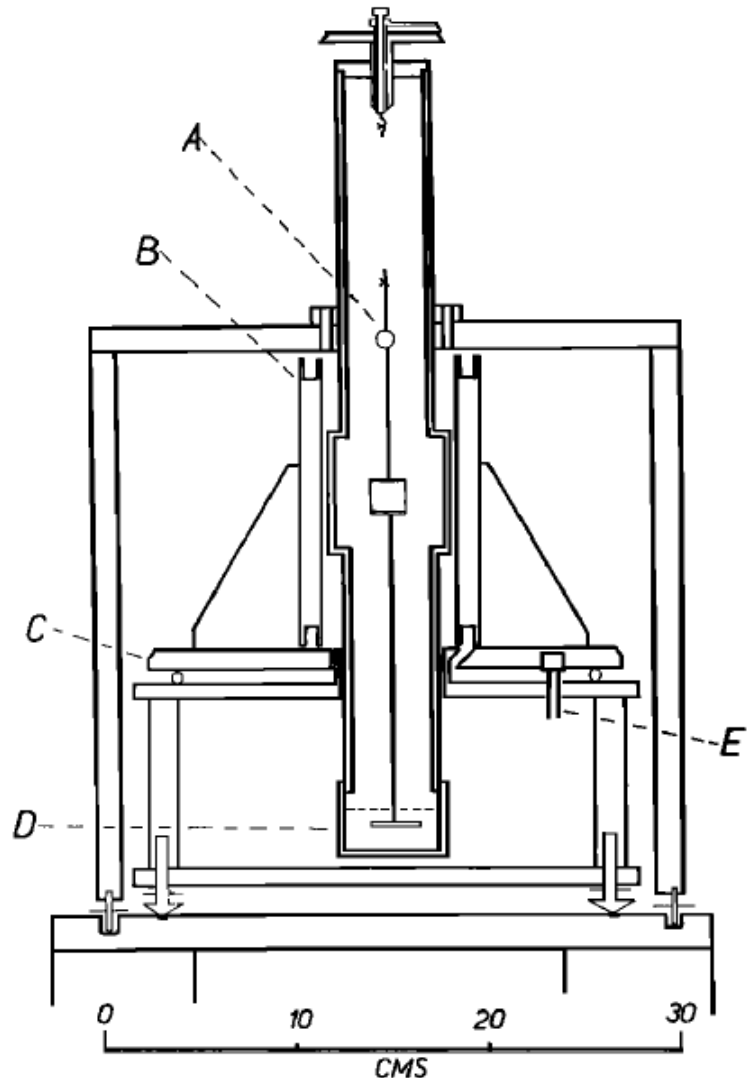


## Gustaf Ising's Early Work on Magnetic Fabrics

**Ted Evans**

University of Alberta, Canada  
 tedevans.evans403@gmail.com

Andrea Biedermann's excellent article on magnetic fabrics (in what is destined—alas—to be the final IRM Quarterly to appear in printed form) jogged my memory and took me back to my first encounter with the subject in 1964, under the guidance of Don Griffiths and Roy King at the University of Birmingham. So I pulled out some ancient reprints, and with a little help from Google, discovered some facts that might be of interest to IRMQ readers. Roy King's seminal work on the inclination error is familiar to us all and is still widely quoted (King, 1955). It was a natural extension of research into detrital remanence then being pursued at Birmingham, building on the studies of Swedish varves that Don Griffiths had initiated in 1951 (Griffiths, 1953). Why varves? Why Sweden? What motivated Griffiths was the possibility of using annually-layered varves to determine the pre-observatory secular variation of the geomagnetic field. This had already been attempted in the U.S.A. using a 200-year sequence of varves (McNish and Johnson, 1938), but Sweden offered much longer sequences based on the classic chronology worked out by Gerhard De Geer (De Geer, 1912). Griffiths was well aware that the Swedish varves had already been studied by Gustaf Ising (1883-1960) at Stockholm University (Ising, 1943). It was the re-reading of this paper after so many years that piqued my interest. I had forgotten that Ising was just as interested in anisotropy of magnetic susceptibility (AMS) as in magnetic remanence, perhaps more so. He had started these studies in 1926, and by 1933 had established that the remanence was shallower than expected, and that the sediments had "a considerable anisotropy of susceptibility with the lowest value of susceptibility in the vertical direction". This early (earliest?) observation of magnetic fabric considerably pre-dates John Graham's comments about AMS (Graham, 1954). But there's more. Ising argued that AMS ought to be better than remanence as a recorder of the geomagnetic field. He questions the assumption that remanence (including TRM) "should have remained unchanged during the centuries, not to speak of geological ages". On the other hand, he puts forward a mechanism favouring AMS. He imagines ice sliding over bedrock and picking up "immense numbers" of grains and lithic fragments, "of which a fairly large proportion may be supposed to have got an elongated



**Fig. 1. The sensitive instrument. A, the suspended system; B, field coils; C, turntable; D, damping pot; E, remote control drive.**

Original figure and caption from King and Rees (1962) depicting the torque-meter built following the design of Ising.

shape". After being transported into deep, quiet water they would be aligned by the ambient field, "like floating magnets", eventually leading to sediments carrying an AMS "that would not be affected by later field actions". His first experiments, in the summer of 1926, were carried out with a "simple induction balance". He found that the remanence of some natural clay samples was "easily measurable", but that the instrument was not sensitive enough to detect any anisotropy. He then built a torsional

*cont'd. on  
 pg. 12...*

# Visiting Fellow Reports

## Pyrrhotite in Albian Shales, Pyrenees.

Charles Aubourg

LFCR Laboratory, Pau University, France

charles.aubourg@univ-pau.fr

I have investigated the occurrence of pyrrhotite in metamorphic Albian marls from the Chainons Béarnais (North Pyrenees, France). In this retro-foreland, an earlier paleomagnetic study done by Oliva-Urcia et al., (2010) shows the prevalence of a high-temperature (HT) and a medium-temperature (MT) paleomagnetic components in Albian shales. The HT component is obviously carried by magnetite ( $T_{ub} \sim 580^\circ\text{C}$ ). MT is carried by undetermined iron sulfides ( $T_{ub} \sim 320^\circ\text{C}$ ). Since Oliva-Urcia et al. (2010) study, new data bring two major inputs. First, the maximum burial temperature was much higher than initially believed ( $<200^\circ\text{C}$ ), reaching more than  $250^\circ\text{C}$  and up to  $400^\circ\text{C}$  (Clerc et al. 2015). Albian shales are then within the greenschist facies. Second, most of folding took place during late Cretaceous extension and not during the Pyrenean orogeny (Lagabrielle, et al. 2010). My goal was to characterize the magnetic carrier nature of MT in light of metamorphic conditions, constrained by application of Raman geothermometer.

I conducted remanence studies at room temperature (hysteresis loop, FORC) and at low temperature (10-400 K, RT-SIRM, ZFC, FC). In addition, I performed thermal demagnetization of NRM and microscopic observations using NANOSCOPE III Magnetic Force Microscope. Thin section was prepared using 20 nm abrasive powder to obtain the best smoothed surface.

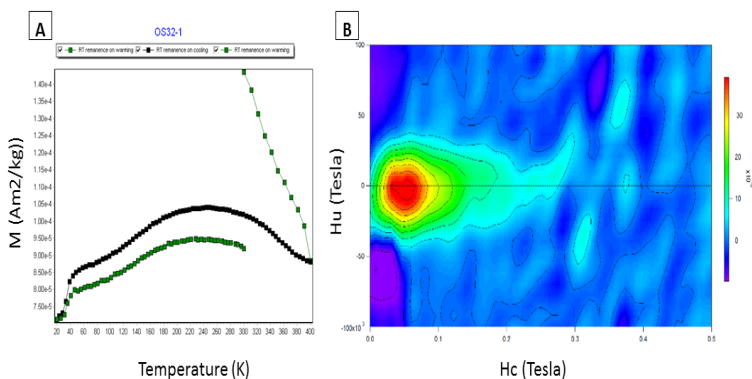


Figure 1. A) RT-SIRM cycling. Note the 400K demagnetization of RT-SIRM to remove goethite contribution. B) FORC diagram (smoothing factor 4). Both measures are done on the same Albian shales sample.

Strong weathering of some samples urged removal of the goethite contribution before running the cooling of RT-SIRM. I first applied a 2.5 T AC field at room temperature and demagnetized the sample at 400 K (Figure 1A). The goethite contribution can represent more than 40% of remanence. Once the goethite component is removed, a nice pattern of RT-SIRM on cooling displays

a non-reversible Besnus transition at  $\sim 32$  K, a firm indication of monoclinic pyrrhotite ( $\text{Fe}_7\text{S}_8$ ) (Rochette, et al. 2011). The h/c ratio, near 0.9 in average, points for micrometer grains (Dekkers, 1989). The FORC (Figure 1B) displays non-interacting SD-type of pyrrhotite with a rather strong coercive field  $H_c$  near 50 mT. Using magnetic force microscope, we had the good chance to observe micrometric pyrrhotite SD to small MD (Figure 2). These pyrrhotites are generally embedded in calcite. All observations support therefore the presence of  $<10 \mu\text{m}$  monoclinic pyrrhotite in the Albian shales. Similar micrometric pyrrhotite have been observed in greenschist metamorphic argillaceous rocks (Appel, et al. 2012).

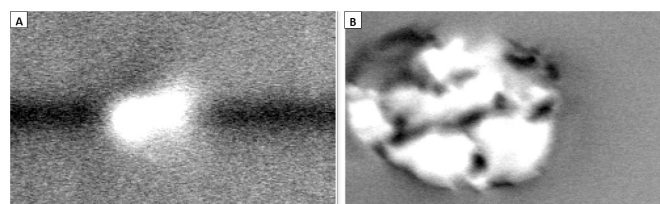


Figure 2. Magnetic force microscope (after application of a 2 T IRM) observation of Albian shales (same sample as Figure 1). A) SD monoclinic pyrrhotite; B) MD monoclinic pyrrhotite (nap-phase retrace). Each image is approximately  $10 \times 6 \mu\text{m}$ .

