I R M
Institute for Rock Magnetism

University of Minnesota *Minneapolis, Minnesota*

Spring 1991 Newsletter *Volume 1, Number 1*

IRM Established

Subir Banerjee

There is a new focal point for nationwide cooperative research in rock magnetism. In the fall of 1990, the ***Institute for Rock Magnetism*** (***IRM***) was established at the University of Minnesota in Minneapolis to provide free access to modern equipment, and to encourage visiting scientists in their study of important topics in rock magnetism and related interdisciplinary fields.

BACKGROUND

In late 1986, the Geomagnetism and Paleomagnetism (GP) section of the American Geophysical Union (AGU) held a workshop at Asilomar, CA both to examine the important and emerging research areas in paleomagnetism and rock magnetism, and to consider the means by which to explore them. In a report of this workshop published by the AGU in September, 1987, two urgent needs were set forth. The first was for interdisciplinary research to be done among the fields of rock magnetism, and mineralogy, petrology, sedimentology, and the like. The second need was for a facility wherein rock magnetists and paleomagnetists around the country could have easy access to the latest equipment in modern magnetics technology. A place which could meet these needs was soon planned and funded. Then, at the GP section of the 1990 fall business meeting of the AGU in San Francisco, only three years since the publication of the report, it was announced that the new ***IRM*** was up and running.

ENDS...

A broad diversity of studies can be pursued at the ***IRM*** - from the process of magnetic reversals, to the physical reasons behind Paleozoic remagnetization associated with large scale fluid flows (the “squeegee” hypothesis), to the environmental magnetic signatures left by paleoclimatic changes. Regardless of the goal however, the approach always starts in the same way: with an investigation of the origin and alteration of natural remanent magnetization (NRM) carried by magnetic oxide and sulfide grains ranging in size from tens of micrometers to tens of nanometers. The spatial resolution required for this can be obtained by studying *in situ* or separated single magnetic grains. The weak magnetizations and complex internal magnetic domain structures of these grains, resulting from multiple magnetiza-

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Workshop Scheduled

An **Environmental Magnetism Workshop** for graduate students and starting postdoctoral fellows is being held in Minneapolis in early June, sponsored by the ***IRM*** and the University of Minnesota’s Global Paleorecords Research Training Group. The workshop is designed for beginning researchers in subjects such as ecology, soils, limnology, or paleoclimatology, who have relatively little background in rock magnetism. The students will be meeting with leaders in the field, attending lectures, discussing projects, and learning to use magnetic instruments. Guest faculty are Dr. **John King** from the University of Rhode Island, Dr. **Dennis Bazylinski** from Virginia Polytechnic Institute, and Dr. **Richard Frankel** from California Polytechnic State University. The ***IRM*** staff will also participate as lecturers and lab demonstrators. A small booklet consisting of the combined lecture and lab notes from the workshop will be available for a small fee (to offset printing costs).

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tion histories, can be measured by such instruments as magnetometers, demagnetizers, and susceptibility bridges; and even imaged using laser and electron optics.

...MEANS

The ***IRM*** already possesses a full complement of standard rock and paleomagnetic equipment. Some more unusual items are also on-line, such as a dual-frequency susceptibility bridge and a high-sensitivity susceptibility anisotropy bridge - the latter built in our laboratory. By 1 July 1991, thanks in part to the generous support of the W. M. Keck Foundation, we hope to have installed three new off-the-shelf instruments: a superconducting susceptometer, an alternating gradient force magnetometer, and a Mössbauer spectrometer [see “New Equipment Available” on page 8 for more details]. Later, in 1992, we will assemble a magneto-optic Kerr effect (MOKE) magnetic domain imager for studying single magnetic grains.

The ***IRM*** is fortunate to have a wealth of outside expertise available both at the University of Minnesota and throughout the Twin Cities of Minneapolis and Saint Paul. Vigorous resource-sharing is underway between the ***IRM*** and University of Minnesota Electrical Engineering Prof. **Jack Judy**’s group at the Magnetics and Information Technologies Center (MINT). Preliminary work on the magneto-optic imager has already begun with the assistance of Dr. **Pat Ryan** at Seagate Technology near Minneapolis. Drs. **Don Krahn** and **Bharat Pant** from Honeywell in Minneapolis are helping with the development of a magneto-resistive flux detector for variable frequency use. We eagerly look forward to more of this sort of stimulating interdisciplinary collaboration among local researchers in the future. In fact, we are even now watching with great interest the construction of an Atomic Force Magnetometer by Prof. **Dan Dahlberg** and Mr. **Roger Proksch** in the University of Minnesota Physics Department.

