The IRM Quarterly
Spring 1993, Vol. 3, No. 1 Institute for Rock Magnetism

A Rock-Magnetic Journey through Asia

Subir Banerjee
IRM

From mid-December, 1992, through mid-March, 1993, I was able to visit a number of Earth Sciences research laboratories in India, China, and Japan. What I mean to do in this short contribution is to pass along my observations for the benefits of those readers who may want to pursue cooperative research with any of these research institutions in the future. However, I also offer the following editorial comments and qualifiers: (1) there is often a lack of detailed observations here in my report due to the mostly short duration of my visits; (2) there is in Asia—especially in India and China—a generally much slower tempo of work, and a smaller number of complex instruments than in the U.S; (3) our international colleagues are nevertheless very enthusiastic about cooperative research. And I must say that, in addition to the joy of simply doing science together, there is also another, more pragmatic reason for engaging in such cooperative efforts: I note that recent decisions of the Indian and Chinese governments have resulted in a drastic decrease in central funding (50% in India!) for many national research laboratories. Therefore, through cooperative research, western scientists can make a difference by lifting the scientific morale of our colleagues and by sharing in field expenses.

India

Delhi and Madras

My Indian visit was arranged under the auspices of the United Nations Development Program (UNDP) which brings expatriate nationals back home to share their scientific expertise. My chief host for this part of the trip was Prof. A. Mitra, head of the Indian national component of the International Geosphere Biosphere Project (IGBP).

In December, my first mission, which was to participate as a paleomagnetism specialist in the national workshop and planning session of the Indian IGBP in Madras, proved impossible to complete. After reaching Delhi, I discovered that the workshop had been canceled because of the riots and political instability unleashed in the wake of the destruction of the 16th-century Babri Mosque in Ayodhya. By an unfortunate coincidence, the Indian Airlines pilots were on strike at the same time. But a plane lent by Uzbek Airlines took me to Hyderabad, the home of the National Geophysical Research Institute (NGRI), for a three-week stay.

Hyderabad

At NGRI, I collaborated with many colleagues, led by Dr. H. Gupta, to draft a plan for a joint rock-magnetic/isotope geochemical research project under the rubric of the Paleorecords of Global Change (PAGES) program of the IGBP. If funded, the project will study, by means of mineralogical, rock-magnetic, and isotopic proxies, the nature of Holocene climate changes recorded in lake sediments. Other purely paleomagnetic projects in progress include magnetic stratigraphy of the Neogene Siwalik sediments of India, paleosecular variation study of Brunhés-age lake sediments, and apparent polar wander

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Visiting Fellows' Reports

We enjoyed working with a nearly continuous stream of Visitors this spring. First were **Mike McWilliams** and **Hagai Ron** from Stanford University, who, after swearing the *IRM* to secrecy regaring the subject of their study, are now willing to divulge everything they've found about the Laschamp event in sediments from Israel. Next came **Don Rodbell** from Ohio State University, who investigated the magnetic properties of pedogenic magnetic minerals in loess from the south-central United States. Finally, we welcomed **John Stamatakos** from the University of Michigan, who measured deformation and SP grains in German rocks, and stuffed himself on Chinese dumplings. As usual, we have prevailed upon each of our visitors to contribute a summary of work done here at the *IRM*:

loess

Donald Rodbell

Mineral magnetic studies of soil development in central Mississippi Valley

Ohio State University

The objectives of this study are to: (1) investigate the relationship between mineral magnetic parameters and soil development, and (2) establish a basis for distinguishing between depositional and pedogenic controls on the mineral magnetic properties of late Quaternary loess deposits in eastern Arkansas and western Tennessee.

Prior to my visit to the *IRM*, I measured standard mineral magnetic parameters on about 200 samples from four exposures that encompass the Peoria, Roxana, Loveland, and Crowley's Ridge loesses—a record of at least 150,000 years of loess deposition and soil development. Parameters measured included *in-situ* (K) and laboratory (χ) magnetic susceptibility, ARM, IRM at 1.2 T, backfield IRM at 0.3 T, and dual-frequency susceptibility (χ_{fd}; at 580 and 5800 Hz). These parameters were measured before and after treatment by the citrate-bicarbonate-dithionite (CBD) technique. The CBD treatment is thought to remove fine-grained, pedogenic iron oxides including ferrihydrite, hematite, and maghemite. It may thus provide a means for identifying variations in mineral magnetic properties that reflect changes in primary loess. Results identify widespread and regionally significant trends in the amount and grain size of magnetic minerals. Regional trends include: (1) intervals of low magnetic susceptibility that mark the contacts between all loess units; (2) χ_{fd} between 0% and 5% for the Peoria and Roxana loesses, and between 6% and 15% for the paleosols at the tops of the Loveland and Crowley's Ridge loesses; and (3) peaks in SIRM/χ and ARM/χ in the Roxana, Loveland, and Crowley's Ridge loesses. Treatment by CBD removed up to 75% of χ and ARM, and approximately 100% of χ_{fd}.

My work at the *IRM* involved: (1) estimation of magnetic grain size, using the VSM on bulk samples before and after CBD treatment; (2) estimation of the total superparamagnetic component (<30 nm) in both unweathered loesses and soils, before and after CBD treatment, using the MPMS Superconducting Susceptometer; and (3) estimation of the mineralogy of magnetic separates from soils and loesses before and after CBD treatment, using Mössbauer spectroscopy. Preliminary results indicate that pedogenesis reduces H_{cr}/H_c and increases J_{rs}/J_s, whereas the CBD treatment reverses these trends. In addition, CBD seems to dissolve not only superparamagnetic grains, but some single-domain grains as well, and it preferentially removes maghemite.

