REINTERPRETATION OF THE STERANE/HOPANE RATIO AND STERANE HOMOLOG DISTRIBUTIONS

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Biomarkers (molecular fossils) are remains of organic molecules of biological origins that are stable over geological timescales and are a frequent tool in palaeoecological reconstructions. Two of the most commonly used biomarker parameters are the sterane/hopane (S/H) ratio, which is believed to reflect the relative input of eukaryotic versus bacterial biomass into sediments, and the sterane trifecta ratio (relative abundance of C27, C28 and C29 steranes), which varies depending on the most prominent groups of eukaryotes in an ancient environment (Brocks and Pearson, 2005; Peters et al., 2005; Volkman, 2005). These parameters thus might contain useful information about ancient ecosystems. However, in some environments, relative sterane and hopanes abundance are altered during degradation in the water column and early diagenesis. An extreme case of such severe degradation in modern environments is, for instance, observed in soils, where primary plant debris may become so severely recycled by the soil microbiome that the S/H drops to << 0.1 (Moldowan et al., 1985; Peters et al., 2005; Ries-Kautt and Albrecht, 1989). However, the relative abundance of C27, C28 and C29 steranes is believed to be quite robust. Here we test the extent to which these parameters may be altered in normal marine environments.

It is generally difficult to separate variations in biomarker parameters that are related to ecological changes from those that are caused by microbial degradation and diagenesis. Thus, to elucidate the impact of degradation on relative steroid abundances we studied ancient and modern systems with a constant biological input. The modern dataset is founded on a series of laboratory degradation experiments on extant macroalgae under varying conditions. The second dataset is composed of organically preserved Ediacaran macroalgae of the same species from the White Sea area in Russia, which is known for exceptional preservation of biomarkers associated with macrofossils (Bobrovskiy et al., 2018a; Bobrovskiy et al., 2018b). The analyses of fossil macroalgae from the White Sea area showed continuous changes in biomarker parameters between the best and worst preserved fossil algae. Most remarkably, the S/H ratio dropped by a factor of 40 between the end members, which was also accompanied by severe changes in the steroid trifecta ratio, with a drop in the proportion of stigmasteroids (C29) by a factor of 2.

Experiments on modern marine macroalgae yielded results that nearly perfectly matched the fossil macroalgae analysis. Under anaerobic conditions, the S/H ratio changed only slightly, and the sterane trifecta ratios stayed very close the initial sterol composition of the macroalgae. During aerobic degradation, however, the destruction of steroids was accompanied by production of hopanoids by heterotrophic and/or methylotrophic bacteria, driving the S/H ratio to lower values. At the same time, the relative proportion of stigmasteroids (C29) dropped by a factor of 5.5. The combined results show that redox conditions during early diagenesis may have tremendous effects on biomarker distributions, even those that are believed to represent exclusively biological sources.
Thus, core biomarker proxies such as the S/H ratio and sterane homolog distributions can be affected by degradation to the extent that ecological information is nearly obliterated. This result has implications for both palaeoreconstructions and basin analysis. In palaeoecological studies, the effect of differential preservation can in principle be accounted for by looking at relationships with other parameters, both organic and inorganic.

References