STAFF

The plans for the ***IRM*** require trained research and technical staff who will work alongside visitors, adapt equipment for novel use, design experiments, and help interpret the data obtained. To this end, the University of Minnesota and the NSF have jointly provided salary support for two new positions. Dr. **Bruce Moskowitz** arrived from UC-Davis in January to serve as Associate Director. Mr. **Chris Hunt** left a position in a consulting firm in Vermont to begin as Scientist and Laboratory Manager last October. Longtime Minnesota residents Prof. **Subir Banerjee** and Mr. **Jim Marvin** complete the ***IRM*** staff as Director and Senior Scientist respectively.

VISITORS

The ***IRM*** exists in part for the use of others. Visiting Fellows will come for a few weeks in order to pursue research related to the current ***IRM*** focus. [see “Visiting Fellowship Program Off to a Good Start” on page 7 for more details and for how to apply]. In addition, the ***IRM*** will always be accessible to graduate students, postdoctoral fellows, or others who may wish to visit for only a day or two.

FOCUS

For the year July 1991 through June 1992, the chosen area for research is alteration of small magnetic grains by chemical change, stress, or temperature. The goal is to study characteristic signatures of paleoclimatic and paleoenviron–mental changes, tectonic events, and formation of ore bodies. Even though these already constitute a fairly broad range of ideas, the Review and Advisory Committee (RAC) [see “***IRM*** Guided By Board” below] has suggested that

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IRM Guided by Board

The ***IRM*** has a six-member **Review and Advisory Committee** (**RAC**) which serves to provide direction and focus for the ***IRM***. One-third of the RAC membership will be replaced every two years. RAC meetings are held regularly at AGU meetings. The current members are:

Prof. **David Dunlop** (University of Toronto - Erindale, RAC Chair)
Dr. **Bob Butler** (University of Arizona - Tucson)
Prof. **Mike Fuller** (University of California - Santa Barbara)
Dr. **Rich Reynolds** (U.S. Geological Survey - Denver)
Dr. **Mike Sharrock** (3M Corporation - Minneapolis)
Prof. **Rob Van der Voo** (University of Michigan - Ann Arbor)

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Current Abstracts

A list of current research articles dealing with various topics in the physics and chemistry of magnetism will be a regular feature of the *IRM Newsletter*. Articles published in familiar geological journals will be included, but special emphasis will be given to current articles from physics, chemistry, and materials science journals. In addition, an extensive reference list of articles primarily about rock magnetism, the physics and chemistry of magnetism, and some paleomagnetism is being compiled at the ***IRM***. This list, with more than 1100 references, will be available in the near future free of charge. As always, your contributions both to the Abstracts section of the *IRM Newsletter* and to the reference list are welcome.

Chemistry

Fujii, T., *et al.*
Depth selective Mössbauer spectroscopic study of iron oxide (Fe_3O_4) epitaxial films, *J. Appl. Phys.*, *68*, 1735-1740, 1990.

Verwey transition observed in 5Å-thick surface layer of well-crystallized magnetite films grown on αAl_2O_3 by vapor deposition.

Özdemir, Ö., and D. J. Dunlop
Chemico-viscous remanent magnetization in the Fe_3O_4-γFe_2O_3 system, *Science*, *243*, 1043-1047, 1989.

The CRM acquired by an SD magnetite grain during oxidation is similar to the VRM acquired under similar field and temperature conditions by a non-oxidizing grain.

Sato, M., *et al.*
Magnetic properties and microstructures of Fe_3O_4-αFe_2O_3 intermediate state, *IEEE Trans. Magn.*, *MAG-26*, 1825-1827, 1990.

TEM studies show that the coercivity increase observed when magnetite oxidizes to hematite is attributable to stress, as indicated by shrinkage, dislocations, stacking faults, and lattice defects.

Zuo, J. M., J. C. H. Spence, and W. Petuskey
Charge ordering in magnetite at low temperatures, *Phys. Rev.*, *42B*, 8451-8464, 1990.

Ordering of Fe^{2+} and Fe^{3+} ions in the octahedral sites in magnetite below the Verwey transition determined. Electron-phonon interactions seen to stabilize the structure.

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Magnetic Anomalies

Thomas, M. D., *et al.*
Ground magnetic and rock magnetic studies near the Appalachian Dunnage-Gander terrane boundary, northern New Brunswick, *Geol. Surv. Can. Paper*, *91-10*, 169-178, 1991.

