Recovering ancient magnetic field intensities from rocks and meteorites using FORC Measurements

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Igneous rocks and many meteorites record a thermoremanent magnetization (TRM) on formation. This remanent magnetisation is often magnetically and chemically stable on geological timescales up to the age of the Earth or longer. Recovering the direction of the ancient magnetisation is relatively straightforward; however, determining the ancient magnetic field intensity (palaeointensity) is much more problematic. The standard methods of determining the palaeointensity rely on replicating TRM acquisition in a known field in the laboratory. There are two main problems: 1) many rocks are dominated by multidomain grains (mostly small vortex structures) and are imperfect recorders, and 2) the magnetic minerals under investigation often chemically alter during the palaeointensity experiment, that lead to low success rates (between 10 and 80%); this is particularly true of meteoritic material This is troublesome, as palaeointensity experiments are very time consuming, e.g., two weeks intensive laboratory work to process 40 samples.

We have developed a non-heating palaeointensity protocol. This involves measuring the original natural remanent magnetisation of a sample, then using first-order reversal curve (FORC) measurements to generate a Preisach distribution. We then use a thermally activated Preisach model to estimate the TRM intensity required to produce the measured natural remanent magnetisation. We have tested this on over 300 historical lavas, where the actual field intensity is known. And applied the method to real geological and meteoritic problems.