Newsletter
of the
International Association of GeoChemistry

Number 71, December 2019

In This Issue

Newsletter Editor – Chris Gardner, BusinessOffice@IAGC-Society.org

New IAGC Council

We are happy to announce six new council members for terms beginning in January, 2020. The voting council for the IAGC consists of six regular members and the four chairs of our active working groups. We are grateful for the service of our outgoing regular council members **Patrice de Caritat** (Geoscience Australia), **Stephen Grasby** (Geological Survey of Canada), **Sophie Opfergelt** (Université Catholique de Louvain), and **Avner Vengosh** (Duke University). Finally, we give a sincere thanks to our departing working group chairs **Richard Wanty** (US Geological Survey), who chaired the Applied Isotope Geochemistry group and **Thomas Kretzschmar** (CICESE), who chaired Water-Rock Interaction. Everyone in the IAGC is grateful for your service to the geochemical community.

Working Group Chairs

Romain Millot holds a Ph.D. in Isotope Geochemistry (IPGP, University of Paris 7, 2002), and is currently a researcher in Water, Environment, Process Development and Analysis Division of BRGM – French Geological Survey in Orléans (France). He is a Senior Project manager in the field of multi-isotope tracing in the environment. He has published more than 60 publications in international peer reviewed journals (14 as a 1st author) concerning river weathering mass budgets, thermo-mineral and geothermal waters characterization, metal pollution source investigation, mineral resources characterization, and the development of new analytical tools in isotope geochemistry. Since joining the BRGM in 2003, he has been involved in different projects dealing with the development and utilization of isotopic tracers in water-rock interaction processes. He is involved in various research projects at the national scale (ANR, ADEME, ANDRA, Water Agency funding) and also at the European level (FP6/7 projects: AquaTERRA, Hiti, AquaTRAIN: EIT Raw Materials: EuGeLi). In 2013, Romain graduated from the University of Orléans with the ability to supervise research (HDR, Professorial thesis). Romain is the new chair of the Applied Isotope Geochemistry working group of the IAGC.

Pierpaolo Zuddas is professor of Geochemistry at Sorbonne University (France). Italian by upbringing and education, he lived and worked in Italy, Canada and France. His career in geochemistry took him from a position with the Marine Salt Agency (Italian Ministry of Finance) to the Non–Nuclear Energy Division of the European Union and then to academic university positions in Italy, Canada and France. He applies thermodynamics, kinetics and surface chemistry to study mineral-solution interactions in aquatic environments and carbonate geochemistry. He has used expertise in the field of water-rock interaction to develop theoretical, experimental and field studies on fluid migration and reactivity in several natural and artificial conditions. He taught at Universities of Cagliari and Palermo (Italy), McGill (Canada), Lyon (France), where also served as Chair of the Institute of Environmental Engineering Eco-development. He supervised 18 PhD dissertations of students from different backgrounds and origins. Pierpaolo coordinated, managed or co-managed international programmes on water quality in mining basins, urban and rural areas and media hosting CO_2 geological sequestration. He also served as technical expert in supranational and national scientific grants to assess risk in water resources for agencies and energy companies. He served as Secretary General for WRI-14. Pierpaolo is the new chair of the Water-Rock Interaction working group of the IAGC.

Regular Council Members

Sergey V. Alexeev is currently Head of Hydrogeology and Engineering Geology Department in the Institute of the Earth's Crust SB RAS, Irkutsk, Russia. He graduated from the Lomonosov Moscow State University in 1981 and received his PhD in 1987. His thesis was entitled "Cryogenesis of Ground Waters and Hard Rocks of the Daldyn-Alakit Region (Western Yakutia). He then earned his Doctor of Science degree, with a thesis entitled "Cryohydrogeological systems of the Yakutian diamond bearing province." From 2013 to present he has been the Chairman of the Dissertation Council (Ph.Ds and Doctors of Science) with specializations in Hydrogeology, Engineering Geology, Geocryology and Ground Engineering. His present scientific focus is to develop the formation scenario for chloride brines in sedimentary basins of the Siberian platform and to develop the theoretical genesis of ground waters with high salinity. He uses complex multiple isotopic tracers to study the evolutionary processes in water-rock systems. This has led to strong evidence that the chloride

brine forms as a result of transformation of connate water under closed conditions and slow water exchange. Additionally, these tracers can be used to assess the enclosing rocks' role in the formation of the chemical and isotope composition of the brine.

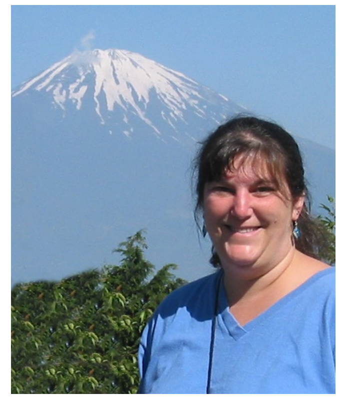
François Chabaux is Professor at the "Ecole et Observatoire des Sciences de la Terre (EOST)" at the University of Strasbourg, France. He was awarded a PhD at the University Paris 7, France in 1993. He was appointed Assistant Professor at the University of Strasbourg, France in 1994, Full Professor in 1998 and Professor CE (Distinguished Professor) in 2012. He was director (2013-2017) of the Laboratoire d'Hydrologie et de Géochimie de Strasbourg. He is Associated Editor of *Applied Geochemistry* and of « Comptes Rendus Geoscience », the scientific journal of the French Science Academy. François has been highly involved in the development and application of the methodology of U-series nuclides to constrain the time scales of weathering and erosion processes in the critical zone. He also investigated with his colleagues in Strasbourg the nature of water-rock interactions controlling the chemical composition of waters in watersheds and aquifers by applying geochemical tracing approaches and more recently the coupled hydrogeochemical modeling approaches. An important part of his work was carried out on the Strengbach watershed, in Vosges mountains, France, contributing to making this watershed one of the current reference sites of the French critical zone observatory network (OZCAR). François also gave the 2019 IAGC Ingerson Lecture at the 1st IAGC International Conference in Tomsk, Russia.

Huaming Guo is Professor of Hydrogeology in the School of Water Resources and the Environment at the China University of Geosciences, Beijing. He has had visiting placements at the Karlsruhe Institute of Technology, US Geological Survey Denver, and Columbia University. Professor Guo was Chair of Sino-German Workshop on Geogenic Arsenic in the Environment in Beijing and Co-Chair of the 7th International Conference on Arsenic in the Environment: Environmental Arsenic in a Changing World ("As 2018") in Beijing. Currently, he is the co-Editor-in-Chief of *Journal of Hydrology*, and Associate Editor of *Applied Geochemistry*. His research interests include: (1) Sources, fate and transport of inorganic pollutants (e.g., arsenic, fluoride, uranium, and chromium) in aquifer systems; (2) Characteristi cs and mechanisms of arsenic and fluoride adsorption on natural geomaterials; and (3) Biogeochemical behaviours of contaminants during mineral-water-microbe-organics interactions.

