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First-order reversal curves of single domain particles: diluted random assemblages and chains

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Exact magnetic models can be used to calculate first-order reversal curves (FORC) of single domain (SD) particle assemblages, as shown by Newell [2005] for the case of isolated Stoner-Wohlfarth particles. After overcoming experimental difficulties, a FORC diagram sharing many similarities to Newell's model has been measured on a lake sediment sample (see A.P. Chen et al., "Quantification of magnetofossils using first-order reversal curves", EGU General Assembly 2009, Abstracts Vol. 11, EGU2009-10719). This sample contains abundant magnetofossils, as shown by coercivity analysis and electron microscopy, therefore suggesting that well dispersed, intact magnetosome chains are the main SD carriers. Subtle differences between the reversible and the irreversible contributions of the measured FORC distribution suggest that magnetosome chains might not be correctly described by the Stoner-Wohlfarth model. To better understand the hysteresis properties of such chains, a simple magnetic model has been implemented, taking dipole-dipole interactions between particles within the same chain into account. The model results depend on the magnetosome elongation, the number of magnetosomes in a chain, and the gap between them. If the chain axis is subparallel to the applied field, the magnetic moment reverses by a pseudo-fanning mode, which is replaced by a pseudo-coherent rotation mode at greater angles. These reversal modes are intrinsically different from coherent rotation assumed Stoner-Wohlfarth model, resulting in FORC diagrams with a smaller reversible component. On the other hand, isolated authigenic SD particles can precipitate in the sediment matrix, as it might occur for pedogenic magnetite. In this case, an assembly of randomly located particles provides a possible model for the resulting FORC diagram. If the concentration of the particles is small, each particle is affected by a random interaction field whose statistical distribution can be calculated from first principles. In this case, the irreversible component of the FORC diagram, which is described by a Dirac delta function in the non-interacting case, converts into a continuous function that directly reflects the distribution of interaction fields. Such models provide a way to identify and characterize authigenic SD particles in sediments, and in some case allow one to isolate their magnetic contribution from that of other magnetic components.

Newell, A.J. (2005), A high-precision model of first-order reversal curve (FORC) functions for single-domain ferromagnets with uniaxial anisotropy, Gechem. Geophys. Geosyst., 6, Q05010, doi:10.1029/2004GC00877.