Earliest minerals in BIF

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Banded Iron Formations (BIF) are the quintessential Precambrian sediment but their mode of formation is contentious. It is generally agreed that they are chemical sediments and as such that they provide an archive of the chemistry of the Precambrian ocean which can inform our understanding of early life and its habitats. The mineralogy of the original seawater precipitates has been modified by subsequent early and late diagenesis, metamorphism and oxidation producing complex assemblages of Fe-oxides (magnetite, hematite), carbonates (siderite, ankerite, dolomite, calcite) and Fe-silicates (greenalite, stilpnomelane, minnesotaite, riebeckite). However, very fine grained vestiges of the original sediments are preserved, and can be characterised by micro- and nano-beam techniques.

SEM and TEM examination of chert-rich samples from the Brockman Iron Formation, Hamersley Group, Western Australia, shows that sedimentary laminations are preserved in chert enclosing nanoscale particles of greenalite and/or stilpnomelane. In some instances sedimentary grading is also preserved. The chert is broken into polygonal structures that are interpreted to be shrinkage features resulting from dehydration of original amorphous silica precipitated at the sediment-water interface. The shrinkage cracks have been filled by a second generation of clear silica (quartz), and cut the sedimentary laminations. TEM images show that the greenalite-chert polygons predate the formation of carbonate and hematite. Where stilpnomelane nanoparticles are present, they have formed by replacement of greenalite nanoparticles. Another feature of well-preserved BIF are spherical microgranules (10-20 μm) composed of stilpnomelane that occur in clear quartz, or greenalite-bearing chert. They are interpreted to have formed by flocculation of Fe-silicate nanoparticles in the water column and deposition in the proto-BIF sediment.

Greenalite nanoparticles have been found in BIF and jaspers from the 3.46 Ga Marble Bar Chert, 2.77 Ga Weld Range BIF, 2.50-2.46 Ga Brockman IF, BIF of the ca 2.5 Ga Klein Naute Formation (South Africa) and ca 1.9 Ga Biwabik IF (USA), showing that these early minerals were a common feature of BIF deposition. Understanding the origin of the minerals in BIF is a prerequisite to unravelling the chemical archive that they preserve.