Geophysical Research Abstracts
Vol. 21, EGU2019-4061, 2019
EGU General Assembly 2019

Unraveling magnetic properties of mixed detrital and biogenic magnetite

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Magnetotactic bacteria (MTB) can form nano-sized magnetite and/or greigite which are known as magnetosomes. Unlike the organic part of MTB, magnetosomes can be well preserved as magnetofossils in sediments under proper burial environments. Magnetofossils are ideal carriers not only for ancient geomagnetic field variations but also for paleoenvironmental information. It is, however, often challenging to faithfully reconstruct the information carried by magnetofossils because the biogenic component is almost always mixed with magnetic minerals of other origins in sediments. For example, recent studies on magnetofossils physically extracted from sediments suggest that the morphotype of magnetofossils could serve as a potential proxy for variations of organic carbon flux and paleoenvironments. But it is unclear whether the extracted magnetofossils could reliably represent the entire ensembles of magnetofossils in the sediment. In this study, we conducted a series of rock magnetic experiments, including low-temperature measurements, isothermal remanent magnetization (IRM) unmixing, and first order reversal curves (FORCs) on a series of synthetic samples consisting of different proportions of *Magnetospirillum gryphiswaldense* strain MSR-1 and andesite powders. The weight percentages of MSR-1 for gradient samples are 0%, 13.7%, 31.4%, 52.9%, 61.3%, 92.5%, and 100%, respectively. Low-temperature measurements showed that the magnetization ratio between field cooled (FC) and zero field cooled (ZFC) measurements at 10 K (M_{FC10K}/M_{ZFC10K}) can best reflect the proportion of the biogenic component of the synthetic samples. The estimates based on IRM unmixing vary with MSR-1 abundance as well, however, the results are also dependent on the model function selected for analysis. For FORCs, a proxy ($B_{u1/20}/B_{u1/2}$) sensitively reflects the change in the abundance of biogenic components. To further examine the suitability of the methods for natural sediments, we applied ZFC-FC measurement & IRM unmixing to freshwater sediments, which contain abundant magnetofossils with different morphotypes, as well as their residuals after magnetic extraction. It is found the relative proportions of biogenic soft (BS, with median coercivity of $\sim$42 mT) and biogenic hard (BH, with median coercivity of $\sim$60 mT) components before and after extraction are comparable, which indicates that the magnetofossils of different morphotypes are extracted with similar efficiency. On the other hand, the ratio of M_{FC10K}/M_{ZFC10K} increases for residual sample while the proportion of detrital magnetite estimated by IRM analysis decreases, suggesting the detrital component is extracted more efficiently than the biogenic one.