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FORCintense: A graphical implementation of the Preisach method of paleointensity estimation within FORCinel

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A non-heating method of paleointensity determination based on Preisach theory has recently been developed [1, 2]. The method uses a first-order reversal curve (FORC) diagram to generate a Preisach distribution of coercivities and interaction fields within the sample and then physically models the acquisition of TRM as a function of magnetic field, temperature and time using thermal relaxation theory. By comparing observed and simulated remanence values, an estimate of paleointensity is obtained that is typically more accurate than other non-heating methods (e.g. REM) and often comparable to Thellier-Thellier estimates. Here we present a modified implementation of the Preisach method within the FORCinel processing package, which allows interactive graphical comparison of the observed and simulated remanence behaviour. The method is tested using a variety of samples incuding historical lavas and synthetic samples of dusty olivine carrying a laboratory TRM.

The input data for the paleointensity estimate comprises a) a FORC diagram, b) the NRM demagnetisation curve, c) the SIRM value and optionally d) the SIRM demagnetisation curve. Our implementation automates the conversion of a standard FORC diagram to a Preisach distribution and corrects for the influence of smoothing factor. After simulating the acquision of TRM in a given field, the NRM and SIRM demagnetisation spectra are calculated and compared directly with the observed values. The presence of magnetic particles with coercivities outside the range of the measured FORC diagram can lead to discrepancies between the observed and simulated demagnetisation spectra and a large overestimation of the paleomagnetic field intensity. Our implementation allows for correction of the excess high-coercivity remanence component, which produces a dramatic improvement in the agreement between simulated and observed demagnetisation curves and a more accurate estimate of the paleofield. Further improvements can be made if the measured SIRM demagnetisation spectrum is available, which allows observed and simulated REM' values to be compared.

The acquisition of TRM in dusty olivine has been simulated in detail using the Preisach method. The comparison of observed and calculated NRM demagnetisation spectra is adversely effected by a large population of particles in the single-vortex state. Comparison of observed and calculated REM' curves, however, yields much closer agreement in the high-coercivity SD-dominated range. Calcuated values of the average REM' ratio show excellent agreement with the experimental values – including the observed non-linearity of the remanence acquisition curve – suggesting that this method has the potential to reduce the uncertainties in non-heating paleointensity methods for extraterrestrial samples.

[1] AR Muxworthy and D Heslop(2011) A Preisach method for estimating absolute paleofield intensity under the constraint of using only isothermal measurements: 1. Theoretical framework. Journal of Geophysical Research, 116, B04102, doi:10.1029/2010JB007843.

[2] AR Muxworthy, D Heslop, GA Paterson, and D Michalk. A Preisach method for estimating absolute paleofield intensity under the constraint of using only isothermal measurements: 2. Experimental testing. Journal of Geophysical Research, 116, B04103, doi:10.1029/2010JB007844.