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Inaugural Summer School for Rock Magnetism Held at IRM



The Summer School for Rock Magnetism Class of 2011.

Julie Bowles, IRM

Twenty-five graduate, undergraduate, and post-doctoral researchers from 14 countries converged on the IRM from June 6-15 for the first biennial Summer School in Rock Magnetism. High demand for the course unfortunately forced us to close registration early and turn away a number of applications, but we were pleased to host such a large group of diverse participants. Students' backgrounds ranged from traditional rock magnetism and paleomagnetism, to paleoclimatology, cyclostratigraphy and environmental science. For most of the students, this was their first course dedicated to rock- or paleomagnetism. Designed to provide a solid theoretical and practical underpinning for magnetic geoscience research, the course combined morning lectures with afternoon hands-on laboratory work. For the laboratory work, students were divided into five groups and were given a set of samples that they were charged with interpreting.

To obtain one of these sample sets, the whole class braved the unseasonable 100°F (38°C) heat and traveled across town to the soil pit on the University of Minnesota St. Paul campus. Used for research and teaching, the soil pit is managed by the Department of Soil, Water and

Climate. Prof. Ed Nater, our tour guide at the soil pit, greeted the group and introduced students to the geology of the site. He described soil formation processes and the soil layers that the group would observe while sampling. Students sampled two sections through the soil profile, then returned to the (blissfully air conditioned) IRM to prepare the samples for measurement. Measurements made during the remainder of the course allowed students to make interpretations about changes in magnetic mineralogy that accompany soil formation.

The remaining group projects included a study of Deep Sea Drilling Project (DSDP) basalts near the Mid-Atlantic Ridge. Students interpreted magnetic data in terms of variable age and oxidation of the samples. A third group worked on a previously unmeasured section of the Tiva Canyon tuff, examining changes in magnetic properties and grain size with stratigraphic height and (presumably) thermal history. A fourth group measured urban air filters provided by the Minnesota Pollution Control Agency. Filters were located at the top of a building in downtown Minneapolis, and the goal was to try to identify variations in magnetic properties with day of week

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Visiting Fellow's Reports

Characterization of arrays of near-identical magnetite crystals produced by lithography

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The essential aim of the Visiting Fellowship was to conduct detailed magnetic characterization of a suite of magnetite samples produced by electron beam lithography (EBL) by Dr. David Krása at the University of Edinburgh. After producing these samples, David Krása left academia to take up a job in administration at the European Research Council in Brussels.

Such samples are difficult to make, yet as they consist of arrays of near-identical crystals (Fig. 1), it makes them perfect for testing fundamental palaeo- and rock magnetic theories and numerical micromagnetic models. The samples consisted of symmetrical dots with a variety of dot diameters between 74 nm and 333 nm, i.e., across the single-domain (SD) to pseudo-single domain (PSD) threshold, with a range of dot spacings (180 – 600 nm) and various dot heights (39 – 192 nm), i.e., some of the dots were plate-like.

I measured the response of these almost unique samples to a wide range of routinely measured rock and palaeomagnetic parameters and responses including magnetic hysteresis, first-order-reversal curve (FORC) analysis, Henkel plot analysis and the stability of anhysteretic remanent magnetization (ARM) and saturation isothermal remanent magnetization (SIRM) to alternating-field (AF) demagnetization. While the samples display hysteresis behavior which is close to the PSD/multidomain (MD)

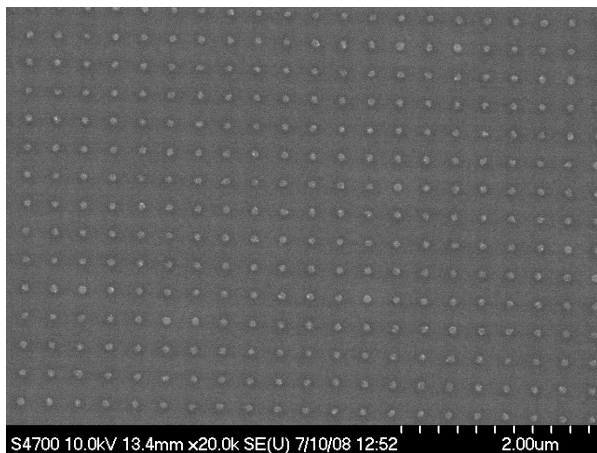


Figure 1. Scanning electron microscope image of sample DK0124right. Dot diameter 74 nm.