To constrain the metamorphic temperature of studied Albian shales, I used Raman spectroscopy carboniferous materials geothermometer (Beysac, et al. 2002). For all samples experiencing  $T_{burial} > 350^\circ\text{C} \pm 30^\circ\text{C}$ , only monoclinic pyrrhotite is found without evidence of magnetite (as sample shown in Figure 1). This burial temperature corresponds therefore to the breakdown of magnetite into pyrrhotite (Rochette 1987). This metamorphic pyrrhotite has the potential to record thermo-remanence on cooling of metamorphic units below its Curie temperature ( $\sim 320^\circ\text{C}$ ) (Appel, et al. 2012). I found that Albian marls carry a well-defined characteristic remanent magnetization of reverse polarity, as initially observed by Oliva-Urcia et al. (2010). This thermoremanent magnetization is essentially post-tilting, though declination and inclination are abnormal in some places. This suggests: 1) that this paleomagnetic component is imprinted after the main folding phase and 2) that this component is imprinted after the C34 long normal chron ( $\sim 83$  Ma), which is also the onset of compression in the Pyrenees. The paleomagnetic results are consistent with Lagabrielle et al. (2010) hypothesis of early folding of Chainons Béarnais during the late Cretaceous hyper extension ( $\sim 100$  Ma) and high thermal conditions (thermal gradient  $\sim 80^\circ\text{C}/\text{km}$ ) (Vacherat, et al. 2014). But upon the significance of these regional results for the Chainons Béarnais, this study allows to bracket for the first time the breakdown temperature of magnetite ( $\sim 350^\circ\text{C}$ ) using Raman geothermometry in combination with rock magnetism.

## References

- Appel, E., et al. (2012). "Pyrrhotite remagnetizations in the Himalaya: a review." Geological Society, London, Special Publications 371(1): 163-180.
- Beysac, O., et al. (2002). "Raman spectra of carbonaceous material in metasediments: a new geothermometer." Journal of Metamorphic Geology 20(9): 859-871.

- Clerc, C., et al. (2015). "High-temperature metamorphism during extreme thinning of the continental crust: a reappraisal of the North Pyrenean passive paleomargin." *Solid Earth* 6(2): 643-668.
- Dekkers, M. J. (1989). "Magnetic properties of natural pyrrhotite part 2: high and low temperature behavior of Jrs and TRM as a function of grain size." *Phys. Earth Planet. Ints.* 52: 376-393.
- Lagabriele, Y., et al. (2010). "Mantle exhumation, crustal denudation, and gravity tectonics during Cretaceous rifting in the Pyrenean realm (SW Europe): Insights from the geological setting of the Iherzolite bodies." *Tectonics* 29(4).
- Oliva-Urcia, B., et al. (2010). "Paleomagnetic evidence for dextral strike-slip motion in the Pyrenees during alpine convergence (Mauléon basin, France)." *Tectonophysics* 494(3-4): 165-179.
- Rochette, P. (1987). "Metamorphic control of the magnetic mineralogy of black shales in the Swiss Alps: toward the use of "magnetic isogrades"." *Earth Planet. Sci. Lett.* 84: 446-456.
- Rochette, P., et al. (2011). "The low-temperature magnetic transition of monoclinic pyrrhotite." *The IRM Quarterly* 21(1).
- Vacherat, A., et al. (2014). "Thermal imprint of rift-related processes in orogens as recorded in the Pyrenees." *Earth and Planetary Science Letters* 408: 296-306.

## Post-deposition diagenesis indicated by mineralogy shifts from magnetic measurements.

Yi Wang

Department of Earth and Environmental Sciences, University of Michigan  
ellawang@umich.edu

Oxygen deficiency has drawn wide attention for both paleo- and modern oceanographic studies to reconstruct atmospheric and oceanic oxygenation histories. To unveil oxygenation of the past, researchers have used iron speciation that is suggested to directly pinpoint anoxic conditions. Iron speciation has been commonly used on sedimentary rocks as a redox proxy to distinguish oxic, ferruginous (iron-rich anoxic water column) and euxinic (sulfide-rich anoxic) water columns on different time scales (Lyons and Severmann 2006). However, among

the few applications of Fe speciation on marine sediments, little attention has been focused on Fe mineralogy shifts downcore in response to diagenesis and instantaneous events (e.g. flood layers and turbidites), which might obscure geochemical interpretations on ambient redox environments.

To address these concerns and provide new insights into post-deposition diagenesis, we examined a box core SPR0901-04BC (34° 16.895' N, 120° 02.489' W, 588 m water depth) retrieved in the Santa Barbara Basin (SBB) where suboxic ( $O_2 < 10 \mu\text{mol/kg}$ ) and sporadically anoxic bottom waters prevail. This core was sampled at continuous 1 cm intervals to generate a total of 62 bulk sediment samples, which were then freeze-dried and ground to  $< 75 \mu\text{m}$  for magnetic analyses.

During my visit to the IRM, low-field mass magnetic susceptibility ( $\chi$ ) was determined at 1-cm interval on an AGICO Kappabridge MFK1 Susceptometer at room temperature, followed by measurements of anhysteretic remanent magnetization (ARM), and saturated isothermal remanent magnetization (SIRM) on a 2G SQUID magnetometer. Magnetic hysteresis properties of bulk sediment samples were measured on a Princeton Measurements Corporation MicroMag VSM. Additionally, first-order reversal curves (FORC) (Pike 2003) are determined on selected samples at room temperature.

Temperature-dependent magnetic properties were also measured for selected samples for further identification of magnetic minerals. Low-temperature treatments were carried out with a Quantum Design MPMS for field cooling (FC), zero field cooling (ZFC) measurements and RTSIRM cycling (first imparting a saturation isothermal remanent magnetization at room temperature and then performing low temperature demagnetization). High-temperature measurements were performed to the same collection of samples on a Kappabridge High-Temperature Susceptometer to detect Fe sulfides that can be oxidized to magnetite at temperatures above 300 °C. For each sample run, ~200-300 mg of samples were weighed, heated from room temperature to 700 °C in the air and then cooled back to room temperature.

Our core shows a major transition in magnetic mineral concentrations and mineralogy with depth. Within the uppermost 35 cm, concentration-dependent parameters

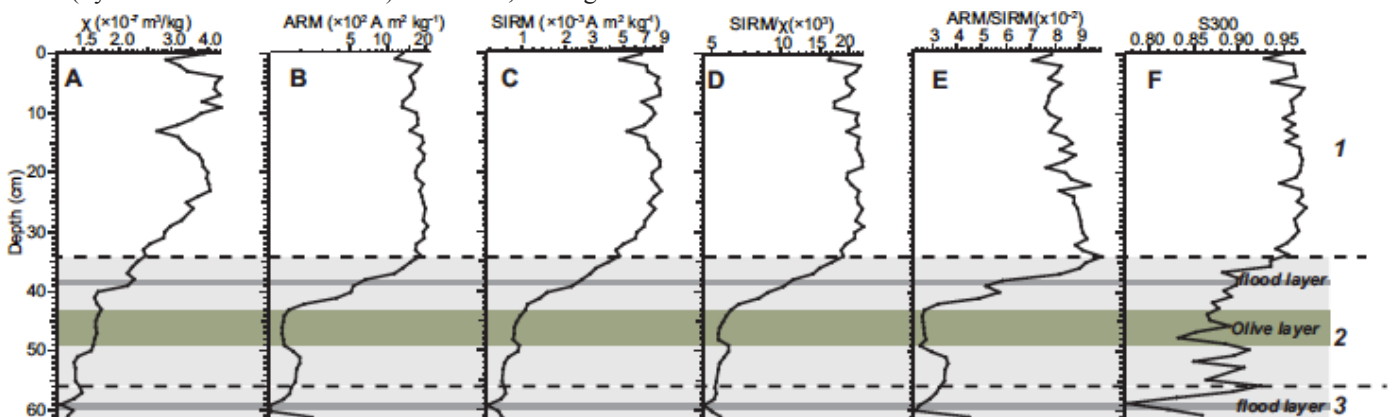


Figure 1. Downcore variability of bulk magnetic parameters. A. susceptibility  $\chi$ ; B. Anhysteretic remanent magnetization (ARM); C. Saturation isothermal remanent magnetization (SIRM); D.  $SIRM/\chi$ ; E.  $ARM/SIRM$ ; F. S300 ratio ( $S300 = -IRM-300mT/SIRM$ ).

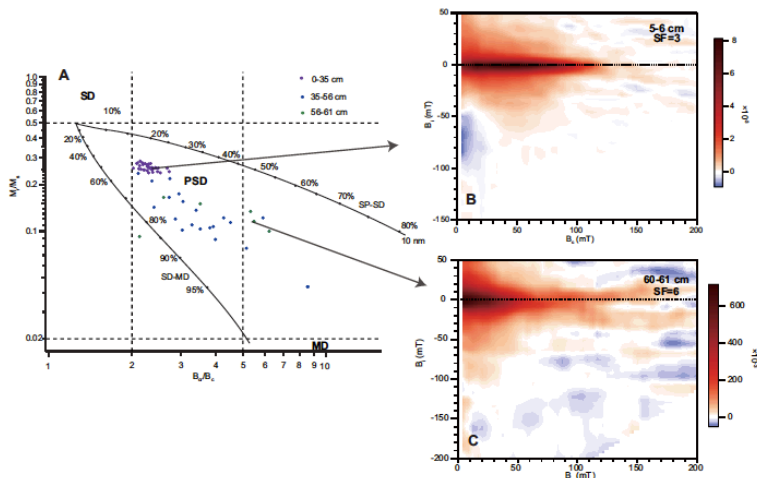


Figure 2. Day plot and selected FORC distributions. A. Day plot following Day et al. (1977); B and C. FORC distributions of 5-6 cm and 60-61 cm, respectively. Smoothing factors (SF) are shown in the figures.

( $\chi$ , ARM, SIRM),  $B_{cr}/B_c$  and  $M_r/M_s$  are distinguished by high values (Fig. 1), suggesting relatively high concentration of pseudo-single-domain (PSD) ferromagnetic minerals and possible contribution of superparamagnetic (SP) particles. FORC distributions also illustrate a mixture of PSD to multi-domain (MD) magnetic mineral assemblages and SD particles within this stratigraphic interval (Fig. 2B). The second zone (35-56 cm) features a major transition to much lower magnetic mineral concentrations and coarser magnetic grain sizes. A noticeable shift to higher values of  $B_{cr}/B_c$  but lower  $M_r/M_s$  is observed (Fig. 2A). Near the bottom of the core (56-61 cm), samples have the lowest concentrations of magnetic minerals with the highest proportion of high coercivity minerals with an average S-ratio of 0.85. FORC distribution further verified mineralogy shifts towards more contribution from high-coercivity Fe oxides (e.g. hematite), indicated by extended divergent contours to  $\sim 200$  mT along the  $B_c$  axis (Fig. 2C). Additionally, the hysteresis parameters and the FORC diagrams indicate SP particle contribution that might be associated with later diagenetic processes, as evidenced by the positive region in negative quadrangle of  $B_1$  (Fig. 2C).

