

Triple Fe isotopic behavior in an expanded array of modern aqueous environments

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Stable iron (Fe) isotope variations have been used to track marine Fe redox cycling and mineralization processes for over twenty years. Large Fe isotopic fractionations occur during abiotic and biologically mediated redox transformations and mineral precipitation processes. However, resolving the impact of numerous geochemical processes in the Fe cycle can be difficult where many combinations of instantaneous fractionations and distillation effects can produce the same ⁵⁶Fe/⁵⁴Fe ratio. This problem is exacerbated for ancient rocks lacking additional contextual data.

Recent studies have demonstrated that different fractionation regimes are resolvable with high-precision triple Fe isotope analyses utilizing multiple Fe isotope ratios (⁵⁶Fe/⁵⁴Fe vs. ⁵⁷Fe/⁵⁴Fe) that can distinguish the impacts of distinct mass fractionation laws (MFLs) in Fe cycling processes (1, 2). In particular, triple Fe isotope analyses of Archean sedimentary rocks and laboratory experiments demonstrated that (equilibrium) redox cycling processes were resolvable from (kinetic) pyritization processes and could be used to quantify Archean ocean oxic and sulfidic Fe sinks (1). Many important Fe cycling processes have yet to be investigated for their triple Fe isotopic fingerprints.

We will present data expanding high precision triple Fe isotopic measurements to two settings hosting processes known to drive large Fe isotopic fractionations: (I) low temperature, potentially microbially-mediated Fe redox cycling in redox-stratified water bodies, and (II) high-temperature (sub-)seafloor pyrite precipitation at mid-ocean ridge hydrothermal vent sites. We will report on triple Fe isotopic analyses of samples from settings where these respective processes occur: (I) waters from the Fe²⁺-rich (“ferruginous”) Deming Lake, Minnesota, USA, and (II) porous and massive hydrothermal pyrites from the TAG hydrothermal mound on the Mid-Atlantic Ridge. We will place our results into the theoretical and empirical context of previous triple Fe isotope studies and discuss how they can sharpen our understanding of Fe cycling processes in modern and ancient environments.

References

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2. N. X. Nie, N. Dauphas, R. C. Greenwood, *Earth Planet. Sci. Lett.* **458**, 179–191 (2017).