Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.36593

Oxidized uranium in organic-rich shales from reducing environments

FRANCES M. MEYER[1], ANTHONY CHAPPAZ[2], DANIEL D. GREGORY[3], EVE CARROTHERS[3], ERIK A. SPERLING[4], JUSTIN STRAUSS[5], LUCIEN NANA YOBO[6] AND KIMBERLY V. LAU[7]

[1]Pennsylvania State University
[2]STARLAB, Department of Earth & Atmospheric Sciences, Central Michigan University
[3]University of Toronto
[4]Stanford University
[5]Dartmouth College
[6]Texas A&M University
[7]The Pennsylvania State University

The availability of oxygen in the Earth's ancient ocean and atmosphere is a key parameter for understanding Precambrian and Paleozoic biotic evolution and nutrient cycling. Due to the lack of direct oxygen measurements in deep time, we must turn to the geochemical signatures preserved in the sedimentary record. The enrichments and isotope ratios of redox-sensitive elements deposited in marine basins, like U, provide a way to reconstruct changes in oxygen availability of the oceans throughout time. However, these proxies rely on many unverified assumptions of how their solubility, speciation, and burial are controlled by redox conditions. Currently, interpreting U in reducing marine shales as a paleo-redox proxy assumes that burial and isotope fractionation are only associated with the reduction of U(VI) to U(IV), and sequestration of U(VI) and U(V) is negligible. Yet, the burial pathways and speciation of U in reducing marine environments still need to be defined. Without fully characterizing the oxidation states or phase associations of U in marine shales, interpretations of the U-based proxies remain uncertain.

In this study, we use synchrotron-based X-ray fluorescence imaging and spatially resolved X-ray absorption near edge spectroscopy (XANES) at the U L3-edge paired with high energy resolution fluorescence detection XANES at the U M4-edge to determine the spatial distribution and speciation of U in marine shales from multiple localities and time intervals. Samples included outcrop and drill core shales from the Cretaceous Eagle Ford Group from Texas, the Devonian Marcellus Formation in Pennsylvania, and the Ordovician Road River Group in Alaska and Yukon, Canada. Linear combination fitting results from XANES spectra at both the U L3- and M4-edge suggest that three U oxidation states (IV, V and VI) are present, despite proxy data suggesting originally anoxic depositional settings. The ubiquitous presence of U(V) and U(VI) in marine shales from reducing environments adds new understanding of the U marine cycle and challenges the current use of U as a paleo-redox proxy.