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Non-seawater REY signatures in modern stromatolites from Shark Bay, Australia: implications for paleo-environmental reconstructions

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Rare earth elements and yttrium (REY) signatures in stromatolitic carbonates have emerged as powerful geochemical proxies to reconstruct paleo-depositional environments of microbial habitats [e.g., 1, 2]. This, however, relies on the assumption that REY are substituted into the carbonate lattice for Ca and directly reflect the chemical composition of the fluid from which the chemical sediment precipitated [3]. Indeed, [1] observed REY signatures in microbialites are similar to those of open ocean seawater. In more restricted environments, however, REY fractionation can occur between waters and stromatolites [4], questioning their reliability as a paleo-environmental proxy to reconstruct microbial habitats through Earth's history.

To better understand REY signatures in stromatolitic carbonates of non-open ocean environments, we studied the hypersaline Hamelin Pool of Shark Bay (Australia), one of the most intensively studied extreme microbial habitats on Earth. We analyzed REY compositions of stromatolitic carbonates with four different textures (smooth, pustular, colloform, cerebroid) and ambient water of subtidal, intertidal, and supratidal environments. Shale-normalized REY (subscript SN) patterns differ between all morphologies, but all show middle REY_{SN} enrichment relative to light and heavy REY_{SN}. These signatures differ not only from those of modern seawater but also from those of the ambient hypersaline lagoon waters. Partition coefficients vary of up to 4000 between REY in carbonate and fluid and show a preferential light REY partitioning into carbonates. The reason for REY fractionation at Shark Bay remains speculative but may be a result of variable micro-environmental conditions, microbial communities, and porewater chemistries of the different stromatolite morphologies, as well as groundwater inflows, and/or REY remineralization and fractionation onto organic ligands.

Regardless of the uncertain REY fractionation process(es) at Shark Bay, our results strongly emphasize that REY geochemistry may be a powerful geochemical proxy in combination with stromatolite morphology to reconstruct microbial habitats through Earth's history. Additional evidence from, for instance, field studies is needed to fully understand the paleo-environmental setting and atmospheric-hydrospheric conditions in microbial habitats.

[1]Webb & Kamber, 2000, GCA 64. [2] Fogret et al., 2024, Chem. Geol. 662. [3] Zhong & Mucci, 1995, GCA 59. [4] Johannesson et al., 2014, MASE 7.