Steroid preservation in hypersaline microbial mats

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Microbial mats are self-sustaining benthic ecosystems composed of highly diverse microbial communities. It has been proposed that microbial mats were widespread in Proterozoic marine environments, prior to the emergence of bioturbating organisms at the Precambrian-Cambrian transition. One characteristic feature of Precambrian biomarker records is that steranes are typically absent or occur in very low concentrations. This has been explained by low eukaryotic source inputs, or degradation of primary produced steroids in benthic microbial mats ("mat-seal effect"). Here we analysed freely extractable and carbonate-bound steroids, and proto-kerogen in a recent calcifying mat (~1500 years) from a hypersaline lake in Kiritimati, Central Pacific. A variety of C_{27}-C_{29} desmethylsteroids and distinctive C_{31} 4α-methylsteroids were detected in both lipid pools. These steroids most likely originated from organisms living in the water column and the upper mat layer. This autochthonous biomass experienced progressive microbial transformation and degradation in the microbial mat, as reflected by a significant drop in total steroid concentrations, up to 98%, in the deeper layers, and a concomitant decrease in total organic carbon. Carbonate-bound steroids were generally low in abundance, suggesting that incorporation into the mineral matrix does not play a major role for the preservation of eukaryotic steroids in this mat. Likewise, pyrolysis revealed that steroids were not sequestered into insoluble organic matter which may give rise to a further bias in the preservation of steroids vs. hopanoids, particularly in the later stages of burial. While these findings argue for 'mat-seal effect' in the mat studied, they markedly differ from recent findings about another hypersaline microbial mat on the same island, where steroids showed no systematic decrease with depth. The observed discrepancies in the preservation of steroids in microbial mats from Kiritimati may be linked to multiple biotic and abiotic factors including salinity and periods of subaerial exposure, implying that caution has to be exercised in the interpretation of steroid distributions in modern and ancient microbial mat settings.