

Deciphering U isotope signatures of Archean banded iron formations

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Redox sensitive metals, such as U, and their stable isotope signatures are frequently used as proxies to reconstruct the redox evolution of early Earth's oceans and atmosphere. Potentials archives for Precambrian ocean water are black shales, carbonates or (banded) iron formations (BIFs)¹, however, it is unclear if they directly record seawater isotope signatures or if isotope fractionation occurs during metal removal from seawater, sediment diagenesis, or potential post-depositional alteration.

Here we present U isotope compositions and trace element analyses of individual BIF layers. Preliminary result for BIFs from the Fig Tree Group (ca. 3.26 Ga), Barberton Greenstone Belt, sampled from the BARB 4 drillcore, indicate distinct differences between hematite, red jasper and sideritic chert layers. While hematite and jasper typically show $d^{238}\text{U}$ values slightly lighter than the continental crust (-0.30‰)² with an average of -0.42‰ , sideritic cherts typically show slightly heavier values (average: -0.24‰). Hematite layers have the highest U concentrations.

Adsorption of U on Fe(oxy)hydroxites, that are later transformed to magnetite and hematite, was likely a sink in the Archean³ and our findings may imply that this process was associated with isotope fractionation towards lower $d^{238}\text{U}$. As both early Archean oceans and atmosphere were overall anoxic, a significant portion of the oceanic U pool was likely present as labile U^{IV} , e.g. mobilized during anoxic weathering by organic ligands⁴ or reduced by Fe^{II} or associated to microbial Fe^{III} reduction³. However, some dissolved U in ocean water may have been already present as U^{VI} , in which case U isotope fractionation during adsorption to hematite may have been similar to that during U adsorption to Fe-Mn oxides in modern oceans². This may have resulted in ocean water that was slightly heavier than that of the crust, potentially recorded by the cherts.

[1] Wang, X. et al. (2018) *Geochimica et Cosmochimica Acta* 238 (2018) 438–452

[2] Andersen, M. et al. (2017) *Reviews in Mineralogy and Geochemistry* 82, 799-850.

[3] Partin, C.A. et al. (2013) *Chemical Geology* 362, 82–90.

[4] Röbbert, Y. et al. (2021) *ES&T*, doi.org/10.1021/acs.est.0c08623.