Dirk Kirste, Associate Professor, is an aqueous geochemist at Simon Fraser University in Vancouver, Canada. Dirk graduated with a B.Sc. (Honours) from the University of British Columbia, a M.Sc. from the University of Waterloo and Ph.D. from the University of Calgary. After graduating he worked as a Post-Doctoral researcher with Geoscience Australia and the Australian National University. Dirk's research is primarily directed towards understanding the processes controlling the composition of groundwater and surface water.

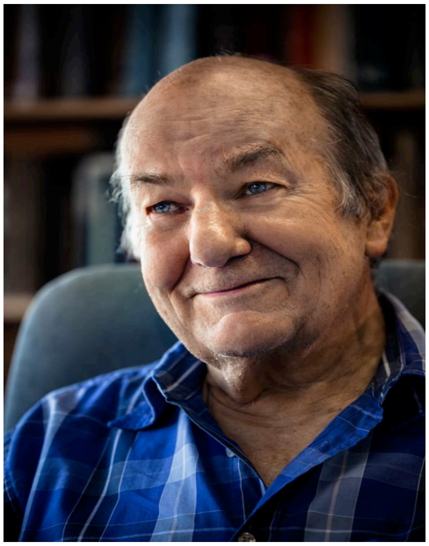
His research involves both lab and field-based work investigating the chemical and isotopic composition of water, minerals and gases. By recognizing and using variations in the chemistry he addresses problems in the environment, in characterizing and predicting the effects of anthropogenic forcings, and in resource exploration and evaluation. He applies a broad range of techniques including developing field based sampling and monitoring strategies; applying different analytical methods; designing lab based experimental procedures; and, developing and applying computer simulations.

Elisa Sacchi graduated in Earth Sciences in 1990 and obtained her Ph.D. in Geochemistry in 1995. Since 2002, she has been at the University of Pavia as Researcher, and since 2015 as Associate Professor. She is officially in charge of teaching Geochemistry and Environmental Geochemistry for students of Earth, Natural and Environmental Sciences. During her post-graduate studies, she developed her research activity in the field of Environmental Geochemistry, obtaining numerous fellowships and contracts (Government of Canada Award, University of Torino, Université de Paris XI, Australian Nuclear Science and Technology Organisation). She also worked as a consultant for Italian and International institutions (INFN, ANDRA, OCDE Nuclear Energy Agency, ANSTO) in the fields of radioactive waste disposal and radiochemical contamination monitoring. Occasionally, she collaborates as expert or tutor with the International Atomic Energy Agency, in the frame of Technical Cooperation Projects. Her main interests are in water, sediment and soil pollution, water-rock interaction and environmental applications of isotope geochemistry. She is author 50 papers in international peer reviewed journals, two books, of which one published by the OCDE, two book chapters and more than 70 contributions to national and international conferences. She is also an Associate Editor for *Applied Geochemistry*.



Elisabeth (Liz) Widom is a Professor and isotope geochemist in the Department of Geology & Environmental Earth Science at Miami University (Oxford, Ohio). Liz received a B.A. in Geology from Cornell University (1984) and a Ph.D. in Geology from the University of California Santa Cruz (1991). She completed a Postdoctoral Fellowship at the Carnegie Institution of Washington's Department of Terrestrial Magnetism, followed by an NRC Postdoctoral Fellowship at the National Institute of Standards and Technology, prior to starting a faculty position at Miami University (1997). Since then, Liz has been honored to be a Pemberton Fellow at Durham University (2005) and a Fulbright Scholar at the Universidad Nacional Autónoma de México (2012). She has served as Department Chair at Miami since 2014, and has held the Janet & Eliott Baines Professorship since 2015. Liz's research involves the application of trace elements and isotopes (radiogenic and stable) to address a range of geologic problems. Current research foci include investigations of processes and timescales operating in active magmatic systems; the composition and evolution of the Earth's mantle, with ongoing projects on ocean islands, subduction zones, and intra-plate continental settings; and the application of radiogenic isotope systems to environmental contaminant tracing and nuclear forensics.

In Memoriam: John J. Gurney (1940 – 2019)



The geochemistry community mourns the recent passing of John Gurney, valued colleague, mentor, and father of modern diamond exploration. An emeritus Professor of Geochemistry in the Department of Geological Sciences at the University of Cape Town, South Africa and actively involved with the Mineral Services Group of diamond exploration consulting companies at the time of his passing, John made important contributions to the field of applied geochemistry throughout his distinguished career.

Born in Liverpool (UK), John was a gifted athlete who was almost recruited for professional football before his family moved to Cape Town in 1959. He received an undergraduate degree in chemistry from the University of Cape Town in 1962 and afterwards joined the research team of Prof. Louis Arhens in the newly formed Geochemistry Department. John's doctoral study of trace elements in eclogite xenoliths led to a Postdoctoral Fellowship at the Smithsonian Institution in Washington DC in 1970-71. While at the Smithsonian, John made the connection between the composition of peridotitic garnet inclusions in diamonds and that of Cr-rich sub-calcic garnets occurring in harzburgite xenoliths which led to the definition of these as indicator minerals of diamondiferous kimberlites. Returning to UCT, he formed the Kimberlite Research Group, which he headed until his retirement in 2003. In 1973, John organized and co-convened the first International Kimberlite Conference in Cape Town. This meeting created a cooperative relationship between academia and the diamond industry that has been sustained over the past 50 years. At UCT, John established himself as a world authority on mantle petrology and diamond formation, was promoted to Full Professor in 1984, and earned the highly prestigious designation as an A-rated researcher by the National Research Foundation of South Africa. John was also a dedicated mentor of students, supervising more than 20 BSc (Hons), 18 MSc, and 16 PhD students at UCT while also acting as co-supervisor for several PhD students at other universities. For 14 years from 1989 to 2003, John led a week-long diamond exploration workshop for students and industry that was part of a MSc course that he taught at Rhodes University.

John's passion for mantle research led him to establish the world-famous 'Mantle Room' at UCT. This collection represents the world's most extensive assemblage of southern African kimberlites and mantle xenoliths, and has been formally re-named the John J. Gurney Upper Mantle Research Collection. John generously made this collection available to researchers from around the world. During the last few years, John used this collection to create a museum-type exhibition, *Messengers from the Mantle*, that was first shown at the International Geological Congress in Cape Town in 2016, displayed in 2017 at the 11th Kimberlite Conference in Botswana, and subsequently has been presented at other international scientific meetings and venues to great acclaim. A career-long Member and Fellow of IAGC, John authored more than

300 publications related to his investigations of the upper mantle beneath the southern African craton, a body of work that has defined our current understanding of kimberlites and established the way in which modern diamond exploration is conducted.

Not only was John an exceptional geochemist, but he was also a successful entrepreneur. Throughout his career, John provided advisory services to commercial marine diamond mining operators along the west coast of South Africa and Namibia, and he also partnered in a number of small-scale but successful, diver-operated diamond mining operations in the shallow waters along South Africa's West Coast. In 1995, John and his son James founded the Mineral Services Group of companies that provides specialist consulting and laboratory services to the diamond industry. John also led several successful public company diamond exploration ventures, notably Benguela Concessions and Motapa Diamonds. It was the application of John's mineral chemistry approach to exploration that led to the discovery of the now world famous diamondiferous kimberlites in northwestern Canada.

