

EUKARYOTE-DERIVED STERANES IN PRECAMBRIAN OILS AND ROCKS: FACT OR FICTION?

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The record of steranes in Precambrian rocks has become a crucial line of evidence for the early evolution of life on Earth, as it has been argued that these are diagnostic biomarkers for eukaryotic organisms. The oldest reliable morphological evidence for eukaryotes occurs in the form of spheroidal acritarchs from the 1.8–1.9 Ga Chuanlinggou Formation in China (Knoll & Walter, 1992). In contrast, traces of side-chain alkylated steranes have been reported in hydrocarbons extracted from shales as old as 2.7 Ga from the Pilbara Craton (Brocks *et al.*, 1999). Unfortunately, controversy clouds reports of such sterane extracts based on (1) arguments for and against syngeneity of the steranes with the rocks, and (2) the interpretation that the steranes were derived from eukaryotes. It is generally accepted that the 1.4 Ga Velkerri Formation contains unequivocal steranes (Summons *et al.*, 1988), but older rocks such as the 1.64 Ga Barney Creek Formation may not (Brocks *et al.*, 2005). The geochemistry of oil-bearing fluid inclusions trapped in Precambrian rocks can help confirm the existence of ancient steranes. Textural relationships are used to constrain the relative timing of oil entrapment, and where this can be clearly demonstrated to have occurred during Precambrian diagenesis then the oil inclusions provide a unique repository of biogeochemical information on the early evolution of life on Earth. Hydrocarbons in oil inclusions may survive greenschist metamorphism (Dutkiewicz *et al.*, 1998) at temperatures of ca. 300°C, whereas free hydrocarbons in fine-grained rocks would have cracked to graphite and methane. Oil inclusions are completely encased in a mineral host which protects them from possible biodegradation and over-printing by later generations of Phanerozoic oil. Thus oil in inclusions is generally pristine, unaltered, and less susceptible to anthropogenic contamination that is difficult to eliminate from rock extracts.

Oil inclusions in ca. 2.45 Ga uraniferous fluvial metaconglomerate of the Matinenda Formation at Elliot Lake, Canada were trapped in quartz and feldspar during diagenesis and early metamorphism of the host rock, probably before ca. 2.2 Ga (Dutkiewicz *et al.*, 2006).

They contain an abundance of diverse steranes from C₂₆ to C₃₀. The 2.1 Ga FA Formation sandstone of the Franceville Basin in Gabon that hosts the Oklo natural fission reactors also contains abundant oil inclusions, inside which syngenetic biomarkers including steranes are preserved (Fig. 1). Comparison with outside rinse and system blanks shows that only some C₂₇ steranes are non-indigenous to the Matinenda and Oklo oil inclusions (Fig. 1). Extensive series of C₂₆, C₂₈, C₂₉ and C₃₀ steranes and diasteranes are absent from the blanks of both samples. This oil inclusion evidence supports the presence of steranes in other Palaeoproterozoic successions. If these diverse steranes come from eukaryotes, which is likely given the narrow range of steranes derived from prokaryotes (Summons *et al.*, 2006), this means that our strain of life not only survived the Neoproterozoic “Snowball Earth” events but also their Palaeoproterozoic equivalents.

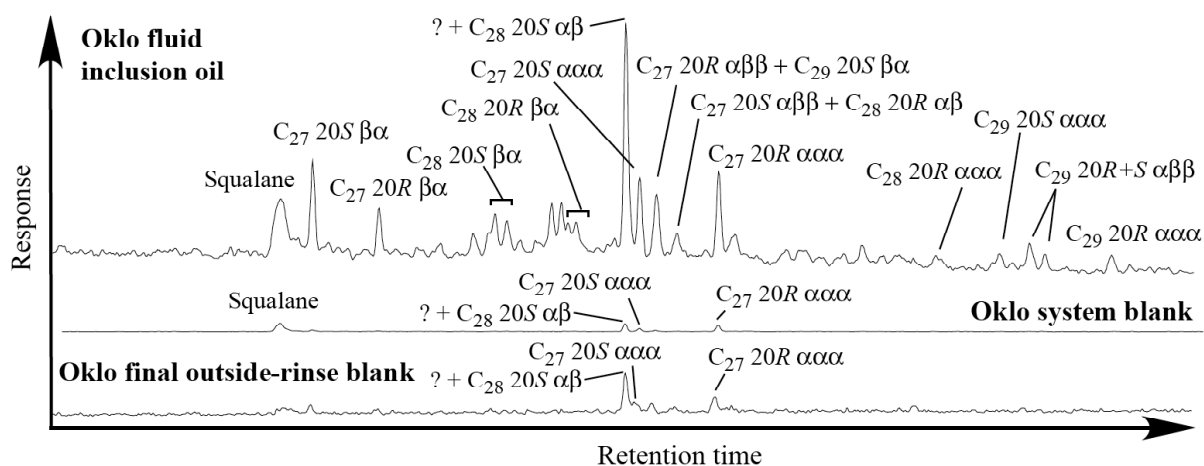


Figure 1. Partial m/z 217 mass chromatograms of the 2.1 Ga Oklo fluid inclusion oil and blanks, showing C₂₇-C₂₉ steranes and diasteranes. The relative responses of the system and final outside-rinse blanks are scaled relative to the FI oil using the internal standard (squalane).

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