Platinum-Group Elements

“Admirably Adapted” for Science and Industry

Platinum-Group Elements in Cosmochemistry

Radioisotope Systems

Key Tracers for the Earth’s Interior

Ore Deposits

Environmental Relevance
The Platinum-Group Elements

James M. Brenan and James E. Mungall, Guest Editors

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I am writing these words on my way home from the 2008 Goldschmidt Conference in Vancouver, so it’s possible that I’m writing in a state of over-stimulation: by any measure it was an extraordinary meeting that lived up to its promise to cover science “from sea to sky.”

Much of the credit for the success of this year’s Goldschmidt Conference should go to the organizers and sponsors of the meeting, and I hope all of you will join me in congratulating the program committee and chairs Rick Carlson, Barbara Sherwood Lollar, and Dominique Weis. Still, I think there is more going on in the field of geochemistry — than a scenic venue and thoughtful planning: the conference took place within the context of far-reaching, fundamental developments in the geochemical sciences. These developments have been apparent at many recent meetings, and I think they will continue to be prominent for the foreseeable future. At the risk of being overly dramatic, I believe we are in the midst of a quiet revolution in the geochemical sciences.

At the root of this revolution is the unprecedented proliferation of technology that not only drives the science we’re doing but also is driven by it. One side of the equation is the breathtaking technology that not only drives the science we’re doing but also is driven by it. One side of the equation is the breathtaking technology that not only drives the science we’re doing but also is driven by it. One side of the equation is the breathtaking technology that not only drives the science we’re doing but also is driven by it. One side of the equation is the breathtaking technology that not only drives the science we’re doing but also is driven by it. One side of the equation is the breathtaking technology that not only drives the science we’re doing but also is driven by it. One side of the equation is the breathtaking technology that not only drives the science we’re doing but also is driven by it. 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THIS ISSUE

Guest editors James Brenan and James Mungall have brought together a cast of international authors to give you an up-to-date overview of the economic, scientific, and environmental significance of the platinum-group elements.

PAST PRINCIPAL EDITOR HONORED

Michael F. Hochella Jr. was honored during the recent Goldschmidt Conference for his distinguished service to the Geochemical Society, as vice president, president, and past president (1998–2003), as co-organizer of the 2001 V.M. Goldschmidt Conference, and as “former Principal Editor of the extraordinarily successful Elements magazine.”

As citationist Scott Wood pointed out, “Mike’s Presidential service in the Geochemical Society was distinguished by several extraordinary achievements. He was the major driving force in involving the Geochemical Society in the Reviews in Mineralogy series, culminating in the change of the name to Reviews in Mineralogy and Geochemistry. In 2001 Mike co-organized a highly successful Goldschmidt Conference held in Hot Springs, Virginia, with Bob Bodnar. Although Mike retired from active service on the GS Board of Directors after 2003, it was not long before he was to serve the society again, this time as one of the founding Principal Editors of the magazine Elements. From the early days when Rod Ewing first pitched to the Geochemical Society his idea for a scientific magazine to be co-published by several mineralogical and geochemical societies, Mike was a strong supporter of the concept. According to Principal Editor Ian Parsons, Mike played a ‘pivotal role’ in making Elements the success it has become.”

Here are some excerpts from Mike’s response: “Whether science or service awards have come my way, I’m just doing what I love to do. I can’t imagine anything more important, in the long run, than understanding this third rock from the sun, what makes it work, where it came from and where it’s going, and how to best care for it. To be so privileged, and to be able to call all of you colleagues, is the greatest joy in my life next to my family. And if I can constructively and productively serve this constituency, as this award implies, then I am definitely on the right track, and I will continue to do that, whether I am testifying to a congressional subcommittee on Capital Hill, or telling a large introductory class that what we do is worth it. ...Earth science, in all its grand forms and permutations, is as important to the global society as ever. Insofar as our societies help us organize and project, anything we can do to serve our organizations is more important than we can possibly imagine.”

ELEMENTS AT THE GOLDSCHMIDT CONFERENCE

The editors met for a full day on July 14, 2008. In attendance were principal editors Bruce Watson, Susan Stipp, and David Vaughan, incoming principal editor Hap McSween, past principal editors Ian Parsons and Rod Ewing (also chair of the Executive Committee), and managing editor Pierrette Tremblay. We reviewed the past year with its highlights and challenges and brainstormed about where we want Elements to be five years from now. Among the highlights of the year, those deserving most mention are that Elements is now available on GeoScienceWorld and that an online version is available to members of participating societies.

