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Magnetic and microscopic characterization of magnetite nanoparticles adhered to clay surfaces

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Abstract

When suspended in solution, clay platelets coated with nanometer-scale magnetite particles behave as magnetorheologic fluids that are important to a variety of industrial applications. Such dual-phase assemblages are also similar to natural aggregates that record the direction and intensity of the Earth's magnetic field in lake and marine depositional environments. This study characterizes the mineralogical structure and magnetic behavior of montmorillonite platelets coated with aggregates of nanometer-scale magnetite crystals. The distribution of magnetite crystal sizes in three different clay-magnetite assemblages was directly measured using conventional transmission electron microscopy and agrees within error with estimates derived from magnetic hysteresis measurements. Magnetic hysteresis and low field susceptibility measurements combined with electron holography experiments indicate that all three samples behave superparamagnetically at room temperature, and show increasing levels of single domain behavior as the samples are cooled to liquid nitrogen temperatures. At such low temperatures, magnetostatic interactions are observed to partially stabilize otherwise superparamagnetic grains in flux closure structures.

Keywords: Magnetite, clay, smectite, TEM, electron holography, electron tomography, granulometry, magnetic properties