributions that integrate proxy data and model scenarios to better understand the mechanisms, feedbacks, dynamics and spatial impacts of such changes.

Session 11b: The sequence of events at glacial terminations

Convenors: *Valerie Masson-Delmotte & Edouard Bard*

Keynote: *Nelia Dunbar & Rickaby Ros*

Glacial Terminations are amongst the largest past climatic changes and their understanding a major scientific challenge. These periods experienced complete reorganizations of all climate compartments, e.g. atmosphere, ice sheets and ocean, together with their associated ecosystems and biogeochemical cycles. These fascinating periods involve transient variations at various spatial and temporal time scales. It is only recently that dating has become sufficiently accurate and precise to allow detailed comparisons of the sequence of events between different Terminations and to enable meaningful comparisons with model simulations performed in a transient mode. Comparing Termination records of sea level, temperature and atmospheric content of greenhouse gases is of particular relevance and has received much attention recently, even outside the scientific community. In addition, Termination records are now available at a global scale, including tropical sites that are very remote from the main center of variation linked to the melting of former ice-sheets. In this session, we welcome abstracts based on various archives and different Terminations, in order to illustrate the progress and remaining questions in this inspiring research field.

Session 11d: Polar ocean process affecting atmospheric CO₂, past and present

Convenors: *Daniel Sigman & Ralph Keeling*

Keynote: *J. R. Toggweiler*

The polar ocean, and the Southern Ocean in particular, has emerged as a region likely playing a major role in the glacial/interglacial carbon dioxide changes. Recent studies also suggest that the Southern Ocean's role in the uptake of anthropogenic carbon dioxide is highly sensitive to climate change. However, an adequate understanding of these polar systems is challenging owing to the complexity of its physical processes and their interaction with surface ocean productivity. In this session, we seek insight from modern and paleoclimate observations and from models to explore the relevance of the polar oceans in regulating atmospheric carbon dioxide on all time scales.

Theme 12: Sources, Sinks and Impact of Atmospheric Aerosols

Coordinators: *Cristina Facchini & Yinon Rudich*

Team Members: *Tami Bond, Peter Liss, Ulrike Lohmann, Surabi Menon & Spyros Pandis*

Session 12a: Organic aerosols: identifying the underlying unknowns

Convenors: *Yinon Rudich & Cristina Facchini*

Keynote: *Allen Goldstein & Maria Kanakidou*

Current research identifies anthropogenic and natural organic aerosol as major uncertainty in climate research. The organic component contributes to the formation, mass, and properties of primary and secondary aerosols. In this session we will query what are the main formation mechanisms, do we account for all of them, what are the relevant properties of the aerosol organic component and how they tie to the large framework of climate and air quality.

Session 12b: Aerosol, precipitation and weather patterns

Convenors: *Ulrike Lohmann & Bjorn Stevens*

Keynote: *Meinrat O. Andreae & Zev Levin*

Aerosols can interact with clouds and precipitation in many ways, acting either as cloud condensation or ice nuclei, or as absorbing particles, redistributing solar energy as thermal energy inside cloud layers. Also, by increasing aerosol and cloud optical depth, anthropogenic emissions of aerosols and their precursors contribute to a reduction of solar radiation at the surface, which affects the surface energy budget, the hydrological cycle and possible weather patterns.

Session 12c: Aerosol and air quality: from local to global scale

Convenors: *Spyros Pandis & Mark Z. Jacobson*

Keynote: *Daniel Jacob & Ted Russell*

Processes contributing to air quality problems including high particulate matter concentrations (both mass and number) take place in scales ranging from the local to the global. This session will focus on recent developments in our understanding of these processes and their interactions as well as the remaining research challenges.

Session 12d: Global aerosol source and sink processes

Convenors: *Tami Bond & Natalie Mahowald*

Keynote: *Laura Gallardo & Joseph Prospero*

This session focuses on atmospheric aerosol cycles by following individual aerosol types, from source to sink to deposition records. Dust, organic matter and black carbon are highlighted here, but other species are welcome.

Session 12e: Aerosol impacts on climate, energy and the economy

Convenors: *Surabi Menon & Jon Egill Kristjánsson*

Keynote: *Filippo Giorgi*

This session will cover topics that relate to aerosol effects on global climate change from the past to the future. This includes physical process treatments, feedbacks, uncertainties and impacts. The choice of energy sources, including renewables, on aerosol and greenhouse gas emissions, plus their corresponding impacts on climate, energy production and the economy will also be considered.

Session 12f: Why the Ocean is Important for the Atmosphere and Vice Versa

Convenors: *Peter Liss & Colin O'Dowd*

Keynote: *William Keene & Roland von Glasow*

Marine aerosol both primary (sea spray generation) and secondary (reaction products of trace gases emitted from the ocean) contribute to both air quality and climate change through modification of haze and cloud layers. Conversely, land-derived dust containing Fe, N and P is transported over and deposited onto the oceans where it can affect biological activity, which can potentially feed back to trace gas formation and

Theme 13: Global Geochemical Challenges: Past Record and Future Impact

Coordinators: *Eric Achterberg & Axel Kleidon*

Team Members: *Guy Munhoven, Daniela Schmidt, Klaus Wallmann & Ning Zeng*

Session 13a: Ocean acidification: past, present and future

Convenors: *Guy Munhoven, Daniela Schmidt & Andy Ridgwell*

Keynote: *Lee Kump*

The ocean will absorb increasing amounts of CO₂ from the atmosphere if fossil fuel emissions continue unabated. The resulting decrease in the pH of surface waters, dubbed 'ocean acidification' will push ocean geochemistry outside of the envelope of at least the last few tens of millions of years. There is concern regarding what the implications such changes in environmental conditions will have for living organisms in the ocean, particularly those which make calcium carbonate (CaCO₃) shells and skeletons. What do we know about past records of ocean acidification? How large were these carbon cycle perturbations and how long did they last? How fast will ocean acidification affect changes in calcite and aragonite saturation horizons in the future and when will areas of the surface ocean become undersaturated? This session welcomes all possible aspects of analysis of ocean acidification, from geological records of past events via measurements of current changes in ocean's pH and biogeochemical models.

Session 13b: The global carbon cycle: Can the past say something about the future?

Convenors: *Nicolas Gruber & Gerald Haug*

Keynote: *Daniel Sigman*

Atmospheric CO₂ is already today higher than anytime during the last 800,000 years and is likely bound to exceed twice the pre-industrial level of 280 ppm within the next few decades. These changes will have a profound impact on Earth's carbon cycle and climate in the coming decades and centuries. Of particular concern is the possibility of positive feedbacks between the carbon cycle and climate, which could lead to an enhancement of anthropogenic climate change. The past can provide many insights into how oceanic and terrestrial processes responded to climate perturbations in the past and what the sign and magnitude of the feedbacks were. What lessons can we learn from this, and what can we expect for the future? This session invites presentations and posters addressing the interaction between the global carbon cycle (terrestrial and oceanic) and climate during the past, present, and future, and on time-scales from many millions of years to decades.

Session 13c: Expansion of oceanic oxygen minimum zones

Convenors: *Lothar Stramma & Denis Gilbert*

Keynote: *Nicolas Gruber*

Over the past five to ten years, changes in dissolved oxygen content has become a focal point of oceanic research. In the open ocean the oxygen content appears to decrease in most (but not all) areas, especially in the oxygen minimum zones. At the same time, low oxygen areas also known as "dead zones" have spread in the coastal oceans during the last decades. The oxygen change is an increasingly important topic due to its large impacts on the ecosystem and sedimentary feedbacks. A better understanding of the processes involved in oxygen change, the expansion of oceanic oxygen minimum zones and the interaction with the dead zones on the shelf shall be derived by discussing the present status of observations and modelling approaches of ocean oxygen changes in the geological past, in the last decades as well as from model predictions for the future.

