

Volume 22, Number 1 (February)

EARTH'S CARBON CYCLE THERMOSTAT: BEYOND THE TEXTBOOK MODEL

GUEST EDITORS: Laurence Coogan (University of Victoria, Canada), Kimberly Lau (Penn State University, USA), and Jeremy Caves Rugenstein (Colorado State University, USA)

Earth's geological carbon cycle is generally considered to act as a "thermostat," regulating climate and preventing global mean temperatures from fluctuating wildly. The textbook model of this regulation involves variations in solid Earth degassing rates, leading to changes in atmospheric CO₂ concentrations, surface temperature, and precipitation; in turn, these change the rate of alkalinity production via continental silicate weathering, which changes the rate of carbonate mineral formation, thereby rebalancing the carbon cycle. Over the last two decades, various alternative or additional mechanisms that may be equally or more important in regulating Earth's carbon cycle have been described. This issue highlights advances in our understanding of the regulation of the long-term carbon cycle and emphasizes the large uncertainties that still remain regarding the fundamental controls of Earth's life-support system.



Is it time to update Earth's thermostat?

- **How Well Do We Understand the Geological Carbon Cycle?** Laurence Coogan (Univ. Victoria, Canada), Kimberly Lau (Penn State Univ., USA), and Jeremy Caves Rugenstein (Colorado State Univ., USA)
- **Igneous and Metamorphic CO₂ Sources: How Large and How Variable?** Emily Stewart (Florida State Univ., USA) and Kei Shimizu (NASA, USA)
- **Continental Weathering as a Geological Thermostat** Gaojun Li (Nanjing Univ., China) and Gen K. Li (Univ. California, Santa Barbara, USA)
- **Seawater Interaction with Oceanic Basement and Sediments** Wolfgang Bach (Univ. Bremen, Germany) and Alex Diehl (Univ. Bremen, Germany)
- **The Fate of Ocean Alkalinity: Carbonate Formation and Reverse Weathering Reactions** Shaily Rahman (Univ. Colorado Boulder, USA) and Elizabeth Trower (Univ. Colorado Boulder, USA)
- **Burned or Buried: What Controls the Long-Term Preservation of Organic Carbon?** Sandra Arndt (Université Libre de Bruxelles, Belgium) and Dominik Hülse (Univ. Bremen, Germany)

Volume 22, Number 2 (April)

DISCOVERY OF VOLATILES ON THE MOON: RENAISSANCE IN LUNAR EXPLORATION SCIENCE & BEYOND

GUEST EDITORS: Deepak Dhingra (IIT Kanpur, India), Mahesh Anand (The Open Univ., UK), and Jennifer Heldmann (NASA Ames, USA)

The discovery of lunar volatiles has marked an important shift in the understanding of the origin and evolution of the Moon (and beyond). Further, it has significantly impacted the current and future lunar exploration, both through existing samples and planned orbital, landed, and sample return missions. Lunar exploration is beginning to be augmented by commercial services and plans for sustained human presence on the Moon by multiple nations. The dynamically evolving lunar research landscape is raising important new questions and powering the search for answers. New technologies, re-examination of "old" samples, and integration of vast volumes of multi-instrument datasets are opening new possibilities. This issue of *Elements* presents the various facets of the story of volatiles on the Moon so far and what the future might hold.



- **The "Bone Dry Moon" Paradigm** Deepak Dhingra (IIT Kanpur, India), Mahesh Anand (The Open Univ., UK), and Jennifer Heldmann (NASA Ames, USA)
- **Volatiles Everywhere on the Moon** Jennifer Heldmann (NASA Ames, USA), Shuai Li (Univ. Hawaii, USA), Carle Pieters (Brown Univ., USA), and Brad Thomson (Univ. Tennessee, USA)

