SCHOOL OF OCEAN AND EARTH SCIENCE AND TECHNOLOGY

Press Release

Thursday, April 10, 2008

New Strategy for Determining Chondritic Meteorite Impact Sizes

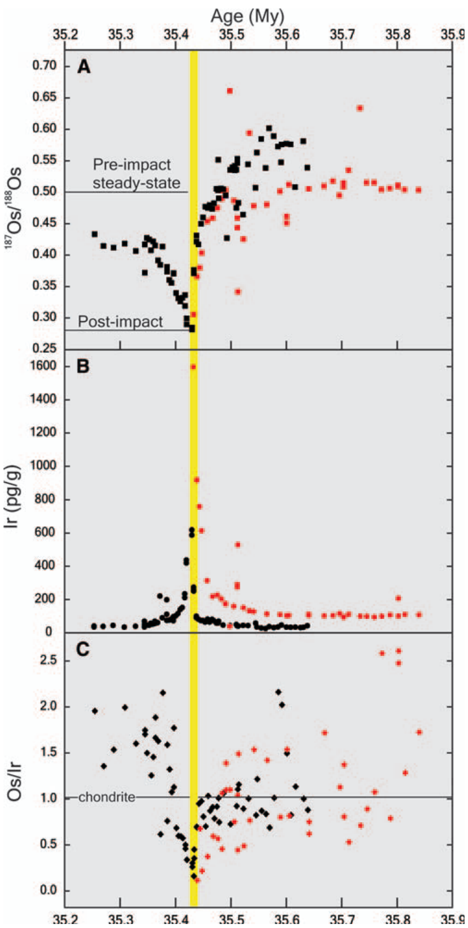
Artist's rendering of an asteroid striking Earth. Image credit: NASA/Don Davis)

Honolulu, HI – Scientists have developed a new tool for determining the projectile size and frequency of chondritic meteorites that have collided with the Earth. François Paquay, a Doctoral graduate student in the Department of Geology and Geophysics at the University of Hawaii at Manoa (UHM) used variations of osmium isotope composition in the marine sediment record to estimate size of these impactors, the results of which are published in the April 11th edition of the prestigious journal Science.

When meteorites collide with the Earth, they carry with them a lower osmium isotope ratio ($^{187}Os/^{188}Os$) than the levels normally seen throughout the oceans. The vaporization of these chondritic impactors carries a pulse of this rare element into the Earth system, which mixes throughout the ocean quickly. Records of these impact induced changes in ocean chemistry are preserved in deep sea sediments. Paquay analyzed more than 130 samples from two sites, Ocean Drilling Program (ODP) site 1219 (located in the Equatorial Pacific), and ODP site 1090 (located off of the tip of South Africa) and measured the $^{187}Os/^{188}Os$ levels during the late Eocene period, a time during which large impacts are known to have occurred. "This very high temporal resolution record in the marine sediment, allowed us to construct a simple model of how the osmium isotopic composition of the ocean changes during and after an impact event," says Paquay. "This good fit between the model and the sediment data allowed us to justify making estimates of impact size based on that dip to low $^{187}Os/^{188}Os$." Paquay and his collaborators expect that this new approach to estimating impact size will become an important complement to using iridium anomalies to recognize impact events and estimate projectile size.

Paquay, along with advisor and co-author Gregory Ravizza, an Associate Professor in the Department of Geology and Geophysics at UHM, and collaborators Tarun Dalai from the Indian Institution of Technology, and Bernhard Peucker-Ehrenbrink from Woods Hole Oceanographic Institute, also used this simple model to make estimates of impact size based on that dip of the osmium isotope ratio at the Cretaceous-Tertiary (K-T) boundary. Even though this model works well for the much larger K-T impact, it would break down for any event much larger than that because the meteorite contribution of osmium to the ocean would overwhelm what was there to begin with. Using the assumption that all the osmium carried by these projectiles dissolved in seawater, they were able to use their model to estimate the sizes of the K-T impact to be 4 to 6 kilometers in diameter, and 3 kilometers diameter for the impact that occurred at the end of the Eocene. These estimates are quite close to independent estimates based on iridium data, but systematic discrepancy is observed due to modeling based uncertainties.

"In most of the earlier work that was done people were trying to figure out what type of projectile was responsible for these impact events, because different meteorites have different osmium isotopic compositions", explains Ravizza. "But all the results always came in a bit too high, too radiogenic. That's because there's this osmium derived from the earth that's mixed into the signal. So our contribution is to think of the marine record in a totally different way, as this mixing process of osmium that's already dissolved in the ocean, with osmium that's vaporized from the meteorite."



Although a number of simplifying assumptions have been made to make these size estimates, the researchers are excited about this approach because it offers a new tool. "We're hoping that these results will motivate work by modelers aimed at better understanding how osmium behaves in the cloud of vaporized meteorite and target rock ejected into the atmosphere immediately after an impact event," says Paquay.

The potential for recognizing previously unknown impact is an equally important outcome of this research. Many impact events are recognized by craters left in the Earth's surface. But since two-thirds of the earth is covered by the oceans, finding alternate methods to determine that impacts have occurred and roughly give a first order estimate of their size is very desirable. "We knew there were two big impacts, and we give an interpretation of how the oceans behave during these big impacts," adds Paquay. "So now we can go look for other impact events, both large and small."

This research was funded by the National Science Foundation.

Image (left): Profiles of ^{187}Os/^{188}Os ratios, Iridium concentrations, and Os/Ir ratios from ODP 1219 (red) and ODP 1090 (black) samples. The yellow line indicates the impact horizon. Minimum vales in ^{187}Os/^{188}Os coincide with the Ir maximum, defining an asymmetric excursion with an abrupt onset and gradual recovery.
Image credit: Francois Paquay, University of Hawaii at Manoa)

For Interviews contact:

François S. Paquay, Graduate Student**,** Department of Geology and Geophysics, School of Ocean and Earth Science and Technology, University of Hawaii at Manoa, paquay@hawaii.edu (808) 388-3768

Gregory E. Ravizza, Associate Professor, Department of Geology and Geophysics, School of Ocean and Earth Science and Technology, University of Hawaii at Manoa, ravizza@hawaii.edu (808) 956-2916

SOEST Media Contact: Tara Hicks Johnson, (808) 956-3151, hickst@hawaii.edu

Article: "Determining Chondritic Impactor Size from the Marine Osmium Isotope Record," by Francois S. Paquay, Gregory E. Ravizza at University of Hawaii at Manoa in Honolulu, HI; Tarun K. Dalai at Indian Institute of Technology in Kharagpur, India; and Bernhard Peucker-Ehrenbrink at Woods Hole Oceanographic Institution in Woods Hole, MA. April 11, 2008; science.1152860