ISSN: 2152-1972

The IRM
Quarterly
Summer 2023, Vol. 33 No. 2

Inside...

Report on the 13th Conference on Rock Magnetism

Figure 1: Group photo taken outside of Nicholson Hall, University of Minnesota. Photo by Maxwell Brown.

Dario Bilardello
Institute for Rock Magnetism
dario@umn.edu

Location and rationale

For the first time in its 33 year history the IRM held its 13th biannual Conference on Rock Magnetism at the University of Minnesota. While we all missed our home away from home at St. John's College in Santa Fe, New Mexico, which has been closed for renovations and may not host future conferences, it made sense to finally have the meeting in Minnesota. The conference is funded by the U.S. National Science Foundation, and while we host an international event every so many years, the meeting must attract wide participation from U.S. scientists, and therefore the meeting is most often held within the United States.

Format

The IRM meetings distinguish themselves from other conferences in their scope and size. They are capped at 50 registrants (Fig. 1) to create a more intimate and collegial environment, and are intended to be discussion-focused meetings, with just as much emphasis on the question and answer sessions as there is on the presentations. IRM staff propose four topical sessions based on emerging trends in magnetism, ensuring a "freshness" of topics for each meeting that cover the gamut of magnetic research. Once sessions are selected, IRM staff officially invite two members of the larger community to chair each session and also provide initial suggestions for invited speakers. Once conveners have accepted, it is entirely up to them to finalize the speaker lists, which are by invitation only. Each session runs for an entire morning or afternoon, with 3-4 talks per session and ample time for discussion. We are frequently asked about the possibility of volunteering talks, though doing so would inevitably affect the distinguishing format of the meeting, taking away time for discussion and/or requiring additional days. To allow a greater number of participants to present their research and justify their expenses, we introduced a poster session in 2019, which has been well received by participants. Our meetings often involve a workshop and/or pre-conference field trip, which allows participants to meet more informally.

This year's four topical sessions were on: "Iron Cycling in Natural and Anthropogenic Environments", convened by Andrew Roberts (ANU) and Robert Hatfield (U. Florida); "Frontiers in Magnetic Microscopy", convened by Roger Fu (Harvard) and Rashida Doctor (IRM); "Fundamentals in Rock Magnetism - in memoriam of Özden Özdemir", convened by Julie Bowles (U. Wisconsin-Milwaukee) and Suzanne McEnroe (NTNU); and finally "Grand Challenges in Paleogeography and Tectonics", convened by Dario Bilardello (IRM) and Peter Lippert (U. Utah).

Lake Shore Cryotronics generously supported a pre-conference workshop on first order reversal curves (FORCs), and the conference closed with a community

cont'd. on pg. 11...

Visiting Fellow Reports

Magnetic fingerprint of hydrothermal alteration across the South Atlantic subseafloor

Claudio Robustelli Test
(& The South Atlantic Transect IODP Expedition 390 & 393 Scientists)

Università degli Studi di Torino and CIMaN-ALP Laboratory, Italy
claudio.robustellitest@unito.it

Seawater-derived hydrothermal fluid-basalt exchange induces alteration of the oceanic crust with oxidation of magnetic minerals and changes in the rock magnetic signature. Hydrothermal alteration of titano-magnetite to less magnetic minerals such as titano-maghemite and titano-hematite locally modifies the magnetization intensity, affecting the interpretation of magnetic anomalies (Bleil & Petersen, 1983; Zhou et al., 2001; Wang et al., 2021).

IODP Expeditions 390 and 393 (i.e., the South Atlantic Transect - SAT) focused on studying the evolution of the basaltic subseafloor and the overlying sediments across the western flank of the Mid-Atlantic Ridge (Coggon et al., 2022; Teagle et al., 2023). The SAT provides a unique opportunity to investigate the spatial and temporal extent of the low-temperature hydrothermal evolution of the ridge flank recorded in the uppermost ocean crust formed at a slow/intermediate-spreading (half spreading rate ~13-25 mm/y) ridge between ~7 to 61 Ma (Coggon et al., 2022; Teagle et al., 2023).

The basement rocks recovered from Expeditions 390 and 393 preserve evidence of reaction with seawater-derived hydrothermal fluids to varying extents. A spectrum of alteration styles was observed, ranging from slight to moderate gray background alteration to complete oxidation and replacement of the groundmass and phenocrysts by secondary minerals (i.e., yellow-brown clay, carbonate, and Fe oxyhydroxides - for details Coggon et al., 2022; Teagle et al., 2023).

Preliminary magnetic mineralogy investigations (isothermal remanent magnetization experiments) performed on board the JOIDES Resolution reveal the dominance of low to intermediate coercivity components, with evidence of partially to highly oxidized titano-magnetite (e.g., titano-maghemite) in basalts characterized by more intense alteration halos. In addition, variations in coercivity (Bc), natural remanent magnetization (NRM) and saturation isothermal remanence (SIRM) intensity occur depending on the alteration type, suggesting changes in mineral assemblages and/or grain-size induced by low-temperature hydrothermal exchange.

In this framework, the objective of my visit at the IRM was to characterize the rock magnetic properties of fresh and variably altered Mid-ocean-ridge basalts (MORB) to unravel the link between variations in magnetic mineralogy and extent of alteration associated with low-temperature fluid-basalt interactions that occurred along a crustal flow line across the western flank of the southern Mid-Atlantic Ridge.

At the IRM, I performed low-temperature remanence (i.e., field-cooled - FC -, zero-field-cooled - ZFC - and room temperature - RT-SIRM cooling/warming cycles) and alternating current (AC) susceptibility (as a function of field amplitude and frequency) measurements using the Magnetic Properties Measurement Systems (MPMS-3) to probe the mineralogy (presence or absence of diagnostic transitions) and to infer variations in Ti content of titano-magnetite and its grain-size distribution. Hysteresis loops and First-Order Reversal Curves (FORCs) were acquired using the Lake Shore VSM 8600 to further characterize the coer¬civity distribution and their magnetic domain state. Additional Mössbauer spectroscopy at room temperature was performed on representative samples to help identify the magnetic minerals (titano-magnetite, maghemite, titano-hematite, and Fe oxyhydroxides).

The main findings confirm the dominance of low-coercivity minerals with Mrs/Ms ratio and Bc values typical of titano-magnetite (Figure 1A). The freshest basalts show a linear distribution with a relatively high slope, suggesting higher Ti content compared to altered samples. With alteration, Bc increases toward the trend

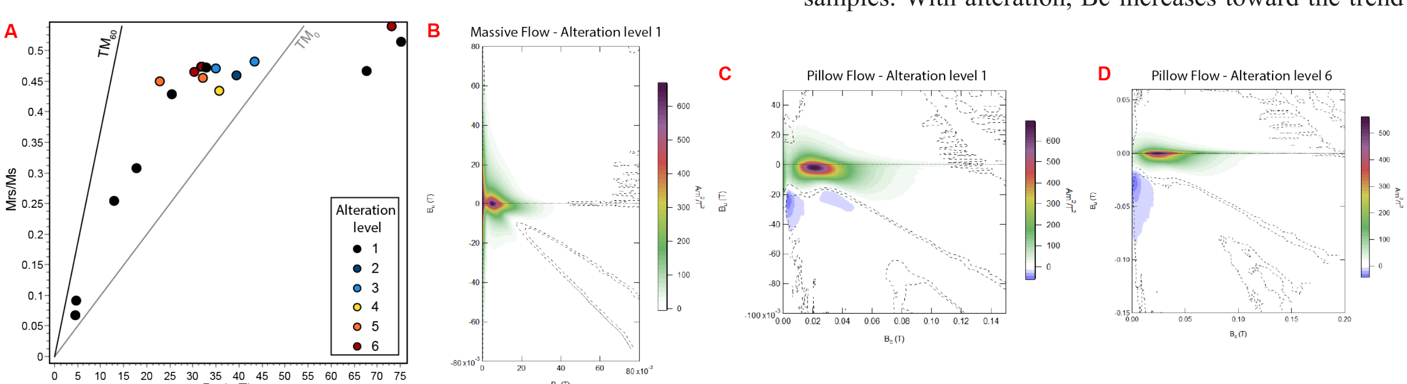

Figure 1. (A) Squareness plot (Mrs/Ms vs. Bc) of a suite of fresh and variable altered basalts. TM60 and TM0 linear trends from Wang et al., 2004 are plotted for reference. FORC diagrams of fresh (B, C) and altered (D) MORB.

of pure magnetite (TM0 - Figure 1A), and further towards higher coercivity, confirming the overall oxidation trend of original titano-magnetite into titano-maghemite (Wang et al., 2004).

FORC diagrams reveal variations in grain-size among fresh samples showing different emplacement styles. Fresh massive flows show a vertically dispersed distribution toward the Bu axis and a central peak along the Bu = 0 axis with three weaker lobes (Figure 1B) typical of a mixture of multi-domain (MD) and vortex state particles (Harrison et al., 2018). In contrast, FORC diagrams of fresh pillow lava (Figure 1C) are characterized by single-domain (SD) grains with a central ridge and a weak negative distribution over the negative Bu axis (Newell, 2005). In general, altered basalts show the dominance of (titano)magnetite SD particle features and an additional broader coercivity distribution over 200 mT (Figure 1D). The higher coercivity dispersion can be associated with the progressive oxidation of titano-magnetite into titano-maghemite and/or the occurrence of small amounts of hematite.

Low-temperature cooling/warming cycles of the RT-SIRM (Figure 2A-D) show reversible curves with a slightly pronounced hump around 200 K which can be related to variations in magnetic anisotropy of Ti-rich titano-magnetite (Wang et al., 2021).

Other evidence of high Ti content in fresh basalts are visible in the ZFC-FC curves that show suppressed to absent Verwey transitions and divergent ZFC and FC curves around ~50 K (Moskowitz et al., 1998). The absence of a Verwey transition and a smoother ZFC curve (Figure 2B, C) can also be a result of partial maghemitization (Özdemir & Dunlop, 2010). Fresh basalts also show frequency-dependent susceptibility between 50-100K and both frequency- and amplitude-dependence above 150K, supporting the occurrence of MD titano-magnetite (Carter-Stiglitz et al., 2006; Church et al., 2011). In addition, both in-phase susceptibilities increase parabolically above 100 K, indicating the presence of SD particles.

In contrast, highly altered pillows (Alteration level 6 – Figure 1D) shows a large separation between FC and ZFC curves, suggesting the possible contribution of goethite. The low-temperature susceptibility shows a dominant paramagnetic contribution with the local occurrence of frequency-dependent susceptibility but no field dependence, typical behaviour of pure magnetite or more oxidized Titano-magnetite (Figure 2F).

Data collected during the IRM fellowship agree well with petrological observations of the alteration style. The freshest basalts have rock magnetic properties typical of Ti-rich titano-magnetite occurring in MORB with mostly grain-size variation related to the origin of the volcanic units. The magnetic properties suggest a progressive oxidation of original titano-magnetite into titano-maghemite during alteration, with additional formation of secondary minerals (as paramagnetic clay minerals and Fe oxyhydroxides) produced by low-temperature ridge flank fluid-basalt interaction.

These newly acquired data will serve to better understand the link between changes in magnetic mineralogy and the extent of hydrothermal alteration that occurred along the SAT, unravelling its influence on the stability of the subseafloor magnetization over time.