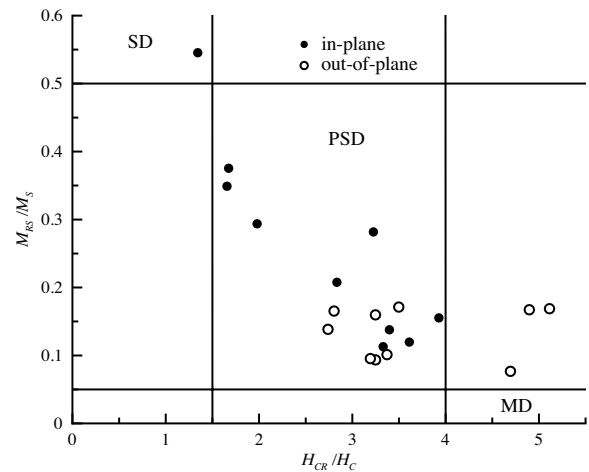


Figure 2: A 'Day plot' (Day et al., 1977) of the ratios of the hysteresis parameters M_{RS}/M_S versus H_{CR}/H_C for the EBL samples. Both in and out of plane measurements are shown. The regions commonly associated with SD, PSD and MD behavior are labeled.

boundary on the 'Day plot' (Fig. 2), the samples still appear to be able to reliably record weak-field ARM, which is similar to those found in nature. During routine AF demagnetization, weak-field ARM was found to be less influenced by inter-grain magnetostatic interactions than high-field remanences (SIRM), that is, ARMs applied perpendicular to the magnetostatic interaction plane retained their direction even at high alternating fields. In contrast, the direction of SIRMs applied perpendicular to the interaction plane was found to relax into this plane as the alternating field increased. This suggests that using in-field magnetic measurements, like magnetic hysteresis, and high-field remanence measurements, like SIRM, as indicators of recording fidelity may not correctly identify reliable palaeomagnetic recorders. For example, using hysteresis measurements to identify SD grains as a pre-selection criteria for palaeointensity experiments, may lead to incorrect rejection of samples.

This work has already been published as:

Krásá, D., Muxworthy, A.R., Williams, W., 2011. Room- and low-temperature magnetic properties of 2-D magnetite particle arrays. *Geophys. J. Int.*, 185, 167-180.

Finally I would like to thank Mike, Peat and Julie and the rest of the IRM for their help and hospitality.

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The IRM Quarterly is always available as a full color pdf online at www.irm.umn.edu

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 abstracts are taken from INSPEC (© Institution of Electrical Engineers), Geophysical Abstracts in Press (© American Geophysical Union), and The Earth and Planetary Express (© Elsevier Science Publishers, B.V.), 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 Abstracts section of the IRM Quarterly are always welcome.

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Archeomagnetism

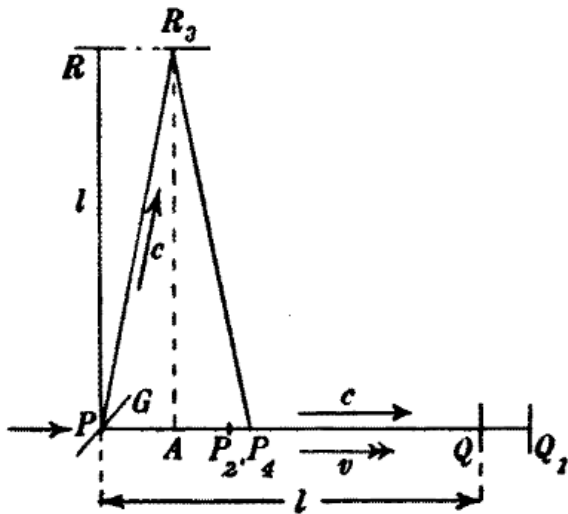
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A figure from Lorentz's "The principle of relativity. Three lectures held in Haarlem Teylers Foundation", 1914.

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Instrumentation

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Sampling a soil profile in the St. Paul soil pit.

or time of year. A final group received a set of “mystery samples” that included variable mixtures of grain sizes and mineralogies.

Each group measured a few samples from each sample set so students could observe different kinds of behavior. However, each group was responsible for the interpretation of one data set and presented their interpretations on the final day of the course. The groups did a phenomenal job given the limitations in time and information available to them. We expect to see great things from them as they continue in their careers!

On Saturday, participants took a break from the lab and the classroom to visit Interstate State Park on the St. Croix River. The park features one of the southernmost outcroppings of the Keweenaw basalts associated with the Precambrian Mid-Continent Rift System. These basalts now host some of the deepest potholes in the world, created by glacial meltwater ~10,000 years ago. The basalts are also of paleomagnetic interest, lying at the center of a debate over the nature of the geomagnetic field during this time [1-3].

Throughout the ten-day course, the enthusiasm and energy of the students persisted and was inspiring. Even beyond the learning that took place in the classroom and in the labs, students learned from one another about their own research. Last, but certainly not least, they began forging relationships with colleagues that we hope will last throughout their careers.



Summer School participants presented interpretations of the group projects on the final day of the course.

The **Geomagnetism and Paleomagnetism Section of the American Geophysical Union (AGU)** provided scholarship support for the school. These special awards went to four students who submitted exceptional applications: Agathe Lisé-Pronovost (Université du Québec à Rimouski), Laura Roberts (University of Liverpool), Vinod Samuel (Indian Institute Of Science), and Allison Teletzke (Lehigh University). Additional scholarship funds were provided by the **National Science Foundation, Earth Science Division**.



Inside the shielded room at the IRM.



Visiting the glacial potholes scoured into Pre-Cambrian Keweenaw basalt at Interstate State Park.

Due to overwhelming demand for the Summer School and the success of this inaugural venture, we expect to offer the course biennially. The next Summer School for Rock Magnetism will be held in 2013.

