Elements

An International Magazine of Mineralogy, Geochemistry, and Petrology

April 2013
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Serpentinites

STÉPHANE GUILLOT and KEIKO HATTORI, Guest Editors

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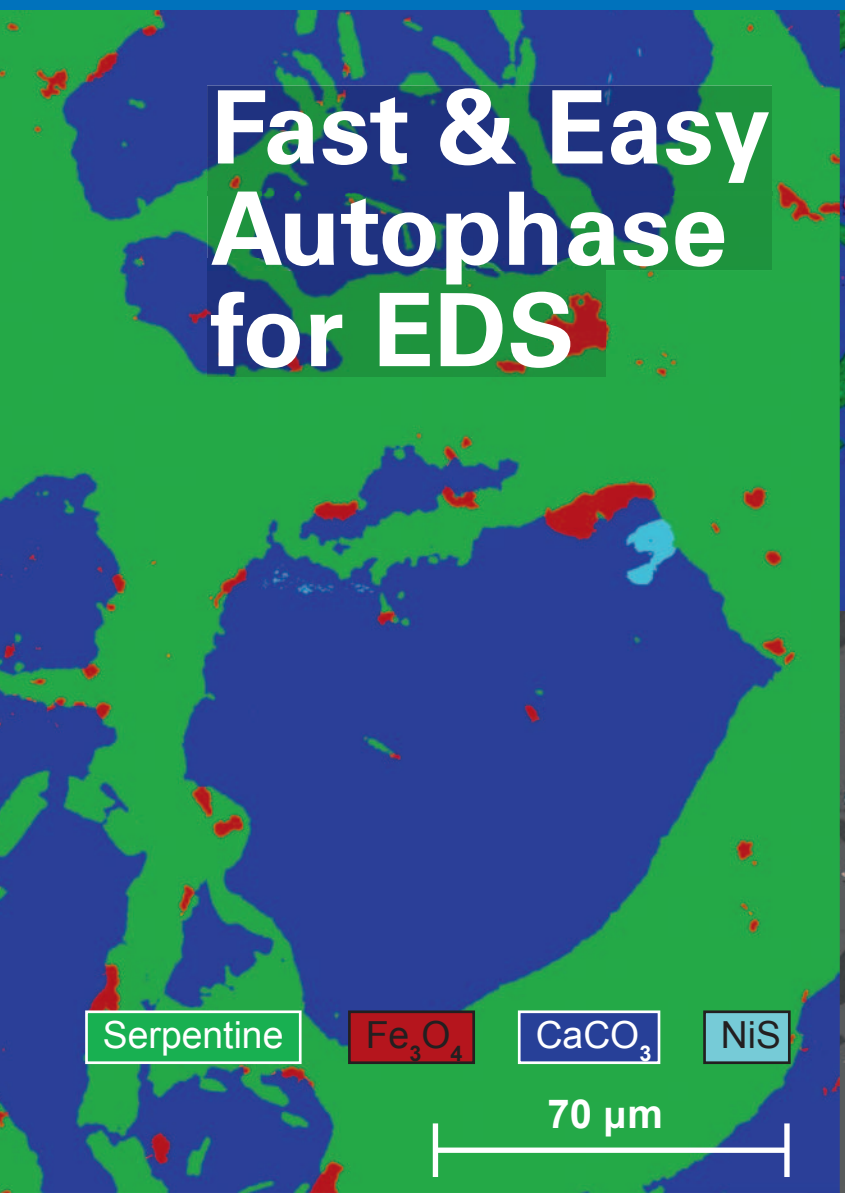

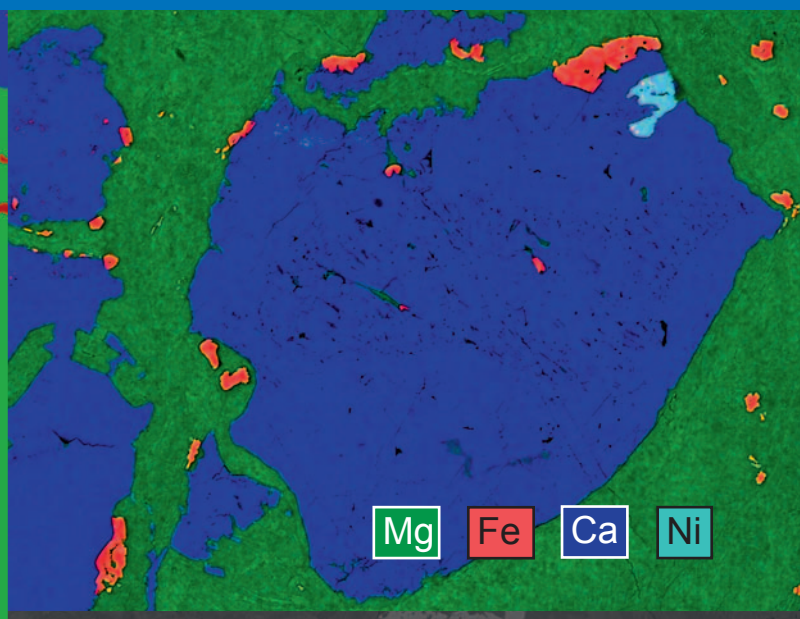

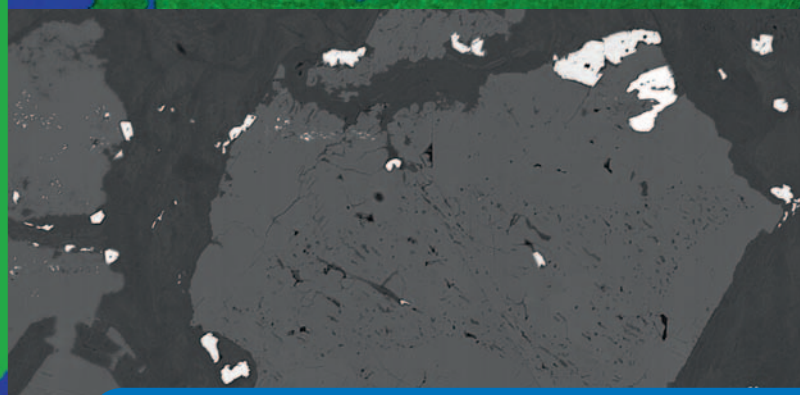

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The images above show a serpentinite sample from the Totalp area near Davos, Switzerland mapped with a QUANTAX EDS system. Areas of similar chemical composition are easily made visible by Autophase, a software option for the QUANTAX ESPRIT software suite.
Sample courtesy of Emily H. Goldstein, University of Texas at Austin.

More details can be found at: www.bruker.com/elements

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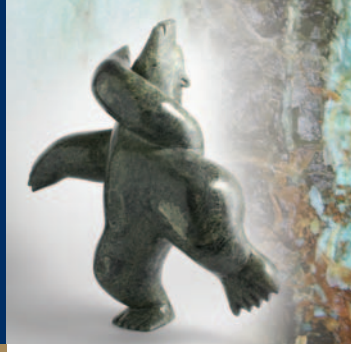

About the Cover: The Inuit people of northern Canada have traditionally used serpentinite for their carvings.

Gleeful Bear (53 × 56 × 20 cm), by Kelly Qimirpik of Cape Dorset, Nunavut, Canada, courtesy of the Inuit Gallery of Vancouver (www.Inuit.com), reproduced with the permission of Dorset Fine Arts.