I would like to thank all *IRM* staff and students for making my one-week stay very productive and enjoyable.

rael

Mike McWilliams
Hagai Ron

Magnetic properties of dry lake sediments from the Lisan Formation, Is-

Stanford University

In a pilot study of seasonally laminated dry sediments from the Lisan Formation in Israel, we believe that we have found a record of the Laschamp Event between 39 ka and 45 ka. The Lisan sediments display a stable remanent magnetization which may provide a very complete record of this important geomagnetic feature, complete with an absolute chronology from U-series disequilibrium TIMS and a relative chronology by laminae counting. To verify that the remanence in these unconsolidated sediments is indeed a reliable recorder of geomagnetic secular variation, and therefore of the Laschamp Event, we conducted a series of experiments over a five-day period at the *IRM* using bulk sediment samples and magnetic concentrates from individual layers in the sediments.

During Pliocene to Pleistocene time, large and small lakes occupied tectonic depressions in the Jordan Arava Valley of Israel. The largest of the lakes was Lake Lisan, the precursor of the modern Dead Sea. Sediments of Lake Lisan are found from the southern shores of the Sea of Galilee in the north to the Arava Valley in the south, a distance of approximately 220 km. Lake Lisan was about 17 km wide and evolved from a small hypersaline water body, very much like the modern Dead Sea. It was later filled with large amounts of fresh water, supplied by the proto Jordan River, at about 72 ka. Lake Lisan existed until about 18 ka, when it shrank to the size of the present Dead Sea.

The sediments which were deposited in Lake Lisan from 72 ka to 18 ka are called the Lisan Formation, and they are composed of alternating white aragonitic laminae and darker detrital laminae, each with a thickness of a few millimeters. These paired laminae probably represent seasonal bands. The detrital material was derived from sedimentary, intrusive, and volcanic rocks which were transported to Lake Lisan by the proto Jordan River.

The aragonitic layers are exceptionally well preserved, a result of the extremely dry climate in the Dead Sea depression. The state of its preservation, the similarity of the formation to the modern aragonitic deposits of the Dead Sea, and its continuous deposition for 49,000

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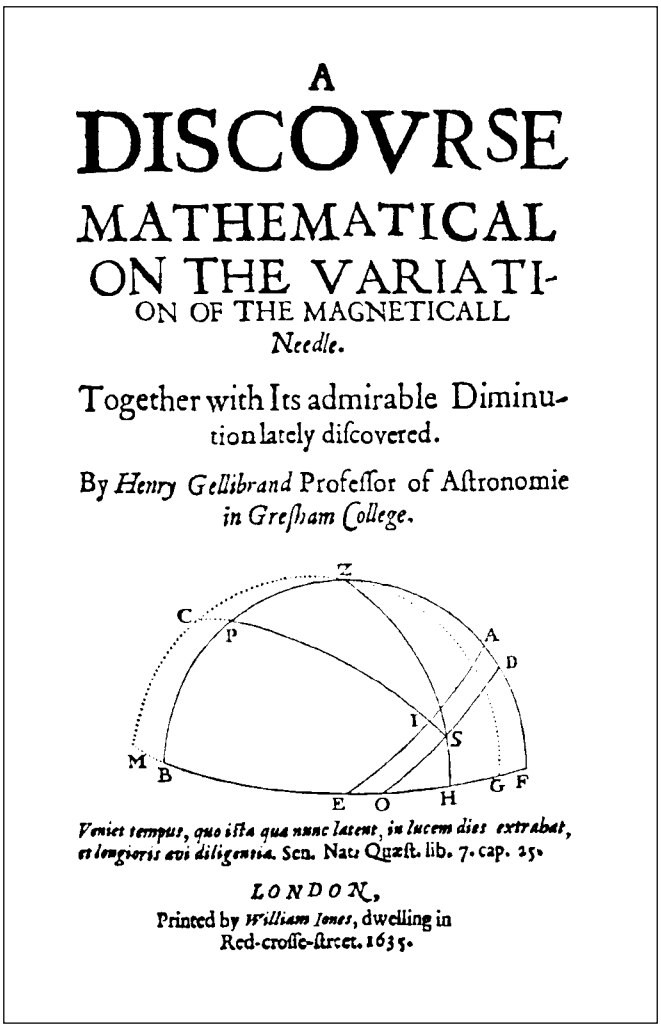


A
DISCOVRSE
MATHEMATICAL
ON THE VARIATI-
ON OF THE MAGNETICALL
Needle.

Together with Its admirable Diminution lately discovered.

By *Henry Gellibrand* Professor of Astronomie *in Gresham College.*

Veniet tempus, quo ista quæ nunc latent, in lucem dies extrahat, et longioris ævi diligentia. Sen. Nat. Quæst. lib. 7. cap. 25.

LONDON,
Printed by *William Jones*, dwelling in
Red-crosse-street. 1635.

Title page from Gellibrand's A Discovrse Mathematical on the Variation of the Magneticall Needle, *1635.*

Current Abstracts

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 culled 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 edited for the* IRM Quarterly. *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 nearly 2000 references, is available free of charge. Your contributions both to the list and to the Abstracts section of the* IRM Quarterly *are always welcome.*

Applications

Karlin, R. E., and S. E. B. Abella
Paleoearthquakes in the Puget Sound region recorded in sediments from Lake Washington, USA, *Science, 258,* 1617-1620, 1992.
The magnetic signatures of Holocene turbidite sediments from Lake Washington can be temporally and areally correlated. Large earthquakes appear to have triggered both slumping on the steep basin walls and landslides in the drainage area, resulting in turbidite deposition. Downcore susceptibility patterns suggest that near-simultaneous slumping occurred in at least three separate locations, two of which now contain submerged forests.