Part of each principal editors meeting is devoted to reviewing proposals for future thematic issues. We had ten proposals on hand to review. We accepted and slated two to complete our 2009 lineup. We asked for revised proposals for three of them, and we plan to slate them in 2010 if the revisions are accepted. Some of the questions we ask ourselves when we review proposals are: Will this topic be of interest to a broad spectrum of members of our community? Will it be of interest to scientists outside our community? To industry? To policy makers? Is this a frontier area of research? Will this be particularly good for teaching? In any given year, we seek to ensure that mineralogists, geochemists, and petrologists will be particularly interested in some of the Elements issues, and that they will find it fun to learn about fields that are not their own from the other issues.

Bruce Watson, Susan Stipp, and David Vaughan, Principal Editors, and Pierrette Tremblay, Managing Editor

EDITORIAL (cont’d from page 219)

New technologies have contributed to our science on other fronts besides chemical and isotopic analysis. New spectrometers allow us to look more closely at rocks and minerals for telltale indicators of geologic history (e.g. tiny grains of coesite indicating ultrahigh-pressure metamorphism; the hydrogen content of nominally anhydrous minerals as a barometer of mantle water fugacity). New microscopes provide images of minerals at the atomic scale. Beamlines at user facilities around the world (see Elements 2, number 1) let us explore structures and properties of phases that were previously inaccessible. The general availability of extraordinarily powerful computers enables us to deduce, through quantum-mechanical and molecular-dynamical models, the energetics and mobility of atoms in fluids and minerals and at the interfaces between them.

Is there really any difference between the present decade and past ones in the interval since V. M. Goldschmidt first elevated our science to the status of a unique discipline? I admit that it may be a matter simply of degree, but I do think the present time is unusual. Incredibly powerful tools are now accessible to a rapidly growing number of scientists applying chemistry and mineralogy to the study of the Earth. This has led to a proliferation not just of data but also of ideas—as well as an extraordinary blossoming of hypotheses that are realistically testable. From our present vantage point of immersion in this scientific ferment, it is easy to overlook the remarkable growth of the geochemical sciences that drives and is driven by advances in analytical capabilities and other technologies. One day, I predict, we will look back upon this time period (say, 2000–2016, assuming Goldschmidt 2008 is the temporal midpoint!) as the defining interval during which our community recognized and quantified many of the chemical processes and phenomena that link the biosphere, atmosphere, oceans, and solid Earth. This is what our science is about, and right now is an exciting time—even if it’s not quite a revolution.

We should bear in mind that much of the knowledge we are accumulating can inform the increasingly urgent international discussion of energy and the environment. Perhaps we will also be able to look back on this time as one during which the geochemical sciences began to influence governmental decisions and policy.

Bruce Watson*
Rensselaer Polytechnic Institute (watsoe@rpi.edu)

* Bruce Watson was the principal editor in charge of this issue
MUSEUMS ARE NOT ATTICS

I am a museum addict. I get a rush when strange, unrelated objects are juxtaposed next to one another behind the glass of a poorly illuminated cabinet. The first symptoms of this affliction appeared early in life, when I proudly displayed rocks and plants from the yard in my garage and charged my parents a modest admission fee. Still, from the human impulse to collect and display comes some of the world’s magnificent museums.

