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Global homogeneity of seawater $\delta^{51}V$ signatures: a case study in the South Atlantic Ocean and the Black Sea

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Vanadium isotope ratios ($\delta^{51}V = 1 - (^{51}V/^{50}V_{sample})/(^{51}V/^{50}V_{std})$) are emerging as a potential redox proxy to refine constraints on local and global marine redox fluctuations, which is rooted in relatively homogeneous seawater $\delta^{51}V$ as proposed by previous research. However, the sparse data and limited spatial distribution elicit uncertainty of this assertion, which is also underscored by certain local/regional processes, for instance, biological uptake in euphotic seawater, riverine inputs in near-coastal areas, and basinal restriction that have the potential to modify the observed V isotope signatures.

In this work, we investigated V concentrations ([V]) and $\delta^{51}V$ values of seawater samples collected during the GEOTRACES at ~40 °S South Atlantic Ocean transect, with sampling profiles intersecting several major global water masses that participate in global ocean circulation. We also studied two seawater samples collected from the anoxic (O_2 and H_2S absent in the water column)-to-euxinic (free H_2S in the water column) boundary in the severely restricted Black Sea. The results show relatively homogeneous seawater [V] and $\delta^{51}V$ values in deep water masses (> 100 m) below the euphotic zone in the South Atlantic Ocean, which agrees with previous research and thus validates the conservative cycling of V isotopes in large-scale ocean circulation. In contrast, the seawater samples collected from the euphotic zone (< 100 m) display minor depletions of [V] and positive shifts in $\delta^{51}V$, which plausibly reflects preferential uptake of ^{50}V by phytoplankton. In the severely restricted Black Sea Basin, the two seawater samples across the anoxic-to-euxinic boundary show lower [V] and more negative $\delta^{51}V$ values than open ocean seawater that cannot merely be explained by conservative mixing of seawater and riverine runoff. Other processes such as oxide cycling in the redoxcline and basinal vertical mixing processes might also play an important role in the Black Sea.

Altogether, our work verifies the previous assertion of the global homogeneity of seawater $\delta^{51}V$ values in deep water masses. However, we also identify $\delta^{51}V$ variations likely resulting from biological uptake in the euphotic zone and the hydrological and biogeochemical circumstances in severely restricted basins.