Pares, J. M., *et al.*
Archaeomagnetic evidence for the age of a Roman pottery kiln from Calahorra (Spain), *Geophys. J. Int., 112,* 533-537, 1993.
Individual bricks from the walls of a Roman pottery kiln have been sampled and measured in order to determine their paleomagnetic directions. Because the structure was heated well above the Curie point of hematite, it was possible to use paleomagnetic declination and inclination data to infer the age of the last heating event.

Rosenbaum, J. G.
Magnetic grain-size variations through an ash-flow sheet: influence on magnetic properties and implications for cooling history, *J. Geophys. Res., in press,* 1993.
Rock-magnetic grain-size properties of a rhyolitic ash-flow sheet, which contains both pre-eruption titanomagnetite phenocrysts and post-eruption cubic Fe oxide (SP and SD) microcrystals, are used to infer cooling history. Titanomagnetite phenocrysts are the dominant remanence carriers in the central 50 m of the section, whereas microcrystals contribute to remanence and magnetic susceptibility in top and bottom zones which are each 15 m thick.

Biomagnetism

Adair, R. K.
Effects of ELF magnetic fields on biological magnetite,
Bioelectromagn., 14, 1-4, 1993.
The effects of 60 Hz magnetic fields of 5 μT (50 mG) or less on biological structures holding magnetite (Fe_3O_4) are shown to be much smaller than those from thermal agitation; hence, such interactions cannot be expected to be biologically significant. [But see Kirschvink below—Ed.]

DeLong, E. F., R. B. Frankel, and D. A. Bazylinski
Multiple evolutionary origins of magnetotaxis in bacteria, *Science, 259,* 803-806, 1993.
Analyses of small subunit ribosomal RNA sequences showed that all known magnetotactic bacteria of the iron-oxide type are associated with the alpha subgroup of Proteobacteria. In contrast, uncultured magnetotactic bacteria of the iron-sulfide type are related to the dissimilatory sulfate-reducing bacteria within the delta subdivision of Proteobacteria. These findings suggest that magnetotaxis based on iron oxides and on iron sulfides evolved independently.

Huang, C. M., *et al.*
Magnetic properties of goethite in radulae of limpets, *IEEE Trans. Magn., MAG-28,* 2409-2411, 1992.
Radular formation in the limpet, *Acmae striata*, was explored by magnetic measurements, Mössbauer spectroscopy, X-ray diffraction, and electron microscopy. It was found that, in undeveloped radulae, acicular goethite precipitated in the matrix-mediated manner. It grew extensively to become interlocking masses in a cusp region which was detected in the porous region. A new mineral phase, hisingerite, was identified to coexist with goethite and an amorphous silicate.

Kirschvink, J. L., *et al.*
Magnetite in human tissues: a mechanism for the biological effects of weak ELF magnetic fields, *Bioelectromagn., suppl. issue,* 101-113, 1992.
A simple calculation shows that magnetosomes, moving in response to Earth-strength ELF fields, are capable of opening trans-membrane ion channels, in a fashion similar to those predicted by ionic resonance models. Hence, the presence of trace levels of biogenic magnetite in virtually all examined human tissues suggests that similar biophysical processes may explain a variety of weak-field ELF bioeffects. [But see Adair above—Ed.]

Crustal Magnetization

Johnson, H. P., and J. E. Pariso
Variations in oceanic crustal magnetization: systematic changes in the last 160 million years, *J. Geophys. Res., 98B,* 435-445, 1993.
Higher-amplitude marine magnetic anomalies are produced above older oceanic crust because of the elevated magnetization in the crustal material. In order to examine the processes responsible for this, a compilation was made of all crustal rock-magnetic data from appropriate Deep Sea Drilling Project and Ocean Drilling Program sites. The observed elevated magnetization of older ocean crust is due primarily to an increased abundance of magnetic FeTi oxides.

Diagenesis

McNeill, D. F., and J. L. Kirschvink
Early dolomitization of platform carbonates and the preservation of magnetic polarity, *J. Geophys. Res., in press*, 1993.
Results from a combination of techniques indicate that fine-grained magnetite is preserved in shallow-water platform carbonates which have undergone recrystallization. Single-domain crystals occur as interacting multigrain clusters, which may help prohibit magnetic reorientation during diagenesis. Early dolomitization (matrix stabilization) may even help protect and extend the subsurface life span of the original polarity.

Instrumentation

Gupta, A. K., and N. Khare
Advances in high-T_c RF-SQUIDs, *Indian J. Pure Appl. Phys., 30*, 652-665, 1992.
A review is made of the progress that has been made in the development of high-T_c RF-SQUIDs which can be operated at liquid nitrogen temperature. Flux noise is discussed, as is the application potential of these SQUIDs in magneto-cardiography, rock magnetism, non-destructive evaluation, and ultrasensitive measurement techniques.

Paleozoic Remagnetization

Elmore, R. D., *et al*.
Remagnetization by basinal fluids: testing the hypothesis in the Viola limestone, southern Oklahoma, *J. Geophys. Res., in press*, 1993.
Paleomagnetic and geochemical evaluations of Ordovician limestone are used to assess the role of basinal fluids in secondary magnetizations. The resulting lack of geochemical evidence for basinal fluids suggests that other mechanisms for the origin of the pervasive CRM need to be tested. Flow of basinal fluids was focused in veins, and only locally altered the host limestone and its magnetization.

