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Detecting subtle changes in magnetic state due to heating: implications for paleointensity methods

Lennart de Groot, Mark Dekkers, and Tom Mullender
Paleomagnetic laboratory Fort Hoofddijk, Utrecht University, Utrecht, the Netherlands (ldegroot@geo.uu.nl)

All paleointensity (PI) methods only yield reliable results if the samples used do not alter, neither chemically, nor magnetically, during the experiment. There are several indicators for chemical alteration due to heating, but changes in magnetic state are harder to detect. Acquisition curves of the anhysteretic remanent magnetization (ARM) are known to be sensitive to changes in magnetic state, particularly in the fine grain-size range. Here we present a method to use ARM acquisition curves to detect changes in magnetic state as a consequence of heating.
To isolate the ARM acquisitions from the natural remanent magnetization (NRM) alternating field (AF) demagnetization curve, four samples are aligned with their NRM parallel to the DC-bias field of the ARM acquisition, and four samples are aligned anti-parallel to that field. Since the NRM is demagnetized in its own direction and the ARM is acquired in the direction of the DC-bias field, the ARM acquisition can be mathematically isolated from the eight samples used in this 'aligned ARM acquisition' experiment. This experiment is done for untreated samples and samples heated to the temperature used in the PI experiment. Differences in the behavior of the acquisition of the ARM between these two sample-sets indicate whether the samples become easier or harder to magnetize as a consequence of heating. The concept of ARM acquisition curves as used here is built on the analogy between ARM and (partial)thermoremanence ((p)TRM). When a sample becomes softer the same pTRM acquisition field induces a stronger remanence and vice-versa.
We applied aligned ARM acquisition experiments on ten historical lava-flows within the realm of the international geomagnetic reference field (IGRF), for which the results of the original multi-specimen-protocol (MSP-DB) PI experiments are known. Four of these flows are from Mt. Etna, Italy, and yield underestimates with respect to the IGRF-value; the other six flows are from the island of La Palma, Canary Islands, Spain. Two of the latter yield an PI underestimate with respect to the IGRF value, two an overestimate and the other two of these flows yield approximately the IGRF-value.
The aligned ARM acquisition experiments for all these ten flows predict the outcome for the MSP-DB PI (an over-, or underestimate, or approximately the IGRF-value) correctly. Thus, the aligned ARM acquisition experiment can be a valuable addition to the MSP-DB PI method for lavas not dated within the IGRF-realm, constraining its outcome as a lower or an upper limit, or verifying the outcome as approximately correct. A correction of the obtained PI based on aligned ARM acquisitions seems not yet feasible.