Background image: vein of serpentine surrounded by garnierite from the Koniambo Massif, New Caledonia

Serpentinites

Guest Editors: **Stéphane Guillot and Keiko Hattori**

DEPARTMENTS

Elements is published jointly by the Mineralogical Society of America, the Mineralogical Society of Great Britain and Ireland, the Mineralogical Association of Canada, the Geochemical Society, The Clay Minerals Society, the European Association of Geochemistry, the International Association of GeoChemistry, the Société Française de Minéralogie et de Cristallographie, the Association of Applied Geochemists, the Deutsche Mineralogische Gesellschaft, the Società Italiana di Mineralogia e Petrologia, the International Association of Geoanalysts, the Polskie Towarzystwo Mineralogiczne (Mineralogical Society of Poland), the Sociedad Española de Mineralogía, the Swiss Society of Mineralogy and Petrology, the Meteoritical Society, and the Japan Association of Mineralogical Sciences. It is provided as a benefit to members of these societies.

Elements is published six times a year. Individuals are encouraged to join any one of the participating societies to receive *Elements*. Institutional subscribers to any of the following journals—*American Mineralogist*, *Clay Minerals*, *Clays and Clay Minerals*, *Mineralogical Magazine*, and *The Canadian Mineralogist*—also receive one copy of *Elements* as part of their 2013 subscription. Institutional subscriptions are available for US$160 (US$175 non-US addresses) a year in 2013. Contact the managing editor (tremblpi@ete.inrs.ca) for information.

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The Mineralogical Society of America is composed of individuals interested in mineralogy, crystallography, petrology, and geochemistry. Founded in 1919, the Society promotes, through education and research, the understanding and application of mineralogy by industry, universities, government, and the public. Membership benefits include special subscription rates for *American Mineralogist* as well as other journals, a 25% discount on Reviews in Mineralogy & Geochemistry series and Monographs, *Elements*, reduced registration fees for MSA meetings and short courses, and participation in a society that supports the many facets of mineralogy.

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The Mineralogical Society of Great Britain and Ireland is an international society for all those working in the mineral sciences. The Society aims to advance the knowledge of the science of mineralogy and its application to other subjects, including crystallography, geochemistry, petrology, environmental science and economic geology. The Society furthers its aims through scientific meetings and the publication of scientific journals, books and monographs. The Society publishes *Mineralogical Magazine* and *Clay Minerals*. Students receive the first year of membership free of charge. All members receive *Elements*.

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The Mineralogical Association of Canada was incorporated in 1955 to promote and advance the knowledge of mineralogy and the related disciplines of crystallography, petrology, geochemistry, and economic geology. Any person engaged or interested in these fields may become a member of the Association. Membership benefits include a subscription to *Elements*, reduced cost for subscribing to *The Canadian Mineralogist*, a 20% discount on short course volumes and special publications, and a discount on the registration fee for annual meetings.

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The Clay Minerals Society (CMS) began as the Clay Minerals Committee of the US National Academy of Sciences – National Research Council in 1952. In 1962, the CMS was incorporated with the primary purpose of stimulating research and disseminating information relating to all aspects of clay science and technology. The CMS holds annual meetings, workshops, and field trips, and publishes *Clays and Clay Minerals* and the CMS Workshop Lectures series. Membership benefits include reduced registration fees to the annual meeting, discounts on the CMS Workshop Lectures, and *Elements*.

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The Geochemical Society (GS) is an international organization founded in 1955 for students and scientists involved in the practice, study, and teaching of geochemistry. Our programs include co-hosting the annual Goldschmidt Conference™, editorial oversight of *Geochimica et Cosmochimica Acta* (*GCA*), supporting geochemical symposia through our Meeting Assistance Program, and supporting student development through our Student Travel Grant Program. GS annually recognizes excellence in geochemistry through its medals, lectures, and awards. Members receive a subscription to *Elements*, special member rates for *GCA* and *G-cubed*, and publication and conference discounts.

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The European Association of Geochemistry was founded in 1985 to promote geochemical research and study in Europe. It is now recognized as the premiere geochemical organization in Europe, encouraging interaction between geochemists and researchers in associated fields and promoting research and teaching in the public and private sectors.

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The International Association of GeoChemistry (IAGC) has been a pre-eminent international geochemical organization for over 40 years. Its principal objectives are to foster cooperation in the advancement of applied geochemistry by sponsoring specialist scientific symposia and the activities organized by its working groups and by supporting its journal, *Applied Geochemistry*. The administration and activities of IAGC are conducted by its Council, comprising an Executive and ten ordinary members. Day-to-day administration is performed through the IAGC business office.

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The Société Française de Minéralogie et de Cristallographie, the French Mineralogy and Crystallography Society, was founded on March 21, 1878. The purpose of the Society is to promote mineralogy and crystallography. Membership benefits include the *European Journal of Mineralogy*, *Elements*, and reduced registration fees for SFMC meetings.

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The Association of Applied Geochemists is an international organization founded in 1970 that specializes in the field of applied geochemistry. It aims to advance the science of geochemistry as it relates to exploration and the environment, further the common interests of exploration geochemists, facilitate the acquisition and distribution of scientific knowledge, promote the exchange of information, and encourage research and development. AAG membership includes the AAG journal, *Geochemistry: Exploration, Environment, Analysis*; the AAG newsletter, *EXPLORE*; and *Elements*.

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The Deutsche Mineralogische Gesellschaft (German Mineralogical Society) was founded in 1908 to "promote mineralogy and all its subdisciplines in teaching and research as well as the personal relationships among all members." Its great tradition is reflected in the list of honorary fellows, who include M. v. Laue, G. v. Tschermak, P. Eskola, C. W. Correns, P. Ramdohr, and H. Strunz. Today, the Society especially tries to support young researchers, e.g. to attend conferences and short courses. Membership benefits include the *European Journal of Mineralogy*, *GMit*, and *Elements*.

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The Società Italiana di Mineralogia e Petrologia (Italian Society of Mineralogy and Petrology), established in 1940, is the national body representing all researchers dealing with mineralogy, petrology, and related disciplines. Membership benefits include receiving the *European Journal of Mineralogy*, *Plinius*, and *Elements*, and a reduced registration fee for the annual meeting.

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The International Association of Geoanalysts is a worldwide organization supporting the professional interests of those involved in the analysis of geological and environmental materials. Activities include the management of proficiency-testing programmes for bulk-rock and micro-analytical methods, the production and certification of reference materials and the publication of the Association's journal, *Geostandards and Geoanalytical Research*.

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The Polskie Towarzystwo Mineralogiczne (Mineralogical Society of Poland), founded in 1969, draws together professionals and amateurs interested in mineralogy, crystallography, petrology, geochemistry, and economic geology. The Society promotes links between mineralogical science and education and technology through annual conferences, field trips, invited lectures, and publishing. Membership benefits include subscriptions to *Mineralogia* and *Elements*.

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The Sociedad Española de Mineralogía (Spanish Mineralogical Society) was founded in 1975 to promote research in mineralogy, petrology, and geochemistry. The Society organizes annual conferences and furthers the training of young researchers via seminars and special publications. The *SEM Bulletin* published scientific papers from 1978 to 2003, the year the Society joined the *European Journal of Mineralogy* and launched *Macla*, a new journal containing scientific news, abstracts, and reviews. Membership benefits include receiving the *European Journal of Mineralogy*, *Macla*, and *Elements*.