Session 13d: Methane sources and sinks

Convenors: *Klaus Wallmann*

Keynote: *George Moridis*

The session will focus on past, present and future methane fluxes on a global scale. Interesting themes could be: Past methane fluxes: - Methane and climate during the Precambrian era - Global methane and

carbon fluxes during Precambrian glaciations - Global methane fluxes during the Phanerozoic - Global methane and carbon fluxes during the Palaeocene-Eocene Thermal Maximum (PETM) Modern methane fluxes: - The budget of modern atmospheric methane: Anthropogenic and natural sources - Global methane emissions from plants - Geological methane sources: Emissions from cold seeps, mud volcanoes and gas hydrates Future methane fluxes: - Methane emissions from melting permafrost deposits - Methane hydrate stability and anthropogenic climate change

Session 13e: Molecular Soil Biogeochemistry

Convenors: *Stefano Bernasconi, Michael W.I. Schmidt & Rienk Smittenberg*

Keynote: *Markus Kleber*

Soil organic matter is the largest terrestrial organic carbon sink, a key driver of soil formation and fertility and an important archive of paleo-environmental conditions. This session focuses on soil organic matter characterization using molecular and/or isotopic techniques. Covered topics include organic matter dynamics under a changing climate, soil organic matter sequestration, fluxes and cycling of individual compounds, paleo-environmental and archaeological reconstructions.

Theme 14: Ocean Chemistry Past and Present

Coordinators: *Martin Frank & Laura Robinson*

Team Members: *Ed Boyle, Anton Eisenhauer, Catherine Jeandel, Ellen E Martin, Jerry McManus & Bernhard Peucker-Ehrenbrink*

Session 14a: Present-Day Ocean chemistry and biogeochemical cycling of elements and metals

Convenors: *Ed Boyle & Robert Anderson*

Keynote: *Mak Saito*

This session will emphasize the marine biogeochemical cycles of trace elements and their isotopes (TEIs), focusing on sources, sinks and internal cycling of TEIs in the modern ocean. A small number of processes dominate the supply of TEIs to the ocean; e.g., dust, rivers, groundwater and exchange with sediments. Similarly, a small number of processes (e.g., biological uptake, chemical scavenging, ocean circulation) regulate their internal cycling and eventual removal. This session invites contributions that offer new insights into these processes. Certain TEIs are particularly diagnostic of specific processes (e.g., Al as a tracer of dust supply; Mn as a tracer of mobilization from reducing sediments; Nd isotopes as a tracer of sediment exchange; micronutrients as tracers of biological uptake and internal cycling). Contributors are invited to highlight findings from selected tracers that can be extrapolated broadly to a larger suite of TEIs. Presentations of new models that predict the transport and fate of TEIs introduced by human activities are invited as well.

Session 14b: New developments in marine geochemical and isotopic proxies

Convenors: *Anton Eisenhauer, Ben Reynolds, Morten Andersen & Basak Kisakurek*

Keynote:

This session will bring together scientists developing new and improving classical proxies for marine geochemistry and paleoceanography. Contributions are welcome which use trace element and isotope ratios as proxy in various marine archives like sediments, carbonates, corals, foraminifera and sclerosponges. Furthermore, we are highly interested in those contributions using biomarkers as proxy to reconstruct particular conditions of the past.

Session 14c: Past Ocean Circulation

Convenors: *Jerry McManus & Tina van de Flierdt*

Keynote: *Gideon Henderson*

The short history of modern oceanographic observations prohibits a full evaluation of how ocean circulation has operated and changed in the past. This limits our understanding of the ocean's influence on Earth's climate, and its potential role in past and future climate change. Trace-element and isotope geochemistry are powerful tools to constrain such changes. For this session we invite contributions addressing past ocean

circulation patterns from millennial to million year time-scales, and from the recent past to deep time. We also encourage contributions that integrate proxy data and models to understand the dynamics of past ocean circulation.

Session 14d: Ocean-Lithosphere exchange and Fluid-rock interaction

Convenors: *Bernhard Peucker-Ehrenbrink*

Keynote: *Katherine Kelley*

The interaction of low- and high-temperature fluids with the oceanic crust significantly modifies the chemical composition of seawater by adding or removing elements and by modifying their isotope composition. Hydrothermal alteration and microbial processes in the shallow oceanic crust also modify the chemical composition and mineralogy of the crust. This has important implications for the composition of the altered oceanic crust that returns into the Earth's mantle. We invite contributions from all related fields ranging from isotopic and elemental analyses, speciation-based studies, to mineralogical investigations including the effects that microbial alteration of oceanic crust has on chemical fluxes and isotope composition.

Contributions focusing on the microbiology, genomics and bioenergetics are referred to session 16f, 17j, and 16b or 19i, respectively.

Theme 15: Human Activities: Environmental Impact, Consequence and Remediation

Coordinators: *Jean-Francois Gaillard & Laurent Charlet*

Team Members: *Marc Amyot, Pablo Pasten, Jérôme Rose, Nita Sahai & Peter Santschi*

Session 15a: Geochemical Processes Controlling the Fate of Radionuclides in the Environment

Convenors: *Peter Santschi, Jordi Bruno & Lara Duro*

Keynote: *Thomas Fanghaenel*

Since the onset of the Manhattan project, fluxes of anthropogenic radionuclides through the environment increased. This has resulted in increased concentrations of a number of anthropogenic radionuclides in the various environmental reservoirs. Consequently, there is a growing need to understand and predict the consequences of increased fluxes of anthropogenic radionuclide, in relation to those of natural radionuclides. At the same time, the input of both anthropogenic and natural radionuclides can provide us, due to their radioactive decay, with the ability to get insights into time and spatial scales of key biogeochemical processes. The objective of this session is increased understanding of biogeochemical processes that control radionuclide cycling and their consequences in natural and anthropogenic systems, including: 1) Radionuclide speciation in aquatic, terrestrial and atmospheric compartments, including particulate and colloidal phases, and the role biological processes play in determining radionuclide mobility, oxidation state and degree of organic complexation. 2) Sources, production rates and sinks of radionuclides in the geosphere, including dissolution from primary phases, sorption and incorporation into secondary phases. 3) The use of natural radioisotopes to trace geochemical and biogeochemical processes in surface and subsurface environments by defining their space and time scales. 4) Geochemical and geochronological applications of natural and anthropogenic radionuclides in natural archives and reservoirs. 5) Geochemical controls on the dose to man and human health, relevant in population risk assessments and nuclear waste assessment models.

Session 15b: Geochemical vs. biological drivers of mercury accumulation in aquatic foodwebs in a changing environment.

Convenors: *Marc Amyot, Daniel Cossa & Tamar Barkay*

Keynote: *Robie Macdonald*

Mercury is a neurotoxicant that accumulates in aquatic food webs and presents a health hazard to fish consumers. Its accumulation in food webs is controlled by both geochemical and biological drivers, the relative importance of which is a subject of debate. These drivers are likely to be modified by climate change, the most extreme examples being encountered in high latitude aquatic systems. We welcome contributions on the geochemical controls of Hg bioavailability, on the biological controls of Hg accumulation in top predators, on the relative importance of geochemical vs. biological drivers of Hg accumulation and on

the anticipated impact of climate change on these various drivers.

