Geochemical tracing of the Early Archaean hydrothermal chemotrophic biosphere

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Chemotrophic biosignatures from the Early Archaean (3.8-3.3 Ga) are poorly understood because their traces in the fossil record are enigmatic. However, recent studies of hydrothermal-sedimentary niches have shown that chemotrophic biomass and its preservation can be exceptional and appears to be controlled by hydrothermal activity [1].

In the 3.33 Ga Josefsdal Chert, Barberton, a flourishing community of anaerobic phototrophs and chemo(litho)trophs is preserved in three-dimensions in strongly hydrothermally permeated sediments [1]. Interpreted chemotrophs occur as rounded clots ‘sedimented’ between phototrophic mats and, intriguingly, as spiky, irregularly shaped clots interpreted as colonies floating in the silica effluent itself. This suggests that chemotrophic microbes grew *in situ* and used the nutritional potential of hydrothermal fluids directly. In volcanogenic sediments of the 3.446 Ga Kitty’s Gap Chert, Pilbara craton, monolayer colonies of coccoidal organisms coat volcanic particles, also tunnelling into them, presumably fuelled by the range of ions in igneous minerals and their alteration products, with which they are intimiately associated [2, 3].

In the 3.46 Ga stratiform ‘Apex chert’, Pilbara, and in the 3.45 Ga Hooggenoeg Formation and 3.42 Ga Buck Reef Chert, Barberton, clotted textures with similar, in-sediment, putatively chemotrophic biosignatures are under investigation in order to understand the extent of the Archaean chemotrophic biosphere and its role in early ecosystems [4]. We study these biosignatures with a multi-scale, multi-technique morphological-geochemical approach (correlative microscopy), involving SEM, Raman, PIXE and LA-ICP-MS to detect the mineralogical and elemental signatures by which enigmatic chemotrophic fossils can be traced on Earth and, if present, using geochemical instrumentation on Mars rovers.

[1] Westall *et al.*, 2015, *Geology*, **43**, 615.[2] Westall *et al.*, 2011. *PSS*, **59**, 1093. [3] Foucher *et al.*, *Icarus*, **207**, 616. [4] Hickman-Lewis *et al.*, 2017, Abstract #3125, AbSciCon.