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The Swiss Society of Mineralogy and Petrology was founded in 1924 by professionals from academia and industry and amateurs to promote knowledge in the fields of mineralogy, petrology, and geochemistry and to disseminate it to the scientific and public communities. The Society coorganizes the annual Swiss Geoscience Meeting and publishes the *Swiss Journal of Geosciences* jointly with the national geological and paleontological societies.

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The Meteoritical Society is an international organization founded in 1933 for scientists, collectors, and educators to advance the study of meteorites and other extraterrestrial materials and their parent asteroids, comets, and planets. Members receive our journal, *Meteoritics & Planetary Science*, reduced rates for *Geochimica et Cosmochimica Acta*, which we cosponsor, the *Meteoritical Bulletin*, and *Elements*. We organize annual meetings, workshops, and field trips, and support young planetary scientists worldwide. Through our medals and awards, we recognize excellence in meteoritics and allied fields.

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The Japan Association of Mineralogical Sciences (JAMS) was established in 2007 by merging the Mineralogical Society of Japan, founded in 1955, and the Japanese Association of Mineralogists, Petrologists, and Economic Geologists, established in 1928. JAMS covers the wide field of mineral sciences, geochemistry, and petrology. Membership benefits include receiving the *Journal of Mineralogical and Petrological Sciences* (*JMPS*), the *Ganseki-Koubutsukagaku* (*GKK*), and *Elements*.

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Affiliated Societies
The International Mineralogical Association, the European Mineralogical Union, and the International Association for the Study of Clays are affiliated societies of *Elements*. The affiliated status is reserved for those organizations that serve as an "umbrella" for other groups in the fields of mineralogy, geochemistry, and petrology, but that do not themselves have a membership base.

Elements

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VERSATILE SERPENTINE

Georges Calas

It is always fascinating to see how much science has not only progressed but also diversified during the last few decades. Even focusing on a single mineral or rock allows us to visit many facets of the Earth and environmental sciences and related domains, such as materials science and cultural heritage. Indeed, I marvel how each time an issue of *Elements* is devoted to a single mineral, it reveals that specialization does not necessarily lead to a narrow vision but actually opens new doors. Here we see that research activity on one of the most classical minerals—used by man for millennia and investigated since the founding of geology and mineralogy—is now making a strong "comeback," with scientists tackling the role of serpentine in present-day hot topics such as alternative energies and the origin of life.

This issue of *Elements* demonstrates clearly that serpentine is a mineral group exhibiting many contrasts. As the dominant hydroxyl-bearing mineral in CM carbonaceous chondrites, serpentine is among the oldest witnesses of the formation of our Solar System. Serpentine is suspected to have formed as a direct nebular condensate or by aqueous alteration of anhydrous silicates during the cooling of the solar nebula. But present-day serpentinization is also a major geological process, as dramatically illustrated by the serpentinite-hosted Lost City hydrothermal field on the Mid-Atlantic Ridge, where hydration reactions are the driving force of the hydrothermal system. This issue also illustrates well the fact that there is an intimate interdependence between the fundamental and applied aspects of serpentine. At a time when funding for research and higher education is difficult and when science is sometimes questioned by officials about its relevance for opening new ways to benefit the economy and society, it is important to reiterate that a better understanding of our planet will provide robust answers to key questions about the future of our societies.

Serpentine is also well known in cultural heritage as an important historical material. For example, it was probably among the first materials to have been used in many different civilizations, in tool making, in decoration, or for its magic properties, such as protection from snakebites. A spectacular illustration is provided by cylinder seals—small items that may have been used as much as 5 millennia ago as administrative tools or amulets. The unique mechanical properties of serpentine may have been instrumental in helping develop such objects: serpentine is an easily worked material, but hard enough to keep the information engraved on it from becoming blunted over time. This may explain the high quality of these small masterpieces now displayed in museums (see figure).

The origin of serpentine has been discussed for more than two centuries because of its close association with a large diversity of rocks. In the late 1800s and early 1900s, there was a vigorous debate regarding the origin of serpentines: sedimentary or igneous? Alexandre Brongniart, who taught mineralogy with René-Just Haüy at the newly founded University of Paris during the early years of the 19th century, insisted that serpentines were more common than presumed, and he advocated an igneous origin for serpentine-bearing rocks. Later in the century, microscopic observations by Tschermak and others demonstrated that olivine alters to serpentine. Serpentinites also received the attention of many geologists in the second half of the 19th century, when they were recognized as being definitely derived from peridotites. And the quantification of the stability field of serpentine was the purpose of a pioneering hydrothermal study by Bowen and Tuttle in 1949, during their classical investigation of the $MgO–SiO_2–H_2O$ system. Current research on serpentine now encompasses many different fields in the Earth and environmental sciences, including geomicrobiology and energy science. For this reason, many countries hold scientific meetings to bring together this rapidly growing community. Such is the case for Serpentine Days (www.sfmc-fr.org/spip.php?article131), a series of meetings that began 6 years ago in France and now attracts an international audience.

Left: The serpentine cylinder seal of Shilishu, Mesopotamia (2.9 cm high; from about 2400 BC). The seal is carved in reverse in order to leave a positive image on clay (Right). Paris, musée du Louvre © RMN-Grand Palais (musée du Louvre) / Franck Raux

Looking ahead, nickel-bearing serpentinites, together with their weathering products, are exploited in many countries. As pointed out in this issue, serpentine-related mineral resources will become the world's main source of nickel and cobalt. However, in the fragile tropical environments where these deposits commonly occur, mining must be done in a sustainable, environmentally benign manner. New cooperative research is emerging to minimize the environmental and societal impacts of future mining operations, such as at the New Caledonian Center for Technological Research on Nickel and Its Environment (www.cnrt.nc), funded by the French government, regional authorities, and mining companies. From observing the early Solar System to caring about the future evolution of our environment, we have come a long way by following the serpentine track.

Georges Calas*

* Principal editor in charge of this issue

THIS ISSUE

As so ably outlined by Principal Editor Georges Calas in his editorial, the study of serpentinites leads to just about every area of the Earth sciences. Back in the 1970s, I remember presenting a paper on the serpentine problem during a seminar class. The "space problem" was a big deal at that time. Nowadays the focus is on the discovery of serpentinite on other planets and its role in plate tectonics and the origin of life.

While working on this issue, I visited the McMichael art gallery in Kleinburg, Ontario, Canada. The native art exhibits, entitled Exploring Cape Dorset Art, were very inspiring, and it seemed natural to use a beautiful Inuit serpentinite carving for the cover of this issue. We thank Darlene Wight, the curator of these traveling exhibits from the Winnipeg Art Gallery, who graciously agreed to write a text for Parting Shots, illustrated with some outstanding carvings by Kiugak Ashoona. The photograph for the cover was provided by the Inuit Gallery of Vancouver, and we thank Melanie Zavediuk, director of the gallery, for facilitating the process, and Kelly Qimirpik of Cape Dorset, the sculptor of the *Gleeful Bear*, for granting us permission to use the photo of his art.

Open access is at the heart of the future of scientific societies: we encourage you to read our Perpective article in order to understand what is at stake. It was written by Alex Speer, Kevin Murphy, and Sharon Tahirkheli, who monitor closely the rapidly evolving situation.

THANKING TIM DREVER!

