**Novel stable isotopes as biomarkers for bio-geochemical metal cycling in microbialites**

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Microbial communities are representing some of the earliest habitats for life on Earth and possibly other planets. Microbe interactions with the primitive atmosphere and hydrosphere and the first enzymatic cycling of bioessential elements make their fossilised remnants and modern analogues ideal natural laboratories to study Early life. In the past, research on microbialite (i.e., lithified microbial mats) primarily focused on their macroscopic morphologies and petrographic observations of their micro-and nanoscopic growth and fossilisation features. In the last two decades, trace elemental and traditional stable isotope research further broadened our understanding of microbial interactions with the environments they thrived in.

Here, we show how novel stable isotope applications in microbialites can reconstruct the habitats in which the earliest life on Earth developed. Although the behaviour and fractionation processes in microbial communities are partly incompletely understood, the stable metal isotope proxies of Fe, Mo, Cr, U, Ni, Cd and Ba have a unique potential to understand better redox conditions, metal availability and (biogenic) metal cycling processes in microbial habitats. We provide insights into a few potential isotope applications, emphasising the Cd, Ba and Ni isotope systems and their future perspectives as isotope biomarkers to bridge the gap between geochemistry and microbiology and better understand the evolution of microbial life on Earth and beyond.