- **The Once Dry & Now Wet Moon: Re-thinking Lunar Origin and Evolution** Charles Shearer (Univ. New Mexico, USA), Paul Lucey (Univ. Hawaii, USA), and Kevin Righter (Univ. Rochester, USA)
- **The World is Going to the Moon** S. Megala (ISRO Headquarters, India), Yang Liu (National Space Science Center, China), and Ben Bussey (Intuitive Machines, USA)
- **Volatiles: The New Fuel for Planetary Exploration** Mahesh Anand (The Open Univ., UK) and Deepak Dhingra (IIT Kanpur, India)
- **Key Knowledge Gaps in Lunar Volatile Science: Emerging Results & Path Forward** Barbara Cohen (NASA GSFC, USA), Casey Honniball (NASA GSFC, USA), Deepak Dhingra (IIT Kanpur, India), and Matt Siegler (Univ. Hawaii, USA)

Volume 22, Number 3 (June)

MINERAL PHYSICS APPLIED TO EARTH AND PLANETARY SCIENCES

GUEST EDITORS: Patrick Cordier (Université de Lille and Institut Universitaire de France, France) and Jennifer Jackson (California Institute of Technology, USA)

Understanding the physical and transport properties of minerals is essential for deciphering geophysical and planetary processes. Building on Haüy's early recognition of the link between crystal structure and macroscopic behavior, modern spectroscopic, thermal, mechanical, electrical, and magnetic techniques now probe these properties across all scales—from atoms to planets. This issue of *Elements* explores how minerals respond to external fields. Those interactions reveal clues about the past history of the minerals and influence of dynamic processes that continue to shape the Earth and other planetary bodies at present. This issue presents key concepts in mineral physics alongside recent technological advances that enhance our ability to study planetary interiors. Through selected research areas, the issue illustrates how this knowledge deepens our understanding of planetary evolution and highlights the major scientific challenges that lie ahead.



- **From Atoms to Planets: The Physics of Minerals Across Scales** Jennifer Jackson (California Inst. of Technology, USA) and Patrick Cordier (Université de Lille and Institut Universitaire de France, France)
- **Illuminated Worlds: How Spectroscopy Lights the Way in Earth, Environmental and Planetary Sciences** Natalia Solomatova (Miraterre Technologies and Arca Climate Technologies, Canada), Eva Scheller (Stanford Univ., USA), and Samantha Trumbo (Univ. California San Diego, USA)
- **The Heat is On: Thermal Transport and Melting** Jennifer Jackson (California Inst. of Technology, USA), Vasilije Dobrosavljevic (Carnegie Institution for Science, USA), and Kenji Ohta (Inst. of Science Tokyo, Japan)
- **Carrying the Planet on their Backs: How Minerals Respond to Stress** Mattia Luca Mazzucchelli (Université de Lausanne, Switzerland), Patrick Cordier (Université de Lille, France), and Claudia Trepmann (Ludwig-Maximilians-Universität München, Germany)
- **Plugged-in Planet: Accessing the Interior of the Earth and other Terrestrial Bodies via Electrical Properties** Anne Pommier (Carnegie Institution for Science, USA), Michael Tauber (Univ. California San Diego, USA), Kate Selway (Univ. Tasmania, Australia), and Daniel Heyner (Technische Universität Braunschweig, Germany)
- **Paleomagnetic Recording at the Grain Scale** Roger Fu (Harvard Univ., USA) and Richard Harrison (Univ. Cambridge, UK)

Volume 22, Number 4 (August)

QUARTZ

GUEST EDITORS: Gerald Raab (Dalhousie University, Canada; University of Graz, Austria), Axel Müller (University of Oslo, Norway), Jens Götze (TU Bergakademie Freiberg, Germany), Yuanming Pan (University of Saskatchewan, Canada), and Sumiko Tsukamoto (LIAG Inst. for Applied Geophysics; University of Tübingen, Germany)

This thematic issue explores the diverse applications of silica, with a particular focus on quartz, across various fields of science, industry, and everyday life. Quartz, a complex polymorph of SiO_2 , has played a pivotal role from the Stone Age, through the development of glass, to its current essential uses in high-tech industries such as photovoltaics, semiconductors, and precision equipment. The issue will feature a comprehensive insight into the uniting aspects of quartz crystallography, occurrence, and its impact on technological progress. It will also highlight quartz's value as a geological indicator and the importance of high-purity quartz deposits, aiming to deepen understanding of the mineral's diversity and the factors influencing its properties and industrial significance.