Time sure flies when you are having fun! It seems like yesterday that Tim joined the *Elements* editorial team, but his three-year term ended at the close of 2012. I first met Tim at the 2003 GSA meeting, when negotiations between the newly formed Executive Committee of *Elements* and the Geochemical Society were happening. Tim was vice-president of the Geochemical Society at that time, and I venture to say that he was instrumental in getting the GS board to agree to join *Elements*. I next met him at a party held during the 2008 Goldschmidt Conference in honor of his retirement. It was obvious that Tim was held in great affection by colleagues and former students alike. I especially remember a young student in awe of meeting the author of *The Geochemistry of Natural Water*. I got my "Friend of Tim" button, and it is still in my memento box.

During his tenure at *Elements*, Tim was in charge of the following issues: Soil Remediation (v6n6); Global Water Sustainability (v7n3); Mine Wastes (v7n6); Minerals, Microbes, and Remediation (v8n2); and Urban Geochemistry (v8n6). As a final contribution, he has agreed to take charge of the Nitrogen issue, to be published in October. So even though we officially thank him here, he will still be working for *Elements* until that issue is in press. Tim has been a conscientious editor, always willing to go the extra mile to help authors write their very best; he has also volunteered for many extra tasks, like spending time at the *Elements* booth at Goldschmidt meetings and writing job descriptions. It has been a pleasure to work with him, and we thank him on behalf of the whole mineralogy-geochemistry-petrology community for his involvement in *Elements*. His gentle and caring ways will be missed.

UPCOMING EDITOR 2014–2016

We are delighted that Gordon Brown of Stanford University has accepted our invitation to join the editorial team. He will replace Georges Calas, whose term of office will end in December 2013. We will introduce Gordon more formally when his term starts in 2014.

ELEMENTS FEATURES

Elements is your magazine, and you can contribute to many features—some published regularly, others from time to time. Unless otherwise indicated, send your ideas and contributions to Pierrette Tremblay (tremblpi@ete.inrs.ca).

Letters to the Editors: Has an editorial spurred some thoughts? Have you a short news item of interest to the membership of *Elements*? Consider submitting a letter to the editors.

People in the News highlights the accomplishments of members of our community: awards they have received, especially outside our community, or exciting new projects in which they are engaged.

Triple Point raises issues of broad interest to the readers of *Elements* and explores different aspects of our science (teaching, publishing, historical aspects, etc.), our societies, funding, policy, and political issues.

The Elements' Toolbox presents new technological developments of interest to our readers. You can send your ideas and suggestions for coverage to Michael Wiedenbeck (michawi@gfz-postdam.de), the editor of this feature.

CosmoElements keeps us in touch with exciting discoveries in cosmochemistry, provides short articles that can be used in the classroom, and reports on the space missions carrying geochemical and mineralogical instruments. Contact Cari Corrigan (corrigan@si.edu).

A Life in Science is dedicated to supporting the career aspirations and progress of geoscientists, from students to retired professionals. It focuses on ways to make your life easier and to help you establish a satisfying career in the geosciences. Contact Penny King (penny.king@anu.edu.au).

Travelogue: Have you done field work in or traveled to an exotic location? Consider writing an account of your experiences.

Parting Shots fills one of the back pages, and its job is to entertain, to provide something lighter than all the serious stuff in the earlier pages. Intriguing, beautiful, or baffling photographs take the reader on a relaxing voyage into the web of connections that makes the realm of *Elements* so enthralling. Contact Ian Parsons (ian.parsons@ed.ac.uk).

CALL FOR PROPOSALS – THEMATIC TOPICS 2015

Your research area deserves an issue of *Elements*? Consider submitting a proposal. You would like to read about a certain topic? Let the editors know.

At their next meeting on October 26, immediately preceding the Geological Society of America conference in Denver, Colorado, the editors will review the proposals on hand to determine the 2015 lineup. The six proposals chosen will represent a balance among mineralogy, geochemistry, and petrology topics and of course will be the most exciting and pertinent for *Elements*' audience.

Many potential guest editors first send an e-mail of enquiry to one of the editors about their idea for a topic. The "feeler" e-mails are circulated to the editorial team, and feedback on the proposed theme and the way the proposer plans to tackle it is then provided to the proposer. This enables him or her to develop a full proposal. You can download the proposal form at www.elementsmagazine.org/proposal.htm.

Pierrette Tremblay, Managing Editor

OPEN ACCESS: A CURRENT PERSPECTIVE

J. Alex Speer[1], Kevin Murphy[2], and Sharon Tahirkheli[3]

The open access logo on the left was originally designed by the Public Library of Science. An alternative logo design (below) can be found at open-access.net. While no official logo exists, organizations are free to select the logo style that best supports their visual language.

INTRODUCTION

Open access (OA) means different things to different people. To some, OA means immediate access to scientific content in its final form on the publisher's website when published. This is Gold OA, made possible when the author or the author's institution pays the publisher an article processing charge (APC). A "lesser" version is Green OA, wherein no fee is paid and the posted work is either the peer-reviewed, accepted manuscript or the published article after an embargo period (typically 6 months or more). The term *public access* is used in the US for free access to publications, reports, and data of federal government–funded research. A recent flurry of activity suggests that, at least in some countries and subject areas, OA is set to become a reality. In this short review, we outline the current state of OA and what it will mean for authors and for nonprofit/learned society publishers.

WHERE IS OA WORK PUBLISHED?

An OA work can be made available in a number of places: the publisher's website, full-text online databases (e.g. GeoScienceWorld), an institutional repository or archive (Harvard's DASH repository, DSpace @ MIT, USGS Publications Warehouse), a central repository (Europe's OpenAIRE, PubMed–biomedical sciences, arXiv.org–physics), the author's personal website, or discussion forums (e-mail lists, blogs, wikis, file-sharing networks). The publisher can be the "self-publishing" author; one of the traditional society, university, or commercial publishers; or a start-up OA publisher, such as PLOS (Public Library of Science), eLife, Copernicus Publications, Bentham Science Publishers, or MDPI. Peer review of these OA publications ranges from the traditional concept, to moderated or endorsement (arXiv.org), to open peer commentary with non-anonymous commentaries and author's reply published with the paper, to none whatsoever. Copyright laws apply to OA publications.

HISTORY

Open access in its current guise first appeared more than a decade ago. It was made feasible when we acquired the ability to deliver scientific publications electronically, eliminating the expense of producing, delivering, and archiving print copies. Other drivers for OA are the increasing cost of journal subscriptions at a time when library budgets are static or being cut, while significant profits are being made by commercial scientific, technical, and medical (STM) publishers. Profits as a percentage of revenue for large, commercial STM publishers in 2010 or early 2011 are of the order of 32% to 42% of income (Taylor 2012). A related driver is the fact that publishers often acquire the copyright of the works. The largest publishers of STM journals are commercial publishers, and the income generated by the publication and sale of STM content is significant. Nonprofit STM organizations account for a relatively small proportion of the overall monies paid for journals, but the significant difference is that any surpluses generated from their publishing activities are returned to the science, in the form of lower publication costs, subsidized memberships, conferences, student grants, and general support for scientific activity. Anecdotally, >75% of the operating surplus of nonprofit scientific organizations comes from their publishing activity.