Association News

2020 IAGC Awards – Call for Nominations

We strongly encourage members to nominate peers and colleagues who make significant contributions to the advancement of geochemistry for one or more of the numerous IAGC awards. We are accepting award nominations for 2020 **through January 15, 2020**. You may nominate colleagues for the following awards, using the [Award Nomination Cover Sheet](#).

The Vernadsky Medal - awarded for a distinguished record of scientific accomplishment in geochemistry over the course of a career:
http://www.iagc-society.org/vernadsky.html

The Harmon Distinguished Service Award - bestowed on a deserving candidate to recognize outstanding service by an IAGC member to the Association or to the geochemical community that greatly exceeds the normal expectations of voluntary service.
http://www.iagc-society.org/distinguished_service.html

The Kharaka Award - bestowed to two deserving scientists (which may include senior graduate students) from developing countries. The award consists of a framed certificate plus an IAGC membership and *Applied Geochemistry* subscription for a term of three years.
http://www.iagc-society.org/kharaka_award.html

IAGC Fellow - bestowed to a scientist who has made significant contributions to the field of geochemistry.
http://www.iagc-society.org/iagc_fellows.html

Certificate of Recognition - awarded to IAGC Members for outstanding scientific accomplishment in a particular area of geochemistry, for excellence in teaching or public service, or for meritorious service to the Association or the international geochemistry community.
http://www.iagc-society.org/certificate_recognition.html

Charitable Giving

Members can make a charitable gift to IAGC, either for general fund support or for special initiatives during online membership renewal. You may donate at any time online, either during your membership renewal or separately.

US members who need an additional tax deduction for 2019 should make their contribution prior to 31 December.

Please donate right now through the IAGC web site (www.iagc-society.org/donate.html)

IAGC is a 501(c)3 non-profit organization and donations to the Society are tax-deductible in the U.S. (EIN: 48-0943367).

Renew Your Membership for 2020!

Don't forget to renew your IAGC membership for 2020 by January so you don't miss any issues of *Elements* magazine! Believe it or not, our annual membership fee is STILL only $25 and includes a hard copy subscription to *Elements* as well as online access. Membership also rewards you with lower cost registration rates at IAGC-sponsored working group conferences. Online access to our journal, *Applied Geochemistry*, is also available.

Renew with a credit card

Renew with a check

Check your membership status

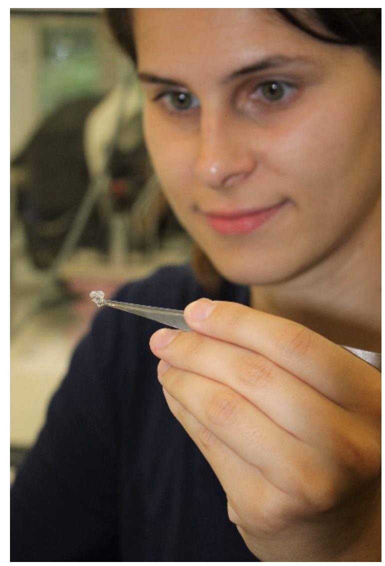
Elsevier IAGC Student Research Grants

Thank you for spreading the word about our 2020 Student Research Grants – this year we received 49 proposals from PhD students around the world. We plan to fully support at least five proposals this year. The announcement of the winners will be on or before 1-May, 2020.

http://www.iagc-society.org/phd_grants.html

Catching up with a previous Elsevier PhD Student Research Grant Winner

Suzette Timmerman received an IAGC Student Research Grant in 2017 for her proposal entitled 'Diamonds – time capsules of volatiles and the key to dynamic Earth evolution'. Suzette received her bachelor's and master's in Earth Sciences from the VU University Amsterdam. For her PhD at the Australian National University, Australia, she determined noble gas compositions in diamonds in order to develop a better high-resolution model of the structure of the Earth's mantle and its evolution. She looked at diamonds from different depths, ages, and locations to see how the noble gas compositions have changed through time and vary within the mantle in the Earth. Diamonds have the potential to reveal noble gas compositions through time in



the mantle, as they retain noble gases in fluid inclusions, can form at different depths, and span a wide range in formation ages (3.5 Ga to 0.07 Ga).

As part of her PhD and with the support of the IAGC, she investigated superdeep diamonds from the transition zone (410-660 km depth) beneath the Juina area in Brazil to look at what is happening deep in the mantle. Helium isotope analyses were combined with CL imaging, nitrogen systematics, carbon-strontium-lead isotope analyses, and trace element contents. In order to collect enough material for trace element concentration and Rb-Sr-Pb isotope analyses an offline laser ablation system at the University of Alberta was used. Microscopic inclusions in these diamonds showed a range in helium isotope compositions, with high $^{3}He/^{4}He$ ratios linked to higher helium concentrations proofing the existence of a primordial reservoir at more than 410 km depth. C-Sr-Pb isotope compositions and trace elements provided evidence for recycled material in the transition zone. The interaction of a high $^{3}He/^{4}He$ source with recycled material in the transition zone can result in a large range of chemical compositions that are also recorded in ocean island basalts. The results from this study were recently published in *Science* (Timmerman et al., 2019. Primordial and recycled helium isotope signatures in the mantle transition zone. Science 365, 692-694). Suzette was awarded a Banting post-doctoral fellowship to continue her work on superdeep diamonds at the University of Alberta.

Meeting Reports

1st IAGC International Conference (WRI-16 and AIG-13)

The 16th International Symposium on Water–Rock Interaction (WRI-16) and the 13th International Symposium on Applied Isotope Geochemistry (1st IAGC International Conference) were held 21–26 July 2019 in Tomsk (Russia). The Organizing Committee was led by its Secretary General, Dr. Natalia Guseva (School of Earth Sciences & Engineering, Tomsk Polytechnic University), who was greatly assisted by many colleagues and graduate students. More than 300 delegates from over 28 countries registered for the symposium. The largest numbers of participants represented Russia, China, France and the United States.

Scientifically, WRI-16 and AIG-13 continued the excellent tradition of previous symposia. The oral and poster presentations covered the latest research results on water–rock interaction and applied isotope geochemistry. The most important problems of various branches of geology, hydrology, hydrogeology, hydrochemistry, and ore geochemistry were discussed. Some of the major topics covered were as follows:

1. Geological evolution of water-rock system: mechanisms, processes, factors, stages. The session was dedicated to Stepan Shvartsev's memory.
2. Organic geochemistry, biogeochemistry, formation of oil and gas deposits.
3. Water-Rock Interaction during oil and gas field development and operation.
4. Thermodynamics and kinetics of water-rock interaction, experimental geochemistry.
5. Modeling of hydrogeochemical and ore formation processes.
6. Geochemical cycles of elements and global environmental changes.
7. Geochemistry of natural waters: from atmospheric precipitations to deep brines.
8. Magmatic, metamorphic and geothermal processes.
9. Water-rock interaction controlling water quality and human health issues.