Study of NRM to constrain ground magnetic anomaly interpretations, and of susceptibility anisotropy to examine magnetic fabrics.

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Magnetic Parameters

Argyle, K. S., and D. J. Dunlop
Low-temperature and high-temperature hysteresis of small multidomain magnetites (215-540 nm), *J. Geophys. Res.*, *95B*, 7069-7083, 1990.

Coercive force and saturation remanence data for PSD-size magnetites from the Verwey transition to the Curie point, including a thermal fluctuation analysis of activation volume and a demagnetizing factor calculation.

Li, H., and S. Beske-Diehl
Magnetic properties of deuteric hematite in young lava flows from Iceland, *Geophys. Res. Lett.*, in press, 1991.

Directions of titanohematite and titanomagnetite components of remanence are identical. Titanohematite unblocking temperatures are between 610° and 650°C, and intensity increases with deuteric oxidation.

Menyeh, A., and W. O'Reilly
The magnetization process in monoclinic pyrrhotite (Fe_7S_8) particles containing few domains, *Geophys. J. Int.*, *104*, 387-399, 1991.

Domain state and anisotropy constant characterized for six fractions of 1-to-30 µm grains, then compared with theory.

Özdemir, Ö.
High-temperature hysteresis and thermoremanence of single-domain maghemite, *Phys. Earth Planet. Inter.*, *65*, 125-136, 1990.

Magnetic properties of acicular SD maghemite measured. High temperature stability allows study of TRM and temperature dependence of coercive force.

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Current Abstracts

Models

Borradaile, G. J.
Correlation of strain with aniso–tropy of susceptibility, *Pure Appl. Geophys.*, *135*, 15-29, 1991.

A re-examination of correlations between strain and anisotropy of low-field magnetic susceptibility (AMS) allows use of a single parameter to express the intensity of both strain and AMS within a certain strain window.

Dunlop, D. J., R. J. Enkin, and E. Tjan
Internal field mapping in single-domain and multidomain grains, *J. Geophys. Res.*, *95B*, 4561-4577, 1990.

Vector internal field maps of single-domain and two-domain magnetite grains calculated using a one-dimensional micromagnetic model.

Honig, J. M., J. Spalek, and P. Gopalan
Simple interpretation of the Verwey transition in magnetite, *J. Am. Ceram. Soc.*, *73*, 3225-3230, 1990.

Free energy of possible electronic states for octahedral electrons minimized to model equilibrium condition. Verwey transition seen to be driven by Coulomb repulsion. Comparison with Strassler-Kittel model.

Remember:
Send in your abstracts for inclusion in the next issue.

Hrouda, F., and L. Hruskova
On the detection of weak strain parallel to the bedding by magnetic anisotropy: A mathematical model study, *Stud. Geophys. Geod.*, *34*, 327-341, 1990.

Five models of the superposition of deformational magnetic fabric on sedimentary magnetic fabric are presented, with diagrams to help recognize weak ductile deformation in sedimentary rocks.

Lyberatos, A., and R. W. Chantrell
Calculation of the size dependence of the coercive force in fine particles, *IEEE Trans. Magn.*, *MAG-26*, 2119-2121, 1990.

Numerical micromagnetic modelling of cube-shaped γFe_2O_3 simulates coherent rotation and curling of magnetization during reversal. Thermal fluctuation simulation accounts for coercive forces.

Walton, D.
A theory of anhysteretic remanent magnetization of single-domain grains, *J. Magn. Magn. Mater.*, *87*, 369-374, 1990.

Temperature and frequency-dependence of ARM derived for easy and other directions. In the low-field limit, ARM is a function of log(frequency) in the easy direction.

Worm, H.-U., P. J. Ryan, and S. K. Banerjee
Domain size, closure domains, and the importance of magnetostriction in magnetite, *Earth Planet. Sci. Lett.*, *102*, 71-78, 1991.

Domains observed by the magneto-optic Kerr effect, plus calculation of minimum energy domain configuration in multidomain grains.

Xu, S., and R. T. Merrill
Microcoercivity, bulk coercivity, and saturation remanence in multidomain materials, *J. Geophys. Res.*, *95B*, 7083-7090, 1990.

Bulk coercivity is usually nonlinearly related to microcoercivity in MD grains. Theory developed for bulk coercivity versus temperature agrees with experiment for hydrothermally grown magnetites.

Xu, S., and R. T. Merrill
Thermal variations of domain wall thickness and number of domains in magnetic rectangular grains, *J. Geophys. Res.*, *95B*, 21,433-21,440, 1990.