Suk, D.-W., R. van der Voo, and D. R. Peacor
Origin of magnetite responsible for remagnetization of early Paleozoic limestones of New York State, *J. Geophys. Res., 98B*, 419-434, 1993.
Using SEM and STEM techniques to observe Devonian and Ordovician limestones, it is possible to identify three types of magnetite: pseudoframboids, nonspherical magnetite, and fine-grained magnetite. Results of magnetization studies of each type imply that it is primarily the fine-grained magnetite which carries the Alleghenian remagnetization. This magnetization is thus a chemical remanence due to fluid-mediated authigenic magnetite.

Physics

Mahmood, S. H.
Magnetic anisotropy in fine magnetic particles, *J. Magn. Magn. Mater., 118*, 359-364, 1993.
Magnetization curves and anisotropy energy constants are calculated for three systems of Fe_3O_4 fine particles using a simple model for the particle-size distribution function. The mean particle diameter predicted by the model is in good agreement with the value obtained from TEM images, and the anisotropy constant results are in good agreement with those obtained from the temperature dependence of the remanent magnetization.

Mahmood, S. H., and I. Abu-Aljarayesh
On the static and time-dependent magnetic properties of Fe_3O_4 fine particles: effect of oxidation, *J. Magn. Magn. Mater., 118*, 193-199, 1993.
Both static and time-dependent magnetization measurements on three systems of Fe_3O_4 fine particles led to the following results: Remanent magnetization M obeyed the relation $M = C - S \ln t$ in the temperature range $5\ K < T < 300\ K$ over the time period $30\ s < t < 300\ s$, and annealing a sample at 250°C increased its magnetic anisotropy constant.

Martinez, D., J. I. Lopez-Cabido, and J. Castro
A note on the magnetic after-effect in magnetite at room temperature. Is there more than one relaxation process?, *Phys. Stat. Sol. A, 134*, K33-K36, 1992.
A numerical analysis of the room-temperature magnetic after-effect (MAE) peak in non-stoichiometric magnetite was performed. Using a ceramic technique, polycrystalline magnetite samples were prepared, and the MAE was measured as a time decrease of the initial susceptibility $c(t, T)$, following sample demagnetization at a given temperature T.

Murad, E.
Magnetic properties of fine-grained minerals, in *Magnetic Properties of Fine Particles—Proceedings of the International Workshop on Studies of Magnetic Properties of Fine Particles and their Relevance to Materials Science (Rome, Nov. 1991)*, edited by J. L. Dormann, and D. Fiorani, pp. 339-349, North-Holland, Amsterdam, 1992.
Smaller particles, formed in the weathering environment, have increased quadrupole splitting in the superparamagnetic state, a lowering of magnetic ordering temperatures, and a reduction of magnetic hyperfine fields in the magnetically ordered state, relative to larger particles. In iron oxides, isomorphous substitution and close intergrowth with other minerals may also affect magnetic properties.

Rock Magnetism

Stephenson, A.
Some aspects of the properties of fine particles in geomagnetism, in *Magnetic Properties of Fine Particles—Proceedings of the International Workshop on Studies of Magnetic Properties of Fine Particles and their Relevance to Materials Science (Rome, Nov. 1991)*, edited by J. L. Dormann, and D. Fiorani, pp. 329-338, North-Holland, Amsterdam, 1992.
Gyroremanence can be used to estimate rapidly the size of magnetite or maghemite particles, and to detect alignment of dispersed non-spherical particles in anisotropic rocks. Investigation of the deflection of the thermoremanent magnetization vector away from the local geomagnetic field vector by such anisotropic igneous rocks, with the aim of being able to correct for the effect, has led to yet another method of determining particle size and domain state.

Self-Reversal

Bina, M.-M., and L. Daly
Development of crystalline and self-reversed magnetization in pyrrhotite rocks; consequences for palaeomagnetism and magnetic anomaly interpretation, *C. R. Acad. Sci. (Paris), Sér. II, 316*, 163-169, 1993.
The results of a thermomagnetic study of pyrrhotite-bearing rocks showed that chemical remanent magnetization is produced in the magnetite that forms when the pyrrhotite is exposed to oxidizing conditions. In the case of a partial oxidation, the close coexistence of two ferrimagnetic phases in a single grain may produce, in the pyrrhotite, an interactive thermoremanent magnetization (ITRM), which is reversed with respect to that of the magnetite (self-reversal).

McClelland, E., and C. Goss
Self reversal of chemical remanent magnetization on the transformation of maghemite to haematite, *Geophys. J. Int., 112*, 517-532, 1993.
Self-reversed chemical remanent magnetization (CRM), which has been observed in the maghemite-hematite transition, is strongly dependent on remanence state: if the maghemite is still blocked at transformation, self-reversal occurs ; otherwise, the CRM is normal. This finding supports exchange control of the self-reversal process, which is probably a general feature of the maghemite-hematite transition.

Soils and Sediments

Banerjee, S. K., C. P. Hunt, and X.-M. Liu
Separation of local signals from the regional paleomonsoon record of the Chinese loess plateau: a rock-magnetic approach, *Geophys. Res. Lett., in press*, 1993.
A method is proposed for quantitative estimation of the superparamagnetic (SP) fraction of magnetite produced by pedogenesis in the Chinese loess plateau. This method, which uses thermal unblocking of low-temperature saturation remanence, was applied to records from two sites which have contrasting climates. The SP fraction increased during warm intervals at each site; the more humid site had higher overall SP fractions.

