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Rock magnetic properties of dusty olivine: a potential carrier of pre-accretionary remanence in unequilibrated ordinary chondrites

S.C.L.L. Lappe (1), R.J. Harrison (1), and J.M. Feinberg (2)

(1) University of Cambridge, Dept. of Earth Sciences, Cambridge CB2 3DZ, United Kingdom (RJH40@ESC.CAM.AC.UK, 0044-1223-), (2) Institute for Rock Magnetism, University of Minnesota, Minnesota, MN, United States

The mechanism of chondrule formation is an important outstanding question in cosmochemistry. Magnetic signals recorded by Fe-Ni nanoparticles in chondrules could carry clues to their origin. Recently, research in this area has focused on 'dusty olivine' grains within ordinary chondrites as potential carriers of pre-accretionary remanence. Dusty olivine is characterised by the presence of sub-micron Fe-Ni inclusions within the olivine host. These metal particles form via subsolidus reduction of the olivine during chondrule formation and are thought to be protected from subsequent chemical and thermal alteration by the host olivine.

Three sets of synthetic dusty olivines have been produced, using natural olivine (average Ni-content of 0.3 wt%), synthetic Ni-containing olivine (0.1wt% Ni) and synthetic Ni-free olivine as starting materials. The starting materials were ground to powders, packed into a 2-3 mm3 graphite crucible, heated up to 1350 °C under a pure CO gas flow and kept at this temperature for 10 minutes. After this the samples were held in a fixed orientation and quenched into water in a range of known magnetic fields, ranging from 0.2 mT to 1.5 mT.

We present here for the first time an analysis of a new FORC-based method of paleointensity determination applied to metallic Fe-bearing samples [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. 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. Calculated 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.