10. Disposal of radioactive waste: geological, hydrogeological and geochemical aspects.
11. Advances in analytical techniques for the study of water-rock interaction.
12. Applied isotope geochemistry.
13. Innovative methods for characterizing metal and nutrient budgets in the present and past terrestrial and aquatic environments. The session was dedicated to Tom Bullen's memory.

Additionally, two workshops "High temperature WRI experiments and modeling as international collaboration" by Thomas Gunter Kretzschmar and "Liquid radioactive waste disposal in deep-seated geological formations. The problem of interaction between liquid radioactive wastes and rocks" by representatives of the Federal state unitary enterprise «National operator for radioactive waste management» Viktor Krasilnikov and Andrey Zubkov, professor TPU Leonid Rikhvanov were included in the scientific program of meeting.

During symposium every day scientific program started with plenary lecture covered the major themes of WRI-16. The plenary lectures were given by Sergey V. Alexeev (Institute of the Earth's Crust, SB RAS, Russia) on «Brines of Siberian platform. Geochemistry and Prospects of Processing», by Jennifer Druhan (University of Illinois Urbana-Champaign, USA) on «Isotopic communication across the water - rock interface: Preservation in solids and signatures in moving fluids», by François Chabaux (University of Strasbourg, France) on «Determination of weathering rates by analyzing U-series nuclides in weathering profiles: principle and applications», by Jiubin Chen (Tianjin University, China) on «Unusual fractionation of mercury isotopes in surface environments», by Nathaniel R. Warner (Pennsylvania State University, USA) on «The geochemical and environmental issues related to oil and natural gas production from shale and tight reservoirs», by Qinghai Guo (China University of Geosciences, China) on «Arsenic in the hot springs in the Yunnan-Sichuan-Tibet Geothermal Province, China», by Martine M. Savard (Geological Survey of Canada, Canada) on «The N cycle - an anthropogenic global issue examined at regional scale through the prism of stable isotopes», by George A. Chelnokov on «Mineral waters of the Sakhalin Island (Far East of Russia)» (Far East Geological Institute FEB RAS, Russia).

The scientific content was at a very high level, the talks and posters were excellently presented, and the conference offered delegates a great opportunity to network. The WRI-16 Scientific Committee received a large number of extended abstracts, which resulted in 121 oral presentations, 87 posters.

The posters were evaluated by an international committee consisting of three colleagues who did a great job talking to all of the professionals and students present during the poster sessions. They awarded Ludmila Lebedeva (Melnikov Permafrost Institute, SB RAS, Russia) and Amit Reiss (Ben-Gurion University of the Negev, Israel) with Faure Awards for the best student posters. Daria Vorobeva (TPU, Russia) and Valeria Drebot (TPU, Russia) were awarded the Special Prize for Student poster.

As has been the custom at previous WRI meetings, active scientists associated with the symposia were honoured by the WRI Group: Professor Boris Ryzhenko, Professor Oleg Chudaev, Dr. George Chelnokov, Professor Halldór Ármannsson, Professor Arny Sveinbjornsdottir, Dr. Giovanni De Giudici, Dr. Franco Frau, and Dr. Natalia Guseva. Furthermore, three IAGC leadership awards were presented to Professor Huaming Guo (the IAGC Kharaka Award), Professor D. Kirk Nordstrom (IAGC Fellow), and Professor François Chabaux (the Ingerson International Lecturer).

The Local Scientific Committee offered participants three mid-symposium field trips led by teachers and researchers from Tomsk Polytechnic University: «Geological route», «Open cut & Coal basin» and «Golden rush».

The conference concluded with a post-symposium field trips "Mission to Mars" (The Republic of Altai) and "Geological Walks and Area of Salt Lakes" (The Republic of Khakassia) which were attended by 34 and 6 researchers respectively. The pre-conference field trip "Where Russia begins" (the Kamchatka peninsula) attracted 6 participants and focused on the main topics of thermal and mineral waters and high-temperature geothermal resources.

Secretary General for the 2nd IAGC International Conference (WRI-17 and AIG-14), which will be held in Sendai (Japan) in 2021, will be Noriyoshi Tsuchiya (Tohoku University, Japan).

-Thomas Kretzschmar, Pierpaolo Zuddas, Rich Wanty, Natalia Guseva

Galileo Conference on Mass-extinctions, recovery and resilience

The IAGC occasionally financially supports thematic sessions at international conferences. Email the Business Office for more information.

From August 28 to 31, 2019 more than 90 scientists from 16 different countries convened at Utrecht University for the European Geosciences Union (EGU) 5th "Galileo" Conference on Mass-extinctions, recovery and resilience. Galileo Conferences bring together researchers in cutting-edge themes at the frontiers of Earth science. The goal of this meeting was to examine all aspects of mass extinctions from deep time to the present day. Earth faces unprecedented challenges from anthropogenically-induced environmental change and there are growing concerns that we are now living through Earth's sixth mass extinction. Hence, understanding the causes of the previous "Big Five" mass extinctions, and the nature of ecosystem recovery and resilience to change has never been more timely. One major advantage of smaller-sized meetings is the informal atmosphere that provides an excellent platform for early career scientists to present their latest (and often first) results. With more than half of the 61 oral presentations delivered by PhD students and postdoctoral scientists the meeting achieved one of its main goals. Due to the kind financial support from several sponsors, including the International Association of Geochemistry, many of the early career scientists received travel grants.

Rather than following a geological time-line the meeting was structured around several larger themes within mass-extinction research. On the first day, plenary morning sessions were held on the effects of large igneous provinces as the main drivers of catastrophic change. The participants learned the latest on carbon cycle models and perturbations, and examined new records of mercury, sulfur, and platinum group elements as proxies for the fall-out of flood basalt volcanism. Invited speaker Andrea Marzoli discussed his latest work on carbon dioxide contents in basalts with implications for the end-Triassic carbon cycle. In the afternoon, the effects of LIPs on life and ocean chemistry were discussed and invited speaker Haijun Song summarized the evidence for a remarkable return of more primitive microbial communities in the aftermath of the end-Permian extinction. Several contributions paid attention to "life on the edge" both on land and in the oceans. In the oceans, anoxic conditions are a hallmark of major environmental changes that are directly connected to LIP activity, but shallow marine anoxia is also increasingly linked to ecosystem changes on the continents. Invited speaker Emma Hammarlund turned things upside down by arguing that perhaps the loss of hypoxic habitats during the Phanerozoic, rather than increased anoxia, could be to blame for biodiversity changes, especially of organisms adapted to low oxygen conditions. With the unusually warm temperatures and dry conditions, which is perhaps one of few pleasant effects of climate change on the Dutch weather, the first day concluded with food and drinks outside.