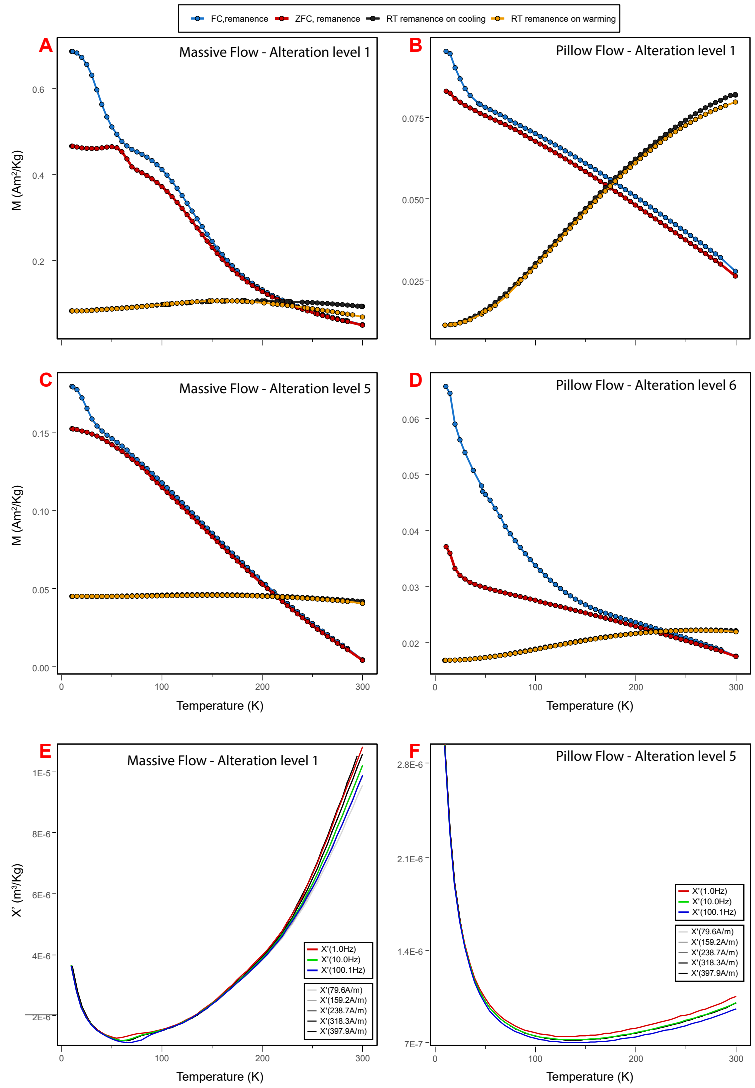

Figure 2. Representatives low-temperature remanent magnetization measurements of fresh (A, B) and altered (C, D) massive and pillow basalt flows. Examples of low-temperature frequency and amplitude dependence of in-phase susceptibility of fresh (E) and altered (F) MORB.

Acknowledgements

I am grateful to Dario Bilardello for assisting me during my visiting fellowship. The IRM staff is thanked for helpful discussions and welcoming me at the IRM Institute. I would like to thank the IODP staff and science parties of the South Atlantic Transect IODP Expedition 390 & 393. This work is supported by ECORD-IODP Italia Science Support Program.

References

Bleil, U., & Petersen, N. (1983). Variations in magnetization intensity and low-temperature titanomagnetite oxidation of ocean floor basalts. Nature, 301(5899), 384–388. https://doi.org/10.1038/301384a0

Carter-Stiglitz, B., B. Moskowitz, P. Solheid, T. S. Berquo´, M. Jackson, & A. Kosterov (2006), Low-temperature magnetic behavior of multidomain titanomagnetites: TM0, TM16,

and TM35, J. Geophys. Res., 111, B12S05, https://doi.org/10.1029/2006JB004561
Church, N., Feinberg, J. M., & Harrison, R. (2011). Low-tem¬perature domain wall pinning in titanomagnetite: Quanti-tative modeling of multidomain first-order reversal curve diagrams and AC susceptibility. Geochem., Geophys., Geo¬syst., 12(7), https://doi.org/10.1029/2011GC003538
Coggon, R. M., Sylvan, J. B., Teagle, D. A. H., Reece, J., Christeson, G. L., Estes, E. R., et al. (2022). Expedition 390 Preliminary Report: South Atlantic Transect 1 (Vol. 390). International Ocean Discovery Program. https://doi.org/10.14379/iodp.pr.390.2022
Harrison, R. J., Muraszko, J., Heslop, D., Lascu, I., Muxwor¬thy, A. R., & Roberts, A. P. (2018). An Improved Algo-rithm for Unmixing First-Order Reversal Curve Diagrams Using Principal Component Analysis. Geochemistry, Geophysics, Geosystems, 19(5), 1595–1610. https://doi.org/10.1029/2018GC007511
Moskowitz, B. M., Jackson, M., & Kissel, C. (1998). Low-temperature magnetic behavior of titanomagnetites. Earth and Planetary Science Letters, 157, 141–149. https://doi.org/10.1016/S0012-821X(98)00033-8
Newell, A. J. (2005). A high-precision model of first-order re¬versal curve (FORC) functions for single-domain ferromag¬nets with uniaxial anisotropy. Geochemistry, Geophysics, Geosystems, 6(5). https://doi.org/10.1029/2004GC000877
Özdemir, Ö., & Dunlop, D. J. (2010). Hallmarks of maghemitization in low-temperature remanence cycling of partially oxidized magnetite nanoparticles. Journal of Geophysical Research, 115(B2), B02101. https://doi.org/10.1029/2009JB006756
Teagle, D.A.H., Reece, J., Coggon, R.M., Sylvan, J.B., Christeson, G.L., Williams, T.J., Estes, E.R., & the Expedition 393 Scientists (2023). Expedition 393 Preliminary Report: South Atlantic Transect 2. International Ocean Discovery Program. https://doi.org/10.14379/iodp.pr.393.2023
Wang, D., & Van der Voo, R. (2004). The hysteresis properties of multidomain magnetite and titanomagnetite/titanomaghemite in mid-ocean ridge basalts. Earth and Planetary Science Letters, 220(1–2), 175–184. https://doi.org/10.1016/S0012-821X(04)00052-4
Wang, S., Chang, L., Tao, C., Bilardello, D., Liu, L., & Wu, T. (2021). Seafloor Magnetism Under Hydrothermal Alteration: Insights From Magnetomineralogy and Magnetic Properties of the Southwest Indian Ridge Basalts. Journal of Geophysical Research: Solid Earth, 126(12). https://doi.org/10.1029/2021JB022646
Zhou, W., Van der Voo, R., Peacor, D. R., Wang, D., & Zhang, Y. (2001). Low-temperature oxidation in MORB of titanomagnetite to titanomaghemite: A gradual process with implications for marine magnetic anomaly amplitudes. Journal of Geophysical Research: Solid Earth, 106(B4), 6409–6421. https://doi.org/10.1029/2000JB900447

Tracking the evolution of iron mineralogy in mid-ocean ridge hydrothermal plumes using magnetics

Hannah Robutka

University of Victoria
hannahrobutka@uvic.ca

Elemental fluxes from hydrothermal vents at mid-ocean ridges play important roles in global ocean biogeochemical cycles (Speer et al., 2002). Recently there has been increasing interest in the contribution of hydrothermal Fe to oceanic reservoirs and its role as an essential micronutrient in the ocean (Tagliabue et al., 2017). As Fe-rich hydrothermal fluids (~350°C) vent from the crust and mix with cold seawater (~2°C) Fe-bearing minerals rapidly precipitate (Mottl & McConachy, 1990). Additional chemical and mineralogical transformations continue as the plume travels off-axis transporting dissolved and particulate Fe into the open ocean (Fitzsimmons et al., 2017). A recent study has investigated the mechanisms of hydrothermal Fe transport on a 100 to 1000 km scale (Fitzsimmons et al., 2017), but here I focus on the initial ~10 km of transport where the most rapid changes in minerology and chemistry occur. It is critical to understand this region in detail because: (i) the near-vent evolution of the plume sets the mineralogy, grain size and composition of particles that can be transported into the far field; and (ii) near-axis sediments are used as records of changes in hydrothermal processes, and correctly interpreting such sediments requires understanding of the early hydrothermal plume. The Endeavour ridge segment of the Juan de Fuca ridge, located in the North Pacific Ocean, is an ideal site to investigate this problem due to ongoing monitoring through the Ocean Networks Canada's cabled observatory providing background physico-chemical data and annual sampling opportunities (Juniper et al., 2019).

The goal of my fellowship was to track changes in the mineralogy of Fe-bearing phases within the first 10 km of the lifetime of a hydrothermal plume. Sediment traps were deployed on-axis and 3 and 9 km off-axis in the direction of plume travel, sampling 21-day intervals of sedimentation throughout the year and providing the opportunity to investigate spatial and temporal variability of hydrothermal sedimentation. A sediment core from ~120 km off-axis, in the opposite direction of suspected plume travel, was included to investigate the magnetic signal from non-hydrothermally derived detrital material.

For each sample, I obtained room-temperature magnetic properties by generating hysteresis loops and direct current demagnetization (DCD) curves on the Lakeshore 8607 VSM. I utilized the Quantum Designs MPMS3 to measure field-cooled (FC) and zero-field- cooled (ZFC) low-temperature (LT) and room-temperature (RT) satu-

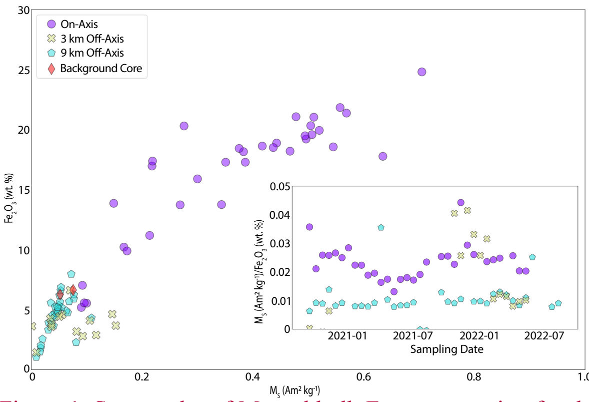

Figure 1. Scatter plot of M_S and bulk Fe concentration for the samples studied. The inset shows the ratio of M_S to bulk Fe concentration throughout the sampling period. Note the increase in M_S independent of Fe concentration observed in the sediment samples collected 3 km off-axis.

ration remanent magnetization (SIRM) on select samples from each location. Saturation magnetization (M_S) obtained from hysteresis loops positively correlates with the concentration of iron in the sediment (Figure 1), both of which are lower in samples collected off-axis. However, the slope of the correlation between Fe concentration and M_S varies between sample locations which I interpret as differences in mineralogy and grain size between sediments collected at different locations. The deviation from a positive correlation in M_S-Fe_2O_3 observed in samples collected 3 km off-axis suggests mineralogical changes over the year as M_S is grain-size invariant and each sample reflects a discrete time interval (Peters & Dekkers, 2003). This interpretation is further supported by the observation of an abrupt change in M_S/Fe concentration of samples collected 3 km off-axis in early 2022 (Figure 1).

MPMS3 measurements and DCD curves were particularly helpful in investigating the mineralogical differences between sampling sites. Within each sampling location, there is variability in the magnitude of magnetization and exact temperature of LT transitions; however, the mineralogy interpreted from LT transitions is consistent within a location. Samples collected on-axis, and 3 km off-axis exhibit Besnus and Verwey transitions, indicating the presence of monoclinic pyrrhotite and magnetite (Figure 2a-b). The magnitude of the Besnus transition is larger in samples from on-axis compared to those collected 3 km off-axis (Figure 2a), suggesting a large abundance of pyrrhotite in the particulates formed immediately as hydrothermal fluids vent into the ocean in this location. The 9 km off-axis sediment trap samples show no evidence of the Besnus transition which I interpret as either aggregation and settling or dissolution of pyrrhotite with distance from the ridge axis. In these samples the Verwey transition is smoothed, curved, and shifted relative to that observed in samples collected closer to the vents, indicating potential maghemitization (Özdemir & Dunlop, 2010) or cation substitution in magnetite (Jackson & Moskowitz, 2020).