Additional photos from the Summer School can be seen on the IRM Facebook page, or on the Summer School website: <http://www.irm.umn.edu/IRM/ssrm2011.html>

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2011 MagIC Science & Database Workshop

September 19-21, 2011
La Jolla, California

Studies using large data sets and centralized long-term data storage are increasingly important in all scientific disciplines. The **Magnetics Information Consortium (MagIC)** is a community effort funded by the National Science Foundation to archive data and enable sharing them across geomagnetic, paleomagnetic and rock magnetic communities. The primary goal of MagIC is to broaden access to data, providing tools that enable researchers to include or compare with any relevant data in their analyses, and facilitating new kinds of studies with comprehensive data sets.

The **2011 MagIC Science & Database Workshop** will offer three invited keynotes, six short science-database talks, and a poster session covering a wide range of topics in paleomagnetism, geomagnetism and rock magnetism. An introduction to the workings of the MagIC database will also be given, along with brief tutorials on archiving your own data and reviewing contributions to the database.

Registration closes: August 31, 2011

Deadline for travel assistance: August 15, 2011

More information:

<http://earthref.org/events/MAGIC/2011/>

Hendrik Antoon Lorentz

b. July 18, 1853, Arnhem, Netherlands

d. February 4, 1928, Haarlem, Netherlands

Lorentz obtained his doctoral degree in 1875 at the age of 22 and was appointed to the Chair of Theoretical Physics at University of Leyden three years later. Lorentz spent the early part of his career advancing the electromagnetic theories of Maxwell, including explaining the reflection and refraction of light. In 1895, he described the force experienced by a moving charge in a magnetic field. Lorentz was the first to conceptualize the electron, proposing that atoms were composed of small, charged particles that produce light waves when oscillating. After Lorentz's former student, Pieter Zeeman, experimentally demonstrated the splitting of spectral lines in strong magnetic fields (the Zeeman effect), Lorentz provided the theoretical explanation, incorporating his theory of electrons; the two shared the Nobel Prize in Physics in 1902. In 1904, Lorentz published a set of transformations to describe electromagnetic phenomena in moving reference frames. Henri Poincaré later dubbed these the "Lorentz transformations" and they served as a foundation for Einstein's work in special relativity. Lorentz officially retired from Leiden in 1912 and served as director of the Teylers Museum in Haarlem until 1928.

Visiting Fellows July - December, 2011

Natalia Bezaeva

Imperial College London

Primary characterisation of natural and synthesised titanomagnetite-bearing samples for further investigations of the effect of chemical alteration on the fidelity paleomagnetic PSD recorders

Ramon Egli

Ludwig-Maximilians University

Low-temperature study of magnetosome chains

Christopher Hanratty*

Colorado State University

Structural Investigation of the cylindrical fault surrounding the Mount Saint Helens lava dome

Max A. Jackl*

Colorado State University

A Test Of General Shear Versus Folding For The Origin Of Mineral Lineations, Nason Terrane, Washington State

Johanna Salminen

Yale University

Origin of high remanent magnetization in the Vredefort impact structure?

Robin B. Traylor*

California State University, Fresno

High Resolution magnetostratigraphy of the Turlock Lake Formation, California

Huapei Wang*

Rutgers University

Thermal Fluctuation Tomography on Galapagos Basalts

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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.

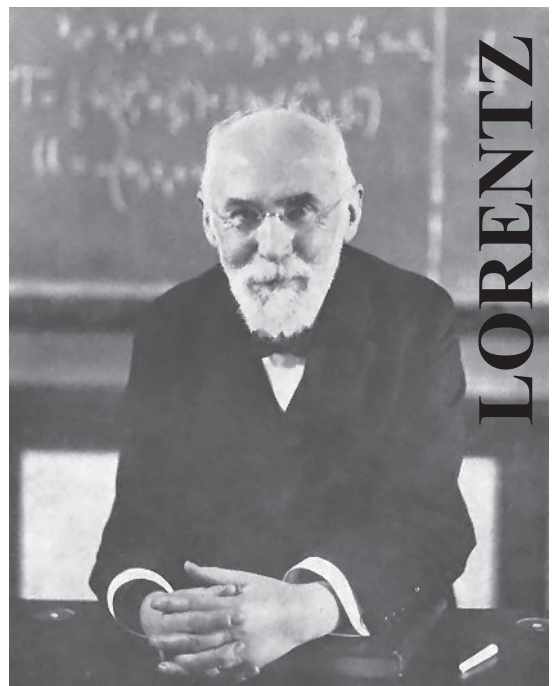
The *IRM* staff consists of **Subir Banerjee**, Professor/Founding Director; **Bruce Moskowitz**, Professor/Director; **Joshua Feinberg**, Assistant Professor/Associate Director; **Jim Marvin**, Emeritus Scientist; **Mike Jackson**, **Peat Solheid**, and **Julie Bowles**, Staff Scientists.

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The *IRM Quarterly* is published four times a year by the staff of the *IRM*. If you or someone you know would like to be on our mailing list, if you have something you would like to contribute (*e.g.*, titles plus abstracts of papers in press), or if you have any suggestions to improve the newsletter, please notify the editor:

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