PUSHING THE LIMITS OF DETECTION: INVESTIGATING THE STRUCTURE OF 2.4 GA OVERMATURE KEROGEN

B. L. Teece[1], B. Pejcic[2], S. C. George[3], G. G. Soares[1], E. V. Barlow[1], A. Pagès[4], M. J. Van Kranendonk[1].

1. University of New South Wales, Australia
2. CSIRO, Mineral Resources, WA, Australia
3. Macquarie University, Australia
4. Department of Water and Environmental Regulation, Western Australia

The study of kerogen can aid in understanding the evolution of life on Earth by yielding geochemical information on ancient organisms. However, the study of kerogen in Precambrian overmature rocks is problematic due to uncertainty regarding the biogenicity of kerogen. Furthermore, ancient kerogens are commonly highly simplified, having lost most of their structural information during catagenesis and metagenesis. Therefore, careful study of candidate Precambrian-age kerogen is required to have any chance of finding any primary structural information. A few previous studies have identified organic matter with features that are distinct from those produced abiotically through Fischer-Tropsch-type synthesis (e.g., Marshall et al., 2007; Duda et al., 2018). Hickman-Lewis et al. (2020) used Fourier transform infrared spectroscopy (FTIR) to show that Paleoarchean kerogens from different strata had primary differences in their structure, enabling determination of the community composition of microbial mats.

Here we examine organic matter in a well-preserved (metamorphic temperature ~230°C) dolomite microbialite reef complex of the ~2.4 Ga Turee Creek Group, Western Australia. This group contains diverse stromatolites, thrombolites, and shallow and deep-water microfossil assemblages preserved in black chert, and enigmatic branched organic structures (Fig. 1; Barlow and Van Kranendonk, 2016; Barlow et al., 2018). There is no evidence for post-depositional introduction of organic matter from veins or fluids.

Total organic carbon values are low (0.02–0.5 wt%), but kerogen bands in Raman spectroscopy are abundant, and consistent with regional thermal maturity estimates. In addition, FTIR and micro-FTIR studies showed significant chemical differences between samples of microfossiliferous chert, stromatolites, and branched organic structures. These differences preclude surface contamination or post-depositional alteration, and Fischer-Tropsch-type synthesis can be ruled out on geological grounds. Instead, the different characteristics support not only biogenicity of the kerogen, but derivation from different living sources. This work demonstrates that information gained from *in situ* measurements of Precambrian overmature kerogen retains more information than from analysis of homogenised kerogens that have lost structural specificity.

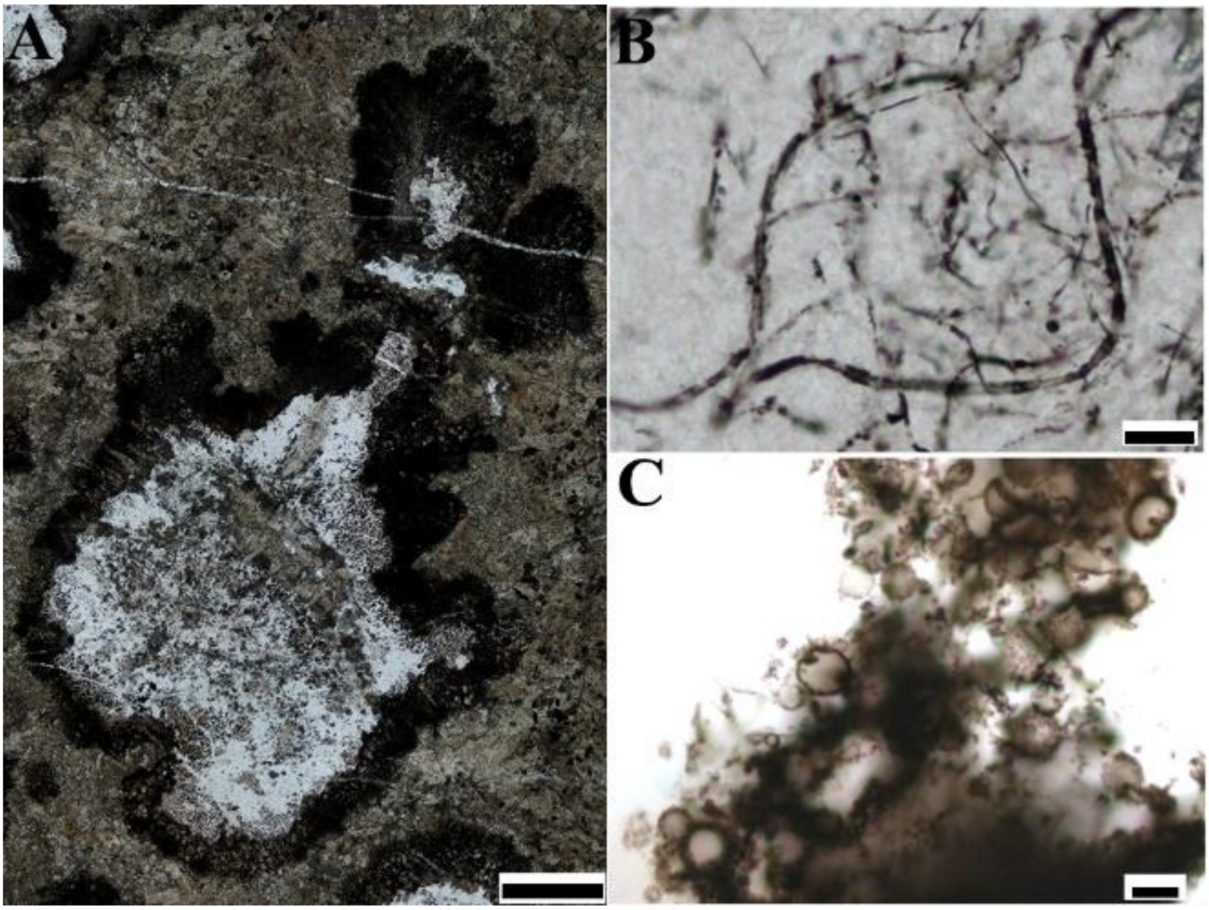

Figure 1. *Photomicrographs of some of the biologically diverse samples from this study. A. Enigmatic tube structures from the Turee Creek Group. Scale bar = 1000 μm; B. Dense tangled filamentous microfossil network. Scale bar = 50 μm; C. Unicells. Scale bar = 10 μm. B and C are from Barlow and Van Kranendonk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

References

Barlow, E., et al. (2016). "Lithostratigraphic analysis of a new stromatolite-thrombolite reef from across the rise of atmospheric oxygen in the Paleoproterozoic Turee Creek Group, Western Australia." Geobiology 14(4): 317–343.

Barlow, E. V. and M. J. Van Kranendonk (2018). "Snapshot of an early Paleoproterozoic ecosystem: Two diverse microfossil communities from the Turee Creek Group, Western Australia." Geobiology 16(5): 449–475.

Duda, J.-P., et al. (2018). "Ideas and perspectives: hydrothermally driven redistribution and sequestration of early Archaean biomass — the “hydrothermal pump hypothesis”." Biogeosciences 15(5): 1535–1548.

Hickman-Lewis et al. (2020) Diverse communities of Bacteria and Archaea flourished in Palaeoarchaean (3.5–3.3 Ga) microbial mats. Palaeontology, 63(6), pp.1007–1033.

Marshall, C. P., et al. (2007). "Structural characterization of kerogen in 3.4Ga Archaean cherts from the Pilbara Craton, Western Australia." Precambrian Research 155(1–2): 1–23.