

Vanadium isotope fractionation in low-temperature environments

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Stable isotope ratios of redox-sensitive metals are of interest to paleo-redox studies because redox reactions are often associated with isotope fractionation. Recent theoretical calculations and laboratory measurements [1, 2] have shown the promise of the vanadium (V) isotope system as geochemical paleo-redox proxy. In order to understand the mechanisms for V isotope fractionation in Earth-surface environments, we investigated V isotope effects during oxidative surface weathering of basalt, and authigenic V uptake by oxic and anoxic marine deposits.

We have measured vanadium isotopic compositions of a laterite profile developed on basalt bedrock in South China, with long-term precision better than 0.1‰ (2SD). The laterite samples displayed a narrow range of $\delta^{51}\text{V}$ values (-0.95 to -0.75‰), indistinguishable from the parent basalt, despite of the mobility of V in laterites. Our study suggested negligible V isotope fractionation during tropical oxidative weathering. The $\delta^{51}\text{V}$ of marine ferromanganese crusts varies from -1.64 to -0.91‰. Such light isotopic compositions are likely related to preferential incorporation of ⁵⁰V from oxic seawater through surface adsorption of V. Ongoing studies are exploring the V isotope for samples from anoxic facies of the Peru Margin to constrain V isotope fractionation under oxygen-deficient settings.

We also determined the $\delta^{51}\text{V}$ of Ediacaran Doushantuo member II organic-rich black shales from deep basin in South China. Our data yielded systematic V isotope variation in the stratigraphic dimension with $\delta^{51}\text{V}$ values ranging from -0.93 to -0.51‰. The top of the profile shows homogeneous V isotope compositions with an average of -0.60 ± 0.10 ‰ (n = 17). A negative shift of $\delta^{51}\text{V}$ (to -0.93‰) occurs at the bottom of the profile accompanied by authigenic enrichment of V, which may be attributed to changes of redox conditions. This study highlight the potential application of the V isotope system to track paleo-redox conditions.

[1] Wu et al., (2015) EPSL, 426, 216-224.

[2] Ventura et al., (2015) Appl. Geochem., 59, 104-117.