Prior work on hydrothermally-derived particles has focused on synchrotron radiation, X-ray diffraction, or

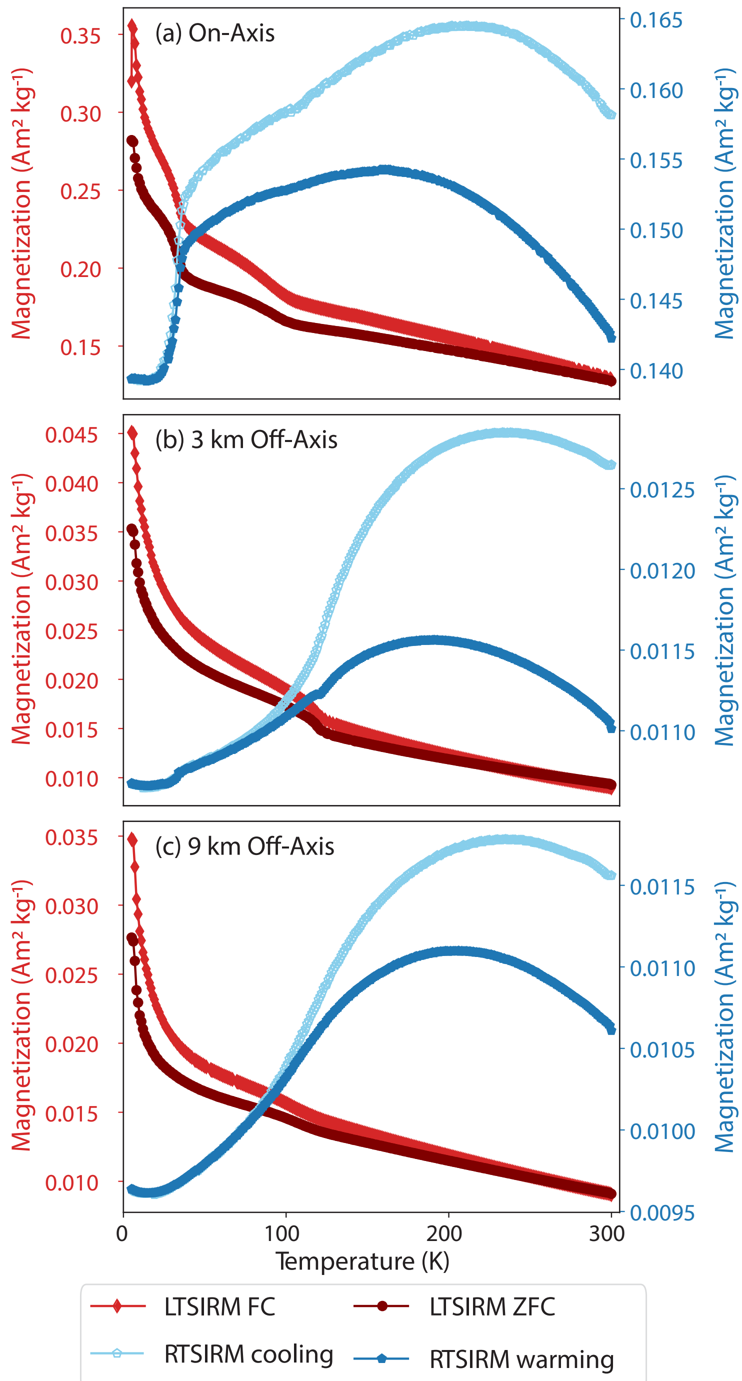

Figure 2. LT (red y-axis) and RT (blue y-axis) SIRM results from representative samples at each location: (a) on-axis, (b) 3 km off-axis, and (c) 9 km off-axis.

X-ray fluorescence analyses for mineralogical characterization; however, magnetic measurements offer a highly sensitive alternative for characterizing these typically low mass samples for the Fe-minerals of great interest. Ongoing interpretations of the data collected during this IRM Fellowship as part of my PhD is providing invaluable insight into the changing mineralogy of particles formed during the evolution of mid-ocean ridge basalt-hosted hydrothermal plumes.

Acknowledgments

I would like to thank Max Brown, Peat Solheid, Plinio Jaqueto, and Josh Feinberg for their assistance and help-

ful discussions during my visit at the IRM. A special thanks to Laurence Coogan and Sarah Slotznick for their ongoing assistance in this project. I am appreciative of the efforts by Ocean Networks Canada and Steve Mihaly especially in collecting the samples used in this study.

References

Fitzsimmons, J. N., John, S. G., Marsay, C. M., Hoffman, C. L., Nicholas, S. L., Toner, B. M., German, C. R., & Sherrell, R. M. (2017). Iron persistence in a distal hydrothermal plume supported by dissolved-particulate exchange. Nature Geoscience, 10(3), 195–201. https://doi.org/10.1038/ngeo2900

Jackson, M. J., & Moskowitz, B. (2020). On the distribution of Verwey transition temperatures in natural magnetites. Geophysical Journal International, 224(2), 1314–1325. https://doi.org/10.1093/gji/ggaa516

Juniper, S. K., Thornborough, K., Douglas, K., & Hillier, J. (2019). Remote monitoring of a deep-sea marine protected area: The Endeavour Hydrothermal Vents. Aquatic Conservation: Marine and Freshwater Ecosystems, 29(S2), 84–102. https://doi.org/10.1002/aqc.3020

Mottl, M. J., & McConachy, T. F. (1990). Chemical processes in buoyant hydrothermal plumes on the East Pacific Rise near 21°N. Geochimica et Cosmochimica Acta, 54(7), 1911–1927. https://doi.org/10.1016/0016-7037(90)90261-I

Özdemir, Ö., & Dunlop, D. J. (2010). Hallmarks of maghemitization in low-temperature remanence cycling of partially oxidized magnetite nanoparticles. Journal of Geophysical Research, 115(B2), 1–10. https://doi.org/10.1029/2009jb006756

Peters, C., & Dekkers, M. J. (2003). Selected room temperature magnetic parameters as a function of mineralogy, concentration and grain size. Physics and Chemistry of the Earth, 28(16–19), 659–667. https://doi.org/10.1016/S1474-7065(03)00120-7

Speer, K. G., Maltrud, M. E., & Thurnherr, A. M. (2002). A global view of dispersion on the mid-ocean ridge. Energy and Mass Transfer in Marine Hydrothermal Systems, 89(November), 263–278.

Tagliabue, A., Bowie, A. R., Boyd, P. W., Buck, K. N., Johnson, K. S., & Saito, M. A. (2017). The integral role of iron in ocean biogeochemistry. Nature, 543(7643), 51–59. https://doi.org/10.1038/nature21058

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.

Archeomag

Garcia-Pimentel, A., R. Cejudo, A. Goguitchaichvili, M. Cervantes-Solano, A. Pelz, R. Garcia-Ruiz, J. Morales, and F. Bautista (2023), Integrated archaeomagnetic and radiometric study of pre-Hispanic fireplace at El Ocote archaeological site (Aguascalientes, Mexico), Boletin De La Sociedad Geologica Mexicana, 75(1), doi:10.18268/BSGM2023v75n1a231122.

Molla, L. D., A. Aranburu, J. J. Villalain, F. Garcia-Garmilla, J. A. Uriarte, A. Zabaleta, A. Bodego, M. L. de Guevara, M. Monge-Ganuzas, and I. Antiguedad (2023), Why Did Red Ereno Limestone Go Red? Linking Scientific Knowledge and Geoheritage Story-Telling (Basque Country, Spain), Geoheritage, 15(3), doi:10.1007/s12371-023-00856-3.

Environmental Magnetism

Alekseev, A. O., P. A. Shary, and V. V. Malyshev (2023), Magnetic susceptibility of soils as an ambiguous climate proxy for paleoclimate reconstructions, Quaternary International, 661, 10-21, doi:10.1016/j.quaint.2023.04.002.

Bautista, F., D. Bautista-Hernandez, A. Pacheco, A. Goguitchaichvili, J. Morales, and A. Gallegos-Tavera (2023), An automated monitoring system of urban pollution using geochemical and magnetic parameters, Boletin De La Sociedad Geologica Mexicana, 75(2), doi:10.18268/BSGM-2023v75n2a100523.

Buynevich, I. V., H. Tonisson, U. Suursaar, D. Pupienis, O. V. Davydov, A. Kont, V. Palginomm, O. Koit, and K. Luik (2023), Diverse erosional indicators along a rapidly retreating Holocene strandplain margin, leeward Hiiumaa Island, Estonia, Baltica, 36(1), 79-88, doi:10.5200/baltica.2023.1.7.

Cheng, L. Q., L. H. Yang, H. Long, J. R. Zhang, X. D. Miao, Y. B. Wu, M. W. Lan, Y. G. Song, and Z. B. Dong (2023), Late Holocene change in South Asian monsoons and their influences on human activities in the southern Tibetan Plateau, Catena, 228, doi:10.1016/j.catena.2023.107153.

Chorley, H., et al. (2022), East Antarctic Ice Sheet variability during the middle Miocene Climate Transition captured in drill cores from the Friis Hills, Transantarctic Mountains, Geological Society of America Bulletin, 135(4-5), 1503-1529, doi:10.1130/b36531.1.

Gao, F. Y., et al. (2023), Rapid retreat of the East Asian summer monsoon on the western Chinese loess Plateau during the middle to late Holocene and its environmental and societal implications, Catena, 231, doi:10.1016/j.catena.2023.107307.