Domain structure and wall thickness are strongly dependent on grain shape and orientation for rectangular magnetite grains. This departure from classical equidimensional-grain theory explained in terms of two competing self-magnetostatic interactions from the ends and sides of the grains.

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New Techniques

Dekkers, M. J., and J. H. Linssen
Grain-size separation of haematite in the <5μm range for rockmagnetic investigation, *Geophys. J. Int.*, *104*, 423-427, 1991.

Small hematite grains separated by centrifuging into six fractions. Electron microscopy confirms theory based on Stokes' Law travel distances.

Pfleiderer, S., and H. C. Halls

Magnetic susceptibility anisotropy of rocks saturated with ferrofluid: A new method to study pore fabric?, *Phys. Earth Planet. Inter.*, *65*, 158-164, 1991.

AMS can provide an estimate of the three-dimensional pore fabric anisotropy in magentic sedimentary rocks saturated with ferrofluid.

Özdemir, Ö., and D. York
^{40}Ar/^{39}Ar laser dating of a single grain of magnetite, *Tectonophys.*, *184*, 21-33, 1990.

The first step toward the direct dating of NRM in paleomagnetism using argon dating by laser step-heating of a single magnetite grain.

Walton, D.
Changes in the intensity of the geomagnetic field, *Geophys. Res. Lett.*, *17*, 2085-2088, 1990.

A new paleointensity technique using baked clays claims to be able to do limited archaeomagnetic dating to ±100 years for 900 BC to 400 AD.

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Paleomagnetism

Radhakrishnamurty, C.
Mixed domain states of magnetic grains in basalts and implications for palaeomagnetism, *Phys. Earth Planet. Inter.*, *64*, 348-354, 1990.

Available data used to gain insight into aggregate behavior of basalts containing magnetite grains from <1 µm to >100 µm. Rock magnetic and paleomagnetic implications discussed.

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Physics

Krivoruchko, V. N., T. E. Soloveva, and D. A. Yablonskii
Electrically active magnetic polaritons in αFe_2O_3, *Optics and Spectroscopy*, *68*, 550-553, 1990.

Electrically active exchange spin excitation waves may be observable by optical methods. Propagation of normal modes studied.

Turov, E. A.
Exchange-enhanced photoelastic interaction and Bragg light diffraction by sound in antiferromagnets, *Sov. Phys. JETP*, *71*, 365-371, 1990.

Under Bragg conditions, the angle and intensity of light diffracted by sound can be controlled by a magnetic field in acousto-optical devices via exchange enhancement in αFe_2O_3.

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Remanences

Jackson, M. J., *et al.*
Detrital remanence, inclination errors, and anhysteretic remanence anisotropy: Quantitative model and experimental results, *Geophys. J. Int.*, *104*, 95-104, 1990.

Inclination shallowing errors in DRM, explained in terms of particle shape and alignment efficiency in magnetic field, can be identified and corrected by normalization of ARM anisotropy.

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Reviews

Dunlop, D. J.
Developments in rock magnetism
Rep. Prog. Phys., *53*, 707-792, 1990.

Comprehensive review of the state of the art of rock magnetism, including domain structure observations and theory, VRM, TRM, CRM, and PSD behavior.

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Seafloor Magnetization

Beske-Diehl, S. J.
Magnetization during low-temperature oxidation of seafloor basalts: No large scale chemical remagnetization, *J. Geophys. Res.*, *95B*, 21413-21432, 1990.

Study of AF demagnetization of titanomagnetites in oceanic basalts with uniform grain size but varying oxidation state shows CRM not to be controlled by field; VRM is dominant secondary component in multicomponent samples.

Hall, J. M., *et al.*
The magnetization of oceanic crust: Contribution to knowledge from the Troodos, Cyprus, ophiolite, *Can. J. Earth Sci.*, in press, 1991.

Evidence from the Troodos ophiolite suggests that the magnetic source layer of the oceanic crust consists of at least two layers: the extrusive carrying NRM, and the sheeted dikes carrying an induced magnetization.

Kikawa, E., and J. Pariso

Current Abstracts

Magnetic properties of gabbros from hole 735B at the Southwest Indian Ridge, *Initial Reports of the Deep Sea Drilling Project, 118*, in press, 1991.

Large stable magnetization suggests that oceanic gabbros contribute to the marine magnetic anomaly source layer.