FINANCIAL MODELS FOR PUBLISHING

For many decades, journal finances worked on a simple, single-journal subscription model. A subscriber (institutional or individual) pays a yearly fee to the publisher and in return receives copies of all material published in that journal for that year. This traditional subscriber- or reader-pays model still exists, but it is now one among many ways to support publishing or to access published works. The models we see today are:

- **Author-pays** – The author, or his or her grant, contract, funder, or institution, pays an article processing charge and, in return, the author's article is immediately made available to all readers without cost. (See a list, compiled by the University of California, Berkeley, Library Collections, of APC fees charged by some of the main commercial publishers at www.lib.berkeley.edu/scholarlycommunication/oa_fees.html.)
- **Hybrid journals** – These are journals with some OA articles, while other articles, for which an APC has not been paid, remain behind the subscription barrier. For some journals, for example, *American Mineralogist* and *Clays and Clay Minerals*, the APC is used to reduce the subscription rate. Over time, if the proportion of authors willing to pay increases, the subscription price decreases, and eventually the entire journal becomes Gold open access.
- **Online journal aggregates or databases of full-text articles** – This is the "Big Deal," an online aggregation of journals bundled as a one-price, one-size-fits-all package of a commercial publisher's journals. The Big Deal means that journals of the largest commercial publishers are more widely available than journals of small, nonprofit publishers. GeoScienceWorld was created to compete with the Big Deal and make society publications more accessible to the wider community, with features that a society publisher could not economically justify for its journals.
- **Gateways** – These are collections of links to publishers' full-text content. The gateway does not host the full text but includes header information about the work, that is, information about the abstract, author, article title, references, etc. An example of a gateway is an abstracting and indexing service like GeoRef.
- **Document delivery or pay-per-view** – This model exists in a number of forms, such as the new service MinPubs.org, where you can purchase print and electronic versions of *Elements* and other publications.
- **Institutional membership discounts** – Institutions that make significant use of open access sites, such as BioMed Central, arXiv.org, and PLOS, may make "volunteer" payments based on the amount of uploading and downloading by their institutions. The net result sounds very much like an "OA subscription."
- **Non-journal revenue** – In this model, publishers support OA from revenue streams other than from journals. These include advertising, secondary rights or copyright licensing, back-issue access, sponsorship of journal issues by third parties, society dues, and grants.
- **Bulk publishing** – This is an author-pays, OA publishing model but with minimal or no peer review as a cost- and time-saving measure.

A significant financial uncertainty in OA publishing is the cost of archiving and migrating electronic files to ever-changing new formats and platforms. In the future, it is expected that the archiving and migrating function will be carried out largely by the publisher. This aspect of OA is rarely discussed, and it is likely to be an ongoing publisher's expense that many overlook.

RECENT ACTIVITY IN OA

Strong lobbying by the OA community has achieved some success, as detailed below.

Cont'd on page 86

1 Mineralogical Society of America, Chantilly, VA, USA

2 Mineralogical Society of Great Britain and Ireland, London, UK

3 American Geosciences Institute, Alexandria, VA, USA

Cont'd from page 85

United Kingdom

In June 2012, the British government published the "Report of the Working Group on Expanding Access to Published Research Findings" (the Finch report: www.researchinfonet.org/publish/finch/wg). The main points of the report are:

- The main vehicle for the publication of research, especially when it is publicly funded, should be OA or hybrid journals funded by article processing charges.
- All public sector bodies funding research should establish more effective and flexible arrangements to meet the costs of publishing in OA and hybrid journals.
- Support for OA publication should be accompanied by minimal restrictions on rights of use and reuse, especially for noncommercial purposes.
- Universities, funders, publishers, and learned societies should continue to work together to promote further experimentation in OA publishing of scholarly monographs.
- Universities, publishers, and learned societies should work together on subscription pricing while taking into account the financial implications.
- Representative bodies in the public and private sectors should work together with publishers, learned societies, libraries, and other stakeholders to consider the terms and costs of licences.
- Funds should be found to extend current licensing arrangements to cover all institutions in the higher education (HE) and health sectors.
- Infrastructure for subject and institutional repositories should be strengthened further.
- The "Green" access/embargo model should be kept under review to avoid risk to valuable journals that are not funded in the main by APCs.
- The report's best estimate is that the new policy would require an additional expenditure of £50–60 million per annum by the HE sector. There would be a one-off £5 million in transition costs.

Research Councils UK (RCUK), which distributes academic funding for the government, has begun publishing its implementation policy (Guinnessy 2012). The RCUK will provide block grants to universities which, in turn, will pass the money, up to $10,000 per article, on to researchers. A statement on 15 February 2013 by the House of Lords has been critical of several aspects of the implementation of the RCUK's OA policy and calls for an early review. The RCUK position looks increasingly isolated in terms of favoring Gold rather than Green open access (see below), and the UK House of Lords is critical of the RCUK policy on this point.

European Union

The European Commissioner for Research, Innovation and Science, Máire Geoghegan-Quinn, met with key stakeholder groups in September 2012 to discuss open access to scientific information produced in Europe. Commissioner Geoghegan-Quinn stated that "open access is about giving European taxpayers a better return on their €87 billion annual public investment in research and development." The commissioner met with traditional publishers, OA publishers (represented by the Open Access Scholarly Publishers Association), the OA community (Scholarly Publishing and Academic Resources Coalition), and research funders and others (Wellcome, DFG, and Knowledge Exchange).

The European Commission (EC) has asked members, as part of its Horizon 2020 research program, to consider making 60% of European publicly funded research OA by 2016 (Guinnessy 2012). The EC's Horizon 2020 yet-to-be approved guidelines allow authors to submit to any OA journal and recommend that all physical sciences and engineering papers be available at no charge after six months.

The European Organization for Nuclear Research has as its goal to make nearly all papers in high-energy particle physics OA. They hope to achieve this by having libraries redirect money otherwise spent on subscriptions to SCOAP3 (Sponsoring Consortium for Open Access Publishing in Particle Physics). SCOAP3 is an international group of funding agencies, laboratories, and libraries that have committed to support the transition of 12 journals to OA by paying the APC.

United States

The United States National Library of Medicine at the US National Institutes of Health (NIH) has been the leader in public access in the US with PubMed. This free database of references and abstracts on life sciences and biomedical topics has >22 million records going back to 1809; 12.38 million of these articles are listed with their abstracts, and 12.81 million articles have links to full texts (3.54 million of these are available full-text for free to any user). About 500,000 new records are added each year. Several funding organizations, including the NIH, the Howard Hughes Medical Institute, the Wellcome Trust, and the UK Medical Research Council, mandate that authors they support deposit published articles into PubMed and that articles be made available to the public either 6 or 12 months after publication.

The US National Science Foundation has voiced support for the concept of open access, saying it is developing a strategy. The US Department of Energy (DOE) has its *Information Bridge*, which provides free public access to over 303,000 full-text documents and bibliographic citations of DOE research-report literature. The United States Geological Survey's *Publications Warehouse* gives free access to >100,000 publications from its >100-year history.

On 22 February 2013, the White House Office of Science and Technology Policy (OSTP) directed federal agencies with budgets in excess of $100 million per year in research and development spending to develop plans in six months to make the published results of federally funded research freely available to the public within one year of publication, and required researchers to better account for and manage the digital data resulting from federally funded scientific research (OSTP 2013). The final peer-reviewed manuscript *or* the final published document is to be made public. It appears that the likely embargo period for green access will be set at 12 months, though the wording appears to allow challenges from subject areas where this might be damaging to stakeholders. The details of how this will work will be better known after OSTP has reviewed the various agencies' plans.