Low temperature measurements confirm existence of maghemite and magnetite mixture. A suppressed remanence decrease between  $\sim 100$  K and  $\sim 120$  K is observed across the Verwey transition ( $T_v$ ) at  $\sim 120$  K, suggesting the presence of magnetite (Fig. 3). RTSIRM cooling curves (Fig. 3) typically undergo a gradual increase first with a subsequent faster decrease and define hump-shaped curves that are matched with humped curves on warming, indicating maghemitization process (magnetite oxidation) throughout the core (Özdemir and Dunlop 2010). Furthermore, a downcore shift towards less oxidized inorganic magnetite is suggested by a transition from a double-peak signature across  $T_v$  to a bell-shaped suppressed peak (Chang et al. 2016). High-temperature measurements, however, have shown pyrite existence throughout the core, suggesting a highly reducing pore-water environment. Common appearance of magnetite in the core challenged the traditional view of magnetite reduction in anoxic environments and may provide a

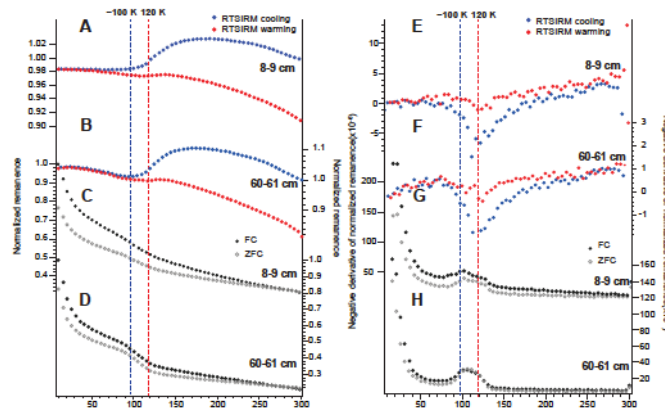


Figure 3. Low temperature measurements. A and B. Normalized remanence in RTSIRM cooling and warming curves for 8-9 cm and 60-61 cm (normalized over RTSIRM); C and D. Normalized remanence in FC and ZFC curves for 8-9 cm and 60-61 cm (normalized towards the first data point in each curve); E and F. Derivatives of RTSIRM cooling and warming curves of the two samples; G and H. Derivatives of FC and ZFC curves.

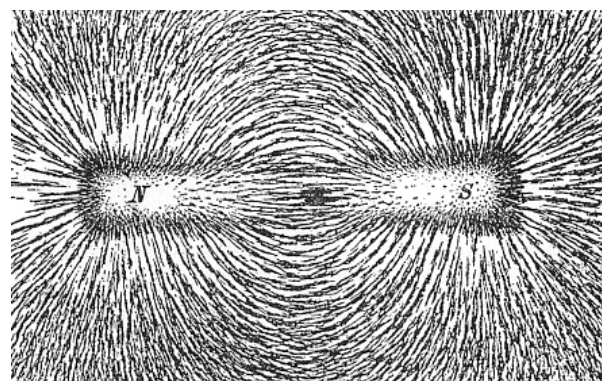
new insight into post-deposition diagenesis processes in marine sediments with other geochemical analyses.

#### Acknowledgments

I would like to thank IRM for offering me US Visiting Student Fellowship to make my visit possible. I would also like to acknowledge Dario Bilardello, Peter Solheid and Mike Jackson for their generous help on instruments and professional suggestions.

#### References

- Chang, L., D. Heslop, A. P. Roberts, D. Rey and K. J. Mohamed (2016). "Discrimination of biogenic and detrital magnetite through a double Verwey transition temperature." *Journal of Geophysical Research: Solid Earth* 121: 3-14.
- Day, R., M. Fuller and V. A. Schmidt (1977). "Hysteresis properties of titanomagnetites: Grain size and compositional dependence." *Physics of the Earth and Planetary Interiors* 13: 260-267.
- Lyons, T. W. and S. Severmann (2006). "A critical look at iron paleoredox proxies: New insights from modern euxinic marine basins." *Geochimica et Cosmochimica Acta* 70(23): 5698-5722.
- Özdemir, Ö. and D. J. Dunlop (2010). "Hallmarks of maghemitization in low-temperature remanence cycling of partially oxidized magnetite nanoparticles." *Journal of Geophysical Research* 115(B02101): 1-10.
- Pike, C. R. (2003). "First-order reversal-curve diagrams and reversible magnetization." *Physical Review B* 68(104424).



# 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.

## Aeromagnetism, Magnetic Anomalies, and Surveying

- Afshar, A., G. H. Norouzi, A. Moradzadeh, M. A. Riahi, and S. Porkhial (2017), Curie Point Depth, Geothermal Gradient and Heat-Flow Estimation and Geothermal Anomaly Exploration from Integrated Analysis of Aeromagnetic and Gravity Data on the Sabalan Area, NW Iran, *Pure and Applied Geophysics*, 174(3), 1133-1152.
- Anderson, E. D., T. Monecke, M. W. Hitzman, W. Zhou, and P. A. Bedrosian (2017), Mineral Potential Mapping in an Accreted Island-Arc Setting Using Aeromagnetic Data: An Example from Southwest Alaska, *Economic Geology*, 112(2), 375-396.
- Balkaya, C., Y. L. Ekinci, G. Gokturkler, and S. Turan (2017), 3D non-linear inversion of magnetic anomalies caused by prismatic bodies using differential evolution algorithm, *Journal of Applied Geophysics*, 136, 372-386.
- Blanchard, J. A., R. E. Ernst, and C. Samson (2017), Gravity and magnetic modelling of layered mafic-ultramafic intrusions in large igneous province plume centre regions: case studies from the 1.27 Ga Mackenzie, 1.38 Ga Kunene-Kibaran, 0.06 Ga Deccan, and 0.13-0.08 Ga High Arctic events, *Canadian Journal of Earth Sciences*, 54(3), 290-310.
- Damaceno, J. G., D. L. de Castro, S. N. Valcacio, and Z. S. Souza (2017), Magnetic and gravity modeling of a Paleogene diabase plug in Northeast Brazil, *Journal of Applied Geophysics*, 136, 219-230.
- Gan, F. P., K. Han, F. N. Lan, Y. L. Chen, and W. Zhang (2017), Multi-geophysical approaches to detect karst channels underground - A case study in Mengzi of Yunnan Province, China, *Journal of Applied Geophysics*, 136, 91-98.
- Golshadi, Z., A. K. Ramezanali, and K. Kafaei (2016), Interpretation of magnetic data in the Chenar-e Olya area of Asadabad, Hamedan, Iran, using analytic signal, Euler deconvolution, horizontal gradient and tilt derivative methods, *Bollettino Di Geofisica Teorica Ed Applicata*, 57(4), 329-342.
- Honsho, C., T. Yamazaki, T. Ura, K. Okino, H. Morozumi, and S. Ueda (2016), Magnetic anomalies associated with abundant production of pyrrhotite in a sulfide deposit in the Okinawa Trough, Japan, *Geochemistry Geophysics Geosystems*, 17(11), 4413-4424.
- Li, J., Z. H. Pang, Y. L. Kong, F. L. Lin, Y. L. Wang, G. J. Wang, and L. H. Lv (2017), An integrated magnetotelluric and gamma exploration of groundwater in fractured granite for small-scale freshwater supply: a case study from the Boshan region, Shandong Province, China, *Environmental Earth Sciences*, 76(4).
- Mazhari, N., A. M. Shafaroudi, and M. Ghaderi (2017), Detecting and mapping different types of iron mineralization in Sangan mining region, NE Iran, using satellite image and airborne geophysical data, *Geosciences Journal*, 21(1), 137-148.
- Pak, S. J., J. W. Moon, J. Kim, M. T. Chandler, H. S. Kim, J. Son, S. K. Son, S. K. Choi, and E. T. Baker (2017), Wide-spread tectonic extension at the Central Indian Ridge between 8 degrees S and 18 degrees S, *Gondwana Research*, 45, 163-179.
- Pedrosa, N. C., R. M. Vidotti, R. A. Fuck, R. Branco, A. R. de Almeida, N. C. V. Silva, and L. R. C. Braga (2017), Architecture of the intracontinental Jaibaras Rift, Brazil, based on geophysical data, *Journal of South American Earth Sciences*, 74, 27-40.
- Percival, J. A., and V. Tschirhart (2017), Trans-Hudsonian far-field deformation effects in the Rae foreland: An integrated geological-3D magnetic model, *Tectonophysics*, 699, 82-92.
- Sokolov, S. Y. (2017), Sedimentary cover deformations in the equatorial Atlantic and their comparison with geophysical fields, *Geotectonics*, 51(1), 74-88.
- Tavakoli, S., M. Dehghannejad, M. D. Garcia Juanatey, T. E. Bauer, P. Weihed, and S. A. Elming (2016), Potential Field, Geoelectrical and Reflection Seismic Investigations for Massive Sulphide Exploration in the Skellefte Mining District, Northern Sweden, *Acta Geophysica*, 64(6), 2170-2198.
- Tschirhart, V., and S. J. Pehrsson (2016), New insights from geophysical data on the regional structure and geometry of the southwest Thelon Basin and its basement, Northwest Territories, Canada, *Geophysics*, 81(5), B167-B178.
- Usui, Y., Y. Ogawa, K. Aizawa, W. Kanda, T. Hashimoto, T. Koyama, Y. Yamaya, and T. Kagiya (2017), Three-dimensional resistivity structure of Asama Volcano revealed by data-space magnetotelluric inversion using unstructured tetrahedral elements, *Geophysical Journal International*, 208(3), 1359-1372.
- Wang, X. J., L. F. He, L. Chen, L. G. Xu, J. Li, X. Y. Lei, and D. H. Wei (2017), Mapping deeply buried karst cavities using controlled-source audio magnetotellurics: A case history of a tunnel investigation in southwest China, *Geophysics*, 82(1), EN1-EN11.
- Zerrouk, S., A. Bendaoud, M. Hamoudi, J. P. Liegeois, H. Boubekri, and R. Ben El Khaznadj (2017), Mapping and discriminating the Pan-African granitoids in the Hoggar (southern Algeria) using Landsat 7 ETM+ data and airborne geophysics, *Journal of African Earth Sciences*, 127, 146-158.
- Zhang, L., S. P. Huang, R. Fu, and X. Y. Tang (2017), Application of magnetotellurics in geothermal exploration and research in volcano areas, *Acta Petrologica Sinica*, 33(1), 279-290.
- Zhu, X. S., and M. J. Lu (2016), Regional metallogenic structure based on aeromagnetic data in northern Chile, *Applied Geophysics*, 13(4), 721-735.

