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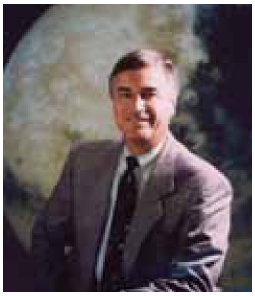
LIVING IN THE FAST LANE



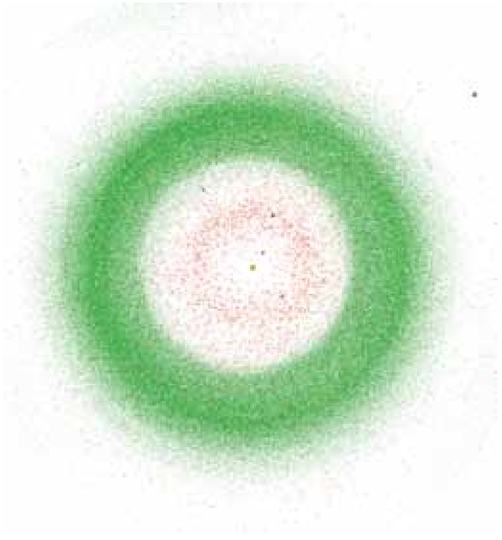
Hap McSween

We spend our days on a world that is constantly battered by foreign objects ("bolides") traveling at very high speeds. The consequences of bolide impacts are described in this issue of *Elements*. Before bolides encounter our planet, they are called near-Earth objects (NEOs), denoting asteroids or comets whose orbits approach the Earth's orbit and so are potentially capable of striking us with devastating effect.

So how great is the risk? The current estimate of the long-term average human fatality rate from bolide impacts is slightly less than a hundred per year. Compared to the myriad other ways that we die, this number seems trivial. Most bolides (the sources of meteorites) are small and thus their impacts are inconsequential. However, a body larger than a few kilometers in diameter, thought to impact every hundred million years or so, could cause worldwide damage, affecting all of humanity and its living space. The geologic-scale catastrophe caused by the >10 km Chicxulub bolide at the K–T boundary is well known to geoscientists. The modern risk was highlighted by the impacts of the disaggregated comet Shoemaker-Levy 9 into Jupiter in 1994; any one of these fragments would have been devastating to Earth. In 2004, astronomers raised the alarm that the 300 m diameter NEO Apophis could strike the Earth in 2029; later observations ruled this out, but its discovery raised concerns that other dangerous Apophis-sized NEOs have yet to be found.

Although humans have always been at risk from impacts, recognizing that fact is a new phenomenon. Two centuries ago, scientists scoffed at the idea that solid objects could fall from the sky. One century ago, prominent geologists marshaled arguments against the impact origin of Meteor Crater, Arizona. Only in the last few decades have a few governments awakened to the notion that we should assess this hazard and perhaps learn how to mitigate it.

Eros spacecraft image of 433 Eros, the second-largest known NEO, measuring 34 km in its longest dimension. Image courtesy of NASA



The currently known distribution of asteroids, as of December 2011. The large dot in the center is the Sun, and the small blue dots are planets. The green dots are main belt asteroids, which do not approach Earth. The red dots are NEOs that cross Earth's orbit. The illustration is misleading, in that the sizes of asteroids are enlarged and the space between them is mostly empty. Figure courtesy of Scott Manley

In 2008 the United States Congress commissioned a study by the National Research Council (NRC), with the intent to prompt NASA to complete an inventory of potentially hazardous NEOs and explore deflection capabilities. That study, entitled *Defending Planet Earth: Near-Earth-Object Surveys and Hazard Mitigation Strategies**, was published in 2010. It makes sobering reading. The report finds that although Congress has directed NASA to discover 90% of NEOs larger than 140 m by 2020, no funding has been appropriated. This goal could be accomplished using ground-based telescopes, perhaps augmented with an orbiting telescope. The Large Synoptic Survey Telescope (LSST), a very capable instrument for detecting NEOs, received top priority in the newly completed NASA astronomy decadal survey, but funding may be problematic in the current economic environment. The NRC report also noted that objects smaller than 140 m are capable of causing significant damage to Earth.

For hazard mitigation, the report considered 4 options:

1. Slow-push or slow-pull tractors, which would change the object's orbit by adjusting its velocity in the direction of motion (deflection sideways is much less efficient) through the application of a small but steady force over decades
2. Kinetic impactors, which would instantly change the object's velocity in the direction of motion by colliding a massive spacecraft payload with the object
3. Nuclear explosions, which would change the object's velocity or possibly disaggregate it
4. Civil defense measures, which are probably the only feasible option for advanced warning times shorter than a year or two

Cont'd on page 4

* National Research Council (2010) Defending Planet Earth: Near-Earth-Object Surveys and Hazard Mitigation Strategies. National Academies Press, Washington, DC

THIS ISSUE

Guest editors Fred Jourdan and Uwe Reimold take us on a whirlwind tour of various aspects of impact structures. They focus on terrestrial impact structures because understanding them is key to a better interpretation of impact structures in the Solar System. Many other features in this issue complement the thematic content. Hap McSween's editorial reminds us that near-Earth objects are not just the stuff of science fiction. CosmoElements gives us an overview of space missions searching for and sampling asteroids. Our first Perspective article, by two pioneers of impact research, relates the history behind the development of our thinking regarding impact structures. When we agreed to publish a second Perspective article, on the discovery of icosahedrite, the first natural quasicrystal, we had no idea that an extraterrestrial nature was postulated for this new mineral. The theme of this issue could not have been more fitting for this article.

