Vanadium isotope a new tool for tracking low oxygen conditions

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Vanadium (V) isotopes are potential powerful paleoredox proxy with the possibility to track reduced bottom-water oxygen content. Vanadium has a residence time of ~50-100 thousand years, which is long enough to render modern oxic seawater conservative with respect to concentration and isotopes. The modern mass balance of V isotopes in seawater dictates that there are three dominant outputs: (1) adsorption onto minerals in ferromanganese crusts and nodules as well as clay minerals under oxic conditions, (2) scavenging of dissolved vanadium from seawater by adsorption during the formation of hydrothermal iron oxyhydroxide particles, and (3) reduction and subsequent scavenging of vanadium from seawater in anoxic/euxinic environments. These three outputs appear to exert the primary control of the marine V isotope budget. Here we summarize our observations for V isotope variations of seawater and modern sediments from a variety of sediment depositional environments. The V isotopic composition of highly reducing euxinic sediments record values closest to contemporaneous seawater, thus euxinic sediments have the potential to record the balance of inputs vs. outputs. Our data also suggests that the isotope fractionation of V between marine sediments and seawater is tied to local redox conditions, which is sensitive to subtle variations of bottom water redox conditions. Importantly, there is a significant difference between V isotope composition of sediments deposited with low but measurable oxygen bottom waters compared to oxygen rich environments.

Here we present an isotopic mass balance using our new isotope data and previously published concentration fluxes. This suggests that for relatively short term climate perturbations, seawater V isotopes are more likely controlled by redox variability rather than other parameters inlcuding hydrothermal activity as these are generally thought to be controlled by long-term seafloor spreading rates. Consequently, our current observations and mass balance model of V isotopes suggest this system will be a sensitive proxy to fingerprint subtle variations of seafloor redox conditions at local and/or global scales.