Session 15c: The Environmental Consequences of Mining Earth Resources

Convenors: *Jean-Francois Gaillard & Laurent Charlet*

Keynote:

Since the antiquity humans have mined the surface of the Earth for resources to extract metals and fuels, and process rocks to manufacture cement and the built infrastructure. As a result, the beginning of the industrial revolution has lead humans to become the major agents of geochemical change. The goal of this session is to explore the environmental consequences of human activities related to using Earth materials. Contributions dealing with the environmental consequences of various practices in mining and industrial operations linked to extraction of natural resources are welcome. Examples of such activities include, but are not limited to, metal mining and processing, the extraction and utilization of coal and oil, cement manufacturing and the processing of uranium for energy generation. Presentations about more sustainable practices are also encouraged.

Session 15d: Medical Mineralogy and Geochemistry

Convenors: *Nita Sahai & Pedersen Joel*

Keynote: *Bice Fubini*

Medical Mineralogy and Geochemistry (MMG) is a highly interdisciplinary area of research emphasizing the complex reactivity of mineral surfaces with biological molecules, cells, and tissues in humans and other organisms. Research in this field seeks to understand normal and pathological processes that involve the interaction of dissolved inorganic species and bioorganic molecules with minerals. The range of issues includes medical conditions caused by specific mineral, exposure pathways, geospatial issues, pathogenesis, controlling equilibria and reaction mechanisms, and therapeutics. Discovery of cures often require a deep understanding of normal processes. We invite submissions on MMG studies using a range of experimental, spectroscopic, microscopic, and computational approaches. A partial, but by no means exhaustive, list of MMG topics includes: 1. the toxic and carcinogenic potential of inhaled dusts 2. mineral nanoparticle toxicity 3. heavy metal and radionuclide speciation in body fluids 4. etiology, epidemiology, pathogenesis, geospatial foci and potential genetic-environmental interactions of Guam Amyotrophic Lateral Sclerosis/Parkinsonism-Dementia Complex, Alzheimer's Disease, transmissible spongiform encephalopathies and related neurodegenerative disorders 5. formation of bones, teeth, otoconia, kidney stones, gout and gall stones, and "calcification" of vasculature 6. design and reactivity of ceramic and composite biomaterials for use as prosthetic implants 7. structure, design, and function of oxide-supported model cell membranes. The Keynote Speaker is Prof. Bice Fubini, University of Turin, Italy. The two Invited Speakers are, Prof. Alan T. Stone, Johns Hopkins University, USA and Prof. Laurent Charlet, University of Grenoble, France.

Session 15e: Nanomaterials in the Environment: Reactivity, Transport, and Toxicity

Convenors: *J rome Rose & Bernd Nowack*

Keynote: *Thilo Hofmann & Mark Wiesner*

The technological, scientific, and commercial developments inspired by nanoscience suggests a technological and industrial revolution that may have substantial environmental dimensions. In addition to considerable advances in the area of energy, water supply and remediation, unknown impacts of nanoparticles have created concern in particular regarding possible impacts on environmental and human health. Even though preliminary risk assessments of manufactured nanoparticles (NPs) are emerging, information on their behavior in the environment, bioavailability to biota and trophic transfer are largely lacking. Early studies on the ecotoxicity of nanoparticles, more observational and exploratory than mechanistic, have yielded incomplete and contradictory results. Therefore the aim of the session is to invite researchers involved in understanding the risks and impacts of nanomaterials in products and applications on ecosystems and the environment. The objective is to gather scientists involved in projects dedicated to a better understanding of their chemistry, analytics, mobility, bioavailability, aging, release and ecotoxicity in the environment.

Session 15f: Linking isotope biogeochemistry to water resource science: old questions, new directions, policy implications

Convenors: *Thomas Bullen & Stela Cuna*

Keynote: *Martin Elsner*

The use of isotopes in environmental science has increased considerably over the past several years, largely due to constantly improving analytical capabilities for accurate measurement of isotope compositions in liquids, organic solids and minerals at low "natural" concentrations. Both stable and radiogenic isotopes are powerful source tracers and process recorders that provide unique insight into the mechanisms controlling inorganic and biologic cycling of elements over a range of spatial and temporal scales. Isotopic approaches have found wide application in studies of hydrological systems for identification of sources, sinks, fluxes and residence times of both water and natural and anthropogenic solutes, including atmospherically-derived constituents, allowing increased understanding of biogeochemical processes in earth surface systems. Moreover, isotopic tracing techniques have provided enhanced perspectives for development of regulatory policy directed at critical societal issues such as assessment of water availability and monitoring of remediation activities at contaminated and sensitive sites. For this session, we seek contributions that describe laboratory and field experiments and monitoring activities that link isotope biogeochemistry to water resource science in the broad sense. We particularly encourage contributions that use the integrating power of isotopes to link natural and anthropogenic processes to effects having large-scale climatological, ecological and societal implications, aimed at development of regulatory policy, and which demonstrate the increased diagnostic power obtained from use of "multi-tracer" approaches.

Session 15g: Geomicrobiological Processes Controlling Bioremediation, Natural Attenuation, and Trace Gas Emissions

Convenors: *Michael Friedrich & Hans-Hermann Richnow*

Keynote: *Martin von Bergen*

Environmental pollution strongly impacts geochemical processes at contaminated sites and major biogeochemical cycles as well as the microorganism involved. The last two decades have seen a tremendous progress in assessing which microorganisms are out there in the environment using cultivation independent molecular tools. However, we are only beginning to understand what microorganisms actually do in the environment, and how they change the geochemistry of their habitats on a molecular scale. This session solicits contributions that highlight the latest results and developments in understanding how geomicrobiological processes control pollutant degradation and trace gas emissions (CH₄, N-oxides). For a better understanding of factors limiting bioremediation, studies are required that examine how geomicrobiological processes are affected by and in turn influence the geochemical setting of particular sites. Stable isotope tracer approaches have proven particularly useful in identifying key microbial players involved in geochemical cycling as well as tracing natural attenuation in the environment. Isotope fractionation concepts are increasingly used to trace the activity of microbial degradation processes in the environment. The session aims at an integrative dialogue of molecular scale geochemical and geomicrobiological processes. Contributions that link community composition to function ideally involving isotope based process studies are especially welcome, e.g.:

- Characterization of microbial communities involved in important geochemical processes
- Impact of pollution on site geochemistry and geomicrobiological processes
- Detection of active microbes using stable isotope probing of nucleic acids and other biomarkers (lipids, proteins)
- Metagenomic analysis and environmental proteomics
- Novel methods for analyzing structure and function relationships
- Novel microbial pathways and metabolic capacities with geological and geochemical impact
- Tracing natural attenuation by isotope fractionation concepts

Keynote speaker: *Martin von Bergen (UFZ -Leipzig, Germany) "SIP goes Proteomics - Elucidation of structure and function of microbial communities"*

Session 15h: Environmental Records of Anthropogenic Impacts on Marine Ecosystems

Convenors: *Joan-Albert Sanchez-Cabeza, Peter Kershaw & Sandor Mulsow*

Keynote:

