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Inside...

The Second Summer School for Rock Magnetism Held at the IRM

The Summer School for Rock Magnetism Graduates, Class of 2013

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An unsettling calm pervades the halls of the IRM since the departure of the twenty enthusiastic participants of the second biennial Summer School in Rock Magnetism. The students took the IRM by storm from seven countries worldwide and representing as many as twelve nationalities. Enrollment had been limited to twenty, in order to ensure a more hands-on experience in the labs for everyone and to promote closer relations among students and staff. Acceptance was purely based on a first-come first-served basis, and the slots filled quickly, so we hope we'll be able to host everyone who didn't make it this year for the next summer school in 2015.

We were very happy with the diversity of the group. Each participant brought her/his own background and interests to the IRM, spanning the whole spectrum of applications of rock-magnetism: from the more purely academic to instrumentation and development. The most popular student research topic this year was by far absolute paleointensity (6/20) to study secular variation and understanding the geodynamo, but individual interests were also as specific as "everything you always wanted to know about superparamagnetism and are not afraid to ask" (1/20) or geomagnetic surveying (1/20). Not surprisingly, paleo- and rock-magnetism applied to plate tectonics and structural geology was also very popular (5/20), but two other groups of high interest also stood out: soil magnetic properties for environmental/climate studies (3/20) and applications of rock-magnetism to marine sediment (4/20).

For many participants this was the first course dedicated entirely to rock- and paleo-magnetism: morning classes provided a solid theoretical foundation on all related aspects, from physical basis to applications, whereas the afternoons were spent working on hands-on projects in the labs. Students naturally separated into four lab groups: two groups dealt with hard-rocks, while a third worked on marine sediment cores and a fourth with soils.

The first group project revolved around the magnetic characterization of intrusive rocks recovered from a drill core through the Iowa Osborne complex, an intrusion related to the North American Midcontinent Rift System. The specimens analyzed came from a depth interval of ~550-800 m below the surface that sampled three distinct "cumulates:" a bottom-most plagioclase-olivine enriched cumulate, a middle olivine cumulate and a topmost serpentinized olivine cumulate. This knowledge-driven group performed rock-magnetic measurements on all of the instrumentation at the IRM to identify a magnetic

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Visiting Fellows' Reports

Hysteresis, thermomagnetic, and low-temperature magnetic properties of Southwestern U.S. obsidians

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I had the good fortune to spend nearly two weeks in October, 2011, at the IRM. Who ever said the weather in Minneapolis is not ideal? Not only did I have a great scientific experience, but I enjoyed the company of the IRM staff, strolled across the Mississippi River to see a show at the splendid Guthrie Theater, enjoyed the Weissman Art Museum, and got to watch Roy Halladay pitch a no-hitter in the postseason NLDS while eating pizza on Washington Avenue.

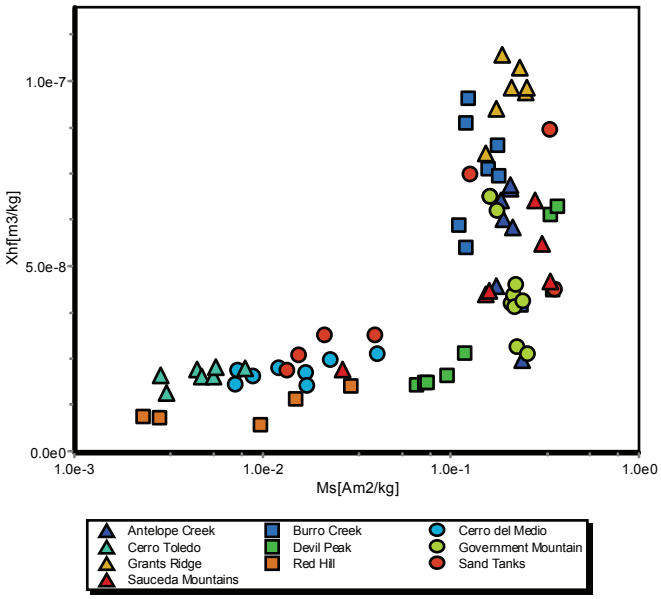
I continued earlier investigations (Sternberg et al., 2010) of the magnetic properties of Southwestern U.S. obsidian, an important lithic material in archaeology because it can be readily worked to form a sharp edge. Archaeologists want to trace the geographic and socioeconomic pathways whereby obsidian was dispersed from its geologic source to archaeological sites where it was used. The most common approach has been to compare the trace element geochemistry of obsidians from geologic sources and archaeological contexts (Shackley, 2005). Several studies have considered whether magnetic properties could be used to distinguish among different geologic sources of obsidian within a region (McDougall et al., 1983; Weaver et al., 2005, 2009; Church and Caraveo, 1996; Urrutia-Fucugauchi, 1999; Vasquez et al., 2001; Frahm and Feinberg, 2013).

