

OXYGEN ISOTOPE FRACTIONATION OF IRON OXIDE MINERALS AT LOW TEMPERATURES

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Various iron oxide/oxyhydroxide minerals (Fe_3O_4 , Fe_2O_3 , FeOOH , $\text{Fe}(\text{OH})_3$, *etc.*) are widely distributed in diverse, low ($\approx 200^\circ\text{C}$) temperature aqueous environments (weathering zones, surface waters, sedimentary basins, geo-hydrothermal systems, extraterrestrial environments). In addition to thermodynamics, reaction pathways, kinetics, and the presence of dissolved constituents in water determine the type of iron oxide/oxyhydroxide minerals formed and transformed at low temperatures. It has also been recognized that microbial activities enhance or retard the dissolution, precipitation, and transformation of iron oxide minerals. Despite increasing recognition of the importance of iron oxides in environmental, biogeochemical, and geologic processes, the behavior of oxygen isotopes during the formation and transformation of these minerals at low temperatures is poorly understood. We summarize results from our ongoing experimental program focused on oxygen isotope fractionation of iron oxide minerals, chiefly magnetite and hematite, from low to elevated temperature.

Black, fine-grained magnetite precipitated inorganically at $70\text{-}90^\circ\text{C}$ by slowly adding a solution of KNO_3/KOH to a solution of FeCl_2 has size and shape similar to those of magnetite-rich iron oxides formed by Fe-reducing thermophilic bacteria (Zhang *et al.*, 1997). Oxygen isotope fractionation ($10^3\ln\alpha_{\text{mt-water}} = 0$ to -4‰) is also similar to that of microbial magnetite. Our $10^3\ln\alpha_{\text{mt-water}}$ values, which are more positive than theoretical and empirical equations in the literature, are also consistent with results obtained from magnetite “teeth” from a mollusk (O’Neil and Clayton, 1964) and magnetite formed intracellularly in a magnetotactic bacterium (Mandernack *et al.*, 1998). It appears that there are only small differences in oxygen isotope fractionation between magnetite and ferric oxides (Fe_2O_3 , FeOOH) (Yapp, 1990; Müller, 1995; Bao and Koch, 1999) precipitated at low temperatures.

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