Guo, J., J. S. Shi, C. Song, Q. Y. Dong, and W. Wang (2023),

Understanding the characteristics of loess strata and quaternary climate changes in Luochuan, Shaanxi Province, China, through core analysis, Open Geosciences, 15(1), doi:10.1515/geo-2022-0502.
Khan, A. A., J. B. Zan, X. M. Fang, W. L. Zhang, and U. F. Jadoon (2023), Global warming drove the Mid-Miocene climate humidification in the northern Tibetan Plateau, Global and Planetary Change, 226, doi:10.1016/j.gloplacha.2023.104135.
Ling, Z. Y., J. H. Yang, Z. Q. Wang, J. H. Jin, D. S. Xia, S. L. Yang, X. Wang, and F. H. Chen (2023), Spatiotemporal differences in Holocene climate change in the Yarlung Tsangpo catchment, southern Tibetan Plateau, reconstructed from two sandy loess sequences, Palaeogeography Palaeoclimatology Palaeoecology, 616, doi:10.1016/j.palaeo.2023.111473.
Liu, J. X., T. Y. Xu, Q. Zhang, X. X. Yu, Y. H. Wu, Q. S. Liu, and X. F. Shi (2023), Exploring Spatiotemporal Paleoenvironmental and Paleoceanographic Changes on the Continental Shelf Using Authigenic Greigite: A Case Study From the East China Sea, Paleoceanography and Paleoclimatology, 38(6), doi:10.1029/2023pa004621.
Lukic, T., et al. (2023), Initial results of the colorimetric indices of the oldest exposed pedocomplex (Titel loess plateau, Serbia), Geologia Croatica, 76(2), doi:10.4154/gc.2023.05.
Ma, C. Y., X. Liu, S. Q. Li, C. C. Li, and R. L. Zhang (2023), Accuracy evaluation of hyperspectral inversion of environmental parameters of loess profile, Environmental Earth Sciences, 82(10), doi:10.1007/s12665-023-10873-8.
Minyuk, P. S., D. S. Pozhidaeva, O. T. Sotskaya, V. V. Akinin, and M. A. Morozova (2023), Magnetic-Mineralogical Anomalies at the Pleistocene-Holocene Boundary in Lacustrine Sediments of Northeastern Russia, Doklady Earth Sciences, 510(2), 453-458, doi:10.1134/s1028334x23600342.
Nag, D., B. Phartiyal, S. Agrawal, P. Kumar, R. Sharma, K. Kumar, A. Sharma, and M. Joshi (2023), Westerly-monsoon variations since the last deglaciation from semi-arid Ladakh region, Trans Himalaya, India, Palaeogeography Palaeoclimatology Palaeoecology, 618, doi:10.1016/j.palaeo.2023.111515.
Nag, D., B. Phartiyal, S. Agrawal, P. Kumar, R. Sharma, K. Kumar, A. Sharma, and M. Joshi (2023), Westerly-monsoon variations since the last deglaciation from semi-arid Ladakh region, Trans Himalaya, India, Palaeogeography Palaeoclimatology Palaeoecology, 618, doi:10.1016/j.palaeo.2023.111515.
Nie, Y. F., H. C. Wu, S. Satolli, E. C. Ferre, M. A. Shi, Q. Fang, Y. Xu, S. H. Zhang, H. Y. Li, and T. S. Yang (2023), Late Miocene to Present Paleoclimatic and Paleoenvironmental Evolution of the South China Sea Recorded in the Magneto-Cyclostratigraphy of IODP Site U1505, Paleoceanography and Paleoclimatology, 38(2), doi:10.1029/2022pa004547.
Niezabitowska, D. K., and R. Szaniawski (2023), The Holy Cross Mountains (Poland) terranes palaeoposition and depositional environment in Silurian-new insights from rock magnetic studies, Geophysical Journal International, 234(3), 1531-1549, doi:10.1093/gji/ggad129.
Ning, W. X., J. B. Zan, F. Heller, X. M. Fang, Y. O. Zhang, W. L. Zhang, J. Kang, and M. M. Shen (2023), Magnetic Proxy of Eurasian Loess Revealing Enhanced Physical Erosion Since the Mid-Pleistocene Transition, Geophysical Research Letters, 50(13), doi:10.1029/2023gl104411.
Ojala, A. E. K., H. Nguyen-Van, I. Unkel, D. Nguyen-Thuy, T. Nguyen-Dinh, Q. Do-Trong, C. Q. Sun, P. E. Sauer, and A. Schimmelmann (2023), High-resolution similar to 55 ka paleomagnetic record of Bien Ho maar lake sediment from Vietnam in relation to detailed C-14 and Cs-137 geochronologies, Quaternary Geochronology, 76, doi:10.1016/j.quageo.2023.101443.
Sanchez-Duque, A., F. Bautista, R. Cejudo, M. Cervantes-Solano, and A. Goguitchaichvili (2023), Magnetic particles as pollution indicators at the Aburr? valley (Colombia), Boletin De La Sociedad Geologica Mexicana, 75(1), doi:10.18268/BSGM2023v75n1a181122.
Sebastian, T., B. N. Nath, P. Miriyala, P. Linsy, and M. Kocherla (2023), Climatic control on detrital sedimentation in the continental margin off Chennai, western Bay of Bengal-A 42 kyr record, Palaeogeography Palaeoclimatology Palaeoecology, 609, doi:10.1016/j.palaeo.2022.111313.
Shi, W., H. C. Jiang, L. J. Liang, H. Y. Xu, and J. W. Fan (2023), Factors controlling the spatiotemporal variability of dust magnetic susceptibility across the Chinese loess Plateau and eastern Tibetan Plateau, Quaternary International, 661, 1-9, doi:10.1016/j.quaint.2023.04.005.
Tosca, N. J., and B. M. Tutolo (2023), Hydrothermal vent fluid-seawater mixing and the origins of Archean iron formation, Geochimica Et Cosmochimica Acta, 352, 51-68, doi:10.1016/j.gca.2023.05.002.
Wang, X. S., et al. (2023), Interactions Between Depositional Regime and Climate Proxies in the Northern South China Sea Since the Last Glacial Maximum, Paleoceanography and Paleoclimatology, 38(3), doi:10.1029/2022pa004591.
Wang, Y. C., et al. (2023b), East Asian hydroclimate responses to the Eocene-Oligocene transition in the Weihe Basin, central China, Palaeogeography Palaeoclimatology Palaeoecology, 615, doi:10.1016/j.palaeo.2023.111436.
Zhang, B., Z. Zhang, X. Q. Meng, J. D. Liu, T. F. Xia, B. Y. Guo, B. Q. Zhou, and J. F. Ji (2023a), Holocene synchronous evolution of precipitation and soil moisture as evidenced by paleosol deposits in the Ili Basin, Central Asia, Palaeogeography Palaeoclimatology Palaeoecology, 615, doi:10.1016/j.palaeo.2023.111466.
Zhang, T. W., X. Q. Yang, J. Peng, Q. X. Zhou, J. Toney, H. Y. Liu, and Y. X. Xie (2023), Decoupled Indian Summer Monsoon Intensity and Effective Moisture Since the Last Glaciation in Southwest China, Geophysical Research Letters, 50(10), doi:10.1029/2023gl103297.
Zhang, X. Z., Y. H. Wang, G. X. Li, Y. Liu, and C. H. Xiao (2023), Authigenic greigite in late MIS 3 sediments: Implications for the Yellow Sea Cold Water Mass and Yellow Sea Warm Current evolution, Marine Geology, 460, doi:10.1016/j.margeo.2023.107057.

Extraterrestrial, High Pressure and Planetary Magnetism

Collado-Vega, Y. M., P. Dredger, R. E. Lopez, S. Khurana, L. Rastaetter, D. Sibeck, and M. Anastopulos (2023), Magnetopause Standoff Position Changes and Geosynchronous Orbit Crossings: Models and Observations, Space Weather-the International Journal of Research and Applications, 21(6), doi:10.1029/2022sw003212.
Manelski, H. T., R. Y. Sheppard, A. A. Fraeman, R. C. Wiens, J. R. Johnson, E. B. Rampe, J. Frydenvang, N. L. Lanza, and O. Gasnault (2023), Compositional Variations in Sedimentary Deposits in Gale Crater as Observed by ChemCam Passive and Active Spectra, Journal of Geophysical Research-Planets, 128(3), doi:10.1029/2022je007706.
Maurel, C., and J. Gattacceca (2023), Estimating Paleointensities From Chemical Remanent Magnetizations of Magnetite Using Non-Heating Methods, Journal of Geophysical Research-Planets, 128(6), doi:10.1029/2023je007779.
Siersch, N. C., G. Criniti, A. Kurnosov, K. Glazyrin, and D. Antonangeli (2023), Thermal equation of state of Fe3O4 magnetite up to 16 GPa and 1100 K, American Mineralo-

gist, 108(7), 1322-1329, doi:10.2138/am-2022-8571.
Vervelidou, F., B. P. Weiss, and F. Lagroix (2023), Hand Magnets and the Destruction of Ancient Meteorite Magnetism, Journal of Geophysical Research-Planets, 128(4), doi:10.1029/2022je007464.

Fundamental and Applied Rock Magnetism

Chang, L., Z. W. Pei, P. F. Xue, S. S. Wang, Z. P. Wang, W. Krijgsman, and M. J. Dekkers (2023), Self-Reversed Magnetization in Sediments Caused by Greigite Alteration, Geophysical Research Letters, 50(12), doi:10.1029/2023gl103885.
Cych, B., M. Morzfeld, D. Heslop, S. Maher, J. Gee, and L. Tauxe (2023), Thermal Resolution of Unblocking Temperatures (TROUT): A Method for "Unmixing" Multi-Component Magnetizations, Geochemistry Geophysics Geosystems, 24(6), doi:10.1029/2023gc010920.
Devienne, J., T. A. Berndt, W. Williams, and L. Nagy (2023), Magnetic Recording Stability of Taenite-Containing Meteorites, Geophysical Research Letters, 50(12), doi:10.1029/2022gl102602.
Kars, M., C. Aubourg, and J. P. Pozzi (2023), Impact of temperature increase on the formation of magnetic minerals in shales. The example of Tournemire, France, Physics of the Earth and Planetary Interiors, 338, doi:10.1016/j.pepi.2023.107021.
Lowe, M., B. Mather, C. Green, T. A. Jordan, J. Ebbing, and R. Larter (2023), Anomalously High Heat Flow Regions Beneath the Transantarctic Mountains and Wilkes Subglacial Basin in East Antarctica Inferred From Curie Depth, Journal of Geophysical Research-Solid Earth, 128(1), doi:10.1029/2022jb025423.
Shcherbakov, V. P., and N. K. Sycheva (2023), Micromagnetic Calculations of the Domain Structure of Submicron- and Micron-Sized Magnetite Grains, Izvestiya-Physics of the Solid Earth, 59(2), 283-300, doi:10.1134/s106935132302012x.
Tselebrovskiy, A. N., V. I. Maksimochkin, A. A. Tatarintsev, Y. A. Alekhina, and R. A. Grachev (2023), Properties of Red Sea Pillow-Basalt Titanomagnetite at Different Distances from the Crust, Izvestiya-Physics of the Solid Earth, 59(1), 89-101, doi:10.1134/s1069351323010081.

Geomagnetism, Paleointensity and Records of the Geomagnetic Field

Cych, B., L. Tauxe, G. Cromwell, J. Sinton, and A. A. P. Koppers (2023), Changes in Non-Dipolar Field Structure Over the Plio-Pleistocene: New Paleointensity Results From Hawai'i Compared to Global Data Sets, Journal of Geophysical Research-Solid Earth, 128(6), doi:10.1029/2023jb026492.
Goguitchaichvili, A., J. Morales, R. Garcia-Ruiz, F. Montejo, V. Kravchinsky, R. Cejudo, M. Cervantes, and C. Reina (2023), Possible evidence for geomagnetic intensity anomaly around 5500 BP from archaeomagnetic analyses of San Jacinto pottery, Caribbean Colombia, Physics of the Earth and Planetary Interiors, 341, doi:10.1016/j.pepi.2023.107061.
Goguitchaichvili, A., J. Morales, R. Trindade, and V. A. Kravchinsky (2023), Testing the Mesozoic Dipole Low in the Early Cretaceous with multispecimen paleointensities from the Parana Flood Basalts, Southern Brazil, Cretaceous Research, 148, doi:10.1016/j.cretres.2023.105539.
Lloyd, S., A. Biggin, M. Hill, L. De Groot, N. Suttie, J. Morris, H. Boehnel, and J. Shaw (2023), The use of high frequency microwaves in absolute palaeomagnetic intensity experiments, Frontiers in Earth Science, 11, doi:10.3389/feart.2023.1188528.
Mahgoub, A. N., M. Korte, and S. Panovska (2023), Characteristics of the Matuyama-Brunhes Magnetic Field Reversal Based on a Global Data Compilation, Journal of Geophysical Research-Solid Earth, 128(2), doi:10.1029/2022jb025286.
Mahgoub, A. N., M. Korte, and S. Panovska (2023), Global Geomagnetic Field Evolution From 900 to 700 ka Including the Matuyama-Brunhes Reversal, Journal of Geophysical Research-Solid Earth, 128(6), doi:10.1029/2023jb026593.
Moncinhatto, T. R., W. P. de Oliveira, M. B. Haag, G. A. Hartmann, J. F. Savian, W. Poletti, D. Brandt, C. A. Sommer, A. T. Caselli, and R. I. F. Trindade (2023), Palaeosecular variation in Northern Patagonia recorded by 0-5 Ma Caviahue-Copahue lava flows, Geophysical Journal International, 234(3), 1640-1654, doi:10.1093/gji/ggad166.
Reilly, B. T., J. S. Stoner, S. Olafsdottir, A. Jennings, R. Hatfield, G. B. Kristjansdottir, and A. Geirsdottir (2023), The Amplitude and Timescales of 0-15 ka Paleomagnetic Secular Variation in the Northern North Atlantic, Journal of Geophysical Research-Solid Earth, 128(6), doi:10.1029/2023jb026891.
Robert, B., F. Corfu, M. Domeier, and O. Blein (2023), Evidence for large disturbances of the Ediacaran geomagnetic field from West Africa, Precambrian Research, 394, doi:10.1016/j.precamres.2023.107095.
Schanner, M., L. Bohsung, C. Fischer, M. Korte, and M. Holschneider (2023), The global geomagnetic field over the historical era: what can we learn from ship-log declinations?, Earth Planets and Space, 75(1), doi:10.1186/s40623-023-01852-1.
Tselebrovskiy, A. N., V. I. Maksimochkin, A. A. Tatarintsev, Y. A. Alekhina, and R. A. Grachev (2023), Properties of Red Sea Pillow-Basalt Titanomagnetite at Different Distances from the Crust, Izvestiya-Physics of the Solid Earth, 59(1), 89-101, doi:10.1134/s1069351323010081.

