Reappraising the U isotope composition of seawater and deep-sea corals: Implications for paleo-environmental reconstructions

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Uranium isotope ratios are widely utilized in paleoceanography. The $\delta^{238}\text{U}$ ratio (expressed as $\delta^{238}\text{U}$) is leveraged as a proxy for the areal extent of seafloor anoxia, and the $\delta^{234}\text{U}_{\text{sec}}$ ratio (expressed as $\delta^{234}\text{U}_{\text{sec}}$) tracks riverine and estuarine inputs to the ocean, in addition to featuring prominently in U-series geochronology. Both of these ratios are thought to be recorded by biological carbonates precipitating from seawater, with corals serving as one of the most commonly-used archives of seawater U isotope ratios in the past. The utility of the U isotope proxy in biological carbonate archives relies not only on this faithful recording of ambient seawater signatures, but also on the homogeneity of the seawater U isotope composition, which enables samples to be leveraged as proxy for the entire ocean.

In this work [1], we revisit the foundational assumption of homogeneity of the marine U reservoir, and the capacity of deep-sea corals to record the U isotopic composition of ambient seawater. To this end, we first reevaluated the analytical limits of precision and accuracy achievable for both $\delta^{238}\text{U}$ and $\delta^{234}\text{U}_{\text{sec}}$ analysis by MC-ICP-MS. We then measured the U isotopic composition of 26 deep-sea coral and 45 seawater samples from multiple sites around the world (i.e., North and South Atlantic, and South Pacific localities). Seawater samples were obtained from GEOTRACES stations in close proximity to the deep-sea coral specimens studied. We find subtle $\delta^{238}\text{U}$ and $\delta^{234}\text{U}_{\text{sec}}$ heterogeneity that correlates with U concentrations, which allows us to calculate new salinity-normalized global mean seawater values for $\delta^{238}\text{U}$ (-0.379 ± 0.023 ‰) and $\delta^{234}\text{U}_{\text{sec}}$ (+145.55 ± 0.28 ‰). At each site, biological carbonates act as precise archives of the seawater $\delta^{238}\text{U}$ value. The same is true for $\delta^{234}\text{U}_{\text{sec}}$, with a few exceptions where samples appear to show vital effects that cause intra-sample $\delta^{234}\text{U}/\delta^{238}\text{U}$ repartitioning. In sum, these observations support deep-sea corals as a robust archive of seawater U isotope ratios, but highlight the importance of utilizing multiple sample sites and replicate analyses to overcome coral vital effects (for $\delta^{234}\text{U}_{\text{sec}}$) and subtle marine U isotopic heterogeneity.