OSTP incorporated much of the Fair Access to Science and Technology Research Act (FASTR), introduced on 14 February 2013 in both the US Senate and the House of Representatives, cosponsored in the Senate by Sens. John Cornyn (R-TX) and Ron Wyden (D-OR) and in the House of Representatives by Reps. Mike Doyle (D-PA), Kevin Yoder (R-KS), and Zoe Lofgren (D-CA). The statute would require federal agencies to make federally funded research available for free online access by the general public no later than six months after publication in a peer-reviewed journal. The public access version need not be the published version, but can be the manuscript version accepted for publication after peer review.

China

Over the past 10 years, many western publishers have reported a dramatic increase in the numbers of papers submitted by Chinese authors—up to 40% of all articles submitted is a commonly mentioned statistic. Decisions made in China about OA will clearly have a major impact on journal finances for many publishers. In 2003, China signed the Berlin declaration, an early statement of intent for the OA movement. A cursory review of a large body of literature about OA in China suggests that the Chinese are inclined to take an "internal" view of OA. The vast and rapid increase in the number of submissions by Chinese authors to many journals was seen as a way of increasing the visibility of the work by Chinese researchers. Many in China, however, view the profits made by commercial publishers from work supported by the Chinese state as a problem, and the movement seems to be encouraging efforts to support indigenous OA repositories and journals. Not unlike the rest of the world, there does not appear to be new money available to pay APC fees.

Australia/Asia

The Australian National Health and Medical Research Council (NHMRC) has adopted a Green OA policy. All recipients of NHMRC grants are required to post a copy of their research articles on one of the 40+ Australian universities' institutional repositories within 12 months of publication. The version of the article submitted must comply with individual journal/publisher requirements. NHMRC grants can only be used for the research activity and not for additional infrastructure costs, which currently excludes publication fees.

Japan

Japan will actively encourage researchers and their institutions to pay for OA publication of their research. It is not clear at present how prescriptive this will be, or which funding agencies will lead this change.

Germany

In August 2012, six Helmholz centers announced an agreement with Copernicus Publications (http://publications.copernicus.org/home.html), the largest OA publisher of geoscience literature, with 28 peer-reviewed journals. Publication fees will be billed centrally to Helmholz and not to the author.

HOW CAN OA BE MADE TO WORK?

Authors want their work to be widely available. A learned society's purpose is to promote scientific discourse and accelerate the pace of discovery by wide dissemination of its publications. OA is an ideal mechanism for meeting both goals. The current movement to mandate depositing of primary data used in research will accelerate expectation of OA articles. The desire, rationale, technology, and infrastructure are in place for OA; so why is OA not the dominant publishing model?

OA publishing lacks a demonstrated and sustainable business model. Few believe they should be the ones to pay, and few have sufficient resources to do so. Much OA thinking is based on the current experiences of the biomedical field, a well-funded discipline where researchers expect instant access to the latest research and papers are considered no longer relevant after weeks to months—hardly a situation describing the Earth sciences. The situation is made worse by the current global financial situation. Still, there appears to be tacit acknowledgment that OA is here to stay. Commercial publishers are no longer resisting, but rather are finding ways to show that they are on board with OA and to make it profitable. Do nonprofit/learned society publishers need to do likewise? In a word, yes, but in a way that preserves quality and financial viability. There may be enough money currently in the journal-support system, combined with cost savings, to make OA journals economically sustainable using an author-pays model.

UK university libraries spend about £200 million per year on journal subscriptions. In the US, expenditures for current electronic serial subscriptions by academic/college and university libraries alone is ~$1.0 billion (NCES 2012). If an author's organization or funding source mandates open access publishing, it makes sense that they provide the money for APC. But will universities and their libraries be willing or able to transfer some or all of these subscription funds or money spent to archive and house print journals to pay author fees? Will research funding agencies and researchers designate a sufficient portion of their grants and contracts to pay author fees? Both authors and nonprofit/learned society publishers must publicize the need to redirect money no longer spent on subscriptions.

Problems with the APC Model

There could be unintended consequences to author-pays OA: the search for the best publishing deal as a cost-saving measure, resulting in a competitive race to the bottom; dictates from institutions as to where to publish; rationing by universities of the number of author publications; journal selection by authors applying their limited funds only to journals with high impact factors, resulting in the squeezing out of other publishers; and excessive fees charged to faculty needing to publish in certain places to advance their careers. For publishers, maintaining scientific quality might conflict with the pressure to accept and publish papers faster and in greater numbers to prevent possible loss of journal income.

Other revenue sources to support OA seem unlikely. Publications such as *Elements*, with above-average advertising support, are the exception. It is unlikely that other *Elements*-family journals could attract paid advertising or sponsorship in more than minor amounts. It is difficult to imagine the rationale one could use to sell secondary rights, copyright licensing, or back-issue access to publications that are open access. Using other society programs or dues to support publications merely shifts the financial burden to perhaps other underfunded programs. Private and government agencies like to fund "new" things, not support long-term projects. It is significant that PLOS was launched with grants totaling US$13 million but with the expectation that it become self-sustaining. The three nongovernment organizations funding the eLife start-up have the same expectation.

Change in Editorial Standards to Reduce Editorial Costs

According to its newest peer-review form, *PLOS One* instructs its reviewers to evaluate submissions not on the basis of their perceived importance or significant advance to the field, but rather by determining if the reported study has been performed correctly and if the data support the conclusions (Pattinson 2012). The reviewers are also asked whether the submission adheres to data-sharing standards and if the manuscript is written in intelligible standard English. With these criteria, *PLOS One* hopes to reduce the burden on reviewers and decrease time in review, and therefore costs (Butler 2008).

Migrating to OA via Hybrid Journals

For nonprofit/learned society publishers, the prudent approach to OA appears to be a gradual one: either an embargo period of Green OA or hybrid journals. An embargo period allows for a period of paid access, so that the publisher can still sell subscriptions and recover costs before the content is made OA. The often-stated 6–12 months, based on the biomedical experience, appears too short for the Earth sciences, where the half-life, or median age, of the articles that are cited in a year can approach ten years. A hybrid journal may be a better way to transform a current subscription-based journal into an OA one. Authors are given a choice as to whether or not they are willing to pay a publication charge. If they are, the paper is made open access on publication. If they are unable to pay, the paper is only made available to subscribers. A hybrid journal is the way to solve the problem of authors without research funding, authors whose original research grant has lapsed or did not include an allowance for APC, or coauthors from countries or with funding sources with differing mandates. As the proportion of authors willing to pay increases, the publisher can begin to reduce the subscription price. Eventually, if OA becomes the norm, the entire journal becomes open access.

To meet the requirements of funding agencies, many journal copyright policies now allow authors, even in the absence of paid APCs, to post their accepted manuscript on their personal websites, in their institution's repository, or in an approved repository.

Within the *Elements* family, several journals, including *American Mineralogist, Clays and Clay Minerals, Clay Minerals, Elements, and Mineralogical Magazine,* are hybrid journals. If you are required to publish in an OA journal, you ought to consider these and similar journals. A directory of open access journals can be found in the online Directory of Open Access Journals (http://www.doaj.org/).

ACKNOWLEDGMENTS

The authors have drawn on comments from Wiley-Blackwell, the Association of Learned and Professional Society Publishers, the Finch report, and the Science Council (UK) on the subject of open access.