## Archeomagnetism

- Liedgren, L., G. Hornberg, T. Magnusson, and L. Ostlund (2017), Heat impact and soil colors beneath hearths in northern Sweden, *Journal of Archaeological Science*, 79, 62-72.

## Biomagnetism

- Yamazaki, T., and K. Horiuchi (2016), Precessional control on ocean productivity in the Western Pacific Warm Pool for the last 400 kyr: Insight from biogenic magnetite, *Geochemistry Geophysics Geosystems*, 17(11), 4399-4412.

## Environmental magnetism and Climate

- Aird, H. M., K. M. Ferguson, M. L. Lehrer, and A. E. Boudreau (2017), A study of the trace sulfide mineral assemblages in the Stillwater Complex, Montana, USA, *Mineralium Deposita*, 52(3), 361-382.
- Alappat, L., S. Joseph, S. Tsukamoto, S. Kaufhold, and M. Frechen (2017), Chronology and weathering history of red dunes (Teri Sands) in the southwest coast of Tamil Nadu, India, *Zeitschrift Der Deutschen Gesellschaft Fur Geowissenschaften*, 168(1), 183-198.
- Anchuela, O. P., P. Frongia, F. Di Gregorio, A. M. C. Sainz, and A. P. Juan (2017), Magnetometry and ground-penetrating radar surveys applied to tracing potential collectors of mining-derived pollutants in coastal sediments (Piscinas Bay, Montevocchio mining area, SW Sardinia), *Environmental Earth Sciences*, 76(5).
- Badesab, F., P. Dewangan, A. Usapkar, M. Kocherla, A. Peketi, K. Mohite, S. J. Sangode, and K. Deenadayalan (2017), Controls on evolution of gas-hydrate system in the Krishna-Godavari basin, offshore India, *Geochemistry Geophysics Geosystems*, 18(1), 52-74.
- Bol'shakov, V. A. (2017), The Use of the Rock Magnetic and Paleomagnetic Data for the Loess Plateau Deposits in China for Their Climatic and Chronologic Correlation to the Oxygen Isotopic Timescale, *Izvestiya-Physics of the Solid Earth*, 53(2), 293-310.
- Chang, L., et al. (2016), Asian monsoon modulation of non-steady state diagenesis in hemipelagic marine sediments offshore of Japan, *Geochemistry Geophysics Geosystems*, 17(11), 4383-4398.
- Dutuc, D. C., G. Pe-Piper, and D. J. W. Piper (2017), The provenance of Jurassic and Lower Cretaceous clastic sediments offshore southwestern Nova Scotia, *Canadian Journal of Earth Sciences*, 54(1), 33-51.
- El-Desoky, H., A. Khalil, S. Farouk, and W. Fahmy (2017), Dakhla-Kharga iron-rich paleosols, Western Desert, Egypt: geology, geochemistry, and mineralization, *Arabian Journal of Geosciences*, 10(4).
- Fay, E. L., and R. J. Knight (2016), Detecting and quantifying organic contaminants in sediments with nuclear magnetic resonance, *Geophysics*, 81(6), EN87-EN97.
- Fernandes, L. L., P. M. Kessarkar, G. Parthiban, and V. P. Rao (2017), Changes in depositional environment for the past 35 years in the Thane Creek, central west coast of India: inferences from REEs, metals and magnetic properties, *Environmental Earth Sciences*, 76(5).
- Gamboa, A., J. C. Montero-Serrano, G. St-Onge, A. Rochon, and P. A. Desiagne (2017), Mineralogical, geochemical, and magnetic signatures of surface sediments from the Canadian Beaufort Shelf and Amundsen Gulf (Canadian Arctic), *Geochemistry Geophysics Geosystems*, 18(2), 488-512.
- Hosek, J., P. Pokorný, J. Prach, L. Lisa, T. M. Grygar, I. Knesl, and J. Trubac (2017), Late Glacial erosion and pedogenesis dynamics: Evidence from high-resolution lacustrine archives and paleosols in south Bohemia (Czech Republic), *Catena*, 150, 261-278.
- Hounslow, M., H. E. White, N. A. Drake, M. J. Salem, A. El-Hawat, S. J. McLaren, V. Karloukovski, S. R. Noble, and O. Hlal (2017), Miocene humid intervals and establishment of drainage networks by 23 Ma in the central Sahara, southern Libya, *Gondwana Research*, 45, 118-137.
- Karimi, A., G. H. Haghnia, S. Ayoubi, and T. Safari (2017), Impacts of geology and land use on magnetic susceptibility and selected heavy metals in surface soils of Mashhad plain, northeastern Iran, *Journal of Applied Geophysics*, 138, 127-134.
- Kissel, C., Z. F. Liu, J. H. Li, and C. Wandres (2017), Magnetic signature of river sediments drained into the southern and eastern part of the South China Sea (Malay Peninsula, Sumatra, Borneo, Luzon and Taiwan), *Sedimentary Geology*, 347, 10-20.
- Kulgemeyer, T., H. Muller, T. von Dobeneck, K. R. Bryan, W. P. de Lange, and C. N. Battershill (2017), Magnetic mineral and sediment porosity distribution on a storm-dominated shelf investigated by benthic electromagnetic profiling (Bay of Plenty, New Zealand), *Marine Geology*, 383, 78-98.
- Li, B. F., D. H. Sun, W. H. Xu, F. Wang, B. Q. Liang, Z. W. Ma, X. Wang, Z. J. Li, and F. H. Chen (2017), Paleomagnetic chronology and paleoenvironmental records from drill cores from the Hetao Basin and their implications for the formation of the Hobq Desert and the Yellow River, *Quaternary Science Reviews*, 156, 69-89.
- Liu, X. M., M. M. Ma, H. B. Wu, and Z. B. Zhou (2017), Identification of aeolian loess deposits on the Indo-Gangetic Plain (India) and their significance, *Science China-Earth Sciences*, 60(3), 428-437.
- Liu, J., et al. (2017), Sedimentary environment evolution and biogenic silica records over 33,000 years in the Liaohe delta, China, *Limnology and Oceanography*, 62(2), 474-489.
- Lohr, S. C., D. T. Murphy, L. D. Nothdurft, R. Bolhar, S. Piazzolo, and C. Siegel (2017), Maghemite soil nodules reveal the impact of fire on mineralogical and geochemical differentiation at the Earth's surface, *Geochimica Et Cosmochimica Acta*, 200, 25-41.
- Long, X. Y., J. F. Ji, V. Barron, and J. Torrent (2016), Climatic thresholds for pedogenic iron oxides under aerobic conditions: Processes and their significance in paleoclimate reconstruction, *Quaternary Science Reviews*, 150, 264-277.
- Moulin, M., F. Fluteau, V. Courtillot, J. Marsh, G. Delpech, X. Quidelleur, and M. Gerard (2017), Eruptive history of the Karoo lava flows and their impact on early Jurassic environmental change, *Journal of Geophysical Research-Solid Earth*, 122(2), 738-772.
- Mzuzza, M. K., Z. Weiguo, L. S. Chapola, M. Tembo, and F. Kapute (2017), Determining sources of sediments at Nkula Dam in the Middle Shire River, Malawi, using mineral magnetic approach, *Journal of African Earth Sciences*, 126, 23-32.
- Noda, S., and Y. Yamaguchi (2017), Estimation of surface iron oxide abundance with suppression of grain size and topography effects, *Ore Geology Reviews*, 83, 312-320.
- Reilly, B. T., C. J. Natter, and S. A. Brachfeld (2016), Holocene glacial activity in Barilari Bay, west Antarctic Peninsula, tracked by magnetic mineral assemblages: Linking ice, ocean, and atmosphere, *Geochemistry Geophysics Geosystems*, 17(11), 4553-4565.
- Roberts, N. J. et al. (2017), Multiple tropical Andean glaciations during a period of late Pliocene warmth. *Sci. Rep.* 7, 41878; doi: 10.1038/srep41878.
- Sebastian, T., B. N. Nath, S. Naik, D. V. Borole, S. Pierre, and A. K. Yazing (2017), Offshore sediments record the history of onshore iron ore mining in Goa State, India, *Marine Pollution Bulletin*, 114(2), 805-815.
- Skeries, K., H. Jamieson, H. Falck, S. Paradis, and S. Day (2017), Geochemical and mineralogical controls on metal(loid) dispersion in streams and stream sediments in the Prairie Creek district, NWT, *Geochemistry-Exploration Environment Analysis*, 17(1), 1-19.
- Spinola, D. N., R. D. Portes, C. Schaefer, E. Solleiro-Rebolledo, T. Pi-Puig, and P. Kuhn (2017), Eocene paleosols on King George Island, Maritime Antarctica: Macromorphology, micromorphology and mineralogy, *Catena*, 152, 69-81.
- Taheri, M., F. Khormali, X. Wang, A. Amini, H. T. Wei, M.