I recently had the opportunity to visit one of my favorites, the Harvard Museum of Natural History. It is in an old red brick building, and ironwork stairs lead to the second-floor entrance. The main attraction is the collection of glass flowers, representing hundreds of species as scientifically accurate, life-size models. The collection is the work of Leopold and Rudolph Blaschka, father and son descendants of Bohemian glass-makers, who made these models over a fifty-year period ending in the 1930s (see Parting Shots, page 287). Next to the room of glass plants are the mineral-specimen displays. Giant crystals occupy floor-to-ceiling cabinets on opposite sides of the room and act as huge magnets for the small children pressing up against these cases. Smaller specimens are arranged by chemical group in old-style, glass-covered cabinets that rise to just below waist level. Most visitors pass through the grid of cases too quickly to appreciate what has been preserved for them, rushing to touch a few large meteorites in a small exhibit. Beyond is a narrow, crooked room with a series of exhibits on global climate change that features a constantly running film by Daniel Schrag (an Elements author) discussing the effects of climate change and challenging the audience to register their views by pressing buttons on a console in front of the screen. The kids treat answering his questions as if it is a video game where speed and force are more important than the right answer. With a quick turn, you pass into a room that (as I later realized) must be part of the Peabody Museum, but you are still not out of hearing of the pounded buttons of climate change. You pass large-scale reproductions of Mayan murals lining both sides of the room, until you finally emerge into a larger room of huge stone carvings and glass cases with a mixed assortment of Mesoamerican objects, such as brightly quilted vests, mannequins in natural dress, and a contemporary array of objects that celebrate the Dia de Los Muertos. If you go upstairs, you are in the South Pacific; downstairs, you may view a collection of early Japanese photographs with fine images of the indigenous Ainu. By retracing your steps back to the entrance, you can begin another journey in the opposite direction, where there is an exhibit of nests and eggs (with the world’s largest egg), a display of the skeletons of dinosaurs and mammals in small dioramas, and at the very end of this journey a giant, 42-foot, short-necked plesiosaur, the Kronosaurus, from the Cretaceous of Queensland. After some hours on this Sunday afternoon, I reached saturation and walked into a fresh rain, happy that museums are very much a part of life.

Today’s museums are moving beyond this sense of “collection” and are becoming interactive, “hands-on” affairs that have the laser focus of a google search. You can walk through lava tubes with badly simulated glowing lava below your feet or stand on a shaking platform that imitates an earthquake. Modern museums are becoming an entertainment for the senses, but often provide precious little for the mind. This shift from science to entertainment means that it is very unlikely that the museum becomes an economic “driver,” pulling visitors to the community or locals to a renewed downtown. This change in purpose has an important impact on the fate of the precious collections so meticulously gathered by generations of natural scientists.

Once a collection becomes static—and the main issues become cost and space—then the banners of neglect, sell, and disperse are on the horizon. A recent major example of this fate was the mineral collection of the Philadelphia Academy of Natural Sciences (see www.minoscam.org/ article-87.html). The collection dates from the earliest years of the Republic, and the first contribution (1725 specimens) was from the first American formally trained in mineralogy, Adam Seybert (1773–1825), who studied under René Haüy. Through subsequent, major additions (the Franklin Institute donated its entire collection, as did William Vaux on his death in 1882), the collection grew to some 30,000 specimens by the early 20th century. The last curator was Samuel G. Gordon (1897–1952), who also founded the American Mineralogist, first published in 1916. After Gordon, there were no mineral curators (except for a period of five years) to look after the collection. Most of the collection was stored, with the loss of some material by neglect. In 2006, much of the collection (about 19,000 specimens) was sold to a consortium of mineral dealers in order to raise funds for other scientific activities of the Academy. Nearly half of the collection went to other museums, such as the Carnegie Museum in Pittsburgh and the Gemological Institute of America.

What can be done? I think that the first step is to make clearer statements about the cultural and scientific value of such collections. There is a special connection to the past in handling material first studied by René Haüy. The scientific value lies in having material that has already been carefully analyzed or that has special properties or provenance. I have often relied on museums for a few rare minerals that preserve a record of radiation damage in specific, but unusual, structures. Professional mineralogists may appreciate the value of collections, but this is less clear to the public that sees only the exhibits at the museum. This is why it is so important to carry out scientific research on the collection, as well as emphasize public outreach, acquisition, and curating.

Finally, with proper financial support, certain national and regional museums should be designated as the proper recipients of collections that no longer have a home. It is not easy for an institution to divest itself of a collection. Most institutions want to preserve the cultural and scientific value of their collection, but this can be complicated by...
PEOPLE IN THE NEWS

2008 AGU VGP FELLOWS

Congratulations to the 2008 Fellows of the American Geophysical Union (Volcanology, Geochemistry, and Petrology Section)!