Float samples were measured from 10 source areas in Arizona, Nevada, and New Mexico. Five samples were selected from each source, and specimen splits were cut from each sample.

Previous measurements (Sternberg et al., 2010) had looked at: magnetic susceptibility, at two frequencies; NRM and AF demagnetization; some hysteresis, backfield and thermomagnetic curves. That work suggested that intra-site variability of NRM and susceptibility was less than inter-site, and these two properties could distinguish a number of sites from each other.

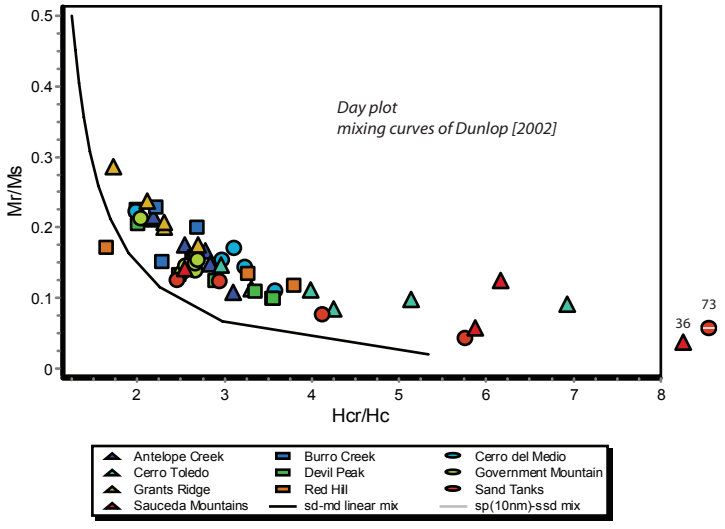
During my visit to the IRM, we measured additional hysteresis (76 specimens), backfield (55 specimens) and thermomagnetic (25 specimens) curves, using VSMs; low-temperature susceptibility including frequency dependence (8 specimens) and low-temperature remanence cycles (13 specimens), using the MPMS.

Ferrimagnetic coercivities and magnetite-like Curie temperatures (550-585°C) were found for all sites. There was more than two orders of magnitude variation in inter-site ferromagnetic concentration; within-site variation is typically less than a factor of 4 (Figure 1). Paramagnetic iron content varies by a factor of 10 (Figure 1).



Mean grain sizes vary from fine to coarse PSD; significant SP contributions were found in only two sites (Figure 2). Intra-site variability is about half that of inter-site variability for the variables plotted in Figure 2.

Magnetic characterization does seem to provide a useful supplement to geochemical methods of obsidian source determination. A Keck Geology Consortium project (http://keckgeology.org/Obsidian2013) this coming summer co-organized with Steve Shackley and Josh Feinberg, with nine participating undergraduate geology students, will further pursue this problem.



Special thanks to Mike Jackson, who was a wonderful mentor during my stay, and to Julie Bowles for her additional help in the lab. It was a pleasure to lunch and have the typically engaging conversation with Subir Banerjee, and to visit with Bruce, Josh, and other staff and students of the IRM.

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The next Visiting Fellowship application deadline is October 30, 2013.

Current Articles

A list of current research articles dealing with various topics in the physics and chemistry of magnetism is a regular feature of the IRM Quarterly. Articles published in familiar geology and geophysics journals are included; special emphasis is given to current articles from physics, chemistry, and materials-science journals. Most are taken from ISI Web of Knowledge, after which they are subjected to Procrustean culling for this newsletter. An extensive reference list of articles (primarily about rock magnetism, the physics and chemistry of magnetism, and some paleomagnetism) is continually updated at the IRM. This list, with more than 10,000 references, is available free of charge. Your contributions both to the list and to the Current Articles section of the IRM Quarterly are always welcome.

Anisotropy and Magnetic Fabrics

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Magnetic Field Records and Paleointensity Methods

