

## Discovery of the oldest known biogenic molecules at the edge of detectability

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Lipid biomarkers represent an important source of information about ancient ecosystems, particularly in the mid-Proterozoic (1.8–0.8 billion years ago, Ga) when marine basins were almost exclusively inhabited by microorganisms. Currently, the oldest known indigenous biomarkers come from the 1.64 Ga Barney Creek Fm in the northern Australian McArthur Basin, indicating a marine ecosystem dominated by bacteria [1]. In this study, we extend the biomarker record back in time by investigating carbonaceous shales of the 1.73 Ga Wollongorang Fm in the McArthur Basin.

The discovery of mid-Proterozoic indigenous biomarkers is a challenge, since biologically informative molecules of such antiquity are commonly destroyed by metamorphism or overprinted by drilling fluids. Additionally, at some degree of thermal alteration and somewhere in deep geological time, we will encounter an unresolved overlap between biological signatures and thermodynamic ambiguities. In this uncertain boundary scenario, the biomarker molecules might not indicate the presence of biological precursors but represent random abiogenic products. The current study provides an example of such a scenario. The Wollongorang Fm experienced heating by an underlying dolerite sill, and this is reflected by a steep thermal maturity trend. Extracted bitumens contain series of trimethylated aryl isoprenoids (AI), which show a systematic change in the isomer distribution with increasing maturity. While the AI in the most mature samples reach a metastable equilibrium and represent thermal rearrangement products, in the least mature samples the 2,3,6-AI series have a biogenic origin based on its elevated abundances relative to abiogenic isomers. These compounds represent the oldest known biogenic molecules on Earth and reveal the activity of phototrophic bacteria at 1.73 Ga ago [2].

[1] Brocks *et al.* (2005). Biomarker evidence for green and purple sulphur bacteria in a stratified Palaeoproterozoic sea. *Nature*, 437, 866. [2] Vinnichenko *et al.* (provisionally accepted). Discovery of the oldest known biomarkers provides evidence for phototrophic bacteria in the 1.73 Ga Wollongorang Formation, Australia. *Geobiology*.