海底堆積物中の生物源マグネタイトの低温酸化

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Low-temperature oxidation of biogenic magnetite in deep-sea sediments

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Magnetites in marine sediments of oxic environments such as surface sediments above the Fe-redox boundary and red clay cores that do not have the Fe-redox boundary usually have suffered low-temperature oxidation. This is evidenced, for example, by a blurred Verwey transition in low-temperature measurements, and explained as that a shell of a magnetite particle is oxidized to maghemite, whereas a core of the particle remains intact. Under a transmission electron microscope (TEM), it is often observed that biogenic magnetites (magnetofossils) in oxic environments are covered with very fine particles of a few nanometers in size. We applied a reductive etchant to a red clay sample, in which biogenic magnetite dominates the magnetic mineral assemblage. The reductive etchant was prepared to be -60 mV in the oxidation/reduction potential (ORP) and 5.7 in pH using ascorbic acid (5%) buffered with $NaHCO_3$. The fine particles covering magnetofossils were mostly dissolved by applying the etchant for 72 hours. We do not think that maghemite was altered by the etchant, because the results of low-temperature measurements (low-temperature cycling of SIRM acquired at 300K and thermal demagnetization of 10K SIRM) before and after applying the etchant were identical with each other and did not show the Verwey transition even after applying etchant, and because SIRM of the sample did not change for 72 hours. The color of the sediments is still reddish after applying the etchant, which also suggests that maghemite still remains. We estimate that the fine particles dissolved by the etchant may be hematite; Fe ions diffused from a magnetite lattice by low-temperature oxidation may have been combined with dissolved oxygen in interstitial water, which resulted in the production of hematite. The effect of the hematite dissolution by the etchant would not appear in the low-temperature measurements because the hematite particles are superparamagnetic in size, their total volume is smaller than that of magnetite-maghemite, and the saturation magnetization of hematite is much smaller than that of magnetite-maghemite. The low-temperature oxidation occurs in a geologically short period of time; magnetofossils with hematite cover are observed commonly under a TEM even in sediments at the sediment-water interface (the top of a pilot core).