Beer, J., *et al*.
^{10}Be and magnetic susceptibility in Chinese loess, *Geophys. Res. Lett.*, *20*, 57-60, 1993.
^{10}Be and magnetic susceptibility have been measured in a loess profile from Luo-chuan, China, and correlated with the SPECMAP d^{18}O profile to provide a time-scale. A simple model for the ^{10}Be dust flux demonstrates that a significant part of the magnetic susceptibility signal in paleosol horizons is due to *in situ* pedogenic production. During times of high loess accumulation (cold paleocli-mate) this contribution is negligible.

Heller, F., *et al*.
Quantitative estimates of pedogenic ferromagnetic mineral formation in Chinese loess and palaeoclimatic implications, *Earth Planet. Sci. Lett.*, *114*, 385-390, 1993.
Magnetic low-field susceptibility was used to reconstruct Pleistocene climates in the central Chinese loess plateau. From comparison with the ^{10}Be concentration throughout the sequence, it was possible to determine the contributions to susceptibility from both inherited and authigenic sources. Since the production of authigenic magnetite is directly related to regional precipitation, annual paleoprecipitation rates could be calculated.

Special Issues

Magnetic Characteristics of Well Defined Samples, *Phys. Earth Planet. Inter.*, *76*, no. 1–2, 1993. [XX General Assembly of IUGG. Vienna, Austria, 20 Aug 1991.]
The following topics were dealt with: pseudo-single-domain magnetite grains, grain geometry, magnetic moments, oriented Fe particles, titanomagnetites, low-temperature susceptibility peaks, pyrrhotite, magnetic anisotropy, texture, grain shape, antiferromagnetic phases, ferrimagnetic phases, intergrowths, remanent magnetization, pressure effects, paleomagnetic cleaning effects, and the synthetic hematite system.

Techniques

Thomas, N.
An integrated rock magnetic approach to the selection or rejection of ancient basalt samples for palaeointensity experiments, *Phys. Earth Planet. Inter.*, *75*, 329-342, 1993.
A new integrated rock-magnetic method is proposed for sample selection in paleointensity experiments. In this method, the combined results from "thermal" and "non-thermal" rock-magnetic techniques are used to define sets of rock-magnetic behavior for Precambrian basalts. The behavior of all samples in each set is categorized during both Thellier and Shaw paleointensity experiments; thus, a set of selection criteria can be defined.

Thomas, I. M., T. C. Moyer, and J. P. Wikswo, Jr.
High resolution magnetic susceptibility imaging of geological thin sections: pilot study of a pyroclastic sample from the Bishop Tuff, California, USA, *Geophys. Res. Lett.*, *19*, 2349-2352, 1992.
High-resolution magnetic susceptibility imaging is a new technique for studying the magnetic properties of geologic thin sections. The two-dimensional distribution of both remanent and induced magnetization can be determined with a spatial resolution on the order of the phenocryst size in the sample. Preliminary tests on an ignimbrite sample indicate that secondary iron-titanium oxide particles are responsible for the bulk susceptibility.

Weeks, R., *et al*.
Improvements in long-core measurement techniques: applications in palaeomagnetism and palaeoceanography, *Geophys. J. Int.*, *in press*, 1993.
Using new small-access cryogenic magnetometers, improvements in continuous whole-core measurements of magnetic parameters have been made. The spatial resolution and accuracy that were achieved using continuous measurements of u-channel samples are equivalent to those obtained using discrete samples, but with significantly less sediment disturbance. Examples include continuous measurements of low-field susceptibility, NRM, ARM, IRM, and H_{cr}.

VGP Paths

Egbert, G. D.
Sampling bias in VGP longitudes, *Geophys. Res. Lett.*, *19*, 2353-2356, 1992.
It was found that even simple, statistically homogeneous models of secular variation can produce a distribution of VGP longitudes that peak 90° away from the sampling longitude. Consequently, unevenly distributed sampling sites might produce a non-uniform distribution of VGP longitudes. Thus, the preferred VGP paths seen in reversal and secular variation data might simply be statistical artifacts resulting from the non-uniformity of sampling sites.

Gubbins, D., and K. Zhang
Symmetry properties of the dynamo equations for palaeomagnetism and geomagnetism, *Phys. Earth Planet. Inter.*, *75*, 225-241, 1993.
Recently, both paleomagnetists and geomagnetists have searched for symmetries in their data which would give some guide to the nature of the Earth's dynamo. Presented here are spherical harmonic expansions for the separable solutions to the dynamo equations which allow reversals and dipole/quadrupole separation. The types of data required to discriminate among the different symmetries are also indicated.

McFadden, P. L., C. E. Barton, and R. T. Merrill
Do virtual geomagnetic poles follow preferred paths during geomagnetic reversals?, *Nature*, *361*, 342-344, 1993.
Although previous analysis of the database of reversal records indicates that VGP paths do show an overall preference for two antipodal longitudinal bands, it is premature to accept the hypothesis of mantle control over the core during geomagnetic reversals: Site longitudes are also strongly grouped, and a comparison of the transitional longitudes with site longitudes shows an unlikely grouping under the hypothesis of a genuine geographical preference for transitional VGPs.

Van Hoof, A. A. M., and C. G. Langereis
The upper and lower Thvera sedimentary geomagnetic reversal records from southern Sicily, *Earth. Planet. Sci. Lett.*, *114*, 59-75, 1992.
There are strong indications that the VGP paths obtained from Pliocene marine marls result from smoothing of non-antipodal stable directions before and after transitions. The excursions found are artifacts of weathering and of post-depositional mineralogy changes. Apparently the registration of transitions of the Earth's magnetic field in sediments is strongly influenced by smoothing and diagenetic processes after deposition. ■

…*VF Reports continued from page 2*

years make the Lisan Formation an ideal candidate for geochemical, geochronological, and paleomagnetic investigation.

