Looking for life: Determining biogenicity of ancient organic matter

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The study of organic matter (OM) can provide insight into how life evolved on Earth and help determine its existence elsewhere in the solar system (De Gregorio et al., 2011). OM can be found in some of the earliest rocks on Earth (i.e., Archean, > 2.5 Ga), but there are commonly questions regarding its syngeneity, biogenicity, and potential contamination (French et al., 2015). Therefore, robust synthesis of morphological, chemical, and contextual data is required for the confident interpretation of the early organic record (Hayes et al., 2017).

Problematically, microfossil-like carbonaceous microstructures and organic molecules can be formed abiotically (Rouillard et al., 2018). Distinct molecular fingerprints of life are furthermore commonly blurred by thermal maturation (Mißbach et al., 2016), resulting in molecular inventories that are indistinguishable from abiotic products formed via Fischer-Tropsch type (FTT) synthesis (Mißbach et al., 2018). Yet studies of individual early Archean samples have identified indigenous organic molecules exhibiting features distinct from FTT reaction products (e.g., Duda et al., 2018; Marshall et al., 2007).

Here we examine OM in low-grade meta-dolomites with bedded and nodular cherts from the ~2.4 Ga Turee Creek Group, Western Australia. The investigated samples represent different environments and comprise a variety of evidence for life, including microbial textures (stromatolites, thrombolites), various microfossil assemblages, and enigmatic, as yet unidentified, branching organic-siliceous structures (Fig. 1; Barlow and Van Kranendonk, 2016). Total organic carbon contents are relatively low (0.02-0.05 wt%). Field observation, petrographic analysis and Raman spectroscopy revealed that OM exclusively occurs embedded within the matrix; there is no evidence for a later introduction of OM in any of these samples. Raman spectra are in good occordance with the thermal history. The OM is preferentially linked to microbial textures as well as to microstructures that group into morphologically distinct populations (Fig. 1). Fourier Transform Infrared Spectroscopy (FTIR) and microFTIR show chemical differences for OM linked to different microbial textures and microstructures. The spatial restriction of OM to various microbial textures and distinct fossil morphotypes indicates a biological origin. Further work is going to be done to present a robust synthesis of data regarding the syngeneity and biogenicity of OM in these samples.

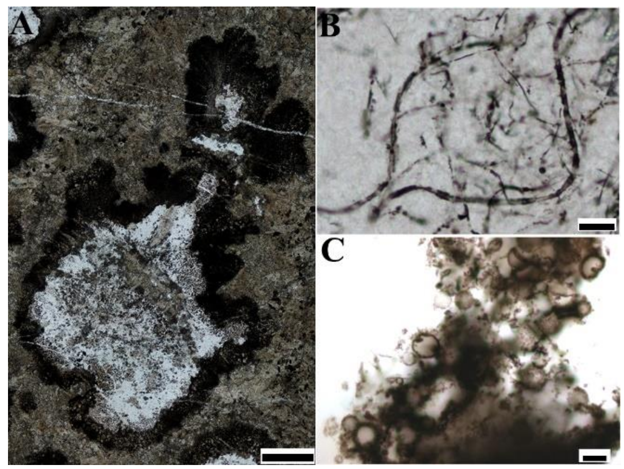

Figure 1. Photomicrographs of some of the biologically diverse samples from this study. A. Enigmatic tube structures from the Turee Creek Group. Scale bar = 1000µm; B. Dense tangled filamentous microfossil network. Scale bar = 50µm; C. Unicells. Scale bar = 10µm. A and B from Barlow and Van Kranendonk (2018)

References:

Barlow E.V. and Van Kranendonk M.J. (2016) *Geobiology*, *14*, 317-343
Barlow E.V. and Van Kranendonk M.J. (2018) *Geobiology*, *16*, 449-475
De Gregorio et al. (2011) *Earliest life on Earth. Springer Science.*
Duda J.P. et al. (2018) *Biogeosciences*, *15*, 1535-1548
French, K.L. et al. (2015) *PNAS*, *112*, 5915-5920
Hayes, L.E. et al. (2017) *Astrobiology*, *117*, 363-400
Marshall C.P. et al. (2007) *PreCam Res*, *115*, 1-23
Mißbach H. Et al. (2016) *Int J Astrobiol*, *15*, 165-175
Mißbach, H. et al. (2018) *Org Geochem*, *119*, 110-121
Rouillard et al. (2018) *Geobiology*, *16*, 279-296