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An analysis of *in situ* carbonaceous matter from the Warrawoona Group, Pilbara, Western Australia: indications of early life in the gel

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Carbonaceous materials (CM) were extracted from black cherts of the 'white smoker type' ca. 3.49 Ga Dresser Formation in the Pilbara of Western Australia [1], and subjected to a series of analytical techniques to determine their thermal history and potential biogenicity. Organic petrology and thermal reflectance (Ro) measurements reveal three types of organic matter, i.e. primary depositional, material subject to secondary heating, and externally sourced thermally over-mature material. The primary CM yielded an Ro of 0.5% (equivalent to vitrinite reflectance of 0.8%), which corresponds to temperatures of circa 130˚C[2]. Reflected light microscopy shows this CM type as laminated silica-impregnated cell-like aggregates, while microstructural analysis under TEM reveals semi-spherical isolated bodies or aggregates exhibiting features analogous to microbial cells, including well preserved wall-like structures. This CM is interpreted to represent relatively well-preserved, *in situ* syn-depositional microbial communities that were not subjected to high thermal stress or significant post-depositional alteration.

The intermediate Ro population (1.0-1.5%) corresponds to temperatures of 150-190˚C, and, when observed under TEM and HRTEM, displays similarities relatable to the putative microbial cells of the primary group. Since the different Ro populations have been found to occur in the same samples, it is likely that they represent a mixing of thermally unstressed organic matter with thermally degraded CM, possibly as the result of vein remobilisation and deposition in the congealing silica gel host.

The third CM group lacks any discernible morphological features and has an Ro range

of 2.5-3.8% (equivalent to temperatures of 240-270˚C). It may represent the 'kerogenous' material reported in previous studies [e.g. 3]. Possibly the result of meteoritic impact affects [4, 5], this material lacks any visible morphological structures and is interpreted to represent recycled CM introduced from an external source by water circulation currents or mass wasting processes.

Consistent with these Ro values, calculation of palaeotemperatures from the quartz δ^{18}O results (13.5-16.1 per mille SMOW), assuming a likely value of –1 per mille SMOW for the Archaean ocean [6, 7], infers a possible depositional temperature for the Dresser Formation cherts of 132 -160˚C. δ^{13}C values for the Dresser Fm CM are also consistent with a biogenic origin, returning bulk sample values of -32.1 to -38.2 per mille PDB.

Overall, these findings suggest that the CM from the Dresser Formation represent the remains of a developing microbial community that inhabited the flanks of an early seafloor hydrothermal vent system.

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