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Simulating Archean Ocean redox stratification to constrain microbial Fe(II) oxidation and Fe mineral formation relevant for BIF deposition

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Banded Iron Formations (BIFs; 3.8–1.85 Ga) archive extensive deposition of Fe(III) (oxyhydr)oxide and silica minerals in Precambrian oceans [1], yet the microbial processes and ecological interactions that could have driven water-column Fe(II) oxidation and primary Fe–bearing particle formation remain debated. In addition to oxygenic photosynthesis by cyanobacteria [2], anoxygenic phototrophic Fe(II)-oxidizers have been proposed as major contributors to Fe(III) production in photic zones [3,4]. A key uncertainty is whether these metabolisms could have coexisted under persistent stratification and continuous solute supply from oceanic and continental sources.

We are establishing a 1.8 m (12 L) dynamic column reactor to simulate a redox-stratified Archean seawater with continuous inflow of Fe(II) and dissolved silica. The column is designed to maintain stable vertical gradients while enabling spatially resolved monitoring of pH and O_2 along the water column, repeated quantification of dissolved Fe and Si speciation and collection of suspended and settled particles. Using monocultures and co-cultures of a model marine cyanobacterium (*Synechococcus* sp. PCC 7002) and a marine anoxygenic phototrophic Fe(II)-oxidizer (e.g., *Chlorobium* sp. strain N1 or *Rhodovulum iodosum*), we (i) quantify Fe(II) oxidation dynamics and spatial separation of oxygenic *vs* anoxygenic Fe(II) oxidation zones, (ii) determine how community composition modulates Fe(III) production and Fe(Si) particle aggregation/settling and (iii) characterize mineral products (µ-XRD, SEM, TEM) to constrain mineralogy, crystallinity and microbe–mineral associations. Given that the reactor spans a meter-scale water column, it permits evaluation of changes during particle settling that may overprint primary precipitates prior to burial.

Overall, this large-scale column is aimed at linking microbial ecology and water-column geochemistry to primary Fe mineral products, providing direct experimental constraints on mechanisms that could have driven large-scale Fe(III) deposition and influenced the Earth's early biogeochemical cycles.

[1] Bekker et al. (2010) Econ. Geol. 105, 467–508.
[2] Konhauser et al. (2017) Earth-Sci. Rev. 172, 140–177.
[3] Kappler et al. (2005) Geology 33, 865–868.
[4] Konhauser et al. (2005) Geobiology 3, 167–177.