- Kehl, M. Frechen, and F. H. Chen (2017), Micromorphology of the lower Pleistocene loess in the Iranian Loess Plateau and its paleoclimatic implications, *Quaternary International*, 429, 31-40.
- Tazikeh, H., F. Khormali, A. Amini, M. B. Motlagh, and S. Ayoubi (2017), Soil-parent material relationship in a mountainous arid area of Kopet Dagh basin, North East Iran, *Catena*, 152, 252-267.
- Wang, Z. W., X. G. Fu, X. L. Feng, C. Y. Song, D. Wang, W. B. Chen, and S. Q. Zeng (2017), Geochemical features of the black shales from the Wuyu Basin, southern Tibet: implications for palaeoenvironment and palaeoclimate, *Geological Journal*, 52(2), 282-297.
- Zan, J. B., X. M. Fang, M. D. Yan, and B. S. Li (2017), New insights into the palaeoclimatic interpretation of the temperature dependence of the magnetic susceptibility and magnetization of Mid-Late Pleistocene loess/palaeosols in Central Asia and the Chinese Loess Plateau, *Geophysical Journal International*, 208(2), 663-673.
- Zhao, H., Y. B. Sun, and X. K. Qiang (2017), Iron oxide characteristics of mid-Miocene Red Clay deposits on the western Chinese Loess Plateau and their paleoclimatic implications, *Palaeogeography Palaeoclimatology Palaeoecology*, 468, 162-172.
- Extraterrestrial and Planetary Magnetism**
- Abe, K., N. Sakamoto, A. N. Krot, and H. Yurimoto (2017), Occurrences, abundances, and compositional variations of cosmic symplectites in the Acfer 094 ungrouped carbonaceous chondrite, *Geochemical Journal*, 51(1), 3-15.
- Castle, N., and C. D. K. Herd (2017), Experimental petrology of the Tissint meteorite: Redox estimates, crystallization curves, and evaluation of petrogenetic models, *Meteoritics & Planetary Science*, 52(1), 125-146.
- Dehouck, E., S. M. McLennan, E. C. Sklute, and M. D. Dyar (2017), Stability and fate of ferrihydrite during episodes of water/rock interactions on early Mars: An experimental approach, *Journal of Geophysical Research-Planets*, 122(2), 358-382.
- Garrick-Bethell, I., B. P. Weiss, D. L. Shuster, S. M. Tikoo, and M. M. Tremblay (2017), Further evidence for early lunar magnetism from troctolite 76535, *Journal of Geophysical Research-Planets*, 122(1), 76-93.
- Hewins, R. H., et al. (2017), Regolith breccia Northwest Africa 7533: Mineralogy and petrology with implications for early Mars, *Meteoritics & Planetary Science*, 52(1), 89-124.
- Hood, L. L., and P. D. Spudis (2016), Magnetic anomalies in the Imbrium and Schrodinger impact basins: Orbital evidence for persistence of the lunar core dynamo into the Imbrian epoch, *Journal of Geophysical Research-Planets*, 121(11), 2268-2281.
- Johnson, C. L., and S. A. Hauck (2016), A whole new Mercury: MESSENGER reveals a dynamic planet at the last frontier of the inner solar system, *Journal of Geophysical Research-Planets*, 121(11), 2349-2362.
- Lamali, A., et al. (2016), Geophysical and magneto-structural study of the Maadna structure (Talemzane, Algeria): Insights on its age and origin, *Meteoritics & Planetary Science*, 51(12), 2249-2273.
- MacPherson, G. J., K. Nagashima, A. N. Krot, P. M. Doyle, and M. A. Ivanova (2017), Mn-53-(53) Cr chronology of Ca-Fe silicates in CV3 chondrites, *Geochimica Et Cosmochimica Acta*, 201, 260-274.
- Nabert, C., D. Heyner, and K. H. Glassmeier (2017), Estimation of a planetary magnetic field using a reduced magnetohydrodynamic model, *Annales Geophysicae*, 35(3), 465-474.
- Nagashima, K., A. N. Krot, and M. Komatsu (2017), Al-26-Mg-26 systematics in chondrules from Kaba and Yamato 980145 CV3 carbonaceous chondrites, *Geochimica Et Cosmochimica Acta*, 201, 303-319.
- Nie, N. X., N. Dauphas, and R. C. Greenwood (2017), Iron and oxygen isotope fractionation during iron UV photo-oxidation: Implications for early Earth and Mars, *Earth and Planetary Science Letters*, 458, 179-191.
- Oliveira, J. S., and M. A. Wieczorek (2017), Testing the axial dipole hypothesis for the Moon by modeling the direction of crustal magnetization, *Journal of Geophysical Research-Planets*, 122(2), 383-399.
- Righter, K., B. M. Go, K. A. Pando, L. Danielson, D. K. Ross, Z. Rahman, and L. P. Keller (2017), Phase equilibria of a low S and C lunar core: Implications for an early lunar dynamo and physical state of the current core, *Earth and Planetary Science Letters*, 463, 323-332.
- Sungatullin, R. K., G. M. Sungatullina, M. I. Zakirov, V. A. Tsel'movich, M. S. Glukhov, A. I. Bakhtin, Y. N. Osin, and V. V. Vorob'ev (2017), Cosmic microspheres in the Carboniferous deposits of the Usolka section (Urals foredeep), *Russian Geology and Geophysics*, 58(1), 59-69.
- Fundamental Rock and Mineral Magnetism**
- Berndt, T., and A. R. Muxworthy (2017), Dating Icelandic glacial floods using a new viscous remanent magnetization protocol, *Geology*, 45(4), 339-342.
- Bezaeva, N. S., et al. (2016), The effects of 10 to > 160 GPa shock on the magnetic properties of basalt and diabase, *Geochemistry Geophysics Geosystems*, 17(11), 4753-4771.
- Bowles, J. A., and M. J. Jackson (2016), Effects of titanomagnetite reordering processes on thermal demagnetization and paleointensity experiments, *Geochemistry Geophysics Geosystems*, 17(12), 4848-4858.
- Chang, L., A. P. Roberts, D. Heslop, A. Hayashida, J. H. Li, X. Zhao, W. Tian, and Q. H. Huang (2016), Widespread occurrence of silicate-hosted magnetic mineral inclusions in marine sediments and their contribution to paleomagnetic recording, *Journal of Geophysical Research-Solid Earth*, 121(12), 8415-8431.
- Church, N. S., K. Fabian, and S. A. McEnroe (2016), Nonlinear Preisach maps: Detecting and characterizing separate remanent magnetic fractions in complex natural samples, *Journal of Geophysical Research-Solid Earth*, 121(12), 8373-8395.
- Fabian, K., V. P. Shcherbakov, L. Kosareva, and D. Nourgaliev (2016), Physical interpretation of isothermal remanent magnetization end-members: New insights into the environmental history of Lake Hovsgul, Mongolia, *Geochemistry Geophysics Geosystems*, 17(11), 4669-4683.
- Fujii, M., K. Okino, H. Sato, K. Nakamura, T. Sato, and T. Yamazaki (2016), Variation in magnetic properties of serpentinized peridotites exposed on the Yokoniwa Rise, Central Indian Ridge: Insights into the role of magnetite in serpentinization, *Geochemistry Geophysics Geosystems*, 17(12), 5024-5035.
- Gribov, S. K., A. V. Dolotov, and V. P. Shcherbakov (2017), Experimental Modeling of the Chemical Remanent Magnetization and Thellier Procedure on Titanomagnetite-Bearing Basalts, *Izvestiya-Physics of the Solid Earth*, 53(2), 274-292.
- Heinrich, F. C., V. Schmidt, M. Schramm, and M. Mertineit (2017), Magnetic and mineralogical properties of salt rocks from the Zechstein of the Northern German Basin, *Geophysical Journal International*, 208(3), 1811-1831.
- Luhmann, A. J., B. M. Tutolo, C. Y. Tan, B. M. Moskowitz,

- M. O. Saar, and W. E. Seyfried (2017), Whole rock basalt alteration from CO<sub>2</sub>-rich brine during flow-through experiments at 150 degrees C and 150 bar, *Chemical Geology*, 453, 92-110.
- Mare, L. P., M. O. De Kock, B. Cairncross, and H. Mouri (2016), Magnetic evaluation of the palaeothermal variation across the Karoo Basin, South Africa, *South African Journal of Geology*, 119(2), 435-452.
- Robinson, P., S. A. McEnroe, and M. Jackson (2017), Lamellar magnetism and exchange bias in billion-year-old metamorphic titanohematite with nanoscale ilmenite exsolution lamellae - II: exchange-bias at 5 K after field-free cooling of NRM and after cooling in a+5 T field, *Geophysical Journal International*, 208(2), 895-917.
- Searle, R. C., B. Young, and E. Mwandoo (2016), The Palaeogene Armathwaite-Cleveland Dyke in upper Teesdale, northern England: magnetic characteristics and relationship to mineralization, *Proceedings of the Yorkshire Geological Society*, 61, 148-154.
- Spagnoli, G., A. Hordt, M. Jegen, C. Virgil, C. Rolf, and S. Petersen (2017), Magnetic susceptibility measurements of seafloor massive sulphide mini-core samples for deep-sea mining applications, *Quarterly Journal of Engineering Geology and Hydrogeology*, 50(1), 88-93.
- Szitkar, F., M. A. Tivey, D. S. Kelley, J. A. Karson, G. L. Fruh-Green, and A. R. Denny (2017), Magnetic exploration of a low-temperature ultramafic-hosted hydrothermal site (Lost City, 30 degrees N, MAR), *Earth and Planetary Science Letters*, 461, 40-45.
- Tan, W., H. P. He, C. Y. Wang, H. Dong, X. L. Liang, and J. X. Zhu (2016), Magnetite exsolution in ilmenite from the Fe-Ti oxide gabbro in the Xinjie intrusion (SW China) and sources of unusually strong remnant magnetization, *American Mineralogist*, 101(12), 2759-2767.
- Geodynamo**
- O'Rourke, J. G., J. Korenaga, and D. J. Stevenson (2017), Thermal evolution of Earth with magnesium precipitation in the core, *Earth and Planetary Science Letters*, 458, 263-272.
- Instrumentation and Techniques**
- Kodama, K. (2017), High-sensitivity multifunctional spinner magnetometer using a magneto-impedance sensor, *Geochemistry Geophysics Geosystems*, 18(1), 434-444.
- Macnae, J. (2016), Fitting superparamagnetic and distributed Cole-Cole parameters to airborne electromagnetic data: A case history from Quebec, *Geophysics*, 81(6), B211-B220.
- Magnetic Fabrics and Anisotropy**
- Bhatt, S., V. Rana, and M. A. Mamtani (2017), Deciphering relative timing of fabric development in granitoids with similar absolute ages based on AMS study (Dharwar Craton, South India), *Journal of Structural Geology*, 94, 32-46.
- Biedermann, A. R., M. Jackson, D. Bilardello, and S. A. McEnroe (2017), Effect of magnetic anisotropy on the natural remanent magnetization in the MCU IVE' layer of the Bjerkreim Sokndal Layered Intrusion, Rogaland, Southern Norway, *Journal of Geophysical Research-Solid Earth*, 122(2), 790-807.
- Hoyer, L., and M. K. Watkeys (2017), Using magma flow indicators to infer flow dynamics in sills, *Journal of Structural Geology*, 96, 161-175.
- Hrouda, F., M. Chadima, J. Jezek, and J. Pokorny (2017), Anisotropy of out-of-phase magnetic susceptibility of rocks as a tool for direct determination of magnetic subfabrics of some minerals: an introductory study, *Geophysical Journal International*, 208(1), 385-402.
- Hrouda, F., K. Verner, S. Kubinova, D. Buriánek, S. W. Faryad, M. Chlupacova, and F. V. Holub (2016), Magnetic fabric and emplacement of dykes of lamprophyres and related rocks of the Central Bohemian Dyke Swarm (Central European Variscides), *Journal of Geosciences*, 61(4), 335-354.
- Kon, S., N. Nakamura, Y. Nishimura, K. Goto, and D. Sugawara (2017), Inverse magnetic fabric in unconsolidated sandy event deposits in Kiritappu Marsh, Hokkaido, Japan, *Sedimentary Geology*, 349, 112-119.
- Parsons, A. J., E. C. Ferre, R. D. Law, G. E. Lloyd, R. J. Phillips, and M. P. Searle (2016), Orogen-parallel deformation of the Himalayan midcrust: Insights from structural and magnetic fabric analyses of the Greater Himalayan Sequence, Annapurna-Dhaulagiri Himalaya, central Nepal, *Tectonics*, 35(11), 2515-2537.
- Wang, K., D. Jia, L. Luo, and S. W. Dong (2017), Magnetic fabric and structural deformation, *Chinese Journal of Geophysics-Chinese Edition*, 60(3), 1007-1026.
- Zavada, P., T. Calassou, K. Schulmann, F. Hrouda, P. Stipska, P. Hasalova, J. Mikova, T. Magna, and P. Mixa (2017), Magnetic fabric transposition in folded granite sills in Variscan orogenic wedge, *Journal of Structural Geology*, 94, 166-183.
- Mineralogy, Petrology, Mineral Physics and Chemistry**
- Chen, Y., E. J. Bylaska, and J. H. Weare (2017), Weakly bound water structure, bond valence saturation and water dynamics at the goethite (100) surface/aqueous interface: ab initio dynamical simulations, *Geochemical Transactions*, 18.
- Dubbin, W. E., and F. Bullough (2017), Dissolution of Al-Substituted Goethite in the Presence of Ferrichrome and Enterobactin at pH 6.5, *Aquatic Geochemistry*, 23(1), 61-74.
- Gunther, T., R. Klemm, X. Zhang, I. Horn, and S. Weyer (2017), In-situ trace element and Fe-isotope studies on magnetite of the volcanic-hosted Zhibo and Chagangnuoer iron ore deposits in the Western Tianshan, NW China, *Chemical Geology*, 453, 111-127.
- Kawasumi, S., and H. Chiba (2017), Redox state of seafloor hydrothermal fluids and its effect on sulfide mineralization, *Chemical Geology*, 451, 25-37.
- Keith, M., K. M. Haase, R. Klemm, U. Schwarz-Schampera, and H. Franke (2017), Systematic variations in magmatic sulphide chemistry from mid-ocean ridges, back-arc basins and island arcs, *Chemical Geology*, 451, 67-77.
- Kim, Y., K. Yuan, B. R. Ellis, and U. Becker (2017), Redox reactions of selenium as catalyzed by magnetite: Lessons learned from using electrochemistry and spectroscopic methods, *Geochimica Et Cosmochimica Acta*, 199, 304-323.
- Korinevsky, V. G., and E. V. Korinevsky (2016), Unusual shape of pyrrhotite inclusions in scapolite of igneous rocks from the southern Urals, *Geology of Ore Deposits*, 58(8), 691-696.
- Kreissl, S., R. Bolanz, J. Gottlicher, R. Steininger, M. Tarassov, and G. Markl (2016), Structural incorporation of W<sup>6+</sup> into hematite and goethite: A combined study of natural and synthetic iron oxides developed from precursor ferrihydrite and the preservation of ancient fluid compositions in hematite, *American Mineralogist*, 101(12), 2701-2715.
- Ming, X. R., L. Liu, M. Yu, H. G. Bai, L. Yu, X. L. Peng, and T. H. Yang (2016), Bleached mudstone, iron concretions, and calcite veins: a natural analogue for the effects of reducing CO<sub>2</sub>-bearing fluids on migration and mineralization of iron, sealing properties, and composition of mudstone cap rocks, *Geofluids*, 16(5), 1017-1042.
- Palyanova, G., K. Kokh, and Y. Seryotkin (2016), Transformation of pyrite to pyrrhotite in the presence of Au-Ag alloys