During the second day, the morning session focused on the response of marine invertebrate organisms. Two invited speakers, Sara Pruss and Andrey Zhuravlev, provided their latest insights into the evolution of early animal life during the extinction of Cambrian sponge reefs from the United States and Russia. Other contributions focused on links between extinction and body sizes, both small and large, of marine invertebrates. The second morning session jumped to the extinction and resilience of land plants, starting with Devonian plants in Greenland and Svalbard, crossing all the way to the southern hemisphere high-latitude Permian forests. New and exciting insights in the linkage between atmospheric chemistry, genetic mutations in plants, and the resilience of plants to adverse environmental conditions were presented. The afternoon session continued with terrestrial ecosystem disturbance and plant responses with keynote presentations by Elke Schneebeli-Hermann and Charles Wellman on the Permian and Devonian, respectively. The final two talks of the second day were delivered by invited speakers Catalina Pimiento and Kathleen Lyons shifting attention to more recent extinctions of megafauna, such as Megalodon sharks and large mammals. These talks set the stage for a round-table discussion on lessons learned from past extinctions for ongoing and future extinctions driven by anthropogenic activities.

On the final day, morning sessions continued with extinctions in plant communities. A keynote presentation by Margret Steinthorsdottir showcased the use of plant stomata in reconstructing changes in atmospheric carbon dioxide concentrations across mass-extinction boundaries. In addition, new palynological, sedimentological, and geochemical proxy data was presented for the KPg extinction. The second morning session was kicked-off by invited speaker David De Vleeschouwer on the role of orbital forcing in the end-Devonian extinction and concluded with a keynote lecture by James Witts on disentangling the effects of the Deccan volcanism and the Chicxulub impact on the evolution of end-Cretaceous invertebrates. The meeting concluded with an entire afternoon on biogeochemical cycles and geochemical proxy records. Invited speaker Martin Schobben discussed how the cycling of phosphorus may have preconditioned shelf areas to widespread anoxia. In other talks the focus was on the biogeochemical cycling of nitrogen and heavy metals and the effects on ecosystems. Invited speaker Michael Joachimski had the honour of closing the oral program with a lecture on the use of carbon, oxygen and sulfur isotopes to understand mass-extinction mechanisms.

The meeting was a great success in that it brought together many young researchers, was highly interdisciplinary with talks ranging from micropaleontology, to genetics, to the evolution of birds and dinosaurs, impacts and volcanism, all mixed with a lot of cutting-edge geochemistry and proxy-records. The general feeling was that this format should be repeated in the future and perhaps become a more regular meeting. If that is the case we hope the IAGC will again act as a generous sponsor for travel support of early career scientists and scientists from developing countries.

-Bas van de Schootbrugge (Utrecht University) & David Bond (Hull University)

Applied Geochemistry – The Past, the Present and the Future

The following is a pre-print of a paper to be published in the 2nd edition of the Encyclopedia of Geochemistry

Michael Kersten
Geosciences Institute, Johannes Gutenberg-University,
Mainz 55099, Germany

Russell S. Harmon
Department of Marine, Earth & Atmospheric Sciences,
North Carolina State University

Introduction – The Past

Geochemistry uses the principles and analytical tools of chemistry to study the Earth and understand its systems and processes. Applied geochemistry is the sub-discipline that addresses the practical application of chemistry to any aspect of human endeavor and societal relevance across the earth sciences. As such, its focus is more practical and problem solving in orientation. Typical areas of application include the search for economic and energy resources, waste disposal, the effect of the environment on human health, and sustainability of the natural environment.

Applied geochemistry has strong roots in parts of the world with a long history of mining, such as Scandinavia and Germany. Modern geochemistry had its beginnings with V.M. Goldschmidt, today known as the 'Father of Geochemistry'. Goldschmidt was appointed the director of Norway's Raw Materials Laboratory in 1917, where his work focused on finding Norwegian sources of minerals that were in short supply due to World War I. He became strongly influenced by the physical aspects of chemistry promoted by the 'Ionists' around the turn of 19^{th} to 20^{th} century, among them S. Arrhenius, W. Ostwald, and his father H.J. Goldschmidt. He translated these principles into crystal chemical rules of element distribution within the terrestrial system, published in a series of nine monographs entitled "*Geochemische Verteilungsgesetze der Elemente*" (geochemical rules for the partitioning of elements), when he was working at Göttingen University in Germany and establishing the foundation for applied geochemistry. It is interesting that V.I. Vernadsky and A. Fersman drew upon Goldschmidt's work in the 1930s to develop systematic methodologies for geochemical prospecting for mineral resource exploration in the Soviet Union. The techniques developed there spread first back to Scandinavia and then to North America. Today, geochemical surveying is a standard approach for economic mineral exploration worldwide and the same approaches are used in national and international programs of geochemical mapping that have been implemented not only for mineral exploration but also for environmental and water resource management. At Göttingen University, Goldschmidt's legacy was taken up after World War II by C.W. Correns and his student J. Hoefs, who started one of first laboratories of isotope geochemistry in 1959.

The application of chemistry within the geosciences has been driven for over a century by advances in analytical methodology and instrumentation. It was only with the advent of new analytical capabilities for the measurement of elemental abundances and isotopic compositions of the rocks, minerals, fluids, and gases within the Earth system that current hypotheses about geological processes could be tested and new ideas developed. Thus, analytical geochemistry is a critical sub-field of applied geochemistry, with advances in analytical instrumentation frequently inspired by geological problems with analytical geochemists actively involved in the development of new analytical instruments and the methodologies for their utilization. The branch of applied geochemistry focused on isotope partitioning was thus greatly advanced during the late-1940s to early 1950s with the advent of sector field mass spectrometry enabling the study of element isotope distributions. H.C Urey had discovered deuterium, the heavy isotope of hydrogen, in the 1930s and then studied the vapor behavior of D, ^{15}N and ^{18}O, conducted tracer studies using these isotopes. Subsequently, noting the temperature dependence of the $^{18}O/^{16}O$ exchange between carbonate ion and water, Urey proposed that the O- isotope compositions of marine carbonate fossils might provide information on the temperatures of ancient oceans because of the decrease of the fractionation factor by 1.004 between 25°C and 0°C. Urey's student S. Epstein, with Urey at the University of Chicago, then developed the analytical procedures to extract CO_2 for isotopic measurement from skeletal carbonate shells and produced a carbonate paleotemperature scale to a precision of better than 0.8°C. Epstein himself, in an illustrious geochemical career at the California Institute of Technology, went on to make pioneering discoveries regarding variations of the stable isotopes of H, C, N, O, Si, and Ca on the Earth, the Moon, and in meteorites. More recently, the profound insight of J. Eiler, a successor to S. Epstein at the California Institute of Technology, led to creation of the field of clumped isotope geochemistry, which has demonstrated that actual paelotemperatures for Phanerozoic carbonate materials can be determined without needing to know the isotopic composition of the water from which precipitation occurred (Eiler, 2007).

As the universal principles of physical chemistry determine the complex interactions of solutions with rocks and minerals in the natural geological environment, another branch of applied geochemistry was developed that seeks to understand reactions, kinetics, equilibrium and chemical affinities, rather than focusing on compound, element, and isotope distributions. It was J.W. Gibbs, an aqueous chemist and physicist at Yale end of 19th century, who laid the foundations of chemical thermodynamics. This tradition was utilized for a half-century in petrology, but was only taken up for application in low-temperature geochemistry after World War II by R.M. Garrels, who applied experimental physical chemistry data and techniques to a broad range of geological problems. His book *Solutions, Minerals, and Equilibria* revolutionized hydrogeochemistry. While at Harvard, Garrels and his student H.C. Helgeson studied the genesis of hydrothermal ore deposits and introduced the concept of geochemical equilibrium modeling into research related to water-rock interaction. Ideas about geochemical thermodynamics were quickly adopted, and it was W. Stumm at Harvard and his student J.J. Morgan, who introduced these principles into aquatic chemistry and civil engineering in the 1960s. Morgan subsequently went to the California Institute of Technology, where his student F.M.M. Morel started to adopt these ideas into the X-QL family of software, and later at MIT expanded into the field of surface complexation modeling. Morgan became also the founding editor of the very highly regarded American Chemical Society journal *Environmental Science & Engineering*.