Magnetic Fabrics and Anisotropy

Acosta, A. C. M., L. M. Florisbal, J. F. Savian, B. L. Waichel, M. S. da Silva, and R. I. F. da Trindade (2023), Emplacement dynamics of the plumbing system and lava pile of the Parana Magmatic Province in Morro da Igreja, Santa Catarina, Brazil, Journal of Geodynamics, 157, doi:10.1016/j.jog.2023.101974.
Bolle, O., M. Corsini, H. Diot, O. Laurent, and R. Melis (2023), Late-Orogenic Evolution of the Southern European Variscan Belt Constrained by Fabric Analysis and Dating of the Camarat Granitic Complex and Coeval Felsic Dykes (Maures-Tanneron Massif, SE France), Tectonics, 42(4), doi:10.1029/2022tc007310.
Chatterjee, S., S. Singh, Shalivahan, and S. Mondal (2023), Magneto-tectonic framework of the East Indian Shield: The present state of knowledge, Journal of Asian Earth Sciences, 251, doi:10.1016/j.jseaes.2023.105667.
Lu, H. J., X. W. Cao, M. G. Malusa, Z. Y. Zhang, J. W. Pan, and H. B. Li (2023), Slowing Extrusion Tectonics and Accelerated Uplift of Northern Tibet Since the Mid-Miocene, Tectonics, 42(8), doi:10.1029/2023tc007801.
Nahas, I., L. Goncalves, C. C. Goncalves, and M. I. B. Raposo (2023), Unraveling the relationship between a tonalitic pluton and shear zones: Insights from magnetic fabrics and microstructures of the Alto Maranha similar to o batholith, Mineiro belt, southern Sa similar to o Francisco craton, Journal of Structural Geology, 172, doi:10.1016/j.jsg.2023.104887.
Neves, S. P., C. X. G. Dantas, T. A. Carrino, G. Mariano, and P. D. Correia (2023), Multiple fabrics in the Tavares pluton (NE Brazil): Insights on the interplay between emplacement mechanism, internal magmatic processes, and

tectonic deformation, Journal of Structural Geology, 167, doi:10.1016/j.jsg.2023.104793.
Roxerova, Z., M. Machek, V. K. Kusbach, and A. Vavrova (2023), Strain Localization: Analog Modeling and Anisotropy of Magnetic Susceptibility, Geochemistry Geophysics Geosystems, 24(2), doi:10.1029/2022gc010630.
Simon-Muzas, A., A. Casas-Sainz, R. Soto, E. Beamud, and J. Gisbert (2023), Dyke or pipe? Contributions of magnetic fabrics to the reconstruction of the geometry of an eroded subvolcanic body (Cadi basin, Pyrenees), Journal of Structural Geology, 172, doi:10.1016/j.jsg.2023.104891.
Zamani, N., G. W. Heij, E. C. Ferre, M. A. Murphy, and B. Bagley (2023), High-Velocity Slip and Thermal Decomposition of Carbonates: Example From the Heart Mountain Slide Ultracataclasites, Wyoming, Journal of Geophysical Research-Solid Earth, 128(5), doi:10.1029/2022jb026185.

Magnetic Microscopy, Instrumentation and Techniques

Kodama, K. (2023), Analysis of inhomogeneous magnetization using a spinner magnetometer, Frontiers in Earth Science, 11, doi:10.3389/feart.2023.1212367.
Kosters, M. E., R. A. de Boer, F. Out, D. I. Cortes-Ortuno, and L. V. de Groot (2023), Unraveling the Magnetic Signal of Individual Grains in a Hawaiian Lava Using Micromagnetic Tomography, Geochemistry Geophysics Geosystems, 24(4), doi:10.1029/2022gc010462.
Lee, M. D., S. McEnroe, Z. Pastore, N. Church, and P. Schmidt (2023), Microscale Magnetic Inversion of Remanent Magnetization Mineral Sources From the Black Hill Norite, South Australia, Geochemistry Geophysics Geosystems, 24(5), doi:10.1029/2022gc010796.
Li, G. L., S. Liu, K. Shi, H. L. Zhang, B. X. Zuo, D. Zhu, and X. Y. Hu (2023a), Transformations of borehole magnetic data in the frequency domain and estimation of the total magnetization direction: A case study from the Mengku iron-ore deposit, Northwest China, Geophysics, 88(1), B1-B19, doi:10.1190/geo2022-0216.1.
Tominaga, M., A. Beinlich, E. A. Lima, P. Pruett, N. R. Vento, and B. P. Weiss (2023), High-Resolution Magnetic-Geochemical Mapping of the Serpentinized and Carbonated Atlin Ophiolite, British Columbia: Toward Establishing Magnetometry as a Monitoring Tool for In Situ Mineral Carbonation, Geochemistry Geophysics Geosystems, 24(4), doi:10.1029/2022gc010730.

Magnetic Mineralogy and Petrology, Other

Bian, G., O. Ageeva, V. Roddatis, C. Li, T. J. Pennycook, G. Habler, and R. Abart (2023), Crystal Structure Controls on Oriented Primary Magnetite Micro-Inclusions in Plagioclase From Oceanic Gabbro, Journal of Petrology, 64(3), doi:10.1093/petrology/egad008.
Pope, D. J., A. E. Clark, M. P. Prange, and K. M. Rosso (2023), Magnetic contributions to corundum-eskolaite and corundum-hematite phase equilibria: A DFT cluster expansion study, American Mineralogist, 108(6), 1109-1116, doi:10.2138/am-2022-8584.
Retallack, G. J. (2023), Comment on "Kawahara, H., Yoshida, H., Yamamoto, K., Katsuta, N., Nishimoto, S., Umemura, A., Kuma, R., 2022. Hydrothermal formation of Fe-oxide bands in zebra rocks from northern Western Australia. Chemical Geology 590 (2022), 120699", Chemical Geology, 633, doi:10.1016/j.chemgeo.2022.121105.
Wang, X. X., et al. (2023b), Cenozoic morphotectonic evolution of the northeasternmost Tibetan Plateau: Evidence from detrital thermochronology, Global and Planetary Change, 225, doi:10.1016/j.gloplacha.2023.104131.
Zhang, S. X., Y. L. Li, W. Leng, and M. Gurnis (2023), Photoferrotrophic Bacteria Initiated Plate Tectonics in the Neoarchean, Geophysical Research Letters, 50(13), doi:10.1029/2023gl103553.

Magneto- and Cycle-tratigraphy

Blazejowski, B., A. Pszczolkowski, J. Grabowski, H. Wierzbowski, J. F. Deconinck, E. Olempska, A. Teodorski, and J. Nawrocki (2023), Integrated stratigraphy and clay mineralogy of the Owadow-Brzezinki section (Lower-Upper Tithonian transition, central Poland): implications for correlations between the Boreal and the Tethyan domains and palaeoclimate, Journal of the Geological Society, 180(2), doi:10.1144/jgs2022-073.
Deino, A. L., L. Gibert, and O. Gorge (2023), Using Radiometric Dating, Magnetostratigraphy, and Tephrostratigraphy to Calibrate Rates of Hominin Evolution in the East African Rift, Elements, 19(2), 88-95, doi:10.2138/gselements.19.2.88.
Fetisova, A. M., R. V. Veselovskiy, K. A. Sirotin, V. K. Golubev, and D. V. Rud'ko (2023b), Paleomagnetism and Cyclostratigraphy of the Permian-Triassic Boundary Interval of the Staroe Slukino Section, Vladimir Region, Izvestiya-Physics of the Solid Earth, 59(2), 254-266, doi:10.1134/s1069351323020064.
Fetisova, A. M., V. K. Golubev, R. V. Veselovskiya, and Y. P. Balabanov (2022), Paleomagnetism and Magnetostratigraphy of Permian-Triassic Reference Sections in the Central Russian Plate: Zhukov Ravine, Slukino, and Okskiy Siyezd, Russian Geology and Geophysics, 63(10), 1162-1176, doi:10.2113/rgg20214336.
Horacek, M., and E. Gradinaru (2023), The Spathian-Anisian (Lower-Middle Triassic) Boundary in the candidate GSSP section at Des,li Caira, Romania: Review of existing data, new findings, and comparison with other candidates, Palaeogeography Palaeoclimatology Palaeoecology, 613, doi:10.1016/j.palaeo.2023.111407.
Hounslow, M. W., and R. Gallois (2023), Magnetostratigraphy of the Mercia Mudstone Group (Devon, UK): implications for regional relationships and chronostratigraphy in the Middle to Late Triassic of Western Europe, Journal of the Geological Society, 180(4), doi:10.1144/jgs2022-173.
Jiang, Z. R., B. Ran, Z. W. Li, S. G. Liu, Z. J. Wang, Y. Y. Han, F. Lv, and X. Jiang (2023), A Late Triassic depositional age for the Xujiahe formation, Sichuan basin: Implications for the closure of the Paleo-Tethys Ocean, Marine and Petroleum Geology, 155, doi:10.1016/j.marpetgeo.2023.106346.
Ren, C. Z., Q. Fang, H. C. Wu, J. C. Fang, S. H. Zhang, T. S. Yang, and H. Y. Li (2023), Cyclostratigraphic correlation of Middle-Late Ordovician sedimentary successions between the South China Block and Tarim Basin with paleoclimatic and geochronological implications, Journal of Asian Earth Sciences, 246, doi:10.1016/j.jseaes.2023.105577.
Shin, J. Y., W. Kim, Y. B. Seong, and L. Chang (2023), Quaternary Magnetic Stratigraphy of Deep-Sea Sediments in the Western North Pacific: Influences of Paleomagnetic Recording Efficiency and Lock-In Delay, Journal of Geophysical Research-Solid Earth, 128(4), doi:10.1029/2022jb025490.
Sun, L., C. L. Deng, T. Deng, Y. F. Kong, B. L. Wu, S. Z. Liu, Q. Li, and G. Liu (2023), Magnetostratigraphy of the Oligocene and Miocene of the Linxia Basin northwestern China, Palaeogeography Palaeoclimatology Palaeoecology, 613, doi:10.1016/j.palaeo.2023.111404.
Zeeden, C., A. Ulfers, S. Pierdominici, M. S. Abadi, M. Vinnepand, T. Grelle, K. Hesse, K. Leu, and T. Wonik (2023), Downhole logging data for time series analysis and cyclostratigraphy, Earth-Science Reviews, 241, doi:10.1016/j.earscirev.2023.104436.

Paleomagnetism

Burton-Johnson, A., and A. B. Cullen (2023), Continental rifting in the South China Sea through extension and high heat flow: An extended history, Gondwana Research, 120, 235-263, doi:10.1016/j.gr.2022.07.015.

Cengiz, M. (2023), Palaeomagnetic evidence of the deformation of the Pontides during the closure of the Intra-Pontide Ocean in the early Cretaceous, Geophysical Journal International, 234(3), 1835-+, doi:10.1093/gji/ggad167.

Domeier, M., B. Robert, J. G. Meert, E. V. Kulakov, P. J. A. McCausland, R. I. F. Trindade, and T. H. Torsvik (2023), The enduring Ediacaran paleomagnetic enigma, Earth-Science Reviews, 242, doi:10.1016/j.earscirev.2023.104444.

Ernesto, M., and M. I. B. Raposo (2023), The Late Cretaceous alkaline magmatism in the SE Brazilian coast: new paleomagnetic data and age constraints, Brazilian Journal of Geology, 53(2), doi:10.1590/2317-4889202320220061.

