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Use of S and C isotopes to distinguish between biological and hydrothermal signatures in 3.8 and 2.7 Ga Archaean rocks

N.V. Grassineau (1), E.G. Nisbet (1), P.W.U. Appel (2) and C.M.R. Fowler (1)

(1) Dept. of Geology, Royal Holloway Univ. of London, Egham, TW20 0EX, UK, (2) Geological Survey of Denmark and Greenland (GEUS), 1350 Copenhagen, Denmark (nathalie@gl.rhul.ac.uk / Fax: +44 (0)1784 471780 / Phone: +44 (0)1784 443810)

Carbon and Sulphur isotopes from formations of the Isua Greenstone Belt (3.8Ga) and the Belingwe Greenstone Belt (2.7Ga) have been analysed. Inorganic isotopic signatures are clearly present, including secondary hydrothermal mineralization and overprinting. However, many results are well outside the ranges of typical abiotic processes and most part of these samples are likely biogenic. The contrast between δ^{34}S and $\delta^{13}C_{red}$ results from Isua and Belingwe suggests that microbial biochemistry became more capable and complex over this 1Ga year period.

Early Archaean life, at 3.8Ga, may have been present mainly around high-temperature hydrothermal vents. C and S isotopic compositions suggest biogenic processes. These may have been limited, but post-depositional metamorphism makes it difficult to judge the diversity of the Isuan biosphere.

In contrast, in the Late Archaean at 2.7Ga, much more diverse and complex metabolic processes have been recorded. There is a δ^{34}S range of 38 permil in the Belingwe samples, indicating a complex sulphur reprocessing cycle. $\delta^{13}C_{red}$ varies by 36 permil, with $\delta^{13}C_{carb}$ close to 0 permil, demonstrating that oxygenic photosynthesis was in operation. More generally, both oxygenic and anoxygenic photosynthesis, sulphate-reduction and, possibly, sulphide-oxidation, and methanogenesis and methanotropy were all active. Therefore, the biological sulphur and carbon cycles seem to have reached by 2.7Ga almost full operation, with interactions between well-established microbial mat communities using a variety of pathways.