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KELLY DEUERLING FIRST RECIPIENT OF AGI WALLACE SCHOLARSHIP

Kelly Deuerling

Kelly M. Deuerling is the first recipient of the new Harriet Evelyn Wallace Scholarship for women in geosciences, created by the American Geosciences Institute (AGI). Kelly, a PhD candidate and an NSF Graduate Research Fellow at the University of Florida, was selected from among a group of prestigious applicants for the new scholarship, which is dedicated to increasing the number of women in geoscientific professions. She was chosen for her outstanding contributions to her field, as well as her commitment to extracurricular activities and her strong participation in the geoscience community. Her current PhD work focuses on the chemical weathering of the glacial foreland in western Greenland, using tracers of subglacial hydrologic systems and oceanic fluxes of radiogenic isotopes. The timeliness of her research, its broad appeal, and its potential impact on the greater geoscience community helped to distinguish her as a promising young scientist within the geoscience profession.

Given annually, the Harriet Evelyn Wallace Scholarship is awarded to a female student pursuing a thesis-based master's or doctoral degree in the Earth sciences. The scholarship is awarded to the applicant who is most likely to make a successful transition from her graduate studies to the geoscience workforce. For more information on the scholarship, please visit www.agiweb.org/scholarships/wallace/.

DOE AWARD FOR BEST UNIVERSITY RESEARCH TO HOPE JAHREN AND BRIAN SCHUBERT

Hope Jahren

Brian Schubert

Professor **Hope Jahren** and former postdoctoral student **Brian Schubert** received the Award for Best University Research at the DOE Geosciences Research Symposium for Geochemical Probes and Processes, which was held at Gaithersburg, Maryland, on March 14–15, 2013. Their work was titled "Carbon stable isotope fractionation during C3 photosynthesis and its use in probing the terrestrial rock record."

Hope is a professor in the Department of Geology and Geophysics in the School of Ocean and Earth Science and Technology at the University of Hawai'i at Mānoa, and Brian is an assistant professor in the School of Geosciences at the University of Louisiana, Lafayette.

A. E. Seaman Mineral Museum
Michigan Technological University
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Principal Curatorial Professional Staff

Full position description available at:
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Career Opportunity in
Mineral Exploration Geochemistry
UBC-Industry Exploration Geochemistry Initiative

MDRU, the Mineral Deposit Research Unit in the Department of Earth, Ocean and Atmospheric Science (EOAS) at The University of British Columbia (UBC), Vancouver, Canada has launched a new industry-sponsored research and training venture in **Exploration Geochemistry**. We are seeking a candidate to take the position of **Research Chair** to lead this unique, exciting, and well-funded Exploration Geochemistry Initiative. The successful candidate will have the opportunity to provide leadership and innovation to develop a robust research program building new foundations in the field of Exploration Geochemistry.

For further information, please contact Dr. Craig Hart (Director, MDRU) at chart@eos.ubc.ca or Dr. Peter Bradshaw (Chairman of the Search Committee) at pbradshaw@firstpointminerals.com. Additional background information is available on the MDRU website, **http://www.mdru.ubc.ca**. Expressions of interest consisting of a CV and a one-page cover letter will be accepted until 15 May 2013.

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Phase ID and elemental analysis on a benchtop

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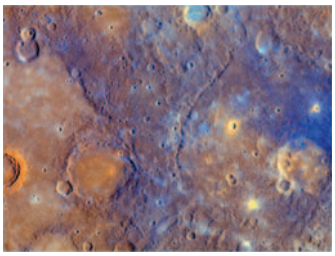
THE SURFACE COMPOSITION OF MERCURY AS SEEN FROM MESSENGER



False color Mercury Dual Imaging System (MDIS) image, illustrating the relationship between the relatively young smooth plains on the left and the older, dark blue material on the right. Image credit: NASA/Johns Hopkins University Applied Physics Laboratory / Carnegie Institution of Washington

Little was known about Mercury, the smallest and innermost planet of the Solar System, prior to NASA's MErcury Surface, Space Environment, GEochemistry, and Ranging (MESSENGER) mission (Solomon et al. 2001). Mercury has a dark and heavily cratered surface, similar in appearance to the Moon, and 45% of its surface was imaged during three Mariner 10 flybys in the 1970s. Mercury does not have an atmosphere, but does maintain a tenuous exosphere containing several species, including H, He, O, Na, K, and Ca. The planet's unusually high density indicates that its interior structure consists of a thin crust and mantle overlying a large core, the outer part of which is molten and gives rise to Mercury's weak magnetic field. It is also possible that there is a solid troilite (FeS) layer at the top of the core (Smith et al. 2012). Earth-based observations identified radar-bright deposits in permanently shadowed craters at both poles, and it has recently been shown that these contain a substantial amount of water ice (Lawrence et al. 2013; Neumann et al. 2013; Paige et al. 2013). The MESSENGER mission was designed to answer several key scientific questions and to increase our understanding of Mercury's geological history and evolution. Remote sensing of the surface's chemical composition has a bearing on a number of these questions. We focus on several of these topics in this article, including models for Mercury's original formation, whether or not Mercury experienced an early magma ocean, and how its mantle and volcanism have evolved with time.

The suite of geochemical instruments in MESSENGER's scientific payload includes the X-Ray Spectrometer (XRS) and Gamma-Ray Spectrometer (GRS), which are used to characterize the surface abundance of several elements via X-ray fluorescence (e.g. Nittler et al. 2011) and gamma-ray spectroscopy (e.g. Peplowski et al. 2011). Together, the XRS and GRS on MESSENGER provide abundant information for several elements, including O, Na, Mg, Al, Si, K, Ca, Ti, Cr, Mn, Fe, Th, and U, with spatial resolutions that range from hundreds to thousands of kilometers.

Orbital results from XRS (Nittler et al. 2011; Weider et al. 2012) have revealed that Mercury's surface is Mg rich but Al and Ca poor, compared to typical materials from the terrestrial and lunar crusts (Fig. 1). The surface's ultramafic composition, in terms of these elements, is similar to terrestrial komatiites (extremely Mg-rich rocks produced by high degrees of partial melting, most of which are Archean in age). A surprising result was the detection of S at an abundance of up to about 4 wt%, a level that is ten times higher than on the other terrestrial planets. The XRS data have also confirmed that Mercury's surface contains a low total amount of Fe (less than 4 wt%), even though the planet as a whole must contain a large amount to account for its high density. The abundances of Al, S, Ca, and Fe as derived from GRS data (Peplowski et al. 2012a; Evans et al. 2012) are generally in agreement with the XRS results. Together, the high S and low Fe abundances indicate that Mercury must have accreted under highly reducing conditions and that its surface mineralogy (probably dominated by Mg-rich silicates such as enstatite and forsterite, plagioclase feldspar, and sulfides) is unlike those of the other terrestrial planets.