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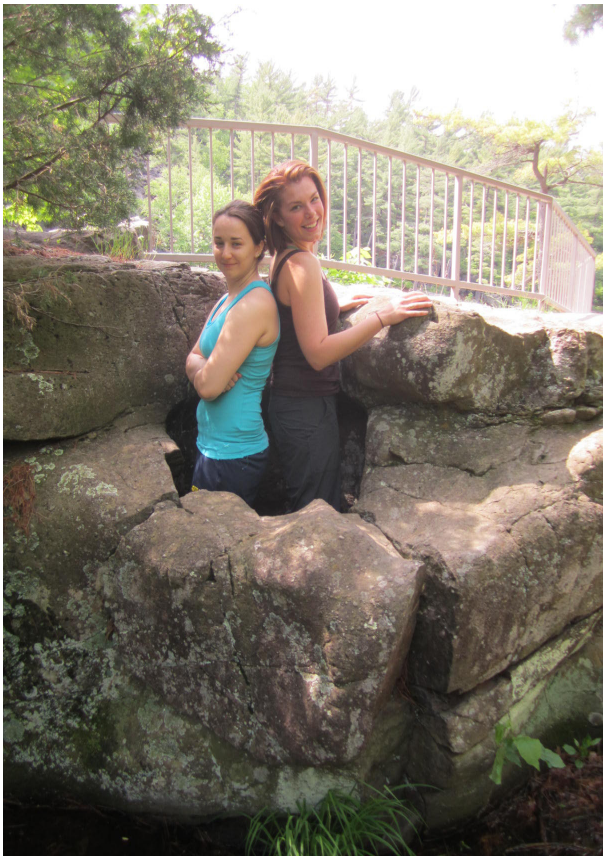
SSRM 2013 (continued from pg. 1)



Samantha Nemkin (U Michigan) and Dana Smith (UW Madison) pose in a pothole at Interstate State Park

fingerprinting of the cumulates, but also outdid itself completing the study performing SEM imaging using energy dispersive spectroscopy (EDS).

The second hard-rock group investigated volcanic extrusive rocks from New Zealand: all of the IRM's instrumentation was put to severe test on a broad collection of basalts, andesites and rhyolites ranging in age from less than ~10 to ~ 1.58 ka. The focus of this research was to characterize the magnetic carriers for these materials for a broader paleointensity/secular variation study. In addition, flow fabrics in the lavas were investigated using a combination of anisotropy techniques, adding a more applied component to the study.

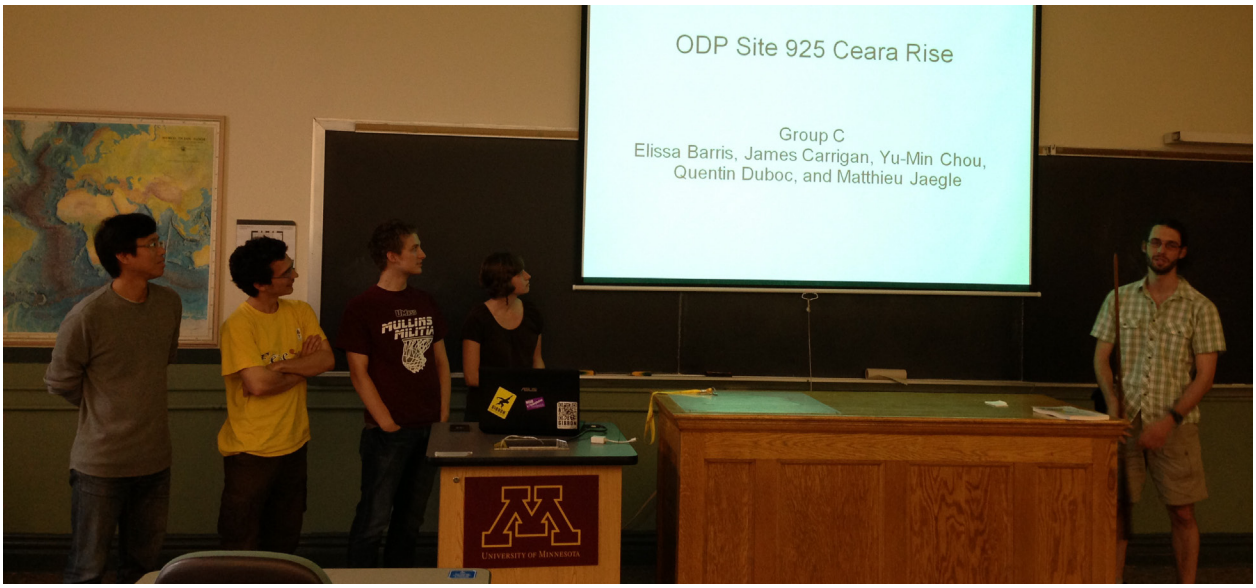
The marine sediment group investigated an ODP core from the Ceara Rise collected off the coast of Brazil during a 1994 mission. The sediment record spans ~40 to ~150 ka, corresponding to isotope stages 3 to 6. The group utilized various rock-magnetic techniques to determine magnetic carriers, magnetic granulometry and relative abundance. Mossbauer spectra were measured in parallel on selected specimens. The goal of the study was to differentiate the O isotope stages using magnetic proxies and probe the validity of magnetic parameters to study climate change. Recent oxidation of the specimens in the lab affected the results somewhat, creating an artificial bias at the expense of the naturally occurring hematite and goethite transported to Ceara Rise by the Amazon river. However, variations in magnetic grain size corresponding to marine isotope stages and Milankovitch cycles were apparent.