Ernst, R. E., D. P. Gladkochub, U. Soderlund, T. V. Donskaya, S. A. Pisarevsky, A. M. Mazukabzov, and H. El Bilali (2023), Identification of the ca. 720 Ma Irkutsk LIP and its plume centre in southern Siberia: The initiation of Laurentia-Siberia separation, Precambrian Research, 394, doi:10.1016/j.precamres.2023.107111.

Fetisova, A. M., R. V. Veselovskiy, and V. K. Golubev (2023), A New 254 Ma Paleomagnetic Pole of the East European Platform: The Moscow Syneclise, the Sukhoborka and Sosnovka Sections, Doklady Earth Sciences, 510(2), 475-480, doi:10.1134/s1028334x2360038x.

Gallo, L. C., et al. (2023), Embracing Uncertainty to Resolve Polar Wander: A Case Study of Cenozoic North America, Geophysical Research Letters, 50(11), doi:10.1029/2023gl103436.

Gordienko, I. V., D. V. Metelkin, V. S. Lantseva, and A. L. Elbaev (2023), The Kataevo Island Arc System of the Paleoasian Ocean (Transbaikalia): Composition, Age, Paleomagnetism, and Formation Geodynamic Settings, Russian Geology and Geophysics, 64(3), 319-333, doi:10.2113/rgg20224519.

Hoffman, P. F. (2023), Snowball earth: The African legacy, Journal of African Earth Sciences, 205, doi:10.1016/j.jafrearsci.2023.104976.

Hosoi, J., Y. Tanii, M. Okada, and Y. Haneda (2023), Rotated Transtensional Basins Formed During Back-Arc Spreading in Japan: Simultaneous Rapid Tectonic Rotation and Basin Subsidence, Tectonics, 42(6), doi:10.1029/2022tc007642.

Huang, W. T., P. C. Lippert, P. W. Reiners, J. Quade, P. Kapp, M. Ganerod, Z. J. Guo, and D. J. J. van Hinsbergen (2023), Reply to comment by Zhao et al. on "Hydrothermal events in the Linzizong Group: Implications for Paleogene exhumation and paleoaltimetry of the southern Tibetan Plateau", Earth and Planetary Science Letters, 603, doi:10.1016/j.epsl.2022.117973.

Jiao, X. W., T. S. Yang, W. W. Bian, S. Wang, J. H. Ma, W. X. Peng, S. H. Zhang, H. C. Wu, and H. Y. Li (2023), Middle Jurassic Paleolatitude of the Tethyan Himalaya: New Insights Into the Evolution of the Neo-Tethys Ocean, Journal of Geophysical Research-Solid Earth, 128(5), doi:10.1029/2023jb026659.

Kadam, N. B., S. J. Sangode, M. Venkateshwarlu, D. C. Meshram, Y. R. Kulkarni, F. Badesab, J. Singh, and S. S. Gudadhe (2023), Acquisition of natural remanence in the basaltic laterites of Deccan volcanic province (India): Implications to palaeomagnetic studies in laterites, Catena, 228, doi:10.1016/j.catena.2023.107154.

Kasbohm, J., B. Schoene, S. A. Maclennan, D. A. D. Evans, and B. P. Weiss (2023), Paleogeography and high-precision geochronology of the Neoarchean Fortescue Group, Pilbara, Western Australia, Precambrian Research, 394, doi:10.1016/j.precamres.2023.107114.

Kosik, S., T. Hasegawa, M. Danisik, K. Nemeth, M. Okada, B. Friedrichs, and A. K. Schmitt (2023), Multi-method constraints on the age and timescale of silicic small-volume eruptions of Puketerata Volcanic Complex, Taupo Volcanic Zone, New Zealand, Earth Planets and Space, 75(1), doi:10.1186/s40623-023-01861-0.

Kurazhkovskii, A. Y., N. A. Kurazhkovskaya, and B. I. Klain (2022), Spectrum of Quaziperiodic Variations in Paleomagnetic Activity in the Phanerozoic, Russian Geology and Geophysics, 63(11), 1261-1269, doi:10.2113/rgg20214403.

Li, X., H. N. Chang, S. Y. Huang, C. M. Luo, Y. J. Duan, H. Zhang, J. K. Xia, Z. Q. Zhong, and L. Y. Wei (2023), Reconstruction of the proto-type basin and tectono-paleogeography of Tarim Block in the Mesozoic, Frontiers in Earth Science, 11, doi:10.3389/feart.2023.1121428.

Li, Y. P., and D. M. Robinson (2023), The India-Asia collision results from two possible pre-collisional crustal configurations of northern Greater India, Earth and Planetary Science Letters, 610, doi:10.1016/j.epsl.2023.118098.

Li, Z. S., X. T. Ma, W. An, R. N. Mitchell, Q. Z. Li, Z. W. Lan, Y. X. Dong, Y. Zhang, and J. X. Li (2023b), Provenance transition of the Mesoproterozoic-Neoproterozoic Xuhuai Basin: Constraining the accretion of the Northern Qinling Terrane with the North China Craton, Journal of Asian Earth Sciences, 251, doi:10.1016/j.jseaes.2023.105675.

Mukherjee, S., and R. Vadlamani (2023), Early Mesoproterozoic (1.72-1.68 Ga) convergence between Bastar and Eastern Dharwar cratons along the Bhopalpatnam orogen, southcentral India and implication for paleogeography of supercontinent Columbia, Precambrian Research, 393, doi:10.1016/j.precamres.2023.107086.

Nikogosian, I. K., et al. (2023), The South Armenian Block: Gondwanan origin and Tethyan evolution in space and time, Gondwana Research, 121, 168-195, doi:10.1016/j.gr.2023.03.023.

Ojala, A. E. K., H. Nguyen-Van, I. Unkel, D. Nguyen-Thuy, T. Nguyen-Dinh, Q. Do-Trong, C. Q. Sun, P. E. Sauer, and A. Schimmelmann (2023), High-resolution similar to 55 ka paleomagnetic record of Bien Ho maar lake sediment from Vietnam in relation to detailed C-14 and Cs-137 geochronologies, Quaternary Geochronology, 76, doi:10.1016/j.quageo.2023.101443.

Reilly, B. T., J. S. Stoner, S. Olafsdottir, A. Jennings, R. Hatfield, G. B. Kristjansdottir, and A. Geirsdottir (2023), The Amplitude and Timescales of 0-15 ka Paleomagnetic Secular Variation in the Northern North Atlantic, Journal of Geophysical Research-Solid Earth, 128(6), doi:10.1029/2023jb026891.

Ren, Q., S. H. Zhang, M. C. Hou, A. Q. Chen, H. C. Wu, T. S. Yang, and H. Y. Li (2023), New Paleomagnetic Constraints on the Amalgamation of the Tuva and Mongolia Blocks From Late Carboniferous Andesites in the Mongolia Block, Tectonics, 42(4), doi:10.1029/2022tc007683.

Rodriguez-Trejo, A., L. M. Alva-Valdivia, and B. I. Garcia-Amador (2023), Paleomagnetism, rock magnetism and age determination of effusive and explosive Holocene volcanism in the Momotombo-Managua-Masaya region, Nicaragua, Journal of Volcanology and Geothermal Research, 437, doi:10.1016/j.jvolgeores.2023.107792.

Shen, Q., et al. (2023), Pulsed counterclockwise rotation of the southwestern Sichuan Basin in response to the India-Asia convergence during 128-42 Ma, Earth and Planetary Science Letters, 611, doi:10.1016/j.epsl.2023.118142.

Siravo, G., F. Speranza, and M. Mattei (2023), Paleomagnetic

Evidence for Pre-21 Ma Independent Drift of South Sardinia From North Sardinia-Corsica: "Greater Iberia" Versus Europe, Tectonics, 42(5), doi:10.1029/2022tc007705.

Song, P. P., L. Ding, L. Y. Zhang, F. L. Cai, Q. H. Zhang, Z. Y. Li, H. Q. Wang, M. K. Jafari, and M. Talebian (2023), Paleomagnetism From Central Iran Reveals Arabia-Eurasia Collision Onset at the Eocene/Oligocene Boundary, Geophysical Research Letters, 50(12), doi:10.1029/2023gl103858.

Thoram, S., et al. (2023), Nature and Origin of Magnetic Lineations Within Valdivia Bank: Ocean Plateau Formation by Complex Seafloor Spreading, Geophysical Research Letters, 50(13), doi:10.1029/2023gl103415.

Uno, K., H. Ohara, K. Furukawa, and T. Kanamaru (2023), Absence of Cretaceous hairpin in the apparent polar wander path of southwest Japan: consistency in paleomagnetic pole positions, Geoscience Letters, 10(1), doi:10.1186/s40562-023-00275-w.

Vinogradov, E. V., D. V. Metelkin, V. V. Abashev, V. A. Vernikovsky, N. Y. Matushkin, and N. E. Mikhaltsov (2023), Paleomagnetism of the Taseeva Group (Yenisei Ridge): on the Issue of the Geomagnetic Field Configuration at the Precambrian-Phanerozoic Boundary, Russian Geology and Geophysics, 64(5), 542-557, doi:10.2113/rgg20224542.

Wang, C., and R. N. Mitchell (2023), True polar wander in the Earth system, Science China-Earth Sciences, 66(6), 1165-1184, doi:10.1007/s11430-022-1105-2.

Wang, C., X. Q. Jing, and J. G. Meert (2023a), Neoproterozoic reorganization of the Circum-Mozambique orogens and growth of megacontinent Gondwana, Communications Earth & Environment, 4(1), doi:10.1038/s43247-023-00883-6.

Wang, R. M., C. C. Xing, B. Wen, X. B. Wang, K. W. Liu, T. Z. Huang, C. M. Zhou, and B. Shen (2023), The origin of cap carbonate after the Ediacaran glaciations, Global and Planetary Change, 226, doi:10.1016/j.gloplacha.2023.104141.

Wang, W. T., R. Huang, Y. Wu, K. Liu, Z. Q. Zhang, Y. P. Zhang, C. C. Liu, D. W. Zheng, and P. Z. Zhang (2023a), Cenozoic clockwise rotation of the northeastern Tibetan Plateau: Paleomagnetic evidence from volcanic sequences in the West Qinling Mountain, Global and Planetary Change, 224, doi:10.1016/j.gloplacha.2023.104097.

Xu, Y., S. H. Zhang, C. L. Zhang, X. T. Ye, Q. Ren, Y. J. Gao, H. Y. Li, T. S. Yang, and H. C. Wu (2023), New Early Neoproterozoic Paleomagnetic Constraints of the Northwestern China Blocks on the Periphery of Rodinia, Journal of Geophysical Research-Solid Earth, 128(2), doi:10.1029/2022jb024821.

Yasuda, Y. (2023), Paleomagnetic evidence for episodic construction of the Mamiyadake tephra ring, Earth Planets and Space, 75(1), doi:10.1186/s40623-023-01858-9.

Zhao, P., E. Appel, C. L. Deng, and B. Xu (2023), Bending of the Western Mongolian Blocks Initiated the Late Triassic Closure of the Mongol-Okhotsk Ocean and Formation of the Tuva-Mongol Orocline, Tectonics, 42(5), doi:10.1029/2022tc007475.

cont'd. from pg. 1...

workshop/discussion on topics of Justice, Equity, Diversity and Inclusivity: “Implementing JEDI in Rock Magnetism.”

IRM conferences also include keynote talks from speakers from disciplines distinct from rock magnetism, but complementary to problems investigated within our community, with the goal of stimulating curiosity and building bridges. The first keynote speaker was Tim Lyons (University of California-Riverside), who set the stage for the session on Iron Cycling, while the second keynote speaker was Emily Cooperdock (Brown University) whose talk on (U-Th)/He dating of magnetite complemented the session on paleomagnetism.

