Species-specific intracellular iron biomineralization in a 1.9-Ga microfossil assemblage

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Gunflint-type Paleoprotezoroic (2.45-1.6 Ga) microfossil assemblages are dominated by spherical (*Huroniospora*) and filamentous (*Gunflintia*) microfossils with phylogenetically ambiguous morphologies. Based on depositional environment, mineral associations (carbonates, Fe-oxides, sulfides), and Fe-, S- and C-isotopes, microfossils have been interpreted variously as cyanobacteria, Fe-oxidizing bacteria, or S-oxidizing bacteria.

We studied microfossils in shallow water stromatolites of the 1.9 Ga Gunflint Iron Formation using a combination of Focused Ion Beam sectioning, Scanning Transmission Electron Microscopy, Electron Energy Loss Spectroscopy, nanobeam electron diffraction, and Scanning Transmission X-ray Microscopy. Taphonomic transformations and primary taxonomic features were distinguished by organic micro- to nanostructures. This defined two populations (thick- and thin-walled) of *Huroniospora*. Moreover, intracellular Fe-oxide minerals were systematically found in thick-walled *Huroniospora*, but not in thin-walled *Huroniospora* or in filaments (*Gunflintia*). Nanoscale distribution of iron oxidation states (Fe^{2+} *vs* Fe^{3+}), petrographic relationships, and cristallography provide constraints on the diagenetic fate of the initial Fe-bearing phases in these microfossils. We propose that these Fe-oxides formed after primary Fe^{3+}-bearing intracellular biominerals in *Huroniospora*. The species-specific Fe-mineralization rules out secondary processes affecting all organic fossils. Moreover, the intracellular locus of Fe-mineralization, coupled with the large size (7-12 μm) of the microfossils put constraints on the metabolism of thick-walled *Huroniospora* and on the chemistry of their environment.