The soil project dealt with the magnetic characterization of modern soil horizons from a soil pit in St. Paul MN, focusing on rock-magnetic measurements for an environmental study. The objectives were to resolve the variations of magnetic properties within the soil horizons in terms of concentration, composition and particle size/domain state and to relate these to the dominant processes (erosion, transport, climate, microbial and/or human activity…). A variety of rock-magnetic techniques were used to separate the magnetic properties of the different soil horizons in a stratigraphic manner. Results indicated a "(superpara-) magnetically enhanced" top soil (A/B horizons) through pedogenesis, whereas the "enhanced horizon E" was found to posses an enrichment of pedogenic magnetite in the SP and SD grain sizes, derived from biological activity. Horizon C instead revealed opposite trends with higher concentrations of coarser and higher coercivity material due to dissolution of the finer fraction and re-precipitation of higher coercivity antiferromagnetic and oxyhydroxide minerals. The parent rock possessed the highest concentration of ferromagnetic particles, in the PSD-MD range.

Taking advantage of the beautiful weather (which was, of course, completely planned) Dr. Nick Swanson-Hysell led a great field trip on Saturday to visit Interstate State Park on the St. Croix River. The Chengwatana Volcanics crop out here and are related to the 1.1 billion y.o. Keweenawan Rift basalts extruded during the Precambrian Mid-Continent Rift System. These basalts also feature some most-impressive potholes, created by the turbulent melt-waters coming off Glacial Lake Duluth, ~ 10,000 years ago. After a picnic lunch in the park, we all took a ~3 mile hike, looking at trough-cross stratifications and diagenetic liesegang bands in the Upper Cambrian Franconia formation. Participants were also able to put their hands on the unconformity with the underlying basalts, an outstanding ~500 million years of missing time! Most importantly, the field trip provided another great opportunity to relax, bond and create friendships, which will hopefully last long past the 10 days spent together at the IRM.

It was a pleasure to host such a lively group of students, and feedback so far suggests a fun and productive

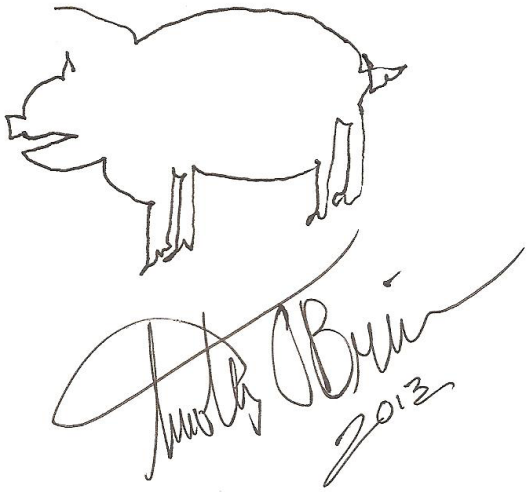
Richard Bono (U Rochester) hard at work



The "ODP Group" (from left to right: Yu-Min Chou, Mathiew Jaegle, James Carrigan, Elissa Barris and Quentin Duboc) presents their results

time: the quality of the final presentations (and results!) from the projects certainly indicate that time spent in the classes and labs was put to good use. The quality of the pigs (drawn whilst blind-folded) indicates that participants nicely embraced the spirit of the IRM: we are (almost) ready for the 2015 Summer School in Rock Magnetism already!

The **Geomagnetism and Paleomagnetism Section of the American Geophysical Union (AGU)** and the **National Science Foundation (NSF), Earth Science Division**, provided scholarship support for the school.



One pig for all... Artist: Timothy O'Brien (U Buffalo)

Summer School for Rock Magnetism 2013 Final celebration

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The IRM Quarterly

The *Institute for Rock Magnetism* is dedicated to providing state-of-the-art facilities and technical expertise free of charge to any interested researcher who applies and is accepted as a Visiting Fellow. Short proposals are accepted semi-annually in spring and fall for work to be done in a 10-day period during the following half year. Shorter, less formal visits are arranged on an individual basis through the Facilities Manager.

The *IRM* staff consists of **Subir Banerjee**, Professor/Founding Director; **Bruce Moskowitz**, Professor/Director; **Joshua Feinberg**, Assistant Professor/Associate Director; **Mike Jackson, Peat Sølheid** and **Dario Bilardello**, Staff Scientists.

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Best Wishes To IRMers

Dr. Ioan Lascu
and
Dr. Nicholas Swanson-Hysell

for their new positions at
University of Cambridge, U.K.
and at
University of California, Berkeley