Before diving into workshop and session specifics, it's worth mentioning that almost all the talks were recorded and have been uploaded to the IRM's YouTube channel (https://www.youtube.com/channel/UCjzG-yAnzKHZneeSL1kFpmw) for everyone's viewing pleasure. Please note that the captioning on the videos is automatically generated through Zoom, and while it is sometimes comically non-accurate, it would be too onerous to adjust.

Pre-conference FORC Workshop

The pre-conference FORC workshop was introduced by IRM's Josh Feinberg, and occurred over almost the entirety of June 5th.

The first presentation was given by Andrew Roberts (Australian National University) and was titled “Fundamentals & Theory of FORCs”. Roberts provided an extensive overview of First-Order Reversal Curve diagrams, which helped emphasize the significance of FORC distributions, the different types of diagrams that can be measured or calculated (e.g., “regular”, “irregular”, classic, remanent, transient, transient-free), and the expressions of different magnetic mineralogies and domain states.

Next up, Ramon Egli (Geosphere, Austria) talked about “FORC measurements and processing: A guided tour through pitfalls and optimization” (Fig. 2). Egli gave a more practical talk, walking the audience through the processing of FORC diagrams, what parameters are involved and selected, from smoothing factors to lower-

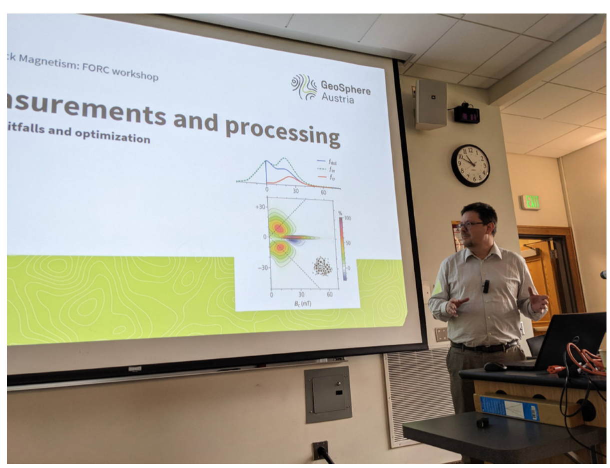

Figure 2: Ramon Egli. Photo by Maxwell Brown.

branch subtractions, and their effects on the final FORC distribution, and described the most recent innovations implemented in his processing code.

The next presentation by Ioan Lascu (Smithsonian Institution), titled "A practical guide to using FORC-PCA" was exactly that. Lascu provided a dataset which could be downloaded in advance, and after describing the theory and significance of FORC Principal Component Analysis, Lascu guided the audience through the necessary processing steps. FORC-PCA coauthor Richard Harrison also assisted with the demonstration remotely.

The final presentation was delivered by Victorino Franco (University of Seville), who offered a perspective on the applicability and novel avenues for FORC diagrams from outside of rock magnetism (Franco is a physicist who works extensively with synthetic magnetic materials). The title of the talk was "Temperature FORC (TFORC), magnetocalorics, and potential applications in rock magnetism". The rationale behind this part of Franco's research is that most of society's energy waste comes from the conversion of primary energy sources into electricity, with most of this conversion performed by magnetic material-based devices. Magnetic materials reversibly heat up when placed in magnetic fields (the magnetocaloric effect) owing to the conjunct of lattice vibrations and relaxation of magnetic moments, working to maintain the bulk material entropy balanced. Capturing such thermal energy by a heat-transfer fluid can allow magnetic refrigeration, but can also be used for thermomagnetic motors or generators, cooling data centers, car-battery life extension, biomedical applications, hydrogen liquefaction… as well as potential applications for rock magnetism.

Sessions and talks

In the first keynote talk of the conference, Timothy Lyons delivered a talk on "Iron cycling through time", where he provided a detailed overview of the models that have been proposed for iron availability in early Earth oceans. From there his talk ranged widely to discuss factors such as the richness of dissolved iron in the absence of dissolved oxygen, based on the temporal distribution of iron and banded iron formations (BIFs), and the latter's subsequent disappearance due to reduced iron solubility. Lyons also discussed evidence from iron mineral speciation studies that suggest persistent iron abundance in anoxic Precambrian deep oceans. The talk also addressed how preservation of primary iron redox environments can be obscured by subsequent burial and metamorphic overprinting. Lyons described fundamental iron formation and iron oxidation pathways, including microbiological implications for greenhouse gas contributions affecting the presence of dissolved iron and ocean productivity. Importantly, paleoenvironmental iron proxies are central to our understanding of marine redox landscapes throughout the balance between oxic, ferruginous and euxinic conditions, making a strong case for rock-magnetic approaches to fingerprint the primary and secondary signatures of the iron cycle.

The first talk within the "environmental magnetism" session on iron cycling was delivered by Allyson Tessin (Kent State University), also not strictly a rock-magnetist: "The roles of redox and reactive iron supply in active benthic iron cycling." Using case studies from the Barents Sea and the Eurasian Arctic margin, Tessin described the complex feedbacks between anthropogenic climate change, ocean productivity and element remobilization, making the case for multiproxy techniques and the usefulness of rock-magnetic techniques.

Next up was Courtney Wagner (Smithsonian Institution), who gave a talk on "Decoding marine records of past global warming events using environmental magnetism." Wagner described how magnetofossils might be indicators of iron cycling and other ocean environmental conditions and how rock-magnetic techniques offer a prime tool to identify and quantify magnetofossils.

David Heslop (Australian National University) followed with a talk titled "Quantifying the role of iron minerals in climate change." Heslop also described the complex feedbacks between atmospheric dust, climate and ocean fertilization, with a focus on how the uncertainties of mineral dust composition limit our ability to accurately model its climatic impacts. Heslop also highlighted the standing problem of quantifying goethite and hematite in dust using environmental magnetism and how these tools are often overlooked by dust-climate researchers outside of the magnetic community.

France Lagroix (Institute de Physique du Globe, Paris) concluded the session with a talk on "Loess and Paleosols in the Global Iron Cycle" (Fig. 3). Lagroix steered the audience from the oceanic realm towards continental archives of atmospheric dust and their grain sizes, exploring how loess-paleosol sequences provide opportunities for studying/understanding local climate changes and the interplay between mineral dust, the iron cycle and climate.

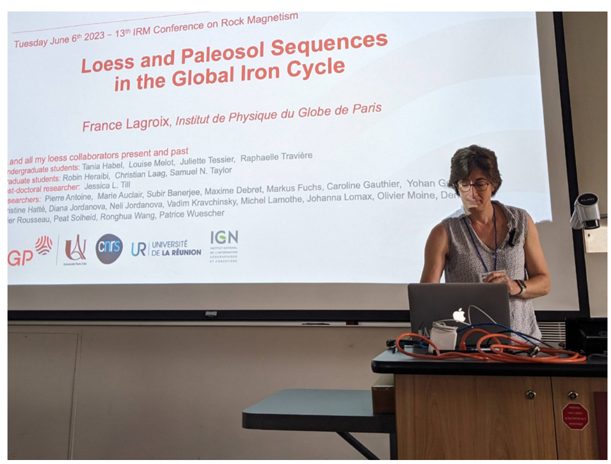

Figure 3: France Lagroix. Photo by Maxwell Brown.

The topical session on Magnetic Microscopy was opened by Eduardo Lima (Massachusetts Institute of Technology): "Estimating net moment from magnetic microscopy data for paleomagnetic studies" (Fig. 4). Lima described the problems associated with estimating the moment of particles through inversions from planar grids of measurements, and presented three estimation techniques. Of these he focussed on a spherical harmonic multipole expansion technique that has been used widely within his group on multiple materials.

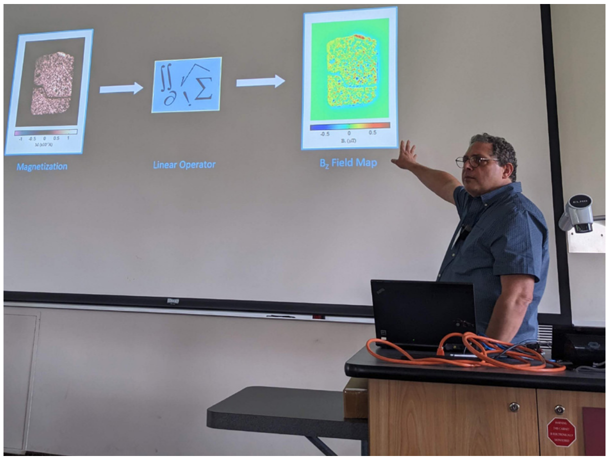

Figure 4: Eduardo Lima. Photo by Maxwell Brown.

Alec Brenner (Harvard University) gave a more applied talk, titled "Revealing Archean seafloor hydrothermal magnetizations with magnetic imaging, or: how I learned to stop worrying and love CRMs." Here, Brenner described a paleomagnetic study conducted at the microscopic scale using the Quantum Diamond Microscope on 3.3-3.2. Ga volcanic rocks from the Archean East Pilbara Craton. Paleomagnetic "field" tests, coupled with textural analysis and U-Pb thermochronology allowed Brenner to identify the remanence carrier as secondary magnetite, and constrain its time of formation and the mineralization pathways leading to its formation.

Next, Lennart de Groot (Utrecht University) talked about "3D interpretations of 2D magnetic scans: where do we stand?" Addressing the non-uniqueness of 2D to 3D magnetic map inversions, de Groot made the case that independent information needs to be integrated. Microcomputed tomography (microCT) allows users to constrain the size and location of individual grains, which informs the inversions and allows grains to be fitted with dipoles, quadrupoles or octupoles using spherical harmonics. Octupoles generally minimize the residuals between modeled magnetizations and surface scans, yet from a directional standpoint, not all inversions appear to be correct. Performing MERRILL micromagnetic models from the starting grain shapes and volumes identified with microCT, and then converting these into spherical harmonic representations, allows for a comparison between the inversion solutions.

The session was ably wrapped up by Suzanne McEnroe (Norwegian University of Science and Technology), who talked about "Multiscale Magnetic Surveys: Can SMM contribute to our understanding of the bulk magnetic response mapped at large scales?" Scanning magnetic microscopes (SMMs) represent the finest scale of observation, whereas satellite and airborne magnetic surveys capture much larger scale phenomena . McEnroe described, in particular, the advances made using unmanned aerial vehicles (UAVs) in carrying out high-resolution surveys, eliminating many terrain-related challenges. At the microscopic level, SMMs provide direct information on the sources of those magnetic anomalies, and joint 3D magnetic inversions of data allow identifying even multiple magnetization sources.

The third session on Rock Magnetism was opened by David Dunlop (University of Toronto) who provided a perspective on the fundamental research performed by his life partner: "Özden Özdemir: A Life in Science" (Fig. 5). David provided a very personal and touching perspective on Özden's scientific achievements, who, throughout her career, dedicated a significant amount of energy to study the magnetic stability of oxidized (titano)magnetite and the acquisition of viscous and chemical magnetizations, as well as many other topics, such as low temperature transitions, magnetic domain imaging, and behaviors in magnetite and other magnetic minerals. In fact, much of her research was conducted at the IRM as she and David made splendid use of the Visiting Fellowship program. Fitting in with the conference and Emily Cooperdock's keynote talk in particular, was Özden's pioneering work on ^{40}Ar/^{39}Ar dating of magnetite.

Figure 5: David Dunlop. Photo by Maxwell Brown.

Ramon Egli (Geosphere Austria) doubled down on FORCs after his pre-conference workshop presentation, with: "Beyond FORC: Identification of reversible and irreversible magnetization changes in hysteretic curves." In his talk, Egli describes a new modification of the FORC protocol combining FORC and Raleigh loops, which measures the reversible, irreversible and viscous magnetization changes. This protocol led to the discovery of single domain particles with no anisotropy and allowed for discrimination between two populations of isolated and clustered pedogenic particles, respectively. Further, the protocol is particularly useful in investigating the edges of the FORC diagram's memory region when the measurements may be affected by the switching from ascending to descending second order reversal curves.

