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Thermomagnetic Stability in Pseudo Single Domain Grains

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The reliability of paleomagnetic remanences are well understood for fine grains of magnetite that are single-domain (SD, uniformly magnetized). In particular Néel's theory [1] outlined the thermal energies required to block and unblock magnetic remanences. This lead to determination of thermal stability for magnetization in fine grains as outlined in Pullaiah et. al. [2] and a comprehensive understanding of SD paleomagnetic recordings.

It has been known for some time that single domain magnetite is possible only in the grain size range 30 - 80nm, which may only account for a small fraction of the grain size distribution in any rock sample. Indeed rocks are often dominated by grains in the pseudo single domain (PSD) size range, at approximately 80 - 1000nm. Toward the top end of this range multi-domain features begin to dominate.

In order to determine thermomagnetic stability in PSD grains we need to identify the energy barriers between all possible pairs of local energy minima (LEM) domain states as a function of both temperature and grain size. We have attempted to do this using the nudged elastic band (NEB) method [3] which searches for minimum energy paths between any given pair of LEM states. Using this technique we have determined, for the first time, complete thermomagnetic stability curves for PSD magnetite.

The work presented is at a preliminary stage. However it can be shown that PSD grains of magnetite with simple geometries (e.g. cubes or cuboctahedra) have very few low energy transition paths and the stability is likely to be similar to that observed for SD grains (as expected form experimental observations). The results will provide a basis for a much more rigorous understanding of the fidelity of paleomagnetic signals in assemblages of PSD grains and their ability to retain ancient recordings of the geomagnetic field.

References:

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[3] D. Sheppard, R. Terrell, and G. Henkelman, "Optimization methods for finding minimum energy paths", J. Chem. Phys. 128, 134106 (2008).