Eoarchaean Life (≥3.7 Ga): Confirmation from Isua (Greenland)

Allen Nutman*

***** School of Earth & Environmental Sciences, University of Wollongong, Wollongong, NSW 2522, Australia

ABSTRACT

In contrast to the majority of Eoarchaean terranes, the 3.8-3.7 Ga Isua supracrustal belt (Greenland) contains tectonic slices with maximum metamorphic temperatures below 550°C, as well as rare domains where deformation is low, resulting in the preservation of Eoarchaean sedimentary structures. Thus Isua is the premier hunting ground for evidence of earliest life in the terrestrial rock record. The first searches for early life focused on the use of carbon isotopic signatures. In the 1970s bulk graphite analysis revealed negative $\delta^{13}C_{VPDB}$ values, and debate surrounded whether this was a biogenic or a solely metamorphic signature by the reaction $6FeCO_3 \leftrightarrow 2Fe_2O_4+5CO_2+C$. To avoid possible metamorphic graphite, subsequent carbon studies sought silicate rocks devoid of carbonate and graphite from greywackes yielded negative $\delta^{13}C_{VPDB}$ values. This graphite has nanoscale morphologies consistent with pyrolyzation of structurally heterogeneous organic compounds during metamorphism.

Over a billion tons of banded iron formation (BIF) occur in Isua. Comparative studies with younger BIF combined with detailed petrographic and Fe-isotopic studies of Isua BIF suggest massive biomediation in the production of these rocks. For many Isua carbonates, biogenic fractionation is the preferred interpretation, because it is observed that units of Isua massive dolomite have rare earth element + yttrium signatures like modern seawater or biomicrites, indicating a sedimentary origin. Given that low temperature dolomite is only known to form by microbial mediation, this is many thousands of tons of simple, robust evidence for early life.

Physical (structure) rather than chemical and isotopic evidence is also sought. In the 1970s, globular structures in metacherts were interpreted as relict microfossils, but subsequent investigations have reinterpreted these as younger abiogenic structures. In a low strain domain discovered in this decade, ~3.7 Ga dolomitic rocks preserve shallow water sedimentary structures and stromatolites. Thus five decades of Isua investigations have resulted in increasing and diverse lines of evidence for Eoarchaean life. The weight of evidence is affirmative, and future research should focus on the diversity of the ecological niches it occupied and its metabolic pathways.