Results and Discussion – The Present

Recent theoretical and analytical developments have resulted in an unprecedented increase in the volume of research on the isotope systematics of past and present terrestrial, aquatic, and atmospheric systems. Similarly, advances in understanding of trace element mobility during water-rock interaction within the Earth's crust and of geochemical processes in the critical zone have increased greatly during the recent past. These advances in geochemical applications have provided (i) stronger constraints on the source and apportioning of elements, (ii) a better characterization of the physiochemical processes controlling their budgets, and (iii) historical records of variations of their cycles in water-rock interaction systems at local and global scales. The B-, Sr-, and Ra-isotope geochemistry of aqueous brines, for example, proved particularly useful in understanding the processes controlling both the salinization of freshwater, a huge problem for many coastal societies, and the fate and transport of the pollutants released to the environment in oil- and gas-field production water. Many areas of applied geochemistry today utilize the isotopic composition of solids to infer the equilibrium conditions of the environment at the time of their formation. A prominent example are paleoclimate studies that use carbonate C- and O-isotopic compositions (i.e. $\delta^{13}C$ and $\delta^{18}O$ values) as proxies to infer atmospheric pCO_2 and temperature at the time of mineral precipitation in soil, cave speleothems, and corals.

The theoretical foundations laid by geochemists since beginning of last century have been used over ensuing decades across the different areas of applied geochemistry and throughout the international geochemical community. At present, such geochemical modeling, which uses the tools of chemical thermodynamics and chemical kinetics to examine the chemical reactions that occur within geologic systems, has become increasingly popular. For example, geochemical modeling is extensively utilized in petroleum and mineral exploration and, more recently, has been applied by the environmental community to understand such varied processes as (i) the mobility and breakdown of contaminants in flowing groundwater or surface water, (ii) the formation and dissolution of rocks and minerals in geologic formations in response to injection of industrial wastes, steam or carbon dioxide, and (iii) the leaching of metals from mine wastes and the generation of acid mine drainage (AMD). The latter topic was the focus of a special issue of the journal *Applied Geochemistry* (v. 62, 2015) dedicated to D.K. Nordstrom, one of first researchers to observe negative pH values in AMD and to utilize geochemical equilibrium modeling for mine site characterization and remediation as detailed in several seminal publications and textbooks. At present, across much of the world, government regulation requires pre-mining baseline characterization and assessment of environmental risks associated with a proposed mine, environmentally sensitive extraction to mitigate environmental contamination from water and mine wastes once operations are underway, and closure to minimize future negative environmental impact after cessation of mining. Such assessments rely on geochemical modeling, in particular also regarding the long-term effects of water flooding of old shafts and weathering of dump heaps.

Scholarly associations play a critical role in bringing science to modern society. There are several international professional societies available to applied geochemists – The Geochemical Society (https://www.geochemsoc.org/), the European Association of Geochemistry (https://www.eag.eu.com/), the Association of Applied Geochemists (https://www.appliedgeochemists.org/), and our International Association of GeoChemistry (http://www.iagc-society.org/), to name just a few. These organizations foster international cooperation and promote the application of geochemistry, publish scientific journals, and sponsor a variety of activities and forums for the presentation of geochemistry, exchange of ideas, and recognition of excellence in geochemistry. A deeper look into the subject of applied geochemistry is provided by our journal of the same name, *Applied Geochemistry*, published monthly since its inauguration in 1986. The journal provides a forum for geochemists interested in the applications of the principles and approaches of geochemistry to current societal challenges. All papers published by our journal have a practical application of geochemistry. For example, an understanding the geochemical processes operating in the critical zone and aqueous environment is paramount for the survival of humanity facing the global climate change. Special issues are regularly published that focus on specific topics of current importance, and the overall scope of our journal is best appreciated by the list of 15 special issues published between 2013-2019:

- Geochemistry of arsenic during low-temperature water-rock interaction
- Geochemical aspects of geologic carbon storage
- Applied isotope geochemistry
- Environmental changes and sustainable development: sources, transport and fate of geological agents in the environment
- Geochemistry for Risk Assessment: Hazardous waste in the Geosphere
- Hydrogeological modelling
- Geochemical Speciation Codes and Databases
- Environmental Geochemistry of Modern Mining
- Geochemistry of Unconventional Shale Gas from Formation to Extraction: Petrogenesis, Hydraulic Fracturing, and Environmental Impacts
- Environmental Impacts of Mining and Smelting
- Environmental and Health Roles of Geogenic Arsenic

- Urban geochemistry
- Transformation and Fate of Natural and Anthropogenic Radionuclides in the Environments
- Trace elements in soils
- Chemistry and Migration Behavior of Actinides and Fission Products - Science for a safe long-term radioactive waste management
- Clays in Natural and Engineered Barriers for Radioactive Waste Confinement
- Soil pollution and reclamation as a geochemical problem

As evident from this illustrative compilation, the field of applied geochemistry itself is comprised of numerous, more focused but frequently overlapping sub-fields. Aquatic geochemistry examines the role of various elements in natural waters and studies of interactions and elemental fluxes between the atmosphere, hydrosphere, and terrestrial sphere. Agricultural geochemistry is concerned with the chemical character of soil in agricultural areas, particularly the natural and anthropogenic sources of metals and their accumulation in agricultural soils and the effect of soil chemistry on plant growth. Environmental geochemistry is concerned with the sources, distribution, and interactions of the chemical elements within the rock–soil–water–air–life system that comprises the natural environment as well as the impact of natural geochemical processes and of anthropogenic perturbations on natural systems. Exploration geochemistry and geochemical prospecting seek to find economic mineral deposits through the detection in surface materials of anomalous concentrations of indicator elements associated with mineral deposits at spatial scales that can range from regional to local. Hydrochemistry examines chemistry of ground and surface waters, particularly the relationship between the chemical characteristics and quality of waters at different spatial scales. Marine geochemistry seeks to understand the chemical composition of coastal and marine water and associated sediments. Medical geochemistry examines and evaluates the relationship between human health and the geological environment. Petroleum geochemistry utilizes chemical approaches in the study of the origin, generation, migration, accumulation, and alteration of petroleum for the purpose of identifying source rocks; determining the amount, type, and maturation level of a hydrocarbon accumulation; evaluating the potential timing of petroleum migration from the source rock and assessing potential migration pathways; and correlating petroleum compounds found in reservoirs, leaks, and surface seeps to find new accumulations of petroleum. Urban geochemistry is concerned with the complex interactions and relationships between chemical elements and their compounds in the urban environment, the influence of past and present human and industrial activities on these, and the impacts or effects of geochemical parameters in urban areas on plant, animal and human health. The wide field of underground waste storage including research in nuclear waste disposal has much benefitted from application of geochemical principles. As the recognition of the Earth functions as an integrated and nested system of process feedback loops has progressed, so have the different sub-field of applied geochemistry converged. For example, there are intrinsic links between agricultural geochemistry, environmental geochemistry, medical geochemistry and urban geochemistry, with practitioners using the same tools to examine similar core issues from different perspectives. This is especially true within the mineral and hydrocarbon exploration areas, where environmental geochemistry has become an integral part of the modern mining and oil-field life cycle.