Increased awareness of the value of marine ecosystem goods and services (e.g. biodiversity, habitats,

natural resources) has led policymakers worldwide to develop and implement national and international legislation aimed to protect them. However, it is often uncertain if the implemented policy actions have had positive impacts in the environment. In many developing countries, anthropogenic impacts (both local and diffuse) seem likely to increase with economic growth, in the absence of concerted remedial action. Such action may be more acceptable if it can be demonstrated that there is a commensurate improvement in environmental quality. In this session we wish to adopt a wide definition of anthropogenic impacts, including all changes that result from human activity at any geographical and temporal scale. In the case of contaminants, this includes all substances present in the environment that result from human activity, such as metals, organic pollutants, plastics, nutrients, anthropogenic radionuclides, sediments, and others that have a negative effect on the marine ecosystems. Dated environmental archives such as sediment cores, corals, and shells are commonly used to reveal the history of anthropogenic impacts in marine ecosystems. Analysis of these records reveals past changes produced in these ecosystems and show overall impact trends. The objectives of this session are to: a) Describe and revise methodologies used in the retrospective assessment of marine ecosystems through dated environmental archives. b) Present new research on the reconstruction of the history of anthropogenic impact in marine ecosystems. c) Provide critical reviews of published data. d) Discuss the role of geochemistry in the interpretation of records of anthropogenic impact. Papers presented might be proposed for publication in a Special Issue of a scientific journal.

Session 15i: Geogenic chemicals in groundwaters and soils: biogeochemistry, hazard mapping/risk assessment, remediation technologies

Convenors: *David Polya & Annette Johnson*

Keynote: *Alexander van Geen*

Geogenic chemicals, including As, Se, Mn, Hg, F and S, in groundwaters and soils are important hazards, affecting the health of hundreds of millions of people worldwide, particularly in areas where alternative sources of water are either scarce or contaminated. Despite great progress over the last decade, much remains to be understood about the detailed biogeochemical controls on the transfer of geogenic chemicals between sediment & water and between soil & plants. Assessment of risks arising from these geogenic components requires a full understanding not only of (i) their distribution in groundwaters and soils, but also of (ii) aqueous and solid phase speciation that controls mobility and bioavailability, (iii) biogeochemical controls on soil-plant transfer; and (iv) human exposure routes. Considerable progress has been made recently in the use of geostatistical approaches to model the distribution of geogenic contaminants. Lastly, water treatment remains a challenge, particularly in low-income countries. Iron oxide-based methods have been developed for arsenic but many questions remain. For fluoride removal much work remains to be done to develop low-cost alternatives to activated alumina. Much remains to be done on the removal of other geogenic contaminants.

Theme 16: Life at the Edge: Extreme Environments

Coordinators: *Samantha (Mandy) Joye & Antje Boetius*

Team Members: *Katrina Edwards, Nadine Le Bris, Ron Oremland, Anna-Louise Reysenbach & Andreas Teske*

Session 16a: Microbial cycling of toxic elements (eg. As, Se, Hg, Te) in extreme environments

Convenors: *Tamar Barkay & Andreas Kappler*

Keynote: *Jonathan Lloyd*

Microbial interaction with toxic elements is a well developed field of research due to the toxicity of these elements to living organisms. This topic is of particular interest to microbial ecologists and geologists as toxic elements impact microbial community structure and function and microbes affect the redox state and chemical properties of the elements. While research on microbe-toxic elements interactions have progressed for decades, the study of these interactions in extreme environments has only recently begun, even though such environments are often characterized by elevated concentrations of such elements. Thus, microbes and communities in environments characterized by high temperature and salinity and low pH have been exposed to toxic elements throughout the course of their evolution. This long term relationships

imply that (i) novel modes of microbial interactions with toxic elements may be found in extreme environments, and (ii) the evolutionary origin for the mechanisms that govern toxic element transformations might be found in extreme environments. This session will be comprised of presentations that summarize current studies that address these issues.

Session 16b: Pathways and regulation of energy and carbon transfer in deep-sea extreme environments

Convenors: *Stefan Sievert & Nadine Le Bris*

Keynote: *Costantino Vetriani*

Some of the most extreme environments on Earth are found in the deep-ocean (hydrothermal vents, methane and hydrocarbon seeps, hypersaline lakes). They exhibit tremendous variability in a number of physico-chemical parameters, including temperature, pH, gas (H₂S, CO₂, CO, O₂) and heavy metal concentrations, and other potentially harmful chemicals. Yet they are among the most productive marine environments. Key processes sustaining deep-sea chemosynthetic communities have been highlighted (chemolithoautotrophy, symbiosis) but the wide range of biogeochemical pathways arising from the variety of redox conditions, and the complexity of energy transfer mechanisms from molecules to organisms remain to be described. Availability of chemical substrates and energy budgets, diversity of carbon fixation pathways, adaptability of symbioses, interactions between invertebrates and biogeochemical processes, and large-scale impact of these processes are major issues for which recent interdisciplinary studies and new analytical capabilities have allowed significant advances. These new insights provide a better understanding of the underlying mechanisms sustaining the high productivities of these ecosystems and their potential impact on global element cycling.

Session 16c: Production and consumption of methane and higher alkanes in extreme environments

Convenors: *Samantha (Mandy) Joye & Jean-Luc Charlou*

Keynote: *Alexander Bradley & Katharina Ettwig*

Microbially-mediated production and/or consumption of methane and higher alkanes occurs, often at high rates, in a variety of extreme environments, including cold seeps, hydrothermal vents, terrestrial hot springs, and saline lakes. The alkanes in such systems are derived from either microbial, thermogenic or abiogenic processes. Alkane cycling often involves complex microbial communities which may foster interactions between alkane consuming microbiota and partner microorganisms. The emission of alkanes, especially methane, from aquatic habitats can impact on global climate, making this a topic of widespread interest. This session will bring together microbiologists, biogeochemists, and modelers to describe the patterns and controls of alkane cycling in extreme environments with the hope of identifying patterns and themes that occur across systems.

Session 16d: Exobiology: Are any terrestrial extremophiles plausible proxies for hypothesized microbial life on Venus, Mars, or the Jovian planets and their satellites (e.g., Titan, Europa, Callisto, Enceladus)?

Convenors: *Mary Voytek & David DesMarais*

Keynote: *David Des Marais*

Investigations of contemporary microbial communities can guide our exploration of Earth's early biosphere as well as our search for life elsewhere in the solar system. Life as we know it requires liquid water. Evidence for the presence or past activity of water has been detected on several planetary bodies besides Earth. Accordingly our search for signs of past or present life elsewhere in the Solar System is enhanced by studies of the biogeochemistry, microbiology and biosignatures of extreme environments on Earth such as those in the subsurface, in hot springs and in frozen deposits. Recent Mars missions are providing additional clues to help focus such Earth-based studies. This session explores a broad range of topics including prebiotic chemical evolution, quantifying the habitability of environments, biogeochemical cycles, biosignatures, and the roles played by mineralization in biological evolution and the preservation of biosignatures.

Session 16e: Biogeochemistry and biology of CO₂ and pH extremes

Convenors: *Antje Boetius & Fumio Inagaki*

Keynote: *James P. Barry*

Among the different extreme environments on Earth, those varying in CO₂ concentration pose a variety of challenges for different life forms. In this session, we would like to invite presentations dealing with field based and experimental studies on aquatic/sedimentary ecosystems and biogeochemical functioning under CO₂ and pH extremes. How are CO₂ concentrations and corresponding pH levels affecting the habitability of an ecosystem? What are threshold levels for changes in organism performance, community structure, biodiversity, and metabolic functioning? By which mechanisms can organisms adapt to or counteract the effect of CO₂ and pH extremes? What are the peculiarities of carbon cycling and other biogeochemical processes in such extreme environments? One focus of the session will be how extreme CO₂ and pH environments can serve as natural analogues, e.g. acidic CO₂ vents for CO₂ leakage from carbon dioxide capture and storage in the terrestrial subsurface and/or deep-sea, or for different levels of ocean acidification; and high pH vents for unique carbonate habitats for microbial life formed by serpentinization.