at 500 degrees C, *American Mineralogist*, 101(12), 2731-2737.

Uenver-Thiele, L., A. B. Woodland, T. B. Ballaran, N. Miyajima, and D. J. Frost (2017), Phase relations of MgFe<sub>2</sub>O<sub>4</sub> at conditions of the deep upper mantle and transition zone, *American Mineralogist*, 102(3), 632-642.

### Paleointensity and records of the geomagnetic field

Channell, J. E. T. (2017), Magnetic excursions in the late Matuyama Chron (Olduvai to Matuyama-Brunhes boundary) from North Atlantic IODP sites, *Journal of Geophysical Research-Solid Earth*, 122(2), 773-789.

Channell, J. E. T. (2017), Mid-Brunhes magnetic excursions in marine isotope stages 9, 13, 14, and 15 (286, 495, 540, and 590 ka) at North Atlantic IODP Sites U1302/3, U1305, and U1306, *Geochemistry Geophysics Geosystems*, 18(2), 473-487.

Frank, U., N. R. Nowaczyk, T. Frederichs, and M. Korte (2017), Palaeo- and rock magnetic investigations on Late Quaternary sediments from low latitudes. I: geomagnetic palaeosecular variation and relative palaeointensity records from the Tobago Basin, Southeast Caribbean, *Geophysical Journal International*, 208(3), 1740-1755.

Kristjansson, L. (2016), Extension of the Middle Miocene Kleifakot geomagnetic instability event in Isafjorour, Northwest Iceland, *Jokull*, 66, 83-94.

Lund, S., L. Benson, R. Negrini, J. Liddicoat, and S. Mensing (2017), A full-vector paleomagnetic secular variation record (PSV) from Pyramid Lake (Nevada) from 47-17 ka: Evidence for the successive Mono Lake and Laschamp Excursions, *Earth and Planetary Science Letters*, 458, 120-129.

Morzfeld, M., A. Fournier, and G. Hulot (2017), Coarse predictions of dipole reversals by low-dimensional modeling and data assimilation, *Physics of the Earth and Planetary Interiors*, 262, 8-27.

Okada, M., Y. Suganuma, Y. Haneda, and O. Kazaoka (2017), Paleomagnetic direction and paleointensity variations during the Matuyama-Brunhes polarity transition from a marine succession in the Chiba composite section of the Boso Peninsula, central Japan, *Earth Planets and Space*, 69.

Salminen, J., R. Klein, T. Veikkolainen, S. Mertanen, and I. Manttari (2017), Mesoproterozoic geomagnetic reversal asymmetry in light of new paleomagnetic and geochronological data for the Hame dyke swarm, Finland: Implications for the Nuna supercontinent, *Precambrian Research*, 288, 1-22.

Usui, Y., and W. Tian (2017), Paleomagnetic directional groups and paleointensity from the flood basalt in the Tarim large igneous province: implications for eruption frequency, *Earth Planets and Space*, 69.

Zhidkov, G. V., V. P. Shcherbakov, A. V. Dolotov, M. A. Smirnov, A. A. Ovsyannikov, and P. Y. Plechov (2017), Test determinations of paleointensity in historical lavas of Kamchatka, *Izvestiya-Physics of the Solid Earth*, 53(1), 162-172.

### Paleomagnetism

Bazhenov, M. L., A. M. Kozlovsky, V. V. Yarmolyuk, N. M. Fedorova, and J. G. Meert (2016), Late Paleozoic paleomagnetism of South Mongolia: Exploring relationships between Siberia, Mongolia and North China, *Gondwana Research*, 40, 124-141.

Belica, M. E., E. Tohver, S. A. Pisarevsky, F. Jourdan, S. Denysyn, and A. D. George (2017), Middle Permian paleomagnetism of the Sydney Basin, Eastern Gondwana: Test-

ing Pangea models and the timing of the end of the Kiaman Reverse Superchron, *Tectonophysics*, 699, 178-198.

Cao, Y., et al. (2017), New Late Cretaceous paleomagnetic data from volcanic rocks and red beds from the Lhasa terrane and its implications for the paleolatitude of the southern margin of Asia prior to the collision with India, *Gondwana Research*, 41, 337-351.

Chen, W. W., S. H. Zhang, J. K. Ding, J. H. Zhang, X. X. Zhao, L. D. Zhu, W. G. Yang, T. S. Yang, H. Y. Li, and H. C. Wu (2017), Combined paleomagnetic and geochronological study on Cretaceous strata of the Qiangtang terrane, central Tibet, *Gondwana Research*, 41, 373-389.

Daradich, A., P. Huybers, J. X. Mitrovica, N. H. Chan, and J. Austermann (2017), The influence of true polar wander on glacial inception in North America, *Earth and Planetary Science Letters*, 461, 96-104.

Davis, J. R., and S. J. Titus (2017), Modern methods of analysis for three-dimensional orientational data, *Journal of Structural Geology*, 96, 65-89.

Evans, D. A. D., A. V. Smirnov, and A. P. Gumsley (2017), Paleomagnetism and U-Pb geochronology of the Black Range dykes, Pilbara Craton, Western Australia: a Neoproterozoic crossing of the polar circle, *Australian Journal of Earth Sciences*, 64(2), 225-237.

Fairchild, L. M., N. L. Swanson-Hysell, J. Ramezani, C. J. Sprain, and S. A. Bowring (2017), The end of Midcontinent Rift magmatism and the paleogeography of Laurentia, *Lithosphere*, 9(1), 117-133.

Fazzito, S. Y., A. E. Rapalini, J. M. Cortes, and C. M. Terrizzano (2017), Vertical-axis rotations and deformation along the active strike-slip El Tigre Fault (Precordillera of San Juan, Argentina) assessed through palaeomagnetism and anisotropy of magnetic susceptibility, *International Journal of Earth Sciences*, 106(2), 631-657.

Fu, R. R., et al. (2017), Evaluating the paleomagnetic potential of single zircon crystals using the Bishop Tuff, *Earth and Planetary Science Letters*, 458, 1-13.

Golovanova, I. V., K. N. Danukalov, A. F. Kadyrov, M. M. Khidiyatov, R. Y. Sal'manova, R. K. Shakurov, N. M. Levashova, and M. L. Bazhenov (2017), Paleomagnetism of Sedimentary Strata and the Origin of the Structures in the Western Slope of South Urals, *Izvestiya-Physics of the Solid Earth*, 53(2), 311-319.

Hagstrum, J. T., R. J. Fleck, R. C. Evarts, and A. T. Calvert (2017), Paleomagnetism and Ar-40/Ar-39 geochronology of the Plio-Pleistocene Boring Volcanic Field: Implications for the geomagnetic polarity time scale and paleosecular variation, *Physics of the Earth and Planetary Interiors*, 262, 101-115.

Huang, W. T., P. C. Lippert, M. J. Jackson, M. J. Dekkers, Y. Zhang, J. Li, Z. J. Guo, P. Kapp, and D. J. J. van Hinsbergen (2017), Remagnetization of the Paleogene Tibetan Himalayan carbonate rocks in the Gamba area: Implications for reconstructing the lower plate in the India-Asia collision, *Journal of Geophysical Research-Solid Earth*, 122(2), 808-825.

