EGU21-14810, updated on 21 Apr 2021
https://doi.org/10.5194/egusphere-egu21-14810
EGU General Assembly 2021

The uranium isotopic composition of modern stromatolites forming in Shark Bay, Western Australia

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Stromatolites represent some of the earliest evidence for life and are valuable geochemical archives for understanding the rise of oxygen on early Earth. Metal redox proxies in carbonates, such as stable uranium isotopes ($^{238}U/^{235}U$), are useful for assessing the oxidation state of ancient waterbodies, but may also be sensitive to local water chemistry and early sedimentary diagenesis. This requires the validation of such proxies in modern environments before applying them to ancient carbonates. Here we measure the U isotopic composition of modern stromatolites forming in Hamelin Pool in Shark Bay, Western Australia – a large hypersaline marine embayment and the largest modern example of stromatolite development globally. Actively-growing stromatolite tops from Shark Bay exhibited a narrow range of $\delta^{238}U$ from -0.30 to -0.33‰, corresponding to an offset of ca. +0.1‰ from seawater. Such an offset has not been found in other biotic marine carbonates, which exhibit seawater-like $\delta^{238}U$ (ca. -0.4‰), but is consistent with findings from carbonate co-precipitation experiments. One hypothesis for our measured +0.1‰ offset is the elevated Ca concentration of the hypersaline Shark Bay seawater relative to open seawater. This results in a greater proportion of dissolved U present as $Ca_2UO_2(CO_3)_3$, which is expected to be isotopically lighter than other U species and not incorporated during carbonate mineral formation. Higher $\delta^{238}U$ up to +0.11‰ were measured in the deeper stromatolite laminae, consistent with the expected U isotope signatures for U reduction. Stromatolite radiocarbon ages show that the diagenetic modification of U occurs within ~1 ka and may be considered syndepositional on geological timescales. These results from the deeper stromatolite laminae support the application of a ca. -0.4‰ correction factor to the $\delta^{238}U$ of stromatolites formed in oxic waterbodies, similar to other biotic carbonates. It is unclear whether the additional +0.1‰ offset found in stromatolite tops is particular to seawater chemistry of Shark Bay or a general feature of microbial carbonate precipitation. This warrants investigation of the $\delta^{238}U$ proxy in other modern environments where stromatolites proliferate.