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

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Gunflint-type Paleoproterozoic (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 (Fe²⁺ vs Fe³⁺), petrographic relationships, and crystallography provide constraints on the diagenetic fate of the initial Fe-bearing phases in these microfossils. We propose that these Fe-oxides formed after primary Fe³⁺-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.