Discovery of new morphotypes in ca. 1.9 Ga Gunflint microfossils and their complex structure and heterogeneous chemistry

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Microfossils in Paleoproterozoic Gunflint Formation have been studied by previous investigators for decades, while no agreements exist for primary producers and complexity of ecosystem in the shallow Gunflint ocean. Here we report discovery of new morphotypes of Gunflint microfossils and their unique microscale structure and elemental distributions.

Morphological observation revealed new morphotypes of microfossils, suggesting cyanobacterial colonies (*Eoentophysalis*) and resting cells (cyanobacterial akinete and spore–like organisms). These provide new evidences of widespread oxygenic photosynthesizing bacteria in Paleoproterozoic surface ocean water. Another type discovered by the present study has various radial appendage (ca. 1–3 μm) on spherical cell structure (ca. 6–10 μm). This type is completely different from morphologies of well-known Gunflint microfossils such as, *Eoastrion simplex* and *Kakabekia*, and most likely representing eukaryotes. Those new findings suggest more diverse characteristics of the Gunflint shallow ecosystem than considered by previous investigators. In addition, in situ analyses of chemical and isotope compositions were performed on individual microfossils by high spatial resolution Secondary Ion Mass Spectrometry (NanoSIMS). Detailed analyses identified multi–layered structure of cell wall, which had not been reported at this age. Moreover, heterogenous elemental, such as nitrogen and sulfur, distribution in intercellular inclusions and cell wall was also observed. A part of such heterogeneity was created during diagenesis, but some parts retained initial heterogeneity in organic matter. Thus, the new information using NanoSIMS analysis on individual microfossils leads to more detailed understanding of the microbial ecosystem in the Gunflint Formation, and also provide a new clue to understand the evolution of early biosphere.