CHARLES R. BACON
For detailed field-based studies of volcanoes leading to establishing critical links between volcanic and tectonic processes

PATRICIA DOVE
For seminal contributions toward a molecular-scale understanding of mineralization and dissolution in inorganic and biological environments

R. LAWRENCE EDWARDS
For pioneering work on U-series systematics and contributions to paleoclimatology, neotectonics, the 14C timescale, and paleoceanography

RONALD GREELEY
For pioneering work on processes and history throughout the solar system through the integration of field, laboratory, modeling, and observational studies

GILBERT N. HANSON
For work in the development and application of fundamental trace-element and isotope tools that are used today in many disciplines of the geosciences

JAMES GREGORY HIRTH
For work on the rheology of quartz, olivine + melt + H2O, serpentine, and gabbro, and interdisciplinary insight, dedicated teaching, and service to AGU

TETSUO IRIFUNE
For contributions to the understanding of the mineralogical structure and dynamics of the Earth’s interior through high-pressure experimental studies

TERRY A. PLANK
For contributions to the understanding of convergent margin processes and the formation of the continental crust

BARRY VOIGHT
For fundamental contributions to the understanding of volcano deformation, assessment of volcanic hazards, and forecasting

TIM DREVER HONORED AT THE GOLDSCHMIDT CONFERENCE

A special session was convened at the 2008 Goldschmidt Conference to pay tribute to James I. (Tim) Drever for his contributions to geochemistry and for his long career at the University of Wyoming. In addition to his best-selling book *The Geochemistry of Natural Waters* and countless research papers, Tim served as a long-time editor of *Chemical Geology* and as the president of the Geochemical Society and was a founding advisor to *Elements* magazine. The session “Rates of Geochemical Processes and Their Application to Natural Systems” included a keynote address by Art White (U.S. Geological Survey) entitled “Approaches to Estimating Chemical Weathering Rates”; invited talks by David Clow (U.S. Geological Survey)—“Sensitivity of Mineral Weathering Rates to Annual Variations in Climate,” and by Chris Gammons (Montana Tech University)—“Biogeochemical Processes in Flooded Underground Mine Workings of Butte, Montana, USA”; and an additional 28 volunteered presentations on mineral weathering and secondary precipitation, global climate cycles, environmental geochemistry of mining, geochemistry of natural waters, and redox reactions at mineral surfaces. A highlight of the festivities was a reception for Tim and his wife, Irene, held at the botanical gardens of the University of British Columbia. Many old and new friends, all wearing a “Friend of Tim” badge, toasted Tim as the “first critical zone geochemist” and a “true gentleman scientist.”

Lisa L. Stillings
USGS

From left to right, present and past presidents of the Geochemical Society: Marty Goldhaber, Sue Brantley, and Tim Drever

The “Friend of Tim” button, destined to be a collector’s item!

TRIPLE POINT (cont’d from page 221)

covenants on donated specimens or the cost of properly appraising the value of the collection. The situation at the Philadelphia Academy is regrettable, but understandable. Collections in storage are not different from our attics filled with old, but valued memorabilia. If we want to prevent these events in the future, we have to clean out our attics and put these collections to scientific use or on display. We need to create a structure and system of support that preserve the cultural and scientific heritage of our mineral collections.

Rodney C. Ewing
University of Michigan (rodewing@umich.edu)
ADVERTISING
Olivier Alard is a CNRS researcher in the core-mantle group at Geosciences Montpellier (France). Since his PhD (GEMOC, Macquarie University, Australia), he has been interested in the formation and differentiation of Earth-like planets and in the long-term evolution of the Earth’s mantle. His approach uses in situ techniques to determine the micron-scale elemental and isotopic distribution of the siderophile and chalcophile elements within their main sulfide and metal-alloy host phases.

James M. Brenan is an associate professor in the Department of Geology at the University of Toronto. He obtained a PhD at Rensselaer Polytechnic Institute in 1990 and then did postdoctoral work at the Geophysical Laboratory and Lawrence Livermore National Laboratory. He simulates rock-forming conditions in the laboratory to establish interphase partitioning of minor and trace elements, to assess the role of diffusion in controlling the rates at which natural systems approach equilibrium, and to determine the extent to which geological fluids influence mass transfer. His recent work has focused on understanding the role of sulfide, oxide, and metal phases in controlling the behavior of highly siderophile elements in magmatic systems.

Richard W. Carlson is a staff scientist in the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. He pursues various applications of isotope and trace-element geochemistry in the fields of cosmochemistry and solid-Earth science. His current research is focused on isotopic anomalies in solar system materials, early planetary differentiation using the 146Sm and 107Pd chronometers, the causes of continental intraplate volcanism, and the processes that form continental crust and its underlying sections of mantle lithosphere, the latter done mostly with the Re–Os system.