Quartz (SiO_2)

- **Quartz and SiO_2 – Simple Yet Exciting** Yuanming Pan (Univ. Saskatchewan, Canada), Jens Götze (TU Bergakademie Freiberg, Germany), Axel Müller (Univ. Oslo, Norway), and Gerald Raab (Dalhousie Univ., Canada)
- **The Narrative of Quartz and Silica in the Earth and Other Planetary Bodies** Axel Müller (Univ. Oslo, Norway), Andreas Audétat (Univ. Bayreuth, Germany), Thomas Monecke (Colorado School of Mines, Boulder, Colorado, USA), Karel Breiter (Czech Acad. of Science, Czech Republic), and Rune Larsen (NTNU Trondheim, Norway)
- **Quartz – Hour-Glass for Surface Processes** Gerald Raab (Dalhousie Univ., Canada; Graz Univ., Austria), Roland Stalder (Univ. Innsbruck, Austria), Sumiko Tsukamoto (LIAG Inst. for Applied Geophysics; Univ. Tübingen, Germany), and Georgina King (Univ. Lausanne, Switzerland)
- **Quartz-derived Solutions in Everyday Products and Renewable Energy** Axel Müller (Univ. Oslo, Norway) and Rainer Haus (ANZAPLAN, Hirschau, Germany)
- **Microcrystalline and Amorphous Silica: Materials that Shaped Humanity** Elisabetta Gliozzo (Univ. Siena, Italy), Peter Heaney (Penn State Univ., USA), Yuanming Pan (Univ. Saskatchewan, Canada), and Carole Perry (Nottingham Trent Univ., UK)
- **The SiO_2 Gemstone Family** Jens Götze (TU Bergakademie Freiberg, Germany), Yuanming Pan (Univ. Saskatchewan, Canada), and Eloïse Gaillou (MINES ParisTech, Musée de Minéralogie, France)

Volume 22, Number 5 (October)

STROMATOLITES – DEEP TIME GEOCHEMICAL ARCHIVES OF MICROBIAL ECOSYSTEMS ON EARTH

GUEST EDITORS: Sebastian Viehmann (Leibniz Univ. Hannover, Germany), Karim Benzerara (Sorbonne Université, France), and Simon Hohl (Tongji Univ., China)

Stromatolites are remarkable bio-mineralizing structures that remain abundant on Earth today. Formed by microbial communities, these bio-sedimentary rocks provide a continuous record of microbial evolution over the last 3.5 billion years. They were first described 120 years ago by the German geologist Ernst Louis Kalkowsky and have recently gained extensive interest across the interdisciplinary fields of the bio-geosciences. Current research is advancing our ability to reconstruct ancient aqueous environments and their associated microbial communities, shedding light on their role in shaping bio-geochemical cycles. Moreover, stromatolites are recognized as possible targets in the search for extraterrestrial life within our Solar System. This issue reviews the latest advances in stromatolite research from a combined geobiology, mineralogy, and (isotope) geochemistry perspective. It also underscores the urgent need to protect these endangered microbial ecosystems on a fast-changing modern Earth.



- **Introduction** Laurane Fogret (Stichting Naturalis Biodiversity Center, The Netherlands) Karim Benzerara (Sorbonne Université, France), Simon Hohl (Tongji Univ., China), Sebastian Viehmann (Leibniz Univ. Hannover, Germany), and Pierre Sans-Jofre (Muséum National d'Histoire Naturelle, France)
- **Diversity, Mechanisms of Formation, and Predicted Fate of Modern Microbialites on a Rapidly Changing Planet** Nina Zeyen (Univ. Geneva, Switzerland), Jeanne Caumartin (Sorbonne Université and Museum National d'Histoire Naturelle, France), and Karim Benzerara (Sorbonne Université, France)

