

Macroscopic fossils of microbial communities in Eoarchean-Hadean jasper from the Nuvvuagittuq Supracrustal Belt

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The oldest known microbial fossils occur as microscopic haematite filaments and tubes in a jasper-carbonate nodule from the banded iron formation (BIF) in the >3.75 Ga, and possibly up to 4.28 Ga, Nuvvuagittuq Supracrustal Belt in Canada. However, the microfossil complexity, community organisation, and possible metabolisms remain to be documented. Newly observed haematitic microfossil specimens from a nodule in this BIF occur as centimetre-sized pectinate-branching and parallel-aligned filaments. Optical images further reveal that some of these have a twisted morphology and are enclosed inside haematite tubes. Decorating the arborescent structure, there are also granules of coarse quartz that contain dozens of oblate spheroids composed of haematite. X-ray-based imaging reveals filaments inside the dense and opaque Fe-oxides, as well as millimetre-long twisted filaments. Associated accessory minerals have geochemical compositions consistent with a biological origin. For instance, filaments often contain ferrous iron in haematite, consistent with diagenetic experiments of the thermal alteration of Fe-oxidising bacterial filaments. Associated calcite rosettes have ¹³C-depletions around -11‰, which points to the oxidation of biomass during diagenesis. Outsized chalcopyrite crystals contain inclusions of apatite-galena, which demonstrate the ancestry of the apatite and Pb-loss during metamorphism. Sulphides in the jasper-carbonate BIF also have ³³S- and ³⁴S-enrichments consistent with an anoxic atmosphere and with microbial sulfur disproportionation. Collectively, the new observations suggest the Nuvvuagittuq microbial communities included photoferrotrophic and S-disproportionating microorganisms. This well-preserved microbial ecosystem is the oldest known on Earth, could be common on other planets with hydrothermal activity, and increases the probability for the widespread existence of extra-terrestrial life.