Session 16f: Life in the deep dark subsurface biosphere

Convenors: *Peter Girguis & Julie Huber*

Keynote: *Everett Shock*

Recent studies show that oceanic crust and sediments host extensive but poorly characterized microbial communities. Data suggest these are the largest microbial communities on Earth, and accordingly, there is continuing debate about the extent and impact of this deep biosphere. This session will examine these issues, highlighting results of novel and interdisciplinary approaches to studying the subsurface biosphere, and examining the role of interdisciplinary approaches to studying microbial processes. This session will specifically focus on the recent and significant advances that provide insight into the physiological potential and activity of these communities. These and other findings have been enabled by recent advances in techniques and technologies, from metagenomics to bioenergetic modeling, and will constitute the basis of our discussion.

Session 16g: *You call this a living?*: The microbial ecology and biogeochemistry of the Atacama Desert and Antarctic dry valleys

Convenors: *Brent C. Christner & Fred A. Rainey*

Keynote: *Alison E. Murray*

This session will lay emphasis on new research conducted in two of the driest regions on Earth. Life requires liquid water as a solvent for biochemical reactions, for mass transfer, and to establish electrochemical gradients. High solute concentrations, absorption of water to solid surfaces, and subfreezing temperatures are all factors that result in decreased water activity. As such, studies of microorganisms and communities inhabiting temperate and polar deserts provide model systems for examining the limits of microbial metabolism under conditions of low water availability. An overarching goal of this session is to connect common microbial strategies for survival in these seemingly disparate environments.

Theme 17: Microbes Rock: Biogeochemical Activity and Biosignatures

Coordinators: *Liane Benning & Danielle Fortin*

Team Members: *Jochen Brocks, Maria Dittrich, David A. Fowle, Anna Gorbushina, Francois Guyot, Andy Knoll & Jonathan Leake*

Session 17a: Geomicrobiology and fossil biosignatures

Convenors: *Tanja Bosak*

Keynote: *Richard Pancost*

Molecular, isotopic and elemental signatures preserved in ancient sedimentary rocks are a significant source of information about past microbial ecosystems, metabolisms and environments. The interpretation of inorganic biosignatures depends on our knowledge about how biominerals in modern microbial ecosystems are formed and modified, and the value of molecular fossils critically depends on information about lipids and

pigments in extant organisms. However, according to some estimates, less than 1% of bacteria and archaea can be grown and studied in pure culture. This session explores modern, and in particular cultivation independent, geochemical, microbiological and genomic techniques to explore microbial ecosystems and the traces that they may leave in the geological record.

Session 17b: Molecular fossils and compound specific isotopes

Convenors: *Jochen Brocks & Roger Summons*

Keynote: *Gordon Love*

Molecular fossils (biomarkers) preserved in ancient sedimentary rocks are a significant source of information about past microbial ecosystems, metabolisms and environments. We invite submissions that apply biomarkers and compound specific C/H/N isotopes to explore ancient microbial ecosystems and metabolisms, environmental and climatic transitions and mass extinctions from the Precambrian to the present. We also welcome general contributions to biomarker research and organic geochemistry.

Session 17c: Fungi and biogeochemical cycles

Convenors: *Steve Banwart, Philippe Van Cappellen & Jonathan Leake*

Keynote: *Anna Gorbushina*

The central role of fungi in biogeochemical cycles includes the acquisition of mineral nutrients through mineral weathering, the sustenance of terrestrial ecosystems through recycling of N and P, and the turnover of soil organic carbon pools. These include effects on biogeochemical cycles that range from molecular scale fungal-mineral interactions to global biogeochemical cycles operating on geological timescales. A particular focus of this session is the symbiosis between plants and mycorrhiza fungi, and how it drives biogeochemical cycling in the rhizosphere. As an example, in ectomycorrhizal (EM) symbioses the distal feeding roots of trees are invested in a mantle of fungal mycelium from which hyphal networks extend, supported by 20-30% of the net photosynthate of the trees. These networks intensively explore soil organic and mineral surfaces. In the boreal forest - the world's largest vegetation system - virtually all nutrient uptake into the plants is through EM fungi, virtually all carbon release from living roots passes through them, and they typically contribute over half the carbon in soil solution. The biomass and activity of EM mycelia are enormous, with several hundreds of km of mycelia in 1 kg of forest soil. These networks penetrate deep into the soil (to the C horizon of the weathered regolith) and into cracks in rocks and minerals. It is now emerging that EM fungi and their microbial associates are far more directly involved in mass transfer of elements from minerals (e.g. P, N, K, Zn, Fe, Cu) than has been previously recognised. This session aims to provide an overview of fungal microbiology and its role in terrestrial ecology, and to present recent advances in understanding the specific impacts on soil geochemistry and element cycles. Contributions are invited on all aspects of fungal microbiology, physiology, ecology and impacts on geochemical cycles and earth systems, especially the impacts on weathering and the cycling of carbon and nutrient elements. Field, laboratory and modelling studies are equally relevant.

Session 17e: Calcification processes and microbes

Convenors: *Maria Dittrich & Anna Gorbushina*

Keynote: *Wolfgang Krumbein*

Carbonates are an important component of the rock record. Abiotic carbonate formation is well known, but several studies have shown that microorganisms are also key players in the formation of various carbonate minerals. This session focuses on ancient and modern examples from terrestrial and marine environments.

Session 17f: Linking geochemical tracers and metabolic pathways

Convenors: *Boswell Wing & Aubrey Zerkle*

Keynote: *Valeriy Smirnov*

Several important problems in geology cannot be solved without including a geomicrobiological component (e.g. deep storage sites of CO₂ or nuclear wastes, oceanic crust hydrothermalism, low temperature serpentinization and hydrogen generation, sediments, generation of gas hydrates, anaerobic oxidation of methane, acid mine drainages, interpretation of ancient mineralization, etc). Approaches relying upon

molecular biology are being developed and it is important to bridge their results with those of geochemical studies (e.g. stable isotopes) which allow for mass balance and fluxes determination. The purpose of this session is to gather studies coupling stable isotopes or other tracers with major metabolic pathways. The session will include studies showing laboratory calibrations of geochemical signatures induced by various microorganisms and biogeochemical interpretation of geochemical signatures due to specific microorganisms.

Session 17g: Functional imaging of microbial-mineral processes at the molecular scale

Convenors: *Steve Bonneville & Karim Benzerara*

Keynote: *Rik Brydson*

The identification, visualization and quantification of metabolic and geochemical processes between microbes and rocks has emerged over the last decades as an important field of research. Understanding microbe-mineral interfacial phenomena (i.e., dissolution, precipitation, secondary mineral formation...) is required in order to develop coherent macroscopic descriptions of a large array of microbial pathways in past and present environments. However, access to and sampling of materials at the scale of the respective interfacial processes is not trivial and it requires new technological approaches that have been developed and applied over the last few years to a variety of biogeochemical problems. This session aims at gathering scientists from a broad range of expertise in order to present the latest developments in microscopic and spectroscopic techniques (e.g., TEM/FIB, STXM, XPS, (Nano)-SIMS...) and proteins-/transcripts- tagging approaches (e.g., FISH, Raman...) applied to geo-microbiological laboratory or fields studies.