Jean-Pierre Lorand is a research director at the Centre National de la Recherche Scientifique (CNRS). He works at the Museum National d’Histoire Naturelle (Paris) as head of the Laboratory of Mineralogy. After pioneering work on mantle-derived sulfide minerals in the 1980s, his research topics focused on the abundance of sulfur in the mantle. More recently, his major topic of research was platinum-group elements (PGE), their distribution among mantle minerals, and their fractionation in response to igneous processes involving the mantle. Now, he centers his attention on the origin of PGE-rich micronuggets in mantle sulfides. He was involved in the organization of the first three International Workshops on Highly Siderophile Elements.

Meet the Authors

Gregory M. Morrison is a professor in the Department of Civil and Environmental Engineering at Chalmers University of Technology, Sweden. His research interests include water-quality analysis, water-systems assessment, and water engineering. He started research on the platinum-group elements during a postdoctoral visit in Australia in 1988 and has maintained his interest in the subject since then.

James E. Mungall is an associate professor in the Department of Geology at the University of Toronto. His research is largely oriented toward understanding the genesis of magmatic ore deposits, using inputs from igneous and hydrothermal geochemistry, extensive field work, and experimental petrology. A major focus of his work in recent years has been the use of platinum-group elements as tracers to illuminate the genetic processes that form magmatic ores, spanning the range from melting and magma transport to phase separation and collection.

Ambre Luguet is an assistant professor at the Steinmann Institut of Bonn University. She completed her PhD at the Paris Natural History Museum in 2000, which was followed by postdoctoral work at Carnegie Institution of Washington (DTM) and at Durham University. She was involved in the organization of the 3rd International Workshop on Highly Siderophile Elements held in Durham and in the resulting special issue of Chemical Geology (volume 248). Her research interests focus on the isotopic compositions of the highly siderophile elements (HSE) and osmium in mantle-derived peridotites and lavas with a particular emphasis on the role of HSE host minerals in controlling these geochemical signatures.

Anthony J. Naldrett is a University Professor emeritus at the University of Toronto. Although he retired from the university 10 years ago, he has continued both his research into the origin of magmatic sulfide deposits and advising mining companies in their exploration for them. Currently he spends five months each year at the University of the Witwatersrand, where he holds an honorary professorship and is studying the concentration of PGE in the Merensky Reef, UG-2, and Platreef.

Herbert Palme is professor of geochemistry and mineralogy in the Department of Geology and Mineralogy at the University of Cologne. Earlier he had spent more than 20 years in the Chemie Max-Planck Institute for Chemistry in Mainz. His main interest is in the formation and early evolution of the solar system, including the Earth. He has published papers on PGE in terrestrial crater samples, in meteorites and their components, and in lunar rocks. Together with Alexander Borisov, he has experimentally determined one-bar solubilities of PGE in silicate melts. These data lead to extremely high metal–silicate partition coefficients for the PGE.

Sebastien Rauch is an associate professor in the Department of Civil and Environmental Engineering at Chalmers University of Technology, Sweden. His research deals primarily with emerging metallic contaminants and the biogeochemical processes controlling the fate of these contaminants. Platinum-group elements have been a major component of this research, resulting in over 30 peer-reviewed articles on platinum-group element analysis, emissions, environmental levels and physicochemical forms, dispersion mechanisms, bioaccumulation, and toxic effects.

Maria Schönbächler is a lecturer at the University of Manchester, UK, since October 2007. She received her PhD in cosmochemistry from ETH Zürich, Switzerland, which was followed by postdoctoral studies in the Department of Terrestrial Magnetism of the Carnegie Institution of Washington and in the Imperial College London. She is partic-
ularly interested in extinct radionuclides, mainly $^{107}$Pd and $^{92}$Nb, in order to understand processes in the early solar system, such as the depletion of volatile elements, the differentiation and evolution of planetary bodies. Further research subjects include stable-isotope fractionation of non-traditional volatile elements, isotopic anomalies in solar system materials, and the development of new techniques for the analysis of isotopes in geologic materials.

Steven B. Shirey
is a staff scientist in the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. He is a trace-element and isotope geochemist interested in problems of continent formation, Archean mantle evolution, and the geodynamics of the modern oceanic mantle. Recent work has centered on the onset of subduction on Earth, the petrogenesis of diamonds, and novel applications of the Re-Os isotopic system to geological processes in the mantle keels beneath continents.

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