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Deconvolving microbial and environmental controls on Laguna Negra stromatolitic oncoid and laminar crust formation

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Microbialites are invaluable archives of Earth's environmental conditions and the evolution of life from the Archean to today. Formed through the interaction between the environment and life, they often preserve biogeochemical signatures of these complex interactions. These chemical signatures serve as proxies for estimating redox conditions, temperature, microbial metabolisms, critical element abundances and more. However, interpreting these proxies can be challenging, particularly when going back to deep time. Their reliability depends on disentangling environmental, biological, and diagenetic influences. This study aims to leverage the micro-scale distribution of trace and rare-earth elements, along with layer color, microtexture, and mineralogy, to understand the incorporation of these elements under relatively well constrained conditions.

The trace-element and REE composition of stromatolitic oncoids and laminar crusts from a hypersaline lake in the high-altitude Puna region of Argentina, Laguna Negra, was mapped, using femtosecond laser ablation ICP-MS, with a focus on redox-sensitive elements. This high-resolution technique resolves elemental variability associated with distinct microtextures and mineralogies, enabling us to disentangle the influences of physicochemical processes and microbial metabolisms as reflected in elemental ratios such as As/Ca, U/Ca, Sr/Ca, Ce/Ca, Mn/Ca, and Mg/Ca. Importantly, femtosecond laser ablation limits the expression of matrix effects. These proxies provide insights to decipher oxic and anoxic environmental and early diagenetic conditions during lamina accretion, microscale mineralogical differences, precipitation rates. By understanding these signatures in a modern environment, we can better interpret how environmental and microbial process and primary signatures may be preserved in the rock record of past eons.