The importance of applied to geochemistry to modern society is also illustrated by three issues of *Elements*, the bimonthly international magazine of mineralogy, petrology, and geochemistry that in each issue explores a topic of broad and current interest through a thematic collection of papers (http://elementsmagazine.org/). A first issue devoted to applied geochemistry discussed the interdisciplinary field of medical mineralogy and geochemistry as regards both normal and pathological interactions between minerals or amorphous inorganic solids and biomolecules or cells within the human body, as well as the transport and fate of prions and protein toxins in the soil environment. The question of how anthropogenic activities in urban environments affect geochemical cycles, water resources, and the health of ecosystems and humans globally was addressed in a second issue. Then, the ways in which advances in analytical capability can be translated into societally beneficial areas that include mineral exploration, environmental problems in cities, food and drink source and/or purity authentication, forensics, and even modern medicine were considered in a later issue.

Conclusions – The Future

There has been a recent attempt bringing together both the branches of applied geochemistry described above through reactive transport modeling. A particularly important application is focused on the relationship between physical heterogeneity and chemical reactivity within the critical zone and aquifers, and ways in which stable isotope ratios are sensitive to this relationship. The critical zone is characterized by strong weathering reactions, whereby the rate of mass transfer keeps these chemically open systems from reestablishing equilibrium. For the isotope ratios that are partitioned between solute and solid phases as a result of such open system interaction, the characteristic fractionation factors creating environmental proxy signatures are either associated with differences in the rate constants (i.e., kinetic fractionation) or differences in equilibrium partitioning (i.e., equilibrium fractionation). In fact, a broad range of geochemistry applications rely on the extent to which isotopic signatures of solids reflect the thermodynamics and kinetics of the environment in which they formed, or their rate of formation, and how these signatures change through time. Given that stable isotopic ratios of minerals can either reflect conditions of equilibrium or kinetically (e.g., microbial) regulated formation, isotopic proxies are often limited by the uncertainty associated with mixed equilibrium and kinetic signatures. A way out of this dilemma is applying geochemical modeling and reactive transport simulation intended as a generalized and predictive framework for these isotope exchange processes.

At this moment, the global challenges facing geochemistry largely fall within the domain of the applied geochemist. These include acquiring a better understanding of (i) the climate change induced effect on the global water cycle and its sustainable exploitation for the societies water need, (ii) the dynamic interactions of the greenhouse gases CO_2 and CH_4 with the biosphere and hydrosphere, (iii) the dynamic behavior within the critical zone of elements that are both important for and detrimental to human health, (iv) the processes that concentrate elements of economic importance at accessible levels within the Earth's crust, and (v) how to dispose of waste materials within the natural environment in the least impactful and most sustainable way. Currently, there is strong debate about the impact and sustainability of geochemical engineering (or "GeoEngineering") to remedy climate warming. Traditionally, marine biogeochemistry research had been limited to observation and tank experiments. It was the marine biogeochemist J. Martin a quarter of century ago, who formulated the hypothesis of seeding the ocean with iron to boost phytoplankton blooms effective in CO_2 sequestration saying jokingly "Give me a half tanker of iron and I'll give you the next ice age". However, since 1993 only three out of a dozen small-scale in-situ experiments were successfully proving his hypothesis. Intriguingly, a last such outdoor experiment in the Gulf of Alaska not only produced a giant algal bloom, but also quadrupled salmon population of the 2012 season. However, those who thought this idea might yield a giant ecosystem disaster called this experiment irresponsible if not dangerous saying fertilizing the sea would be treating the symptom, not the cause, of global warming. Other such intriguing geochemical engineering ideas are suggesting seeding also the atmosphere with chemicals. Despite of the strong debate about in-situ geochemical experiments to turn the earth system into a laboratory, carefully designed research is going on to understand long-term biogeochemical consequences and eventually put those doubts to rest. As H. Powell said, "anchoring all of the arguments for continued research is the brutal fact of global carbon emissions".

Further Reading

Alpers, C.N., Nordstrom, D.K., 1999: Geochemical modeling of water-rock interactions in mining environments. Reviews in Economic Geology 6, 289-324.

Baskaran, M., ed., 2012: Handbook of Environmental Isotope Geochemistry. Springer, 886 p.

Powell. H., Madin, K., Nevala, A., 2007: Exploring Ocean Iron Fertilization: The Scientific, Economic, Legal and Political Basis, Part 1-6. Oceanus Magazine, Woods Hole Oceanographic Institution, available at whoi.edu.

Brantley, S., Kubicki, J.D., White A.F., eds., 2008: Kinetics of Water Rock Interaction. Springer, 736 p.

Brantley, S. L., White, T. S., Ragnarsdottir, K.V., eds., 2003: The Critical Zone: Where Rock Meets Life. Elements 3, 304-338.

Druhan, J.L., Winnick, M.J., 2019: Reactive transport of stable isotopes. Elements 15, 107-110.

Eiler, J.M., 2007: "Clumped-isotope" geochemistry—The study of naturally-occurring, multiply-substituted isotopologues. Earth Planetary Science Letters 262, 309-327.

Garrels, R. M., Christ, C.L., 1965: Solutions, Minerals and Equilibria. Harper and Row, 450 p.

Garrett, R. G., Reimann, C., Smith, D. B., Xie, X., 2008: From geochemical prospecting to international geochemical mapping: a historical overview. Geochemistry: Exploration, Environment, Analysis 8, 205-217.

Goldschmidt, V. M., 1954: Geochemistry. Clarendon Press, 730 p.

Helgeson, H.C., Garrels, R.M., 1968: Hydrothermal transport and deposition of gold. Economic Geology 63, 622-635.

Hoefs, J., 2018: Stable Isotope Geochemistry, 8th ed. Springer, 432 p.

Jarvis, K.E., Williams, J.G., 1993: Laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS): a rapid technique for the direct, quantitative determination of major, trace and rare-earth elements in geological samples. Chemical Geology 106, 251-262.

Krumbein, W.C., Garrels, R.M., 1952: Origin and classification of chemical sediments in terms of pH and oxidation-reduction potentials. Journal of Geology 60, 1-33.

Ludden, J., Albarède F.,, Coleman, M., eds., 2015: Societal and Economic Impact of Geochemistry. Elements 11, 237-270.

Lyons, W. B., Harmon, R. S., eds., 2012: Urban Geochemistry. Elements 8, 417-457.