Toft, P. B., J. Arkani-Hamed, and S. E. Haggerty
The effects of serpentinization on density and magnetic susceptibility: A petrophysical model, *Phys. Earth Planet. Inter.*, *65*, 137-157, 1990.

An inverse correlation between initial magnetic susceptibility and density is typical of ophiolitic serpentinized harzburgites. The observed correlation is explained by a multi-stage serpentinization process such that the rate of production of magnetite increases with the degree of serpentinization.

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Sediments and Soils

Fine, P., *et al.*
Role of pedogenesis in distribution of magnetic susceptibility in two California chronosequences, *Geoderma*, *44*, 287-306, 1989.

The enhancement of magnetic susceptibility extends to a considerable depth in older soils. Using a citrate-bicarbonate-dithionite procedure, contributions from pedogenic and inherited magnetic carriers are distinguished.

Clayton, J. A., K. L. Verosub, and C. D. Harrington
Magnetic techniques applied to the study of rock varnish, *Geophys. Res. Lett.*, *17*, 787-790, 1990.

Rock varnish has a magnetic signature probably carried by magnetite or maghemite. This study represents perhaps the first rock magnetic measurements of a geomorphic surface.

Maher, B. A., and R. Thompson
Mineral magnetic record of the Chinese loess and paleosols, *Geology*, *19*, 3-6, 1991.

Variations in the magnetic susceptibility of the Chinese loess and paleosol sequences correlate with the deep-sea oxygen isotope record. In contrast with earlier studies which claimed this implied a reflection only of global-scale climate change, this study attributes some of the higher susceptibility values in paleosols to pedogenic formation of magnetite, which depends on regional climatic conditions.

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Special Issues

Özdemir, Ö., guest editor
Magnetic interactions: Particles, domains, phases, *Phys. Earth Planet. Inter.*, *65*, 196 pp., 1990.

Papers in experimental and theoretical fine-particle magnetism given at the International Association of Geomagnetism and Aeronomy (IAGA) General Assembly, 31 July 1989, Exeter, U.K.

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Susceptibility

Fannin, P. C., B. K. P. Scaife, and S. W. Charles
An experimental study of the magnetic susceptibility of colloidal suspensions of magnetite as a function of particle volume fraction, *J. Phys. D Appl. Phys.*, *23*, 1711-1714, 1990.

Complex frequency dependence of susceptibility (including 0 Hz) for range of packing fractions of colloidal suspensions of magnetite. Onsager theory of dielectric polarization seems to account for the dependence of the 0 Hz susceptibility on packing fraction.

Potter, D. K., and A. Stephenson
Field-impressed anisotropies of magnetic susceptibility and remanence in minerals, *J. Geophys. Res.*, *95B*, 15,573-15,588, 1990.

Alternating and direct fields applied to weakly anisotropic rocks alter the low-field susceptibility anisotropy by imposing a field-induced anisotropy. Implications for AF demagnetization techniques discussed.

Radhakrishnamurty, C.
Unusually large shift in low-temperature susceptibility peak of $Fe_{2.8}Ti_{0.2}O_4$ with frequency, *Prama−nΩa*, *35*, 377-381, 1990.

Temperature dependence of frequency dependence of susceptibility in titanomagnetite contrasted with lack of such temperature dependence in magnetite.

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Visiting Fellowship Program Off To A Good Start

Interested researchers are encouraged to come and take advantage of the facilities at the ***IRM*** by becoming a **Visiting Fellow**. Applications are accepted twice a year for visits during the following half year. A Fellowship allows preferential access to equipment and expertise, but carries no stipend or other financial support. Applications are used simply to screen applicants and to aid in scheduling of projects. An application consists of a short (two- or three-page) proposal plus necessary figures describing a well-defined project, including what samples are to be measured, what has already been done, and what is to be done at the ***IRM***. Fellows are expected to provide for their own travel and subsistence during a typical visit of one to three weeks. Equipment at the ***IRM*** is provided free of charge, but other non-***IRM*** equipment nearby is often subject to a user fee.

Applications for visits during the first half of 1992 are due by **30 September 1991**. Decisions will be made by 1 November 1991 to provide adequate time to apply to the NSF for travel supplements or small new grants, if necessary.

The ***IRM*** encourages others who wish to use the facilities on a less formal basis for only a day or two to schedule visits as well. Researchers in this category might be graduate students, industry workers, or academics needing to make only a few measurements. Such recent occasional users of the ***IRM*** include people from various University of Minnesota departments, and from companies in the magnetic industry in the Twin Cities, such as Honeywell. Regional institutions like Carleton College, the University of Wisconsin - Eau Claire, and the University of Iowa have sent representatives. We have also welcomed people from national research centers, such as Woods Hole Oceanographic Institution and Lamont-Doherty Geological Observatory. Even visitors from such far-flung places as Göteborg, Sweden and Grenoble, France have made use of the ***IRM***.