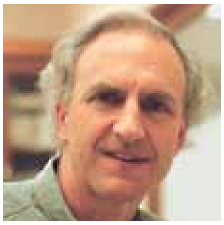
At 80 pages, this is the second largest issue we have published. But this number of pages will become more common, as plans for 2012 include the publication of three 80-page issues to allow for more nonthematic content.

The 54 km diameter Charlevoix impact structure, about 105 km northeast of Quebec City, was my introduction to impact craters in the 1970s. It was "discovered" by Jehan Rondot, a geologist at the Ministère des Richesses naturelles of Quebec. He was the first to postulate an impact origin for this circular structure. In the course of regional mapping, he discovered unusual conic structures that turned out to be shatter cones. Rondot became fascinated by impact structures and spent the rest of his career studying them. A museum dedicated to the interpretation of the Charlevoix impact structure is under development, testimony to the touristic potential of many of these sites.

WELCOMING JAMS MEMBERS

With this first issue of 2012, we welcome the Japan Association of Mineralogical Sciences (JAMS) as the 17th participating society in *Elements*. JAMS is a young society, resulting from the merging of two well-established Japanese mineralogical societies in 2007. We look forward to reading their news on a regular basis (read their first news on page 61). To the many Japanese colleagues who will receive *Elements* for the first time, we look forward to hearing from you and we say *irasshaimase*.

WELCOMING JOHN VALLEY, PRINCIPAL EDITOR 2012–2014



Elements' newest principal editor is John W. Valley, the Charles R. Van Hise Professor and past chair of geology at the University of Wisconsin–Madison. John is known for his research on high-grade metamorphic rocks, Precambrian geology, and stable isotopes and trace elements in zircon as recorders of the Earth's environments. He is a fellow of the Mineralogical Society of America, the Geological Society of America, the American Geophysical Union, and the Geochemical Society/European Association of Geochemistry. John brings expertise in mineralogy, petrology, and geochemistry to his new job as editor. He acted as guest editor for our Early Earth issue (volume 2, number 4), and he has been a member of the advisory board. He comments that "I look forward to continuing the tradition of *Elements*. The vibrant format is fun to read and informative, with a mix of high-quality reviews on topics of scientific and societal interest." Welcome aboard, John.

THANKS HAP!

After this issue, Hap McSween retires as a principal editor of *Elements*. My first encounter with Hap was at the 2004 GSA meeting. He approached Rod Ewing and me with congratulatory words about *Elements*, whose launch issue had just been published, and he enquired if we would be interested in an issue on Mars. We encouraged him to submit a proposal. And indeed, a proposal soon landed on our desks. Our Water on Mars issue was published in June 2006. Hap was an extraordinarily efficient guest editor: the final papers reached me months before the deadline. You could say that he was noticed, and we were delighted when he accepted our invitation to join the editorial team two years later. During his term as principal editor, he was responsible for the following issues: Gold (v5n5), Sulfur (v6n2), Thermodynamics of Earth Systems (v6n5), Cosmochemistry (v7n1), When the Continental Crust Melts (v7n4), and Impact! (v8n1). During this period, he was also cochair of the Goldschmidt 2010 meeting in Knoxville and he became interim dean of science at the University of Tennessee. Still, his editorials landed on my desk months before they were due, and I could always count on an immediate response to queries. I can only salute such extraordinary efficiency. Hap was also instrumental in getting the Meteoritical Society on board—there is no doubt that his presentation to their council was very convincing. With this issue, he rotates off the editorial board: he will be sorely missed.

ELEMENTS ON GEOSCIENCEWORLD

There has been a major upgrade of the GeoScienceWorld (GSW) site hosting *Elements* (www.elements.geoscienceworld.org). GSW journals are now in a format supported by HighWire's Open Platform technology. This new interface is the visible face of a bottom-up rebuild of HighWire's electronic publishing platform, which was developed to meet the needs of a rapidly evolving Internet environment. The platform infrastructure will interact with many other systems. It is flexible and modular, so it can easily be built upon using Web 2.0 applications, feeds, widgets, and web services.

Even if your institution does not subscribe to GSW, you can still take advantage of many new features, especially the search capabilities. For example, a Google Maps–based search tool allows one to search and browse by topic using latitude and longitude coordinates in GeoRef. Full citations pop up when users hover over references within the text of an article. Keywords are hyperlinked and perform quick searches of that term within all *Elements*' content. Mouse-over previews of abstracts are displayed within both the tables of contents and search-results pages. So check it out at www.elements.geoscienceworld.org.

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Managing Editor

EDITORIAL *Cont'd from page 3*

None of these options is currently available but all could be developed for modest-sized objects if technology funding were appropriated. For NEOs more than a few kilometers in size, which would inflict horrendous global damage and perhaps mass extinctions, there is at present no feasible defense.

Because NEOs pose a global threat, the NRC report suggests that international cooperation is needed and recommends that a suitable international entity be organized and empowered to develop plans for dealing with the NEO hazard. Besides the USA, the Near-Earth Object Dynamic Site in Italy monitors potentially hazardous NEOs. The international community of planetary scientists is acutely aware of the NEO hazard, but their concerns are echoed by only a few officials from various nations. It is high time that the geologic community became engaged in this problem, given our knowledge of the likely consequences to our planet. The impact scars described in this issue of *Elements* demonstrate that the threat is real, albeit infrequent. I cannot imagine a more persuasive reason for nations to work together in common purpose. Whether we do or not remains to be seen.

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* Hap McSween was the principal editor in charge of this issue.