Investigating Early Iron Silicate Inclusions in Banded Iron Formations through Nanoscale Geochemical Characterization and Experimental Constraints

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Archean sedimentary strata on Earth host several types of unusual rocks and minerals; iron-rich chemical precipitates forming deep marine Banded Iron Formations (BIFs) are some of the most remarkable and extensive. While many hypotheses for BIF formation have postulated that the original precipitates were iron oxides, recent discoveries of iron silicate inclusions preserved in early-silicifying chert suggest that the primary precipitates from the Archean oceans may have been iron silicates. However, the oxidation state and chemical form of Fe have not yet been fully characterized. We investigated these iron silicate inclusions and their implications for ancient seawater chemistry in a multi-faceted approach using spectroscopic- and diffraction-based techniques. The crystal structure, Fe oxidation state and Fe coordination environment of the iron nanoparticles were interrogated using bulk and microscale X-ray absorption spectroscopy, transmission electron microscopy, and nanoscale scanning transmission X-ray microscopy. These analyses enabled us to tie particle textures to quantitative Fe(II/III) ratios and mineralogical information. To further explore chemical and biological controls on iron silicate formation, we have also performed laboratory experiments to replicate similar iron-bearing silicate minerals under abiotic conditions and in the presence of iron-oxidizing bacteria. As we probe the mechanism of Fe(II/III)-silicate formation, we will be able to constrain the activity of silica, pH, and pO_2 on early Earth and describe any potential influence of microbial activity on the precipitation of these iron silicate phases.