Publications of the Institute of Geophysics, Polish Academy of Sciences
Geophysical Data Bases, Processing and Instrumentation
vol. 423 (C-112), 2018, pp. 13-14
DOI: 10.25171/InstGeoph_PAS_Publs-2018-008
16th Castle Meeting New Trends on Paleo, Rock and Environmental Magnetism, Chęciny, Poland, 2018

Magnetic Anisotropy of Ferromagnetic Grains – Comparison of Different Methods

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A b s t r a c t

Anisotropy of magnetic properties is related to the crystallographic or shape preferred orientation of minerals, or the distribution of strongly magnetic grains. The preferred alignment of ferromagnetic or remanence-carrying grains is particularly important for paleomagnetic studies, because their anisotropy can deflect the magnetization away from the inducing field, and affect the intensity of magnetization. Hence, a reliable characterization of this anisotropy is crucial for correcting paleodirectional and paleointensity data. Several methods have been developed to characterize the magnetic fabric of ferromagnetic grains or those ferromagnetic grains that carry remanence: anisotropy of anhysteretic remanent magnetization (AARM), isothermal remanent magnetization (AIRM), thermal magnetization (ATRM), or partial remanent magnetizations applied over certain windows of the coercivity or blocking temperature spectra (ApARM, ApIRM, ApTRM). One method that allows separation of the contributions from paramagnetic, ferrimagnetic and antiferromagnetic minerals, is torque magnetometry. Here, we compare these different ways of characterizing magnetic fabrics of ferromagnetic grains for a suite of rocks of different composition. Samples include layered intrusions (Bushveld Complex, South Africa; Duluth Complex, MN, USA), red bed sediments (Mauch Chunk Formation, PA, USA) and metamorphic rocks (Thomson Formation, MN, USA). A set of 7 A(p)ARM tensors has been measured on each sample using coercivity windows of 0–20, 20–50, 50–100, and 100–180 mT as well as 0–50, 0–100, and 0–180 mT. Nine A(p)IRM tensors, and three A(p)TRM tensors have been determined on each sample of a subset of these. These remanence anisotropy results will be compared to the isolated ferrimagnetic and antiferromagnetic contributions as determined by torque measurements.

Initial results show that principal axes' directions as well as the shape and degree of anisotropy can vary significantly when measured with different methods, or over different coercivity ranges. Our results indicate that the magnetic fabrics of remanence-carrying grains, or ferromagnetic grains in general, cannot be described by a single tensor, because they vary between methods and depend on the coercivity range. This is likely related to distinct fabrics of different generations of grains all contributing to a rock's remanence, and has important consequences for paleomagnetic and magnetic fabric studies. Care has to be taken to correct paleomagnetic data for the most appropriate anisotropy tensor or set of anisotropy tensors.

Keywords: magnetic fabric, remanence anisotropy, AARM, AIRM, torque magnetometry.