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Combining trace metal geochemistry and experimental microbiology to explore the role of dissimilatory Fe(III) reducing bacteria in precursor Banded Iron Formations

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Reconstructing the chemical composition of Precambrian (4.6–0.5 Ga) oceans helps us understand not only the oxygen evolution of Earth's surface, but also the conditions that allowed for Earth's diverse biosphere to evolve. With different metals responding to oxygen and sulfide availability to varying degrees, trace metal geochemistry is one method used to explore ocean chemistry in modern and ancient systems. In the geologic record, the relative enrichments and depletions of different trace metals are used as proxies for reconstructing oxygen availability. Trace metals are also critical cofactors for enzymes ('metalloproteins') that are incorporated into all living cells and used in metabolic processes. Thus, the relative enrichments of certain metals can imply micronutrient availability for the evolution of various metabolisms in the Precambrian. By bridging the gap between paleoenvironmental chemistry and micronutrient availability for life, trace metal geochemistry is a useful tool when studying the co-evolution of the biosphere and early Earth.

In this work, trace metal geochemistry and experimental microbiology are used in tandem to evaluate the role of dissimilatory Fe(III) reducing (DIR) bacteria in the development of Banded Iron Formations (BIFs). Although BIFs have long been used as a record of seawater trace metal composition, recent work has suggested that trace metals found in BIFs were actually derived from the degradation of phytoplankton biomass by DIR bacteria. Our work tests this hypothesis by measuring changes in the trace metal composition of anoxic incubations that include the model DIR bacterium *Shewanella oneidensis* MR-1, using phytoplankton biomass as a carbon source and ferrihydrite as an electron acceptor. Results show that while *S. oneidensis* MR-1 consumes some of the carbon substrates from phytoplankton biomass, there is no evidence that this DIR bacteria degraded metalloproteins and subsequently liberated trace metals for potential capture in BIFs. Instead, these data imply that other heterotrophic bacteria (*e.g.*, fermenters) may have had a larger role in the remineralization of organic matter in precursor BIF sediments. More broadly, this work demonstrates the value of integrating trace metal geochemistry with other tools to explore the interplay between life and the environment in the Precambrian.