The Lisan Formation contains primary magnetizations which appear to be excellent records of the geomagnetic field. Before coming to the *IRM*, and in conjunction with the U-series geochronology done by **M. Stein** and colleagues at the Hebrew University, we conducted a pilot paleomagnetic study of the Lisan Formation. Up to 12 oriented samples of the Lisan Formation were taken at each of 15 stratigraphic levels representing 72.1 ka to 23.0 ka. Stepwise alternating-field demagnetization shows that the remanent magnetization of the Lisan Formation is univectorial, with a northerly declination and moderate positive inclination, as expected for this area.

Three features of these preliminary data are worth noting. First, the sample mean directions are extremely well clustered at each stratigraphic level. The average *k* value for the 15 stratigraphic levels is 328, which is comparable to that seen in studies of Holocene lavas. Second, the direction of magnetization varies with stratigraphic position as would be expected if the samples record a secular variation signal; declination varies from 349˚ to 4˚, and inclination varies from 37˚ to 53˚. Finally, an abrupt change in direction is observed at about the time one would expect to see the Laschamp Event.

The reliability of this record depends critically upon the presence of a primary magnetization. To better understand the origin of remanent magnetization in the Lisan, we measured bulk magnetic properties including anisotropy of magnetic susceptibility (AMS), and acquisition and AF demagnetization of SIRM. We also studied the micromagnetic properties of individual laminae to understand the size, shape, distribution, and chemistry of magnetic particles which carry the stable remanent magnetization.

We had hoped that the AMS experiments might tell us something about depositional magnetic fabric, but the results were disappointing, probably because the paramagnetic anisotropy signal was small—about the same size as the diamagnetic signal produced by the plastic sample cube. The SIRM experiments showed that IRM saturation occurs at about 250 mT, and that AF demagnetization of SIRM shows a crossover point at about 0.4; if the magnetic phase were a cubic phase, such as magnetite, this could indicate the presence of SD or PSD grains. This was true for virgin samples (multiple laminae) as well as for samples composed of exclusively aragonitic or exclusively detrital material.

A very detailed set of experiments, which made use of the MicroMag, allowed us to confirm that the stable remanence resides almost exclusively in the detrital layers; the aragonite layers are almost completely diamagnetic, as might be expected. This allows for the possibility that the magnetization is a DRM, despite the fact that the stable remanence of bulk samples shows no sign of inclination shallowing. Analysis of CH_3COOH-insoluble residues yielded similar results. Using the MPMS, we investigated the temperature dependence of SIRM in the detrital layers: we found no evidence for a Verwey transition, but did note that these layers contain up to 80% SP grains.

Our study will continue with another field season in 1993 and, we hope, with a trip to the *IRM* in 1994. Thanks to **Chris Hunt** and **Bruce Moskowitz** for their help during our visit to the *IRM*, and to **Samuel Marco** for help in the field. Our travel was sponsored by the Institute for Petroleum Research and Geophysics, Israel.

John Stamatakos
The University of Michigan

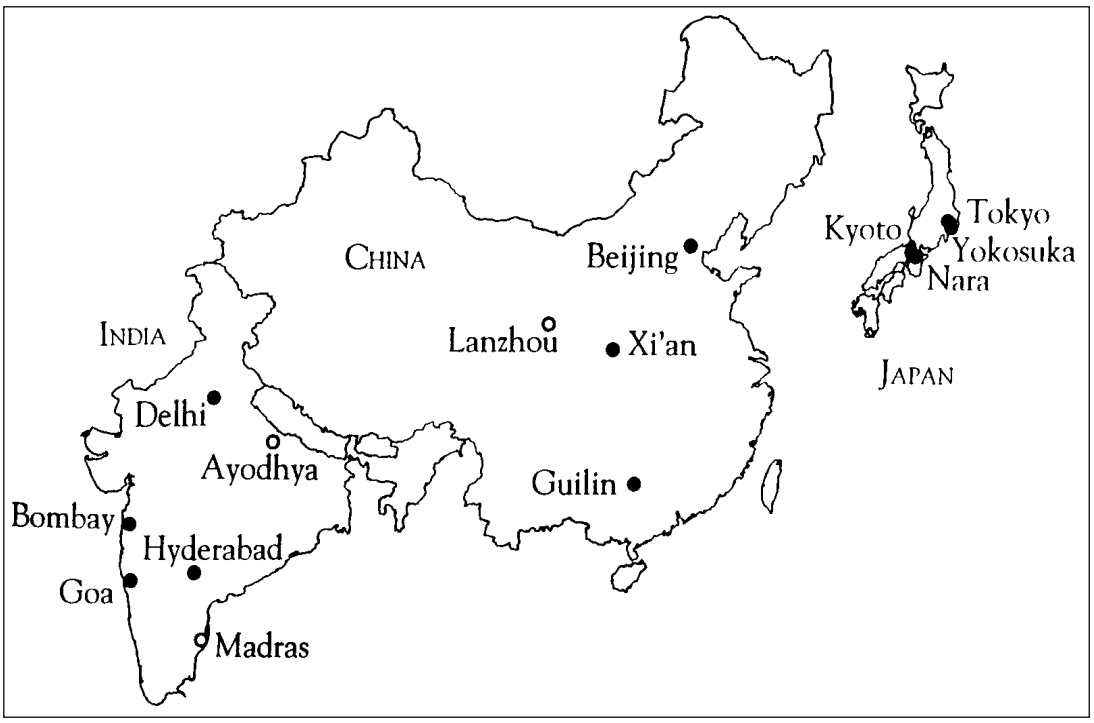
SP magnetite in the Münster Basin limestones of northwestern Germany