The next talk by Annemarieke Beguin (Norwegian University of Science and Technology) was "Magnetic recording properties of dendritic iron-oxides and their three-dimensional characterization, investigated the magnetic recording properties of dendritic structures in titanomagnetite." Using high-resolution X-ray computed tomography, Beguin showed that the 3-dimensional structures of these grains and their connectivity are more complex than can be appreciated from two-dimensional images and what the implications are for paleomagnetic and paleointensity studies.

Finally, Adrian Muxworthy (Imperial College, London) discussed the influence of stress on the magnetic stability of single vortex grains and assemblages in a talk titled "Quantifying the effect of stress on magnetic signatures." While it is now understood that single vortex (SV) grains have more thermal and temporal stability than single domain (SD) grains, and while it has been demonstrated that SD grains do not respond to applied pressure as Néel theory would predict, the response of SV grains to applied external pressure is still largely unknown. Muxworthy addressed this limitation through numerical simulations performed using the micromagnetic modeling tool MERRILL, showing how single SV and assemblages of such grains behave under pressure.

The second keynote talk by Emily Cooperdock, with useful ties to paleomagnetism, was titled: "Dating magnetite in ultramafic systems" (Fig. 6). Cooperdock described the (U-Th)/He dating method that can be applied to magnetite, which measures 8 helium daughter atoms produced during alpha decay of each uranium atom. While magnetites are not particularly rich in uranium, together with thorium and samarium they make up enough material to obtain robust statistical analyses.

The technique is limited by the mobility of helium within the crystal lattice, providing low thermal sensitivity in estimating closure temperatures, which are a function of the mineral's specific He diffusion kinetics, mineral grain size and cooling rates and is typically 250-300°C for magnetite. Thus, relatively large, >80 µm crystals with no impurities are needed for the technique and can produce ages on the order of millions of years, from ~1 Ma (youngest) to 500-700 Ma (oldest) with ~10% uncertainty. Cooperdock provided two case studies from the dating of serpentinized ultramafic mantle peridotites associated with ophiolites, often carbonated, containing magnetite as a byproduct, and aimed at answering questions such as: How long does it take to exhume portions of the mantle? When and at what temperatures do serpentinization and carbonation processes occur? Answers to these questions provide insight into how readily these systems contribute to geochemical, climate, biological cycles on Earth and other planets. While it is very difficult to date serpentinites, the first case study from the Wadi Fin Samail ophiolite in Oman targeted cross-cutting magnetite-bearing carbonate veins, and obtained an unexpected Miocene age. The second example from Syros, Greece, examined subducted and subsequently exhumed oceanic crust, and observed two generations of magnetite: one population of larger grains older than 16 Ma, which formed during alteration above 400°C; and a secondary generation of finer grains, formed around 3 Ma during fluid circulation associated with Pliocene faulting. Cooperdock also made the case that the (U-Th)/He dating method is also being used for hematite and goethite, and that other magnetite dating techniques also exist, such as ^{3}He, ^{36}Cl and ^{10}Be radionuclide dating as well as others, all bearing their own unique challenges.

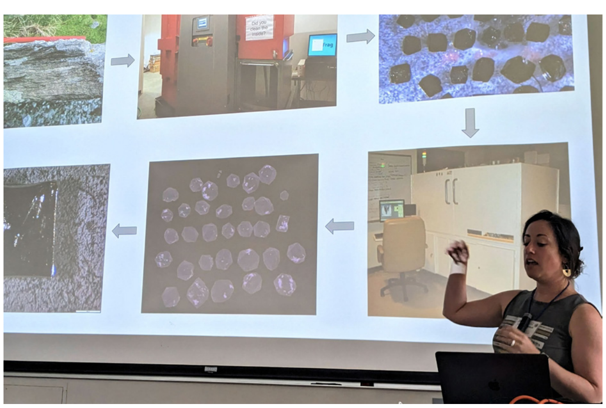

Figure 6: Emily Cooperdock. Photo by Maxwell Brown.

The conference's final topical session on Paleogeographic Reconstructions was opened by Bram Vaes (Utrecht University) with the talk "On pole position: new approaches to quantifying polar wander and relative paleomagnetic displacements." Vaes described an approach to calculate apparent polar wander paths (APWPs) from synthetic site-level, rather than formation level data, generated from an updated database of published paleomagnetic poles. Vaes discussed the advantages of such a method, processed using a free -and open source- web application, in terms of eliminating weighing-biases to the data, as well as incorporation of age uncertainties.

Next up, John Tarduno (University of Rochester) delivered a talk titled: "Hadean to Eoarchean stagnant lid tectonics recorded by the paleomagnetism of zircons." The talk was based on the paleomagnetic signal recovered from zircon single crystals from the ~3.9 to ~3.4 Ga metamorphic rocks of the Jack Hills from Western Australia, which avoids the high-grade metamorphism experienced by these rocks. Results indicate near constant paleolatitude for the time period, consistent with a fixed lithosphere regime for the time period and are validated by results obtained from zircon single crystals from South Africa. Further, preliminary numerical models suggest the viability in long-lasting stable mantle plumes in generating the observed zircon ages and stable paleolatitudes.

Moving closer to the present day, Yiming Zhang (University of California - Berkeley) presented: "New approaches to apparent polar wander path development constrain the late Mesoproterozoic assembly of Rodinia." Zhang compared two very different approaches for calculating apparent polar wander paths for Laurentia in the late Mesoproterozoic: the first being a Bayesian inverse problem involving Euler pole analysis, and the second being a Monte Carlo resampling to propagate uncertainties from from site-level data to paleopoles. Both techniques take into account the uncertainties of pole positions and ages, whereas the second technique also includes the uncertainty of inclination shallowing for sedimentary rocks. Nevertheless, and despite the fundamentally different assumptions, both methods are in good agreement with each other, and improve existing Rodinia reconstructions.

The last talk of the conference was delivered by Derya Gürer (University of Queensland): "Embracing uncertainty and noise in paleomagnetic data: application to global tectonics" (Fig. 7). Gürer discussed issues with constructing apparent polar wander paths (APWPs) and presented the advantages of the Monte Carlo resampling technique using a compilation of Cenozoic North American data. Gürer then used the same approach to re-evaluate the upper Paleozoic-Mesozoic APWP portion from East Gondwana, which has historically been problematic and incongruent with data from Laurussia and West Gondwana. Next, Gürer shifted to the difficulties of reconstructing Africa-Eurasia kinematic plate reconstructions during the Cretaceous Normal Superchron. Using geomagnetic intensity variations rather than reversals, data show that convergence rate changes correlate with the initiation and arrest of a plume-induced subduction zone. On a regional scale, changes in plate motion constrained by mantle dynamics appear to drive a self-perpetuating plate circuit.

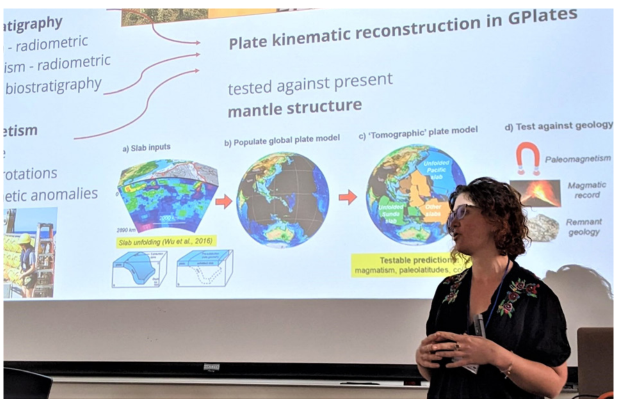

Figure 7: Derya Gürer. Photo by Maxwell Brown.

Community Workshop

The last day of the conference was dedicated to a workshop on: "Implementation of Justice, Equity, Diversity & Inclusivity (JEDI) Principles within the US based paleo- and rock magnetism community." Workshop goals were to identify collaborative strategies for improving justice, equity, diversity, and inclusion within the US(geo) magnetic communities. The workshop was kicked off with a summary of diversity data that was collected prior to the meeting (e.g., from AGU, IAGA VI, recent publications, and a recent public survey). Participants presented examples of ongoing DEI activities at their home institutions in which they are involved and that are potentially scalable across the entire community. In an informal discussion, results of these findings were synthesized to identify cross-institutional strategies for improving diversity in our communities, with the goal of producing a white paper to be shared with NSF and other organizations. While the Community Workshop was not recorded, here is a final reminder that all other talks are viewable on the IRM's YouTube channel (https://www.youtube.com/channel/UCjzG-yAnzKHZneeSL1kFpmw).

Who was there?

This year's conference was widely attended by participants from institutions located in 13 different countries. A total of 59 people attended in-person, including IRM staff, postdocs and students, as well as other interested University of Minnesota students. 4 people traveled from Australia, 2 from Norway and 2 from the Netherlands. 1 person participated from Austria, Brazil, Czech Republic, Finland, France, Israel, Italy, Spain and the UK, respectively, whereas 42 people participated from the US. Of the latter, 7 were from non-academic organizations. Of the remote participants, 8 were from India, 6 from the UK (1 non-academic), 4 from France, 4 from Norway, 3 from Australia, 2 from Italy, 1 from Brazil, the Czech Republic, Finland (non-academic), Iran, Israel, and New Zealand. 12 people from the US participated remotely (3 of which non-academic).

While oral presentations at the conference were by invitation only, anyone could present an in-person poster (an online poster session was not offered this year due to limited interest): 15 people contributed a poster, 12 of which were from the US (1 non-academic), and 1 from the Czech Republic, Finland and Italy, respectively.

Finally, from a demographic survey we sent to all registrants, 63 people responded indicating that 38 identified as "Male", 23 as "Female", 1 as "Female, gender queer / gender nonconforming, neither exclusively male nor female", and 1 as "Male, Female". Of 61 respondents, 11 indicated that they identified as "Asian", 1 as "Black or African American", 6 as "Hispanic or Latino", 45 as "White", and 1 as "European".

Conference post-participation Survey

A post-conference survey was sent to all participants to gauge satisfaction on all aspects of the meeting and gather feedback for future meetings. The FORC workshop received an average rating of 9.0/10 from 21 respondents, with a handful of these specifically asking to expand the workshop's practical components. In general, the conference was highly-rated, with an average score of 9.5/10 from 24 respondents. Participants enjoyed the format, variety of topics, and balanced participation from people at different stages of their careers. The poster session received a broader spectrum of scores, but was ultimately received positively: out of 21 respondents, it received an average score of 9.0/10. Participants enjoyed the space, but some thought it felt crowded at times and weren't able to see all the posters. The JEDI community workshop received an average score of 8.6/10 from 14 respondents, and while participants generally appreciated the presentations and discussion on top of seeing this addition to the conference, the time set aside for the discussion and work was relatively short and some regretted not being able to participate remotely.

Skipping the responses about food and board, which were overall positive, holding the conference in Minneapolis also proved a successful choice with 23 respondents giving an average rating of 9.4/10: it was obvious from the comments that many participants missed Santa Fe, but on the upside found Minneapolis to be a very convenient location, which helped keep costs low. Of the two key questions "how likely are you to attend another IRM conference" and "would you recommend an IRM meeting to others", out of 24 responses for each question the scores were 9.9/10 and 10.0/10, respectively. Nailed it.

Sponsors

Last but not least, the conference was funded by US National Science Foundation grant NSF-EAR Geophysics #2317261. We also kindly acknowledge all of the conference sponsors, in alphanumerical order: 2G Enterprises, ASC Scientific, AGICO, Lake Shore Cryotronics, Quantum Catalyzer (Q-Cat), and Quantum Design.

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 Emeritus/Founding Director; **Bruce Moskowitz**, Professor/Director; **Joshua Feinberg**, Professor/Associate Director; **Maxwell Brown, 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
150 John T Tate Hall
116 Church Street SE
Minneapolis, MN 55455-0128
phone: (612) 624-5049
e-mail: dario@umn.edu
www.cse.umn.edu/irm