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Additional evidence for a sulfur-cycling microbial community preserved in chert from the c. 2.4 Ga Turee Creek Group

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Recent investigations of a c. 2.4 Ga microbialite reef-complex of the Turee Creek Group, Western Australia, have provided insight into ecosystems at the Great Oxidation Event. One study[1] has interpreted some filamentous microfossils as sulfur-oxidisers, based on morphological comparison to modern sulfur bacteria. However, uncertainty surrounds paleophysiological interpretations that rely on morphology alone[2].

Here we present additional lines of evidence for a sulfur-cycling interpretation. Petrographic observations and *in situ* geochemical data record the likely metabolism of two different populations of filamentous microfossils, preserved within different samples from a single unit of nodular black chert (NBC). The two populations (NBC1, NBC2) were positioned offshore from the reef-complex and represent deeper-water benthic communities[3].

In NBC1, we observed ellipsoidal-polygonal clear domains between microfossils that are filled by microquartz of increasing grain size, indicating replacement of pre-existing material[4]. This fabric is comparable to modern-day seafloor sediments that contain nodular anhydrite 'chicken-wire' texture[5] (Fig. 1). Further, a 'life array' of alternating vertically- and horizontally-aligned filaments[3] is analogous to the arrangement of filamentous sulfide-oxidising bacteria within modern-day sediments[6]. These analogies place the fossilised microorganisms in direct association with what was likely to have been nodules of sulfate, in a setting known to be habitable for sulfide-oxidising bacteria.

In NBC2, *in situ* sulfur isotope data from concentrically zoned pyrite that co-occurs with filamentous microfossils returned a $\delta^{34}S$ range spanning -2.92 to +28.42‰ (mean: +17.23 ±6.48‰; n: 68). This data indicates pyrite formation by bacterial sulfate-reduction in the sediment under progressively restricted sulfate supply[7].

Combined, the textural and isotopic data point toward a seafloor-inhabiting community of filamentous bacteria, with NBC1 linked to sulfide-oxidation and NBC2 linked to sulfate-reduction.

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Figure 1. A)-B) Clear domains in NBC1 (A: PPL, B: XPL). C) Nodular anhydrite 'chicken-wire' texture[5]. D) Nodule replacement by microquartz after anhydrite[4].