Iaffaldano, G., and S. Stein (2017), Impact of uncertain reference-frame motions in plate kinematic reconstructions: A theoretical appraisal, *Earth and Planetary Science Letters*, 458, 349-356.

Jordan, T. A., F. Ferraccioli, and P. T. Leat (2017), New geophysical compilations link crustal block motion to Jurassic extension and strike-slip faulting in the Weddell Sea Rift System of West Antarctica, *Gondwana Research*, 42, 29-48.

Kilian, T. M., N. L. Swanson-Hysell, U. Bold, J. Crowley, and F. A. Macdonald (2016), Paleomagnetism of the Teel basalts from the Zavkhan terrane: Implications for Paleozoic

- paleogeography in Mongolia and the growth of continental crust, *Lithosphere*, 8(6), 699-715.
- Li, Z. Y., L. Ding, P. P. Song, J. J. Fu, and Y. H. Yue (2017), Paleomagnetic constraints on the paleolatitude of the Lhasa block during the Early Cretaceous: Implications for the onset of India-Asia collision and latitudinal shortening estimates across Tibet and stable Asia, *Gondwana Research*, 41, 352-372.
- Madureira, P., et al. (2017), The 1998-2001 submarine lava balloon eruption at the Serreta ridge (Azores archipelago): Constraints from volcanic facies architecture, isotope geochemistry and magnetic data, *Journal of Volcanology and Geothermal Research*, 329, 13-29.
- Malandri, C., K. Soukis, M. Maffione, M. Ozkaptan, E. Vasilakis, S. Lozios, and D. J. J. van Hinsbergen (2017), Vertical-axis rotations accommodated along the Mid-Cycladic lineament on Paros Island in the extensional heart of the Aegean orocline (Greece), *Lithosphere*, 9(1), 78-99.
- Marton, E., D. Zampieri, V. Cosovic, A. Moro, and K. Drobne (2017), Apparent polar wander path for Adria extended by new Jurassic paleomagnetic results from its stable core: Tectonic implications, *Tectonophysics*, 700, 1-18.
- Mattei, M., F. Cifelli, H. Alimohammadian, H. Rashid, A. Winkler, and L. Sagnotti (2017), Oroclinal bending in the Alborz Mountains (Northern Iran): New constraints on the age of South Caspian subduction and extrusion tectonics, *Gondwana Research*, 42, 13-28.
- Mikhaltsov, N. E., Y. V. Karyakin, V. V. Abashev, V. Y. Bragin, V. A. Vernikovskiy, and A. V. Travin (2016), Geodynamics of the Barents-Kara margin in the Mesozoic inferred from paleomagnetic data on rocks from the Franz Josef Land Archipelago, *Doklady Earth Sciences*, 471(2), 1242-1246.
- Morris, A., M. Meyer, M. W. Anderson, and C. J. MacLeod (2016), Clockwise rotation of the entire Oman ophiolite occurred in a suprasubduction zone setting, *Geology*, 44(12), 1055-1058.
- Nemkin, S. R., D. Lageson, B. van der Pluijm, and R. Van der Voo (2016), Remagnetization and folding in the frontal Montana Rocky Mountains, *Lithosphere*, 8(6), 716-728.
- Schmidt, P. W., and G. E. Williams (2017), Paleomagnetic age of ferruginous weathering beneath the Hamersley Surface, Pilbara, Western Australia, and the Cenozoic apparent polar wander path, *Australian Journal of Earth Sciences*, 64(2), 239-249.
- Symons, D. T. A., K. Kawasaki, P. J. A. McCausland, and C. J. R. Hart (2017), Palaeopole for the 69 Ma Prospector Mountain stock: a critique of the Carmacks/'Baja BC' transport estimate for Yukon, Canada, *Geophysical Journal International*, 208(1), 349-367.
- Tong, Y. B., Z. Y. Yang, X. Q. Jing, Y. Zhao, C. H. Li, D. J. Huang, and X. D. Zhang (2016), New insights into the Cenozoic lateral extrusion of crustal blocks on the southeastern edge of Tibetan Plateau: Evidence from paleomagnetic results from Paleogene sedimentary strata of the Baoshan Terrane, *Tectonics*, 35(11), 2494-2514.
- Wen, B., D. A. D. Evans, and Y. X. Li (2017), Neoproterozoic paleogeography of the Tarim Block: An extended or alternative "missing-link" model for Rodinia?, *Earth and Planetary Science Letters*, 458, 92-106.
- Yan, Y. G., B. C. Huang, J. Zhao, D. H. Zhang, X. H. Liu, P. Charusiri, and A. Veeravananakul (2017), Large southward motion and clockwise rotation of Indochina throughout the Mesozoic: Paleomagnetic and detrital zircon U-Pb geochronological constraints, *Earth and Planetary Science Letters*, 459, 264-278.
- Yang, X. F., X. Cheng, Y. N. Zhou, L. Ma, X. D. Zhang, Z. S. Yan, X. M. Peng, H. L. Su, and H. N. Wu (2017), Paleomagnetic results from Late Carboniferous to Early Permian rocks in the northern Qiangtang terrane, Tibet, China, and their tectonic implications, *Science China-Earth Sciences*, 60(1), 124-134.
- Stratigraphy**
- Andriashchek, L., and R. Barendregt (2017), Evidence for Early Pleistocene glaciation from borecore stratigraphy in north-central Alberta, Canada, *Can. J. Earth. Sci.*, 54, 445-460.
- Dzyuba, O. S., A. Y. Guzhikov, A. G. Manikin, B. N. Shurygin, V. A. Grishchenko, I. N. Kosenko, A. M. Surinskii, V. B. Seltzer, and O. S. Urman (2017), Magneto- and carbon-isotope stratigraphy of the Lower Middle Bathonian in the Sokur section (Saratov, Central Russia): implications for global correlation, *Russian Geology and Geophysics*, 58(2), 206-224.
- Gnibidenko, Z. N., A. V. Levicheva, N. N. Semakov, and G. G. Rusanov (2017), Paleomagnetism and magnetostratigraphy of Upper Cretaceous and Cretaceous-Paleogene boundary intervals, southern Kulunda basin (West Siberia), *Russian Geology and Geophysics*, 58(1), 87-98.
- Gong, Z., K. P. Kodama, and Y. X. Li (2017), Rock magnetic cyclostratigraphy of the Doushantuo Formation, South China and its implications for the duration of the Shuram carbon isotope excursion, *Precambrian Research*, 289, 62-74.
- Gourbet, L., et al. (2017), Reappraisal of the Jianchuan Cenozoic basin stratigraphy and its implications on the SE Tibetan plateau evolution, *Tectonophysics*, 700, 162-179.
- Guzhikov, A. Y., E. Y. Baraboshkin, V. N. Beniamovskiy, V. S. Vishnevskaya, L. F. Kopaeovich, E. M. Pervushov, and A. A. Guzhikova (2017), New Bio- and Magnetostratigraphic Data on Campanian-Maastrichtian Deposits of the Classical Nizhnaya Bannovka Section (Volga River Right Bank, Southern Saratov Region), *Stratigraphy and Geological Correlation*, 25(1), 39-75.
- Hammer, O., and H. H. Svensen (2017), Biostratigraphy and carbon and nitrogen geochemistry of the SPICE event in Cambrian low-grade metamorphic black shale, Southern Norway, *Palaeogeography Palaeoclimatology Palaeoecology*, 468, 216-227.
- Hounslow, M. W., G. McIntosh, R. A. Edwards, D. J. C. Lamington, and V. Karloukovski (2017), End of the Kiaman Superchron in the Permian of SW England: magnetostratigraphy of the Aylesbeare Mudstone and Exeter groups, *Journal of the Geological Society*, 174(1), 56-74.
- Irace, A., G. Monegato, E. Tema, E. Martinetto, D. Gianolla, E. Vassio, L. Bellino, and D. Violanti (2017), Unconformity-bounded stratigraphy in the Plio-Pleistocene continental record: new insights from the Alessandria Basin (NW Italy), *Geological Journal*, 52(2), 177-206.
- Kent, D. V., P. E. Olsen, and G. Muttoni (2017), Astrochronostratigraphic polarity time scale (APTS) for the Late Triassic and Early Jurassic from continental sediments and correlation with standard marine stages, *Earth-Science Reviews*, 166, 153-180.
- Li, H., C. R. Li, and K. Kuman (2017), Longgudong, an Early Pleistocene site in Jianshi, South China, with stratigraphic association of human teeth and lithics, *Science China-Earth Sciences*, 60(3), 452-462.
- Li, X. W., H. Ao, M. J. Dekkers, A. P. Roberts, P. Zhang, S. Lin, W. W. Huang, Y. M. Hou, W. H. Zhang, and Z. S. An (2017), Early Pleistocene occurrence of Acheulian technology in North China, *Quaternary Science Reviews*, 156, 12-22.
- Navrocki, J., T. Malata, and O. Rosowiecka (2016), Magnetostratigraphy of the Oligocene Lower Krosno Beds from the Hulskie section (Outer Carpathians, Poland), *Geological*

Quarterly, 60(4), 935-942.

- Rostovtseva, Y. V., and A. I. Rybkina (2017), The Messinian event in the Paratethys: Astronomical tuning of the Black Sea Pontian, *Marine and Petroleum Geology*, 80, 321-332.
- Simon, Q., et al. (2017), Authigenic Be-10/Be-9 ratio signature of the Matuyama-Brunhes boundary in the Montalbano Jonico marine succession, *Earth and Planetary Science Letters*, 460, 255-267.
- Suteerasak, T., S. A. Elming, G. Possnert, J. Ingri, and A. Widlund (2017), Deposition rates and C-14 apparent ages of Holocene sediments in the Bothnian Bay of the Gulf of Bothnia using paleomagnetic dating as a reference, *Marine Geology*, 383, 1-13.
- Wang, Z. F., et al. (2017), Magnetostratigraphy and Th-230 dating of Pleistocene biogenic reefs in XK-1 borehole from Xisha Islands, South China Sea, *Chinese Journal of Geophysics-Chinese Edition*, 60(3), 1027-1038.

#### Other

- Adushkin, V. V., D. N. Loktev, and A. A. Spivak (2017), Seismomagnetic response of a fault zone, *Izvestiya-Physics of the Solid Earth*, 53(1), 83-91.
- Guglielmi, A. V. (2017), Diversity of threshold phenomena in geophysical media, *Izvestiya-Physics of the Solid Earth*, 53(1), 1-9.



