A 3480 Ma pyritised microbial mat, Dresser Formation, Western Australia

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We investigated the structure and geochemistry of a newly discovered occurrence of ~3480 Ma pyrite in order to shed new light on sulfur cycling and potential biological activity on the early Earth. The pyrite occurs within a tufted microbial mat, one of a suite of microbially induced sedimentary structures (MISS) recently reported from the Dresser Formation, Pilbara Craton, Western Australia [1].

Quadruple sulfur isotope data (mean $\delta^{34}S$ = +4.4‰; $\Delta^{33}S$ = +1.5‰; $\Delta^{36}S$ = -5.3‰) indicate that the dominant form of sulfur incorporated into the pyrite was mass independently fractionated (MIF) elemental sulfur (S^0). However, significant micro-scale heterogeneity of the data within and between laminations of the MISS ($\delta^{34}S$ = +1.6‰ to +6.7‰; $\Delta^{33}S$ = +0.4‰ to +2.6‰; $\Delta^{36}S$ = -3.1‰ to -8.1‰) and deviation of data arrays away from the typical $\delta^{34}S$ vs $\Delta^{33}S$ and $\Delta^{36}S/\Delta^{33}S$ 'early Archean arrays' [2] indicates that one or more additional pools of sulfur, that were spatially variable at the micro-scale, also contributed to the isotopic composition of the pyrite. We interpret these data in the context of a polysulfide pyrite formation pathway [3]. Here, a significant standing pool of MIF-S^0 present in organic-rich Dresser sediments was mobilized by reaction with small quantities of sulfide, most likely derived from reduction of seawater sulfate, to form polysulfide precursors to pyrite.

Raman and FIB-TEM data demonstrate the close association of pyrite with indigenous organic material and suggest nucleation of pyrite on organic laminations within the MISS. A number of spherical and elliptical pyritic objects are also seen within the microbial mat. These range in size from ~1μm to 50μm or more and most have wall-like zones comprising nano-grains of pyrite and carbon, plus hollow (silica-filled) interiors. The origin and potential biological nature of these microstructures will be discussed.

[1] Noffke *et al* (2013) *Astrobiol.* **13**, 1103-1124. [2] Johnston (2011) *Earth-Sci. Rev.* **106**, 161-183. [3] Farquhar *et al* (2013) *Proc. Nat. Acad. Sci. USA* **110**, 17638-17643.