Session 17j: The genomics of geochemistry

Convenors: *Greg Dick*

Keynote: *Kenneth Nealson*

The availability of thousands of microbial genome sequences and a growing number of metagenomes is opening new views into how and why microorganisms drive elemental cycles. However, significant challenges remain in interpreting this data and translating it into geochemical implications. This session will highlight how genomics is transforming our understanding of microbial biogeochemistry, not only through sequencing of single organisms but also sequencing of mixed communities (metagenomics) and via methods such as transcriptomics and proteomics that address genome dynamics. Contributions that intimately link these emerging approaches to biogeochemical processes are encouraged.

Session 17k: Biogeochemical processes and cycles in lakes, sediments and soils: new approaches, recent findings, and environmental applications

Convenors: *Céline Pallud, Annet Laverman, Eric Viollier & Moritz Lehmann*

Keynote: *Bjorn Sundby*

Biogeochemical cycles of C, N, Fe, Mn and S are tightly interconnected in natural ecosystems. Such interconnections could have important effects on organic matter degradation in soils and aquatic sediments. Anaerobic degradation of organic matter has classically been studied in relation to denitrification, iron-, manganese- and sulfate-reduction. Recent work has shown a large range of alternative processes (e.g. anammox, denitrification coupled to Fe-, S- and CH₄- oxidation), that could potentially affect organic matter degradation rates. We invite presentations on all aspects of geochemical and isotopic tracers and their potential to provide insight into the cycling of bioimportant elements and the origin and fate of organic matter in soil and lake environments. We particularly encourage presentations focusing on links between the C, N, Fe and S cycles and the alternative modes of anaerobic microbial and geochemical pathways.

Theme 18: Frontiers in Analytical Techniques

Coordinators: *James Farquhar & Friedhelm Von Blanckenburg*

Team Members: *Hagit Affek, Paul Mason, Ann Pearson, Erik Scherer, Peter Schlosser, Ronny Schoenberg, John Valley & Edward Vicenzi*

Session 18a: Recent developments in microbeam and microanalytical research and instrumentation

Convenors: *John Valley, Ingo Horn, Simone Kasemann & Detlev Günther*

Keynote: *John Eiler*

New and improved techniques for in situ microanalysis of isotope ratios and trace elements allow correlation with other forms of imaging, have produced dramatic reductions in sample size, and are improved in accuracy and precision. These capabilities contribute to more fundamental understanding in a wide range of disciplines including: biomineralization, diagenesis, paleo-climate, geochronology, diffusion studies, and meteoritics. This session seeks contributions describing new analytical approaches and geochemical applications of in situ microanalysis including: ion microprobe, micro-XRF, and laser microprobe.

Session 18b: 40 years after the ^3He revolution: emerging news from noble gas cosmo- geochemistry at the edge

Convenors: *Igor Tolstikhin, Rolf Kipfer & Rainer Wieler*

Keynote: *John Lupton*

40 years have passed since the discovery of large ^3He excesses (relative to its production in terrestrial environments) in helium extracted from volcanic emanations. Since then, helium isotopes have become an essential tool in many branches of geochemistry, readily distinguishing crustal and mantle materials and highlighting specific differences of mantle domains. In addition, helium has a unique role as tracer for mantle-derived inputs into near-surface fluids, thereby contributing to our understanding of sources and migration pathways of terrestrial volatile species. Despite four decades of study, the isotopes of helium still present some of the most important geochemical conundrums, notably: when and how helium with high ^3He abundance was incorporated into the Earth's mantle? Which material carried this helium from space to the Earth's interior during accretion of the planet? How does ^3He -rich helium relate to the heavy noble gases, particularly its radiogenic and primordial partners in the isotopes of neon and xenon? This session will address what we have learned about solar system and terrestrial processes using the isotope abundances of helium and other noble gases. It also heads to define the most important issues to be resolved in the future and to discuss the most appropriate methods for addressing them. This session will be run in conjunction with another jubilee session at this conference related to ^3H - ^3He systematics, and with a workshop on Noble Gas Geo- and Cosmochemistry at Nancy (June 19 and 20, 2009). We will try to coordinate the programs of all three meetings.

Session 18c: Recent developments in microbial techniques and approaches to geobiology

Convenors: *Ann Pearson & Andreas Kappler*

Keynote: *Volker Thiel*

This session seeks contributions that apply novel molecular, genetic, microscopic, spectroscopic, and/or chemical approaches and techniques to explore questions of geobiology. Such approaches could include - but are not limited to - applications from metagenomics, novel imaging techniques, high-resolution analyses, spectroscopic methods, isotopic proxies (natural level and tracer experiments), and new classes of organic or inorganic biomarkers. Novel approaches to handling microbes and consortia in-situ and to improving culturing approaches also are welcomed.

Session 18d: Recent developments in traditional stable isotope research: Approaches and instrumentation.

Convenors: *Hagit Affek, David Fike, James Farquhar & Michael Evans*

Keynote: *Boaz Luz*

This session focuses on novel methodological approaches to research in traditional light stable isotopes (H,C,N,O,S and their combinations); from development of new isotopic tracers to applications of established methodologies to new materials and to new techniques with improved measurement capabilities. Specific topics might be: mass independent fractionation processes, 'clumped isotopes' and isotopomer analysis, multi-isotopic analysis, site-specific isotope analysis in organic molecules, and application of traditional isotopes methodologies to new source materials.

Session 18e: Recent developments in geochronology

Convenors: *Erik Scherer, Simon Kelley, Paul Renne & Warren Sharp*

Keynote: *Matthew Kohn*

This session targets recent progress in radioisotope-based geochronology, including cosmogenic nuclide studies. Topics include new analytical techniques, improved calibrations, new computational or theoretical approaches, and novel applications to Earth and planetary sciences. Contributions applied or applicable to any geological environment and timescale are welcome.

Session 18f: Pushing precision and accuracy in radiogenic, radioactive, and non-traditional isotope ratio measurements

Convenors: *Ben Reynolds, Paul Mason & Ronny Schoenberg*

Keynote: *Joel Baker*

Recent improvements in the precision and accuracy of radiogenic, radioactive and non-traditional isotope ratio measurements have enabled exciting discoveries in the fields of cosmochemistry, geo(bio)chemistry, and nuclear sciences. This session seeks contributions related to new developments and advances in measurement techniques which can further improve our analytical limits for isotope ratio determinations, using TIMS, MC-ICPMS and IRMS. Discussion of international standards and data processing techniques are also welcome. The focus will be on accurate determination of stable isotope variations, and improved determination of isotopic anomalies.

Session 18g: Synchrotron and Neutron Advances in Environmental Geochemistry and Mineralogy

Convenors: *Sam Shaw, Thomas Borch, Simon Redfern & Nancy Ross*

Keynote: *John Bargar*

Over the past 10 years there has been a large increase in the number of new generation synchrotron (e.g. Diamond Light Source, SSRL Spearg 3 and The Linac Coherent Light Source (LCLS)) and neutron sources (e.g. J-PARC, SNS, FRM-II, OPAL, ISIS-TS2) across the world. The development of these facilities has led to dramatic improvements in beam flux, size and stability which have enabled significant improvements in time resolution, data quality, detection limits and spatial resolution using microfocus techniques.

