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The oxic uranium flux and isotope fractionation in modern deep-sea sediments

FRANTZ OSSA OSSA[1], MORTEN B ANDERSEN[2], LOGAN A TEGLER[3], MAUREEN AURO[3], KASSANDRA COSTA[4], ANN DUNLEA[3] AND SUNE GRØNLUND NIELSEN[3]

[1]Khalifa University of Science and Technology
[2]Cardiff University
[3]Woods Hole Oceanographic Institution
[4]Woods Hole Oceanographic Institute

Presenting Author: frantz.ossaossa@gmail.com

Metal-based proxies can track the geochemical evolution of the ocean, but require well constrained input and output budgets in the modern environment. Many studies have used U isotope composition (δ^{238}U values) in marine carbonates as archives for coeval seawater U isotopic fluctuations to relate changes in δ^{238}U values to marine redox evolution. Modern open-ocean is characterized by δ^{238}U value of −0.39‰. River runoff is the main input of dissolved U(VI) in seawater with minimal isotope fractionation (bulk silicate Earth's δ^{238}U = −0.3‰). Marine outputs, from the largest to smallest flux, are represented by anoxic sinks in oxygen minimum zones (δ^{238}U = −0.25 to 0‰), coprecipitation with calcium carbonates (δ^{238}U near seawater value), low-temperature hydrothermal alteration of mafic oceanic crust (δ^{238}U = −0.2 to 0‰), and oxic sinks represented by adsorption to Fe-Mn oxyhydroxide minerals in pelagic sediments (inferred from Fe-Mn crusts and nodules to be δ^{238}U = −0.7 to −0.5‰). However, little attention has been paid to pelagic sediments, although they exhibit the lowest δ^{238}U values of the outputs with a potential significant isotopic effect on the global seawater U inventory.

Here, we investigate U isotopes in pelagic clay core top samples that cover all major ocean basins. We applied a sequential extraction technique to isolate authigenic components and put constraints on the main drivers of U flux and associated isotope fractionation in oxic sediments. We found that Mn oxides, along with Fe oxide phases, are the main U oxic sinks associated with δ^{238}U values significantly lower than Fe-Mn crusts. Furthermore, clays and clay minerals also represent important U sinks in these oxic pelagic sediments. Although their contribution appears lower than that of Mn- and Fe-oxides, they also carry δ^{238}U values that extend to values lower than Fe-Mn crusts. This suggests that U outputs in pelagic sediments deposited under oxic conditions are capable of inducing variations in seawater δ^{238}U values and subsequently influence the marine U mass balance in the modern and ancient oceans. Our study opens new perspectives for refining the use of δ^{238}U values in marine archives to reconstruct the evolution of ocean redox landscape.