Using uranium isotopes to disentangle biotic from abiotic processes in marine snow aggregates

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Our ability to reconstruct past marine oxygenation rely on authigenic enrichments of redox-sensitive elements like U. While most of the authigenic U (U_{auth}) is formed diagenetically, some authigenesis can occur within marine snow aggregates in highly-productive regions of the ocean.

Here we discuss the first U isotope sediment trap data from the Eastern Tropical North Pacific Oxygen Minimum Zone (Alfonso Basin, Gulf of California). Our goals are to: (1) quantify the authigenic and detrital components of the total U in sinking particles and (2) decipher the processes that cause U_{auth} enrichments and changes in $\delta^{238}U$.

(1) Our data show that the $\delta^{234}U$ composition of settling particulate matter is highly variable (-7 to 98 ‰) and strongly event-dependent. Assuming that $\delta^{234}U$ values reflect a mixture of U_{auth} (seawater ~147 ‰) and detrital U (~0 ‰), we use a two-component mixing model to demonstrate that the authigenic fraction of most samples ranges from 30 to 70 %, although storm-related events sometimes produce aggregates with low $\delta^{234}U$ and almost no U_{auth}.

(2) The $\delta^{238}U$ signature varies from -0.49 to 0.16 ‰, often strongly deviating from the seawater value of -0.4 ‰. Shifts toward high $\delta^{238}U$ are generally linked to microbially-mediated reduction of U(+6) to U(+4). Some samples show evidence for such process reaching $\delta^{238}U$ values as high as -0.06 ‰ while only moderately elevated in U_{auth} (2.13 mg/kg). We attribute the highest observed U_{auth} enrichment (7.34 mg/kg) to adsorption, due to high C_{org} (7.65 %) in the sample, and no significant $\delta^{238}U$ fractionation (-0.32 ‰).

Our results demonstrate that paired $\delta^{234}U$ and $\delta^{238}U$ measurements provide a powerful new tool for disentangling the contribution of U to sinking particles and sediments. These results have important implications for interpreting U enrichments in both modern and ancient marine sediments, even if those have a strong detrital U component.