Geophysical Research Abstracts,
Vol. 10, EGU2008-A-08291, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-08291
EGU General Assembly 2008

Fundamental magnetic properties of greigite (Fe_3S_4)

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Greigite (Fe_3S_4), an authigenic mineral that forms in sulfate-reducing environments, has been widely identified in marine and lake sediments. It is often the main magnetic carrier in some settings, and can therefore be significant in paleomagnetic and environmental magnetic studies. However, unlike its iron oxide counterpart, magnetite (Fe_3O_4), the fundamental magnetic characteristics of greigite are still poorly understood, which is partially due to the metastability of greigite and the difficulty in obtaining high quality greigite samples. We have successfully synthesized pure greigite samples with good crystallinity using a new hydrothermal method. Our detailed low- and high-temperature magnetic measurements document the previously poorly known magnetic properties of greigite, including the first accurate measurement of its saturation magnetization. We have for the first time determined the magnetic structure of greigite by combined neutron powder diffraction and neutron polarization analysis. Low temperature (LT) neutron diffraction spectra reveal the temperature dependence of sublattice magnetizations. The pure synthetic greigite samples are large enough to show pseudo-single-domain (PSD) and multi-domain (MD) behavior. LT cycling (LTC) of saturation isothermal remanent magnetization (SIRM) measurements indicate a continuous demagnetization of remanence during cooling. Preservation of the main features of first-order reversal curve distributions at LT, coupled with LT SIRM warming curves, rule out the presence of substantial superparamagnetic behavior in the studied samples and indicate that PSD/MD greigite is magnetically stable at LT. These fundamental studies provide new constraints on the magnetic behaviour of greigite.