The Visiting Fellowship Program at the ***IRM*** and the open-door policy towards informal visitors will go a long way towards fulfilling our goal of providing state-of-the-art equipment to any interested, qualified researcher.

The **Visiting Fellows** for the second half of 1991 come from all over the world, from Asia to Europe to North America. Their research topics cover just as wide an area. Here is the list, in alphabetical order:

Visiting Fellow	***Institution***	***Research Interest***
Dr. **Dave Douglass**	Pasadena City College	sediments and dike rocks near a baked contact in Utah
Drs. **Dunlop/Özdemir** (Canada)	U. of Toronto	biotite; single crystals; low-temperature demagnetization
Ms. **Gina Frost**	UCSC	carbonates and red sandstones in China
Dr. **Bill Harbert**	U. of Pittsburgh	fire frequency from soils in Yellowstone
Dr. **Eiichi Kikawa** (Japan)	Texas A&M	NRM of oceanic gabbros
Dr. **John King**	U. of Rhode Island	chemical diagenesis in marine sediments
Mr. **Alan Lester**	U. of Colorado	chemical changes in Front Range tuffs
Dr. **Katherine Nazarova** (USSR)	Lamont-Doherty	serpentinization in the oceanic lithosphere

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projects be allowed to deviate from the above focus for this first year. The ***IRM*** is thus open to researchers investigating all rock magnetic and paleomagnetic topics during 1991-1992. We extend a hearty welcome to all potential users and look forward to welcoming them to Minnesota.

[Modified and updated from a news item in *Eos*, *72*, no. 9, pg. 98, 26 February 1991]

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Call for Visiting Fellow Applications:

Visits:
First half of 1992
Deadline:
30 September 1991
Decisions:
1 November 1991

New Equipment Available

The equipment of the ***IRM*** is available free of charge to any interested researcher. One- to three-week visits are arranged through the Visiting Fellowship program [see page 7]. Shorter stays can be scheduled directly with the Laboratory Manager.

The newest additions to our facilities are:

- **Superconducting Susceptometer** (Quantum Design MPMS1)
  sensitivity 1x10^{-11} A·m^2, applied fields from 0 T to 5 T, temperatures from 2K to 400K

- **Alternating Gradient Force Magnetometer** (Princeton Measurements AGFM)
  sensitivity 1x10^{-11} A·m^2

- **Mössbauer Spectrometer** (parts donated by 3M with upgrade parts from Ranger Scientific) [available during the summer of 1991]
  temperatures from 2K to ambient

Other major pieces of rock magnetic equipment at the ***IRM*** include:

- **Susceptibility Anisotropy Bridge**
  sensitivity 1x10^{-7} cgs (1.2x10^{-6} SI), 1.5 minutes for typical sample (8 cm^3)

- **Vibrating Sample Magnetometer (VSM)**
  sensitivity 2x10^{-8} Am^2, applied fields from 0 T to 1.7 T, temperatures from 77K to 1200K, loop time 12 minutes for typical sample (200 mg magnetic separate)

- **Superconducting Rock Magnetometer (SRM)**
  sensitivity 2x10^{-11} Am^2, typical sample 8 cm^3

- **Spinner Magnetometer**
  sensitivity 1x10^{-10} Am^2, typical sample 8 cm^3

- **Thermal Demagnetizer**
  temperatures from ambient to 1100K, optional applied fields from 0 mT to 0.2 mT

- **Alternating Field (AF) Demagnetizers**
  peak applied fields from 0 to 100 mT, biasing fields from 0 mT to 0.2 mT, ARM and partial ARM capability

- **Susceptibility Bridges (Bartington)**
  sensitivity 1x10^{-6} cgs (1.2x10^{-5} SI), dual frequency available

An even more complete description of the ***IRM*** facilities is available upon request.

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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 to become a Visiting Fellow. Proposals are accepted semi-annually in spring and fall for work to be done during the following half year. Shorter, less formal visits are arranged on an individual basis through the laboratory manager.

The ***IRM*** is funded by the **W. M. Keck Foundation**, the **National Science Foundation**, and the **University of Minnesota**.

The *IRM Newsletter* is published periodically by the staff of the ***IRM***. If you or someone you know would like to be on [or off] 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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