Oil and its biomarkers trapped inside fluid inclusions ca. 2.45-2.0 Ga

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Biomarkers extracted from oil-bearing fluid inclusions provide a novel tracer of biological evolution through Earth's history. We present case studies of Palaeoproterozoic conglomeratic sandstones that straddle the "Great Oxidation Event" from the ca. 2.45 Ga uraniferous Matinenda Formation at Elliot Lake, Canada, and the ca. 2.1 Ga FA Formation from the Franceville Basin, Gabon, which is famous for hosting the Oklo natural nuclear fission reactors.

In both cases oil was trapped together with aqueous and carbonic fluids in inclusions in cements and in microfractures within framework quartz grains. In the Matinenda Formation entrapment occurred during diagenesis and early metamorphism. In the FA Formation the oil was trapped during diagenesis and also after cementation at temperatures of and above 250°C possibly linked to reactor functioning.

Inclusion oil from the Matinenda Formation contains typical hydrocarbons of oils, including isoprenoids, hopanes, 2α-methylhopanes and sterane biomarkers at levels well above outside rinses and system blanks. The FA Formation analyte also contains these biomarkers, but by comparison with a solid bitumen extract is interpreted to be a mixture of recalcitrant solid bitumen and fluid inclusion oil. The hydrocarbons were likely sourced locally from organic-rich horizons, such as the black shales of the Francevillian FB Formation and the organic-rich Huronian McKim Formation, within the host sequences.

The 2α-methylhopanes indicate oxygen-producing cyanobacteria, and the steranes indicate a significant contribution from eukaryotes. The Matinenda data suggest that some aquatic settings were sufficiently oxygenated to support sterol synthesis before the "Great Oxidation Event". Furthermore, prokaryotes and eukaryotes flourished to such an extent that they produced one of the world's earliest large sedimentary accumulations of organic matter within the FB Formation shortly after the "Great Oxidation Event".

When constrained by relative and absolute dating, oil trapped inside fluid inclusions has the potential to provide a pristine record of Earth's early ecosystems.