Paper Number: 3132

Early sponges and toxic protists: Cryostane, a new biomarker antedating Sturtian Snowball Earth

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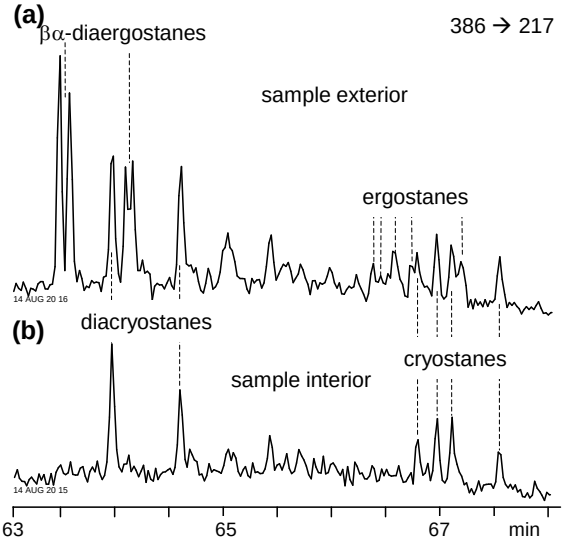

Figure 1. MRM chromatograms showing C_{28} steranes of Chuar Group sample B04026. (A) Contaminated rock exterior including ergostane and cryostane and (B) clean interior where only cryostane signals are visible.

The period 800 to 717 million years (Ma) ago, in the lead-up to the Sturtian Snowball glaciation, saw an increase in the diversity of eukaryotic microfossils as well as the appearance of several modern eukaryotic groups. To afford an independent and complementary view of this evolutionary event, we studied the distribution of eukaryotic biomarkers from three pre-Sturtian basins across the supercontinent Rodinia, the ~780 Ma Kanpa Formation of Western Australian, the ~800 – 740 Ma Visingsö Group in Sweden, and the 740 Ma Chuar Group, Arizona [1]. The distribution of eukaryotic steranes was remarkably similar in the three pre-Sturtian basins but distinct from all other known younger and older sterane assemblages. Cholestane (C_{27}) was the only conventional structure, while indigenous steranes alkylated in position C-24, such as ergostane (C_{28}), stigmastane (C_{29}) and C_{30} steranes were not identified. This unique sterane distribution appears to be age-diagnostic for the mid-Neoproterozoic and attests to the distinct evolutionary state of pre-Snowball eukaryotes with a taxonomic disparity still much lower than in the Ediacaran (635 – 541 Ma).

Intriguingly, hydrocarbons from all three basins revealed a new sterane, cryostane, possessing an unusual side chain modification that, among extant organisms, is solely produced by sponges. Sponges are indeed a plausible source because molecular clocks place the appearance of this earliest animal branch into the mid-Neoproterozoic. However, little is known about the sterol biosynthetic capacity of most heterotrophic protists that may be alternative sources of the unknown compound. Thus, rather than assigning cryostane to sponges or any other clade, it is more instructive to elucidate the function of unusual side-chain alkylated sterols in general. An intriguing hypothesis posits that such sterols may protect organisms against their own membranolytic toxins. Protists release lytic toxins to deter predators and kill eukaryotic prey. This interpretation of cryostane supports fossil evidence of predation

in the Visingsö and Chuar groups and promotes hypotheses about the proliferation of eukaryophagy in the lead-up to the Cryogenian.

References:

[1] Brocks J. et al. (2015) Geobiology DOI: 10.1111/gbi.12165.