

Greenalite first: Making BIFs green again

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Banded iron formations (BIFs) are chemical sediments that were deposited from seawater during the Precambrian. They represent important geochemical archives that can provide insights into the evolution of the biosphere and composition of the early oceans and atmosphere. BIFs are traditionally interpreted to have formed from iron oxides/hydroxides that precipitated when hydrothermal Fe²⁺ upwelled into the photic zone and was subsequently oxidized. Hematite dust in BIFs is interpreted to represent relicts of the ferric oxide/hydroxide precipitates.

New optical, SEM and TEM microscopy of BIFs from Campbellrand platform, South Africa, and Hamersley Group, Australia, reveals the presence of abundant greenalite nanoparticles, interpreted to represent primary precipitates from ferruginous seawater. The particles define sedimentary lamination, and are engulfed in chert cement that preserves shrinkage structures, considered to have formed during dehydration of amorphous silica cement.

A new model is proposed for the deposition of the BIFs involving iron silicate precipitation from seawater. We suggest that ferrous iron and silica were transported in hydrothermal plumes sourced from relatively acidic vent fluids. Upon mixing with cooler, more alkaline seawater, the solubility of ferrous iron and silica fell to levels that favored rapid nucleation and the precipitation of iron-silicate nanoparticles over vast areas of the seafloor. Furthermore, on the seafloor, iron-silicate nanoparticles presumably acted as nucleation sites for dissolved silica, promoting early diagenetic silica precipitation and cementation of the iron-rich muds. Our results indicate that iron silicates were important primary precipitates and suggest that changes in alkalinity rather than redox state played a key role in the precipitation of the precursor sediments of BIFs.