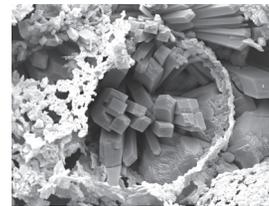
- **Microbialite-associated Microbial Communities, Present and Past** Miguel Iniesto (Université Paris-Saclay, France), David Moreira (Université Paris-Saclay, France), and Purificación López-García (Université Paris-Saclay, France)
- **Stromatolites Through Earth's Early History** Axel Hofmann (Univ. Johannesburg, South Africa), Anna Molekwa (Univ. Johannesburg, South Africa), and Frantz Ossa Ossa (Univ. Johannesburg, South Africa; Khalifa Univ. Science and Technology, United Arab Emirates)
- **Touring Stromatolite Records Using Stable Isotopes** C. Thomazo (Université Bourgogne Europe, France and Institut Universitaire de France, France), R. Havas (Université Bourgogne Europe, France), A. Pellerin (Université Bourgogne Europe, France), and J. Marin-Carbonne (Univ. Lausanne, Switzerland)
- **Recorders of Major Oxygenation Events and Biogeochemical Metal Cycling Through Earth's History** Sylvie Bruggmann (Univ. Lausanne, Switzerland), Sebastian Viehmann (Leibniz Univ. Hannover, Germany), Indrani Mukherjee (Univ. New South Wales, Australia), and Simon Hohl (Tongji Univ., China)

Volume 22, Number 6 (December)

ZEOLITES

GUEST EDITORS: Tobias Weisenberger (Mohammed VI Polytechnic University, Morocco), G. Diego Gatta (University of Milan, Italy), Alessio Langella (Federico II University, Italy), and David Bish (Indiana University, USA)

Zeolites are tectosilicate minerals characterized by an open framework structure that encloses interconnected pores and channels. Their distinctive crystal structures result in their ability to hydrate/dehydrate reversibly, to exchange cations with aqueous solutions, and to act as molecular sieves. Due to their structure-related physicochemical properties, zeolites are an important group of industrial minerals. Natural zeolites are rock-forming minerals that form under low-temperature conditions. Their appearance can provide information on the evolution of a particular system in space and time within the shallow crust. The objective of this issue is to shed light on recent developments on natural zeolites, including their genesis, properties under non-ambient conditions, and applications, including example as additives in modern cements, their applications within environmental remediation, and within pharmaceutical and agricultural research.



- **Natural Zeolites: Understated Minerals with Remarkable Versatility** G. Diego Gatta (Univ. Milan, Italy), Tobias Weisenberger (Mohammed VI Polytechnic Univ., Morocco), Alessio Langella (Federico II Univ., Italy), and David Bish (Indiana Univ., USA)
- **Zeolite Crystal Chemistry: Structural Diversity and Behavior Under Non-ambient Conditions** Paolo Lotti (Univ. Milan, Italy), Annalisa Martucci (Univ. Ferrara, Italy), G. Diego Gatta (Univ. Milan, Italy), and David Bish (Indiana Univ., USA)
- **Zeolites as Tools for Interpreting Geological and Geochemical Conditions** Tobias Weisenberger (Mohammed VI Polytechnic Univ., Morocco) and Simon Spürgin (Hans G. Hauri KG Mineralstoffwerke and LMU Munich, Germany)
- **The Dichotomous Trend of Natural Zeolite Applications: Actual and Potential Uses** Mariano Mercurio (Univ. Sannio, Italy) and Aleksandra Daković (Inst. for Technology of Nuclear and Other Mineral Raw Materials, Serbia)
- **Natural Zeolites: Pathways to Green and Durable Cement and Concrete** Ruben Snellings (KU Leuven, Belgium), Simon Spürgin (Hans G. Hauri KG Mineralstoffwerke and LMU Munich, Germany), and Sevgi Özen (Recep Tayyip Erdoğan Univ., Turkey)
- **Applications of Zeolites in Environmental Remediation** Isabel Díaz (Inst. of Catalysis and Petrochemistry, Spain), Neil Hyatt (Univ. Bristol, UK; Washington State Univ., USA), Hossein Kazemian (Univ. Northern British Columbia, Canada), Tadafumi Koyama (Central Research Inst. of Electric Power Industry and Inst. of Science Tokyo, Japan), and Alessio Langella (Federico II Univ., Italy)