Maher, K., Mayer, K.U., eds., 2019, Reactive Transport Modeling. Elements 15, 73-144.

Morel, F.M.M., Hering, J.G., 1993: Principles and Applications of Aquatic Chemistry. Wiley, 608 p.

Nier, A. O., 1940: A mass spectrometer for routine isotope abundance measurements. Review of Scientific Instruments 11, 212-216.

Nordstrom, D.K., 1982: The effect of sulfate on aluminum concentrations in natural waters: some stability relations in the system Al_2O_3-SO_3-H_2O at 298°K. Geochimica Cosmochimica Acta 46, 681-692.

Nordstrom, D.K., 2011: Hydrogeochemical processes governing the origin, transport and fate of major and trace elements from mine wastes and mineralized rock to surface waters. Applied Geochemistry 26, 1777-1791.

Nordstrom, D.K., Alpers, C.N., Ptacek, C.J., Blowes, D.W., 2000: Negative pH and extremely acidic mine waters from Iron Mountain, California. Environmental Science & Technology 34, 254-258.
Roy-Barman M., Jeandel C., 2016: Marine Geochemistry: Ocean Circulation, Carbon Cycle, and Climate Change. Oxford University Press, 384 p.
Stumm, W., Morgan, J.J. (1996): Aquatic Chemistry. Wiley, 1022 p.
Sahai, N., ed., 2007: Medical Mineralogy and Geochemistry. Elements 3, 381-420.
Waples, D.W., 2013: Geochemistry in Petroleum Exploration. Springer, 213 p.

Author Biography & Photo

Michael Kersten is Professor of Applied Mineralogy and Geochemistry at the Johannes Gutenberg University Mainz, Germany, since 1997. His main research interests are in environmental geochemistry (particularly trace elements) and biogeochemical processes in (natural and anthropogenic) sediments and soils. Recent projects are aimed at imaging and modeling of reactive transport processes that operate at the pore scale, and their application to the fate of pollutants in aquifer materials, thereby integrating such diverse methods as synchrotron x-ray micro-tomography, positron emission tomography, geochemical equilibrium models, and advanced pore-scale fluid transport simulators. He was an Associate Editor of Applied Geochemistry from 2001-11 and has been Executive Editor since 2012.

Russell Harmon retired as Director of the International Research Office of the US Army Corps of Engineers Engineer Research and Development Center at the end of May 2017 and presently is an Adjunct Associate Professor in the Department of Marine, Earth, and Atmospheric Sciences at North Carolina State University. A geochemist who has worked at the NASA Manned Spacecraft Center, the Scottish Universities Research and Reactor Centre, and the UK-NERC Isotope Geosciences Laboratory, he has held faculty positions at Michigan State University and Southern Methodist University. He is a Fellow of the Geological Society of America and National Speleological Society, past Chair of the Geological Society of America Division of Mineralogy, Geochemistry, Petrology, and Volcanology and a Past-President of the International Association of GeoChemistry. He holds a BA from the University of Texas, MS from the Pennsylvania State University, and PhD from McMaster University.

Upcoming Meetings

12th International Symposium of the Geochemistry of the Earth's Surface (GES-12)

GES 12 Earth system interactions on a changing planet

ETH zürich

ETH Zurich (Switzerland), 16–21 August 2020
www.ges12.com

Registration/Abstract submission
Opens January 2020

GES-12 brings together world-leading scientists in all fields of surface geochemistry and environmental geochemistry. The conference has a strong focus on interactions between the Earth's spheres: the lithosphere, hydrosphere, atmosphere and biosphere, and how these interactions respond to changing environmental and climate conditions. The overarching theme of GES-12 is **Earth system interactions on a changing planet.**

The conference aims to strengthen connections between research disciplines and to establish new networks. It features invited plenary talks covering a wide range of cutting-edge research themes. GES12 presents eight themes at the forefront of research and features a list of excellent speakers from prestigious research institutions such as Caltech, MIT, NASA and Harvard. The extensive poster and networking sessions give ample opportunities to discuss newest research highlights and innovations and to visit the exhibitions.

2nd IAGC International Conference (WRI-17 and AIG-14)

Sendai, Japan
2021

Secretary General Noriyoshi Tsuchiya (Tohoku University, Japan).

Watch our website for further details
www.IAGC-Society.org

IAGC Executive Officers

PRESIDENT (2019-2020)
Neus Otero
University of Barcelona
SPAIN

VICE-PRESIDENT (2019-2020)
Jodie Miller
Stellenbosch University
South Africa

PAST-PRESIDENT (2017-2018)
Philippe Négrel
French Geological Survey (BRGM)
FRANCE

TREASURER (2008-2020)
W. Berry Lyons
School of Earth Sciences
The Ohio State University
USA

SECRETARY (2014-2020)
Orfan Shouakar-Stash
Dept of Earth and Environmental Sciences University of Waterloo
CANADA

JOURNAL EDITOR
Michael Kersten
Johannes-Gutenberg-Universität Mainz
GERMANY

BUSINESS OFFICE MANAGER
Chris Gardner
School of Earth Sciences
The Ohio State University
USA
Email: BusinessOffice@IAGC-Society.org

Council Members

Sergey V. Alexeev
Institute of the Earth's Crust SB RAS
RUSSIA

François Chabaux
University of Strasbourg
FRANCE

Huaming Guo
China University of Geosciences
CHINA

Dirk Kirste
Simon Fraser University
CANADA

Elisa Sacchi
University of Pavia
ITALY

Elisabeth Widom
Miami University
USA

Pierpaolo Zuddas
(Water-Rock Interaction)
Sorbonne University
FRANCE

Romain Millot
(Applied Isotope Geochemistry)
French Geological Survey (BRGM)
FRANCE

Steven Banwart
(Geochemistry of the Earth's Surface Chair)
The University of Sheffield
UNITED KINGDOM

Martin Novak
(Biogeochemistry Chair)
Czech Geological Survey
CZECH REPUBLIC

Other Working Group Chairs (non-council)

David B. Smith
(Global Geochemical Baselines)
U.S. Geological Survey
USA

David Long
(Urban Geochemistry)
Michigan State University
USA

Ron Fuge
(Environmental Geochemistry Chair)
Aberystwyth University
UNITED KINGDOM

Olle Selinus
(Environmental Geochemistry Chair)
Linneaus University
SWEDEN

Renew Your IAGC Membership for 2020!

Don't forget to renew your IAGC membership for 2020 before January so you don't miss any issues of *Elements* magazine! Our annual membership fee is STILL only $25 and includes a hard copy subscription to *Elements* as well as online access. Membership also rewards you with lower cost registration rates at IAGC-sponsored working group conferences.

Online access to our journal, *Applied Geochemistry*, is available 2020. Our 2019 rates are still available for a few weeks at $70 for student members and $92 for professional members. We expect this price to rise after Elsevier updates their costs for 2020. You must pay your IAGC dues in order to purchase *Applied Geochemistry*.

To renew online using a credit card through PayPal or Square Market, via check, or to simply check your membership status, follow the links below and enter either your membership number or email address:

Renew with a credit card

Renew with a check

Check your membership status or look up your membership number