Environmental geochemistry and mineralogy research has benefited greatly from these developments as the new facilities allow in situ studies of natural heterogeneous materials (e.g. soil, aqueous phases and poorly-ordered minerals) under near natural conditions. This session will focus on the recent developments in the applications of synchrotron- and neutron- based techniques for the study of low-temperature environmental systems including – but not limited to – biogeochemistry, geomicrobiology, soil science, carbon sequestration, metal and metalloid speciation studies in natural and contaminated environments, aqueous geochemistry, colloid science, nano particles, mineral/solution/bio interface studies, environmental radiochemistry and phytoremediation studies. The session will cover research using all types of synchrotron and neutron based techniques including, XAS, X-ray microscopy (e.g. STXM), tomography, XPS, XRF, X-ray microprobe, scattering (e.g. SAXS/WAXS) XPEEM, diffraction, total scattering, inelastic and quasielastic scattering, infrared and time resolved studies.

Session 18h: Studies of the Dynamics and Mean Residence Times of Natural Waters Using the tritium/³He Method and Other Environmental Tracers

Convenors: *Peter Schlosser & Werner Aeschbach-Hertig*

Keynote: *Martin Stute*

40 years ago Tolstikhin and Kamensky proposed the use of tritium and its radioactive daughter, ³He, as a tool to determine the age of young groundwater, thereby opening the prospect of a new tool for studies of the mean circulation patterns and age of natural waters. Although this method was applied to studies of the ocean circulation within a few years, it took the community almost two decades to apply the concept to hydrological studies. Today, the tritium/³He method represents one of the most reliable dating tools of natural waters. In addition to ³He, ⁴He and other noble gas isotopes such as ⁸⁵Kr and ³⁹Ar have been used in studies of flow patterns and mean residence times in these water bodies. Furthermore, chemical compounds including the Chlorofluorocarbons CFC 11, CFC 12, and CFC 113, as well as Sulfurhexafluoride (SF₆) and Trifluoromethylsulfurpentafluoride (SF₅CF₃) have been successfully used as tracers for studies of the

dynamics of natural waters. This session will provide an overview of the present state of tracer studies of natural waters using environmental tracers including the tritium/³He method, other noble gas isotopes and chemical compounds. The session covers analytical aspects of the methods, sampling techniques, field observations, and modeling studies in groundwater, continental surface waters and the ocean.

Theme 19: Frontiers in Computational Geochemistry

Coordinators: *Carl Steefel & Nora de Leeuw*

Team Members: *Maria Alfredsson, Louise Criscenti, Bjorn Jamtveit, Christophe Monnin, Steve Parker, Nita Sahai, Kostya Trachenko & Bjoern Winkler*

Session 19a: The characterization of chemical equilibrium in natural environments

Convenors: *Christophe Monnin, Laurent Richard & Everett Shock*

Keynote: *Jeffrey S. Seewald*

During the last decade, geochemists have increasingly focused on the study and modeling of time-dependent processes using chemical kinetics coupled to reactive transport. Nevertheless, the question of the achievement of chemical equilibrium in natural systems remains open. Characterizing chemical equilibrium is essential to the calculation of thermodynamic properties of minerals, melts, gases, organic compounds, and aqueous solutions over the large ranges of temperature, pressure, and composition which are encountered in nature. This symposium is intended to bring together communications addressing topics related to equilibrium, such as consistent thermodynamic databases, high accuracy thermodynamic calculations, estimates of uncertainties in equilibrium laboratory experiments, examples of chemical equilibrium in nature, etc. This symposium is expected to foster the discussion on the relevance of the equilibrium model to natural systems.

Session 19b: Biological and Biomimetic Crystal Growth/Dissolution Mechanisms from Computational Chemistry

Convenors: *Nora de Leeuw*

Keynote: *D. M. Duffy*

This symposium emphasizes the importance of discovering both a conceptual and a predictive understanding of biomineralization and biomimetic crystal growth/dissolution mechanisms, over a range of length scales, by using fundamental, physical chemistry-based computational approaches. The quantitative and detailed understanding afforded by computational approaches provides a rational basis for understanding biomineralization and for designing novel synthesis routes for biomimetic composite materials such as silica, carbonates, phosphates, sulfates, and other sparingly soluble salts. Broadly, the symposium includes computational studies on the interactions of organic molecules and water at inorganic solid crystalline and amorphous phases, at all length-scales from electronic and molecular to the meso-scale. Appropriate computational approaches include, but are not limited to, quantum chemical cluster and periodic approaches, classical and theoretical force-field based Molecular Mechanics and Molecular Dynamics, Monte Carlo and growth probability methods. Equally significant are models that link the results of computational approaches to growth/dissolution rate laws. Recognizing the close and necessary inter-dependence of computational, spectroscopic, microscopic approaches, we also encourage submissions reporting on collaborative projects. Relevant topics include, but are not restricted to: * Organic-mediated modifications of nucleation, growth and dissolution mechanisms of silica, carbonates, phosphates, sulfates, and other sparingly soluble salts. * Controlled and induced biomineralization by eukaryotes and prokaryotes in extracellular and intracellular milieu. * Normal and pathological biomineralization within the human body including formation of bones, teeth, and kidney stones. * Solvation changes at the mineral-water-organic interface. * Connecting molecular- and meso-scale processes to micron- and larger scale growth and dissolution rate laws. The organics include amino-acids, peptides, proteins, low molecular weight organic acids, polyacids, high molecular weight natural organic matter including fulvic and humic acids, polysaccharides, chelating agents such as EDTA, phosphonates, etc. The organics represent a wide range of chemical and physical properties such as functional group identity, charge, hydrophilicity/hydrophobicity and secondary and tertiary structure.

Session 19c: Geochemical Properties of Nanopores and Nanoparticles

Convenors: *Maria Alfredsson & Ian C. Bourg*

Keynote: *Virginie Marry*

Nanometer-sized particles and porous media (such as zeolites, clay particles and interlayers, or biogenic manganese oxide nanoparticles) are ubiquitous in natural environments and play an increasing part in our daily life. The chemical and physical properties of nanoparticles and nano-confined fluids are well known to depend strongly on size and morphology, but this dependence has not yet been fully determined and is still scarcely incorporated in geochemical models. For this session, we invite contributions that will capture the breadth of ongoing experimental and theoretical advances in the study of geochemically relevant nanoparticles and nano-confined fluids. We particularly wish to highlight work that explores the relationships between nanosized pores/particles and laboratory- or field-scale behaviors of geological media. We hope to foster a broad discussion on the role of computational modeling to predict the impacts of nanoparticles and nanoporous media in environmental and contaminant chemistry, mineral and gas hydrate nucleation, and other fields of geochemistry.

Session 19d: Modeling the Structure and Dynamics of Aqueous Interfaces

Convenors: *Louise Criscenti, Andrew Stack & Sebastien Kerisit*

Keynote: *James Rustad*

One of the frontiers in computational geochemistry is to understand the structure and dynamics of aqueous interfaces. The air-water interface has been studied primarily by atmospheric chemists while the solid-water interface has been investigated predominantly by those interested in subsurface chemistry. In both cases, however, models have been developed at the continuum and molecular levels to predict both the kinetics and equilibrium conditions for reactions at these interfaces. Critical issues that these models aim to address are the structure of water, the formation of electrical double layers, and the kinetics of interfacial reactions.

Atomistic computational techniques such as classical molecular dynamics and ab initio quantum mechanics are very powerful tools to simulate both interfacial reaction kinetics and equilibrium distribution coefficients, but are currently limited in scope by practical constraints on system size and simulation time. New and exciting areas of interest are the development and application of methods that can extend the useful range of time-scales and system-sizes available using common techniques.

