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Mineral artefacts mimicking microfossils in Archean rocks

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Because prokaryotes populating the early Earth were structurally and morphologically very simple, it is difficult to obtain taxonomic information from microfossils, and even more problematic, to distinguish true fossils from abiotic objects. For example, many self-assembly processes associated with the precipitation of nanoscale minerals in the presence of organic compounds generate cell-like structures. Based on high resolution microscopy observations on natural samples, we describe three types of features common to Archean rocks and suggest that they represent microfossil-like artefacts.

Using Scanning Electron Microscopy we have observed carbon-free silica inclusions in carbonate sediments that are very similar in size and shape (rods and spheres) to microorganisms. The common distribution of organic carbon at grain boundaries in those rocks indicate that such cell-like minerals, when coated by secondarily-migrated carbonaceous mater, could easily be mistaken for microfossils.

The organisation and the micro- to nano-structure of bacteriomorphs might be even more confusing. We have observed chains of spheres that match in size and arrangement with some coccoid bacteria such as streptococci. Transmission Electron Microscopy (TEM) observation of Focused Ion Beam (FIB) sections cut through these spheres shows that they are composed of TiO_2nanocrystallites partly rimmed or linked by nanoscale chlorite films. This assemblage creates smooth cell-like structures at the micron-scale. However, the absence of organic carbon in those structures as well as the observation of many similar TiO_2 chains of spheres dispersed in volcanic glass shards argue against a biologic origin.

Ambient inclusions trails also generate filamentous structures that can be mistaken for microfossils. (Knoll and Barghoorn, 1974) suggested that such pseudofossils could have formed by the displacement of a crystal (e.g. pyrite) in its mineral matrix owing to pressure solution processes linked to gas evolution of associated organic material. We have found garnet filaments within agate of the Maddina Formation (2.7Ga) basalt. TEM analysis of FIB sections cut trough these filaments and Raman mappings of carbonaceous matter confirm the role of organic matter displacement in the formation of those microfossil-like structures. Thus, the existence of such organo-mineral features shows the importance of correlating microbial morphologies with the texture and distribution of organic matter within (to support an indigenous origin) or around (to identify migrations) cell-like micro to nano-structures.

Knoll, A. H. and Barghoorn, E. S., 1974. Ambient Pyrite in Precambrian Chert: New Evidence and a Theory. *Proceedings of the National Academy of Sciences (US)* **71**, 2329-2331.