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Tracing biosignatures from the Recent to the Jurassic in sabkha-associated microbial mats

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Microbial mat ecosystems have been operating at the sediment-fluid interface for over 3400 million years, influencing the flux, transformation and preservation of carbon from the biosphere to the physical environment. These ecosystems are excellent recorders of rapid and profound changes in earth surface environments and biota as they often survive crisis-induced extreme paleoenvironmental conditions. Their biosignatures, captured in the preserved organic matter and the biominerals that form the microbialite rock, constitute a significant tool in understanding geobiological processes and the interactions of the microbial communities with sediments and with the prevailing physical chemical parameters, as well as the environmental conditions at a local and global scale. Nevertheless, the exact pathways of diagenetic organic matter transformation and early-lithification, essential for the accretion and preservation in the geological record as microbialites, are not well understood.

The Abu Dhabi coastal sabkha system contains a vast microbial mat belt that is dominated by continuous polygonal and internally-laminated microbial mats across the upper and middle intertidal zones. This modern system is believed to be the best analogue for the Upper Jurassic Arab Formation, which is both a prolific hydrocarbon reservoir and source rock facies in the United Arab Emirates and in neighbouring countries. In order to characterise the processes that lead to the formation of microbialites we investigated the modern and Jurassic system using a multidisciplinary approach, including growth of field-sampled microbial mats under controlled conditions in the laboratory and field-based analysis of microbial communities, mat mineralogy and organic biomarker analysis.

In this study, we focus on hydrocarbon biomarker data obtained from the surface of microbial mats actively growing in the intertidal zone of the modern system. By comparing these findings to data obtained from recently-buried, unlithified mats and fully lithified Jurassic mats we are able to identify those biochemical signatures of organic matter preserved in microbialites which survived diagenetic disintegration and represent the primary microbial production.

Biomarkers, in the form of alkanes, mono-, di- and trimethylalkanes (MMA, DMA, TMA) were identified in surface and buried mats. Previous studies reported a bimodal distribution of n-Alkanes in the buried mats due to the relatively rapid decline in the abundance of MMAs and DMAs in the C16-C22 range with C24-C45 exclusively found in buried mats, however, this bimodal distribution was not found in our samples. Furthermore, we were able to improve the subsurface facies model for the Jurassic microbialites with our biomarker data as it shows that microbial mats growing in tidal pools or lagoons within the sabkha system form the most prolific hydrocarbon source rocks.