The Münster Basin in northwestern Germany contains a series of interbedded Middle Cretaceous marls and limestones. Throughout most of the basin these sediments are flat-lying. However, Late Cretaceous (?) compression narrowed the basin, creating a thin zone of tightly folded and faulted rocks along the basin's northeastern margin. In 1991, **Friedrich Heller** and I, along with an ETH [Eidgenössische Technische Hochschule–Zürich] student **Ciro Bignasca**, resampled these rocks in order to investigate the possible effects of deformation on the limestone's magnetic properties. Four different structural settings were examined: (1) three sites from the basin's interior away from the deformed zone; (2) a site of relatively flat-lying rocks, with a spaced solution cleavage, within the deformed zone; (3) a panel of upright folds with moderate to steeply-dipping fold limbs; and (4) an asymmetric fold with a severely overturned limb.

Our results suggested that the magnetization of these limestones was strongly affected by the tectonic deformation of the basin. During certain rock-magnetic experiments, we discovered that many of our samples contained a large fraction of superparamagnetic (SP) magnetite. The exact source of the SP magnetite was unknown, although we suspected that it was related either to dissolution during cleavage formation or to authigenic chemical remagnetization related to compression of the basin.

During my visit to the *IRM*, I performed a series of experiments on the MPMS to better characterize this SP component. My initial results show that the SP magnetization is not present in all samples but only in samples from selected sites. There does not appear to be a direct correlation between those sites that have the SP magnetization and structure; I do not, for example, find SP magnetization exclusively in the cores of the two folds. I also found SP magnetite in one of three sites from the basin's interior. Those samples without a significant SP fraction often show a Verwey transition at about 110 K, indicating the presence of single-domain, or larger, magnetite. Our next step is to try to correlate these rock-magnetic observations with microstructural data, including calcite strain measurements.

I also had the chance to sample some of the best home-cooked Chinese food in North America, including the now-famous *IRM* Chinese dumplings. Many thanks to **Wei-Wei Sun** for his culinary skills and hospitality. ■



Major Asian countries on this winter's tour. (Editor's Note: In deference to the *IRM* Director's citizenship, we have drawn Kasmir and nearby areas as part of India; likewise, to honor the *IRM* Dumpling-Maker's citizenship, we have been sure to include Taiwan as part of China.)

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curves from Precambrian dikes and dike swarms.

The NGRI boasts a modern radiogenic and isotopic mass spectrometric laboratory, but it has only an older-vintage paleomagnetic laboratory based on a Schonstedt spinner magnetometer and thermal demagnetizer. Dr. H. Halls of Erindale College, University of Toronto, was on an overlapping sabbatical visit at NGRI in connection with the dike research.

Goa

After three weeks in Hyderabad, and after successfully dodging the fire-raisers in Bombay during an overnight stay, I reached the National Institution of Oceanography (NIO) in Goa on the idyllic, laterite-strewn Konkan coast, decorated with palm fronds. Although there is no paleomagnetic laboratory at the NIO at present, my host, Dr. B. Desai, asked me to look into the usefulness of having one in the future, and to examine the efficacy of a paleomagnetic/rock-magnetic approach to solving the paleoclimatic research projects now under investigation there. The latter mission was an enjoyable one because of the presence of some enthusiastic and curious marine geologists there.

The NIO has been carrying out intensive, but mainly coastal, geological research in the Arabian Sea and in the Bay of Bengal since 1980, using their research vessel *Sagar Kanya* ("*Sea Maiden*"). Sediments are collected mainly from 5 to 10 m below the sediment-water interface, using both box and piston cores. Sedimentological, mineralogical, [non-isotopic] geochemical, and micropaleontological approaches have been used to study the major climatic changes: the Last Glacial Maximum (18–20 ka), the Younger Dryas (12.5 ka), the Holocene boundary (10 ka), and the Holocene Optimum (3–5 ka).

In addition, by using ratios of characteristic saline/fresh-water foraminifera, interannual and decadal variations in monsoon intensity have been postulated and then confirmed by actual historical records. Also in progress are sediment trap studies of mass accumulation rates of eolian particles.

In summation, colleagues at the NIO are very interested both in using paleosecular variation as a relative dating tool, and in initiating rock-magnetic studies to search for fine structure in records of Holocene and pre-Holocene climate changes.

CHINA

Guilin

In mid-February, after my "debriefing" at the UNDP and IGBP offices in New Delhi, I left for Guilin, the first stop in the People's Republic of China. My host was Prof. Yuan D.-X., the director of the Institute of Karst Geology, who reports to a central government ministry in Beijing. Housed in a new building that is only three or four years old, this facility has a fine museum, displaying an incredible variety of karst structures found in central and southern China. In addition to conventional morphological, textural, and geochemical research, there is a group working intensively on the stable isotopic records in speleothems. Cooperative paleomagnetic work on speleothems has been undertaken with a Chinese paleomagnetic group, outside Guilin.

Even though the weather was not the best (cold and wet), a pleasant surprise was the variety of cuisines in Guilin, including "hot and spicy." (I say "surprise" because this was in direct contradiction to what I expected from having read a patronizing description of Guilin food in the *Lonely Planet Guide*.) After a talk on the rock magnetism of carbonate rocks, and the mandatory six-hour cruise on the beautiful Li river which is surrounded by karst hills—albeit with the temperature hovering at 5°C—I left for Xi'an on an Air China flight that left 24 hours after the scheduled departure time.