## Visiting Fellowship Applications!

Due to the IRM's move over the Summer  
**The Next Application Deadline**  
will be  
**October 31st**

Visit our website for details and application information:

[www.irm.umn.edu](http://www.irm.umn.edu)

### Special Issue for David Strangway

Call for submission of research papers in magnetism and electromagnetism to the *Canadian Journal of Earth Sciences* for publication in a special issue of tribute to Dr. David Strangway who died December 13, 2016.

David Strangway was born in Simcoe, Ontario, Canada, in 1934 and raised in Angola by missionary parents. He graduated in Physics and Geology in 1956 from the University of Toronto where he completed his MSc and PhD in magnetism research by 1960. After Assistant Professorships at the University of Colorado and Massachusetts Institute of Technology, he joined the National Aeronautics and Space Administration in 1970 as the head of the geophysics branch and leader of the "Moon rocks" research program. In 1973 Strangway returned to Toronto as Head of the Geology Department, and was later appointed Provost (1980) and President (1983) of the University of Toronto. In 1985 he began a successful twelve years as President of the rapidly growing University of British Columbia. In 1998, Strangway moved to Ottawa for six years as President of the government's new Canada Foundation for Innovation where he was responsible for dispensing \$2.7 billion to Canadian universities for scientific research. Returning to British Columbia, Strangway founded Quest University, which opened in 2007. Today, this innovative liberal arts college has about 700 students. During his lifetime, Strangway held numerous important appointments and won many prestigious awards for his achievements. Above all, Dr. David Strangway was always a Renaissance man with broad-ranging interests and a great scientific curiosity.

This special issue of the *Canadian Journal of Earth Sciences* seeks to publish geophysical papers that report on any aspect of terrestrial and planetary magnetic or electromagnetic research. For magnetism, any of the categories listed in the "Current Articles" section of this issue of the IRM Quarterly will be suitable. The journal accepts papers from any country in English or French.

- Deadline for providing tentative paper title: June 30, 2017
- Deadline for submission of papers: March 30, 2018
- Review, revision, and final acceptance: November 30, 2018
- Tentative publication date of the special issue: January 2019

Please contact the Editorial Office of the *Canadian Journal of Earth Sciences* ([cjes@nrcresearchpress.com](mailto:cjes@nrcresearchpress.com)) or Editor Ali Polat ([polat@uwindsor.ca](mailto:polat@uwindsor.ca)) to submit the tentative manuscript title.

Thank you very much for your consideration, and we hope to hear from you soon.

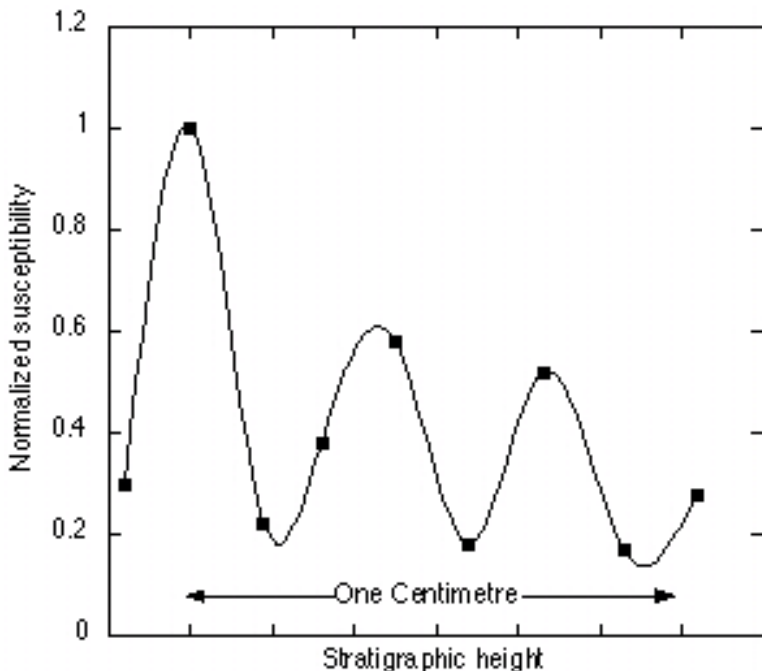
Guest Editors David Symons ([dsymons@uwindsor.ca](mailto:dsymons@uwindsor.ca)), David Dunlop ([dunlop@physics.utoronto.ca](mailto:dunlop@physics.utoronto.ca)), and John Geissman ([geissman@utdallas.edu](mailto:geissman@utdallas.edu))

cont'd. from pg. 1...

apparatus which was able to detect anisotropy, but even after incorporating several improvements (in 1927, and again in 1940), he was still unable to pin down the azimuth of maximum susceptibility. But instruments based on Ising's design eventually met with success, my favourite—naturally—being that built by Roy King himself in collaboration with Tony Rees (King and Rees, 1962).

Despite the fact that Ising never attained his goal as far as AMS was concerned, there are other reasons to remember his scientific work. In the 1943 paper (actually communicated on November 26th, 1941) he invented what we nowadays call environmental magnetism. He established a definite pattern of bulk magnetic susceptibility variations reflecting the annual nature of varves, with peaks due to increased input during spring floods. For these experiments, he increased spatial resolution to the point where he was using successive layers only 1.5 mm (yes, millimetres) thick. (He even proposed the idea that one could dispense with the tedious preparation of individual samples by simply "moving instead the whole collecting box through a registering apparatus", in other words, u-channels.) Broadening his investigations, he went on to observe annual patterns in fossil varves from the Carboniferous of Australia, using slices (he calls them ribbons) only 0.75 mm thick. I couldn't resist re-drawing the corresponding plot (Figure 1). Going out on a limb, Ising finally asked if magnetic analysis combined with laboratory sedimentation experiments might lead to "quantitative data about the hydrographic conditions" prevailing during deposition.

Professor Ising's geophysical work is not much quoted now, but he has other claims to fame. The most outstand-

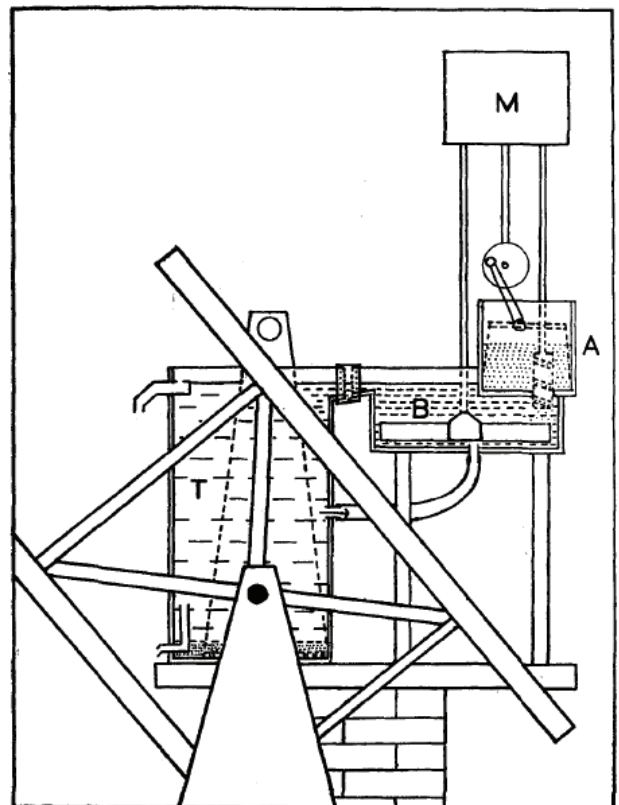


High-resolution magnetic susceptibility fluctuations in Carboniferous shale from Australia, interpreted by Gustaf Ising as annual varve layers. (Cubic spline fitted through data points hand-digitized from Fig.9 of Ising's 1943 paper.)

ing of them being that he was the inventor of the particle accelerator. His initial paper on the subject (Ising, 1924) inspired Rolf Wideröe in Germany, whose 1928 paper was read in the spring of 1929 by Ernest Lawrence at Berkeley. Lawrence rushed to his laboratory—by 1931 he had a cyclotron, by 1939 he had a Nobel Prize. (Perhaps we can mentally award a little bit of it to Gustaf Ising.)

#### References

- De Geer, G., 1912. A geochronology of the last 12000 years. Congr. Géol. Int. Stockholm 1910, C.R., 241-253.
- Graham, J.W., 1954. Magnetic susceptibility anisotropy, an unexploited petrofabric element. Geological Society of America Bulletin 65, 1257-1258.
- Griffiths, D.H., 1953. Remanent magnetism of varved clays from Sweden, Nature, 172, 539-541.
- Ising, G., 1924. Prinzip Einer Methode Zur Herstellung Von Kanalstrahlen Hoher Voltzahl, Arkiv för matematik, astronomi och fysik (in German). 18 (30): 1-4.
- Ising, G., 1943. On the magnetic properties of varved clay, Arkiv för matematik, astronomi och fysik, 29A, 1-37.
- King, R.F., 1955. The remanent magnetism of artificially deposited sediments, Mon. Not. Roy. Astr. Soc. Geophys. Supp., 7, 115-134.
- King, R.F., Rees, A.I., 1962. The measurement of the Anisotropy of Magnetic Susceptibility of Rocks by the Torque Method, Journal of Geophysical Research, 67, 1565-1572.
- McNish, A.G., Johnson, E.A., 1938. Magnetization of unmetamorphosed varves and marine sediments, Terr. Mag. Atmos. Elec., 53, 349-360.



Original figure from King (1955) depicting the sedimentation apparatus used to investigate inclination shallowing.

University of Minnesota  
291 Shepherd Laboratories  
100 Union Street S. E.  
Minneapolis, MN 55455-0128  
phone: (612) 624-5274  
fax: (612) 625-7502  
e-mail: irm@umn.edu  
www.irm.umn.edu

Nonprofit Org.  
U.S Postage  
PAID  
Twin Cities, MN  
Permit No. 90155

# 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.

Funding for the *IRM* is provided by the **National Science Foundation**, the **W. M. Keck Foundation**, and the **University of Minnesota**.

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:

**Dario Bilardello**  
Institute for Rock Magnetism  
University of Minnesota  
291 Shepherd Laboratories  
100 Union Street S. E.  
Minneapolis, MN 55455-0128  
phone: (612) 624-5274  
fax: (612) 625-7502  
e-mail: dario@umn.edu  
www.irm.umn.edu

The U of M is committed to the policy that all people shall have equal access to its programs, facilities, and employment without regard to race, religion, color, sex, national origin, handicap, age, veteran status, or sexual orientation.



UNIVERSITY OF MINNESOTA