



## Effect of maghemization on the magnetic properties of pseudo-single-domain magnetite particles

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# AGU FALL MEETING

San Francisco | 14 – 18 December 2015

## GP43A-1230: Effect of maghemization on the magnetic properties of pseudo-single-domain magnetite particles

ABSTRACT

**Thursday, 17 December 2015****13:40 - 18:00***Moscone South - Poster Hall*

During formation, magnetic minerals record the direction and intensity of the Earth's magnetic field. Paleomagnetists use this information to investigate, for example, past tectonic plate motion and geodynamo evolution. However, subsequent to formation the constituent magnetic minerals are commonly exposed to a range of weathering conditions and environments. One of the most common weathering processes is maghemization, which is the oxidation of magnetite ( $\text{Fe}_3\text{O}_4$ ) at ambient temperatures, i.e., the slow oxidation of  $\text{Fe}_3\text{O}_4$  to maghemite ( $\gamma\text{-Fe}_2\text{O}_3$ ), and is known to alter the original remanent magnetization.

Of the constituent magnetic minerals, particles in the single domain (SD) grain size range ( $< 100$  nm) are regarded as ideal paleomagnetic recorders because of their strong remanence and high magnetic stability, with potential relaxation times greater than that of the age of the Universe. However, magnetic signals from rocks are often dominated by small grains with non-uniform magnetization that exhibit magnetic recording fidelities similar to those of SD grains (termed pseudo-SD (PSD)).

In this context, the effect of maghemization on the magnetic properties of  $\text{Fe}_3\text{O}_4$  grains in the PSD size range is investigated as a function of annealing temperature. X-ray diffraction and transmission electron microscopy confirms the precursor grains as  $\text{Fe}_3\text{O}_4$  ranging from  $\sim 150$  nm to  $\sim 250$  nm in diameter, whilst Mössbauer spectrometry suggests the grains are initially near-stoichiometric. The  $\text{Fe}_3\text{O}_4$  grains are heated to increasing reaction temperatures of  $120 - 220$  °C to investigate their oxidation to  $\gamma\text{-Fe}_2\text{O}_3$ . High-angle annular dark field imaging and localized electron energy-loss spectroscopy reveals slightly oxidized  $\text{Fe}_3\text{O}_4$  grains, heated to  $140$  °C, exhibit higher oxygen content at the surface. Off-axis electron holography allows for construction of magnetic induction maps of individual  $\text{Fe}_3\text{O}_4$  and  $\gamma\text{-Fe}_2\text{O}_3$  grains, revealing their PSD (vortex) nature, which is supported by magnetic hysteresis measurements, including first-order reversal curve analysis. The coercivity of the grains is shown to increase with reaction temperature up to  $180$  °C, but subsequently decreases after heating above  $200$  °C; this magnetic behavior is attributed to the growth of a  $\gamma\text{-Fe}_2\text{O}_3$  shell

with magnetic properties distinct from the  $\text{Fe}_3\text{O}_4$  core.

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