Xi'an

At Xi'an, I was received by the Institute for Quaternary and Loess Research, a justly famous component of the Chinese Academy of Sciences (CAS). In cramped spaces, multiple proxies of climate change in the loess plateau over the last 2.4 Ma are being studied using a variety of disciplines: stable isotope geochemistry (oxygen and carbon); analytical geochemistry (using ICP-MS); thermoluminescence (TL); and magnetism. A compact environmental geomagnetism laboratory exists, equipped with a spinner magnetometer, a thermal demagnetizer, and a Bartington susceptibility bridge. Both field and laboratory measurements of low-field (dual-frequency) susceptibility measurements are emphasized, and important environmental magnetism papers have been published by workers from this laboratory, led by Dr. An Z.-S., in collaboration with U.S. scientists, Drs. G. Kukla and S. Porter. Currently, researchers in this laboratory are working on the suspected magnetic record of the Younger Dryas event near Lanzhou, and on analyzing the aerosols brought in by dust storms from the northern and northwestern deserts, the source of loess deposits. The most rewarding part of my visit was to learn first-hand the complexities of climatic, geomorphic, pedologic, and hydrologic parameters that influence the maturation of loess into paleosols.

The city of Xi'an and its environs are, of course, extraordinarily rich in archaeological treasures dating back 6,000 years. I did make the manda-

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On-line Searching of World Paleomagnetic Database now Possible

Bill Harbert
University of Pittsburgh

I have recently finished an on-line search program which allows remote users to search the "Abase" ASCII version of the World Paleomagnetic Database developed by Jo Lock and Michael McElhinny [see Lock, J., and M. W., McElhinny, The Global Paleomagnetic Database: design, installation, and use with ORACLE, *Surv. Geophys.*, *12*, 317-506, 1991]. The Search program is very simple to use—specific step-by-step instructions can be found in my recent *Eos* article [Harbert, W., Paleomagnetic database search possible, *Eos*, *74*, 100-101, March 2, 1993]. The program will search the Soviet, non-Soviet, rock-unit, and reference databases, and then create output files which can be downloaded to a researcher's local system using the "ftp" command.

After logging in via "telnet," the user is asked a series of questions which, among other things, define the geographic region and the age range of interest. Details about using the package can be obtained by accessing "130.49.3.1" via anonymous ftp, and then downloading the documentation file "Search.doc."

A shortened example of the use of the Search program, using the ftp command, and downloading the resulting files is given in my *Eos* article. Any questions or comments should be sent via e-mail to me at: William.Harbert@pitt.edu. ■

"Math phobic's nightmare."

…*Asia continued from page 7*

tory, and rewarding, visit to the Qin tomb to see the terra-cotta soldiers and a few other sites before leaving for Beijing.

Beijing

Although I gave one talk in Beijing, my time was mostly occupied by consultations with experienced colleagues from the Institute of Geology, the Institute of Geophysics, and the Institute of Vertebrate Paleontology, all within the CAS. These researchers will help us in a joint field trip in China next fall. The leader of the Chinese side is Prof. Liu T.-S., the doyen of Quaternary geology in China, who is involved in cooperative research with us on loess studies.

There are paleomagnetic laboratories in both the Institute of Geology and the Institute of Geophysics; while the geology laboratory is spinner-based, the geophysics laboratory boasts both a spinner and a cryogenic magnetometer which were busy non-stop during my visit. Both thermal and alternating-field demagnetizers were available as well. And, in addition to tectonics and magnetic stratigraphy, our Chinese colleagues are also working on archaeomagnetism and on relative paleointensity from sediments.

Beijing also boasts beautiful architecture, such as the Willow Bridge at the Summer Palace [see cover].

JAPAN

Kyoto

In early March, I left Beijing for Japan, both to visit with my daughter and son-in-law at the U.S. Naval Base in Yokosuka, and to spend some time in the paleomagnetic laboratory at Kyoto University under the direction of Prof. M. Torii. An incredibly large number of paleo- and rock-magnetic instruments were packed in a single room. Both the equipment and the research group (one post-doctoral fellow and five or six graduate students) looked fine and thriving. Many of the research problems being studied here are the same as those being studied in China; there is also special emphasis given to diagenesis and authigenesis in environmental magnetism.

Nara

Among extracurricular activities in Japan, I must mention visits to two excellent vegetarian restaurants attached to Buddhist temples in Kyoto, and a night-time visit to see the Omizutori lit-torch ceremony (and ritual purification of water) in nearby Nara.

By March 15, I was more than ready to catch the direct plane home from Tokyo's Narita airport, the end of a three-month trip to three important countries in Asia. ■

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 during the following half year. Shorter, less formal visits are arranged on an individual basis through the laboratory manager.

The *IRM* staff consists of Subir Banerjee, Director; Bruce Moskowitz, Associate Director; Jim Marvin, Senior Scientist; and Chris Hunt Scientist and Lab Manager.

Funding for the *IRM* is provided by the W. M. Keck Foundation, the National Science Foundation, and the UNIVERSITY OF MINNESOTA.

The *IRM Quarterly* is published four times a year by the staff of the *IRM* with editorial and layout assistance from Freddie Hart. 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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☛ ATTENTION: Deadline is June 11!

Visiting FellowshipApplications for stays this fall and winter are due very soon. Details about how to apply can be found in *Eos* (April 20 and May 11 issues) and in *GSA Today* (May issue). Or just call Chris Hunt at the *IRM*. Don't delay. ■