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Intense arsenic enrichment linked to microbial detoxification processes in a mineralized mat of the Dead Sea

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Fossilized biofilms and microbialites are often used for the reconstruction of early life and the associated environment. To better understand how microbial communities cycle trace elements and immobilize some of them into such structures, a living microbial mat was collected from the sinkhole systems of the western shores of the Dead Sea. This environment provides intense mineral precipitation and varied physicochemical parameters leading to diverse microbial ecosystems. Heavy arsenic enrichment (up to 10000 times compared to concentrations in the water) was measured in one specific layer of this microbial mat. Arsenic was almost uniquely found under the form of organo-arsenic (As(V)) co-occurring with manganese, as shown by XANES spectra and high-resolution elemental mapping. In the whole mat, arsenic cycling genes are associated to arsenic detoxification almost exclusively, supporting an overall active arsenic enrichment in the layer by detoxification process transforming As(V) in organo-arsenic compoundsThe reason for a localized enrichment can tentatively be attributed to a temporal increase in arsenic V concentrations in the subsurface circulating water of the Dead Sea shore.

Our dataset supports the possibility for very intense and localized arsenic enrichment within microbial mats, without showing evidence of the use of arsenic for energy-gaining metabolic activity. In this context, the Dead Sea system example calls for caution when interpreting metal(loid) enrichment (including arsenic) from microbialites-stromatolite or organic matter-rich layers of Precambrian origins. Metallic enrichments may be recorded even in very localized facies due to temporal fluctuations of environmental chemistry. With this respect, metallic signatures in Precambrian organic matter and carbonate rocks may host biosignatures (EPS production and As- binding and detoxification process) without supporting arsenotrophy. They however provide clues to better assess paleoenvironmental conditions at the time of microbial mat formation and sedimentation.