This session invites presentations on modeling the structure and dynamics of air-water, solid-water, and other aqueous interfaces (e.g., oil-water, microbe-water), experimental or analytical data that can be used to guide model validation, and studies that link model development with experimental observation.

Session 19e: Molecular and transport effects on isotopic fractionation

Convenors: *Don DePaolo & Ian C. Bourg*

Keynote: *Juske Horita*

Experimental and theoretical investigations of isotopic effects associated with fundamental physical processes (such as solvation, molecular diffusion, or chemical equilibria) are emerging as an important addition to the isotopic geochemistry toolbox. This session will explore new experimental and modeling approaches to understanding and predicting isotopic fractionation as a result of molecular and transport processes. Approaches to be considered include ab initio, molecular dynamics, and lattice Boltzmann simulation methods. We particularly wish to highlight collaborative research that combines theoretical and experimental investigations of fundamental isotopic effects as well as research that combines fundamental studies of isotopic effects with investigations of their large-scale geochemical implications.

Session 19f: Pattern formation through growth, dissolution or replacement processes

Convenors: *Bjorn Jamtveit, Paul Meakin & Carl Steefel*

Keynote: *Nigel Goldenfeld*

Growth, dissolution or replacement processes often involve nonlinear couplings between chemical reaction kinetics, transport and deformation processes. Such couplings often lead to the formation of emergent patterns of variable complexity and scale. Such patterns include: Erosion and weathering patterns (spheroidal weathering patterns, honeycomb patterns and tafoni etc); growth structures (such as travertine terraces, stalactites, botroidal mineral deposits, dendrites and stromatolites), as well as dissolution patterns (etch pits and complexly dissolving mineral surfaces, and stress-driven features such as stylolites).

Many of these patterns are poorly understood and sometimes ascribed to biological activity, mainly due to their complexity. Sometimes, they are merely regarded as oddities, esthetically pleasing perhaps, but as less interesting parts of the invariably complicated nature. Recent advances in computer modeling of complex geochemical systems have however, shown that many of these patterns can be understood in conceptually simple terms and provide valuable and fundamental insights into the coupling of geochemical processes across scales. Such studies may shed new light on which natural structures demand the presence of life and which do not, clearly useful information when interpreting patterns observed on other planets. Studies of macroscopic pattern-formation through cooperative phenomena in geochemical systems may also connect current computer modeling approaches focusing on sub-nanometer and nanometer scale processes (through quantum mechanical or molecular dynamics methods) to the macroscopic features that can be directly observed in the field.

This session is intended to bring together researchers from a broad spectrum of earth sciences, with a common interest in obtaining a quantitative understanding of the plethora of emergent patterns in geochemical systems that result from growth and dissolution processes.

Session 19g: The dynamics of silicates

Convenors: *Thorsten Geisler*

Keynote: *Martin Dove*

Silicates and related materials are surprisingly flexible at the atomic level, and this flexibility has a significant impact on issues such as stability, properties, and response to changes in temperature and pressure. The importance of silicates to the geology of plants, and ultimately to life, means that we need a fundamental understanding of both the structure and dynamics of silicates. We invite contributions that will present new results on the atomic structure and dynamics of silicates at an atomic level, including for silicates in crystalline, amorphous and fluid states, and as pertain to changes in temperature and/or pressure. Both experimental and computational results will be appropriate.

Session 19h: Computational geochemistry and the geologic disposal of radionuclides

Convenors: *Bjoern Winkler, Dirk Bosbach & Carl Steefel*

Keynote:

The disposal of high-level nuclear waste in deep geological formations poses major scientific and social challenges to be met in the next decades. One of the key issues is related to the long term safety of a waste repository system over extended periods of time (up to 1 million years). Demonstrating the safety over such extended time scales requires a mechanistic understanding of the behaviour of radionuclides in the geosphere. This includes molecular level system understanding as well as understanding the larger scale geochemical behaviour of radionuclides in complex heterogeneous natural systems. Computational approaches can complement experimental work and provide important contributions to the safety case, particularly by extending the time scales over which material performance and radionuclide migration can be considered.

The session is intended to provide an overview of recent advances in computational geochemistry on topics

related to the disposal of nuclear waste at a variety of scales: (i) molecular-scale calculations on structural incorporation of radionuclides in secondary alteration and waste forms, including the effects of self-irradiation damage on mineral stability, (ii) molecular-scale calculations of adsorption reactions involving radionuclides at mineral-water interfaces as well as their complexation in aqueous systems. (iii) recent advances in thermodynamic modeling of complex radiogeochemical systems, and (iv) reactive transport modeling of the migration of radionuclides in repository and far-field environments. We particularly invite contributions that deal with the structure and properties of various waste forms such as glasses, ceramics, cements, or spent nuclear fuel, as well as their secondary alteration products, that are under consideration for disposal in geologic repositories. Contributions focusing on experimental studies that incorporate or complement computational studies are also welcomed.

Session 19i: Bioenergetics in Geochemical Modeling

Convenors: *Doug LaRowe & Andy Dale*

Keynote: *Qusheng Jin*

Biogeochemical reactions are often described in geochemical reaction-transport models using kinetic terms that have Monod-style hyperbolic expressions for promotion or inhibition of microbially-mediated reaction pathways. However, there is a growing interest in developing more rigorous thermodynamically based approaches to describe which processes dominate in coupled biogeochemical reaction networks. On such approach involves the hypothesis that a particular metabolic reaction is catalyzed only when the available Gibbs energy in a given environment exceeds the energy required to synthesize biochemical energy in the form of ATP. Furthermore, the fact that the energy requirements for a variety of microbes and the terminal electron acceptors that they use differ suggests that the extent of the thermodynamic driving force on rates of reaction rates is also likely to vary. This session will survey the current state-of-the-art of the treatment of thermodynamics in biomass-explicit and –implicit microbially-mediated reaction networks and consider the possibilities for developing more nearly universal biogeochemical rate laws which can be incorporated into geochemical models.

Theme 20: General sessions

Coordinators:

Session 20a: General Geochemistry: High Temperature Geochemistry

Convenors: *Greg Holland & Nicholas Goodwin*

Keynote:

If you have been unable to find a session within a theme that provides a fit for your high temperature geochemistry - this is the session to submit your abstract to. The general sessions will be scheduled by the conference science committee and have the same proportion of oral to poster presentations as other sessions. Session chairs will be selected from those who have notified us of their availability during the abstract submission process and like-abstracts will be grouped for presentation.

Session 20b: General Geochemistry: Low Temperature Geochemistry

Convenors: *Zheng Zhou & Michael Lawson*

Keynote:

If you have been unable to find a session within a theme that provides a fit for your low temperature geochemistry - this is the session to submit your abstract to. The general sessions will be scheduled by the conference science committee and have the same proportion of oral to poster presentations as other sessions. Session chairs will be selected from those who have notified us of their availability during the abstract submission process and like-abstracts will be grouped for presentation.

Session 20c: General Geochemistry: Biogeochemistry

Convenors: *Enoma Omoregie & Gunter Wegener*

Keynote:

If you have been unable to find a session within a theme that provides a fit for your biogeochemistry - this is

the session to submit your abstract to. The general sessions will be scheduled by the conference science committee and have the same proportion of oral to poster presentations as other sessions. Session chairs will be selected from those who have notified us of their availability during the abstract submission process and like-abstracts will be grouped for presentation.