The relatively low Al and Ca concentrations and the high Mg content of Mercury's surface indicate that it is unlike the Moon's anorthosite-dominated crust, believed to have formed as a flotation crust in a cooling magma ocean. However, we cannot say for certain whether or not a magma ocean played a role in the formation of Mercury's crust. Brown and Elkins-Tanton (2009) showed that when the total Fe content of a planet's silicate portion is low, as seems to be the case for Mercury, the density contrasts in a magma ocean might be insufficient to permit plagioclase flotation. Without a flotation crust, Fe-rich cumulates forming later than their Mg-rich counterparts could have crystallized closer to the surface. The resulting unstable configuration of the cumulate pile might have promoted mantle overturn, partial melting, and the formation of a secondary crust through lava flows, which may have helped form the surface we now observe. The exact geochemical consequences of a magma ocean on the surface composition of Mercury depend on the planet's starting composition, but no models have yet been reported that are based on the geochemical results from MESSENGER. However, Charlier et al. (2013) suggest that variations in lava composition across Mercury's surface may have arisen from different magma sources within a crystallizing, layered magma ocean.

Before MESSENGER, several hypotheses for the formation of Mercury primarily focused on explaining the planet's high density and therefore high metal-to-silicate ratio. In some of the proposed models, much of Mercury's silicate crust and mantle were removed by a high-temperature event early in its history, for example a giant impact (Benz et al. 1988) or evaporation within a hot (2500–3500 K) solar nebula (Cameron 1985). The ratio of the moderately volatile element K to the refractory element Th for Mercury (Peplowski et al. 2011; 2012b) is similar to that of Mars and higher than for the Moon. Taken together, the high abundances of K, S (Nittler et al. 2011; Weider et al. 2012), and Na (about 3 wt%; Evans et al. 2012) indicate that Mercury is not depleted in volatile elements relative to the other terrestrial planets. Such a characteristic is seemingly inconsistent with formation models that require extreme heating early in the planet's history, but the question is still being investigated (e.g. Stewart et al. 2013). Other formation scenarios invoke accretion of high-temperature equilibrium condensates (Lewis 1973), mixtures of refractory-enriched and Earth-like compositions (Morgan and Anders 1980), or chondritic precursors (e.g. Krot et al. 2001). The XRS and GRS results seem to be most compatible with accretion from highly reduced chondritic material with a high metal-to-silicate ratio and a substantial volatile inventory. Such precursors may have been similar to the metal-

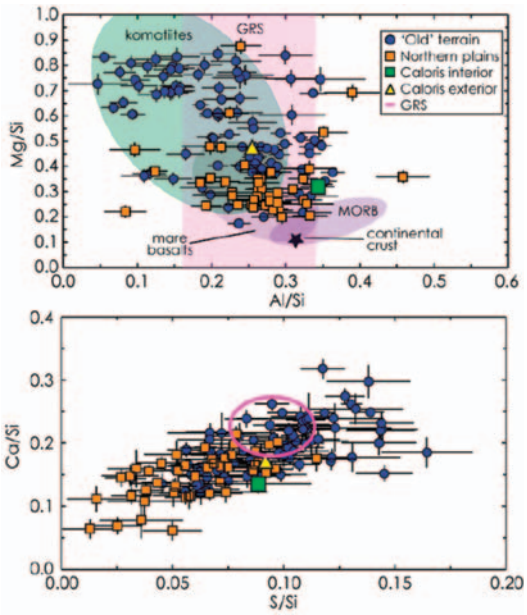


Figure 1 Elemental weight ratios from individual XRS measurements of regions about 100 km in diameter on Mercury's surface (modified from Weider et al. 2012), illustrating the differences in composition between the northern smooth plains and the surrounding older terrain. Compositions for smooth plains interior and exterior to the Caloris basin are also shown. The 1σ errors for the GRS results (from Evans et al. 2012) are shown as a pink band (there is no Mg estimate from GRS) in the top diagram and as a pink ellipse in the bottom one. Compositional fields of terrestrial and lunar rocks are indicated for comparison.

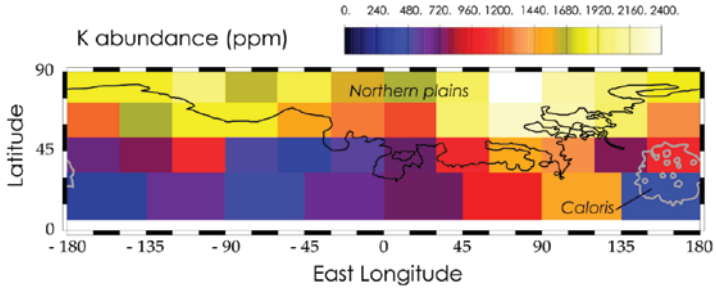


Figure 2 Map of K abundance on the surface of Mercury, showing the outlines of the northern smooth plains (black) and the Caloris basin (grey). Image from Peplowski et al. (2012b)

rich CB chondrites or enstatite chondrites; partial melts from an example of the latter (McCoy et al. 1999) contain about the same abundance of S as the surface of Mercury. Another intriguing possibility is that Mercury was built from solids enriched in C-rich chondritic interplanetary dust particles (Ebel and Alexander 2011).

As the MESSENGER orbital mission has progressed, more-detailed and higher-spatial-resolution geochemical information has been acquired so that heterogeneities related to previously mapped units can be explored. On the basis of Mariner 10 images and images acquired by MESSENGER on its three flybys (2008–2009) of Mercury prior to orbital insertion in 2011, various units were defined according to their morphologies and color differences. One such unit is the volcanic smooth plains that fill low-lying areas and have few impact craters (Denevi et al. 2009). The smooth plains associated with the Caloris impact basin (Murchie et al. 2008) and the northern plains (Head et al. 2011) are deposits with the largest areal extent (see Fig. 2 for locations). Relatively high-spatial-resolution XRS analyses (about 100 km in diameter) have revealed that the northern smooth plains are compositionally distinct (lower in Mg, S, and Ca; higher in Al) from the older, more heavily cratered terrain that surrounds them (Fig.1; Weider et al. 2012). Although there is only a limited amount of data for the Caloris plains, the results suggest that the plains interior to the basin are consistent with the composition of the northern plains, whereas the plains exterior to the basin are more like the older terrain. The lower Mg content of the smooth plains, together with the chemical trends between the two regions (Fig. 1), suggests that this material was derived from a source that was more evolved and had a cooler magmatic temperature than that which produced the older terrain, rather than from remelting of a previously depleted source.

Surface heterogeneities in the abundance of K (Peplowski et al. 2012b) and Na (Evans et al. 2013) have also been identified with the GRS data. An area that approximately, but not precisely, corresponds to the northern plains (Fig. 2) has a K abundance (about 2000 ppm) that is significantly higher than that of the surrounding, older terrain (about 500 ppm). Likewise, the Na abundance at far northern latitudes (~4 wt%) is higher than at more equatorial regions (about 2.5 wt%). Rather than being primarily controlled by the underlying lithology, it has been proposed (Peplowski et al. 2012b; Evans et al. 2013) that the distributions of K and Na may be driven, at least partly, by a surface heating process that mobilizes these volatiles from equatorial and hot-pole regions (these are longitudinal areas subjected to solar radiation for longer periods than the mean surface, due to Mercury's 3:2 spin-orbit resonance, where surface temperatures can reach about 550 K) and redistributes them to the exosphere (which has variable Na content over both geologic poles) and/or polar regions. The smooth plains inside the Caloris impact basin (which lies on one of the hot-poles) have Mg, Al, S, and Ca abundances that are similar to those of the northern plains, but a lower K content, thus providing evidence for this process.

MESSENGER is currently in its extended mission and continues to unravel Mercury's many mysteries. We continue to analyze the surface geochemistry and aim to produce near-global maps for many rock-forming elements. The MESSENGER website provides more information about the mission: http://messenger.jhuapl.edu/.

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