Influence of microbial Fe cycling on the formation of primary BIF sediments

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Both geochemical analyses and laboratory studies suggest an important role for Fe-metabolizing bacteria during the genesis of the 3.8-1.85 Ga old Banded Iron Formations (BIFs). However, the effect of co-occurring microbial Fe(II) oxidation and Fe(III) reduction (i.e., an early microbial Fe cycle) on primary BIF mineralogy remains unclear.

Here, we simulated a microbial Fe cycle with photoautrophic Fe(II)-oxidizing and anaerobic Fe(III)-reducing bacteria under Precambrian ocean-like conditions to determine the influence of repeated and dynamic microbial Fe cycling during sedimentation of primary particles on the primary BIF mineralogy. We determined Fe(II) oxidation and Fe(III) reduction rates using wet geochemical methods, analyzed cell-mineral associations by fluorescence and electron microscopy, and characterized the Fe mineralogy by ^{57}Fe Mössbauer spectroscopy and X-ray diffraction (XRD).

Our results suggest that the presence of Si accelerated Fe(II) oxidation and Fe(III) reduction compared to Si-free setups. Furthermore, Si favoured the formation of short-range ordered minerals, such as ferrihydrite, at the expense of more crystalline minerals, such as goethite. Siderite was shown to form at the expense of mixed-valent Fe(II)/Fe(III) minerals, such as magnetite. Additionally, both Si and microbial biomass were co-precipitated with Fe(III) minerals during Fe(II) oxidation and were released during microbial Fe(III) reduction, suggesting an essential role of biomass and Si during mineral (trans)formation.

In conclusion, microbial Fe cycling during the sedimentation of primary Fe(III) minerals through the photic zone would have resulted in a mixture of short-range ordered Fe(III) minerals and Fe(II) minerals in the initial BIF sediments. The re-mobilization of biomass and Si during Fe cycling back into the water column would have resulted in lower microbial Fe(III) reduction rates in the sediment, resulting in the formation of more crystalline secondary minerals later in the diagenetic history.