The stable tungsten isotope composition of modern igneous reservoirs

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Recent studies showed that W is a highly fluid mobile element in Earth's crust and mantle, but its geochemical cycle and mass balance in magmatic systems still remain poorly understood. Tungsten stable isotopes represent a novel tool with the potential to better constrain this cycle, because of possible W isotope fractionation during changes in redox-state (valence states +4 and +6) and coordination, e.g., via adsorption reactions of dissolved WO_4^{2-}. Our analytical protocol, using a ^{180}W-^{183}W double spike, yields an external reproducibility of ±0.018‰ (2 s.d.) in $\delta^{186/184}W$ [1] and allows to resolve small stable W isotope variations between different magmatic reservoirs.

Here, we present stable W isotope data for extrusive rocks from different igneous settings including mid-ocean ridge basalts (MORBs), ocean island basalts (OIBs) and various subduction-related settings. The $\delta^{186/184}W$ values of MORBs (+0.088 ± 0.017 ‰, n = 8) and OIBs (+0.078 ± 0.020 ‰, n = 5) show a narrow range and are analytically indistinguishable. However, subduction related lavas show significantly higher values in $\delta^{186/184}W$ of up to +0.195 ‰. These extrusive rocks also show elevated W/Th due to selective W enrichment from sediment derived fluids. The co-variation indicates that major stable W isotope anomalies are either related to (1) melting and dehydration of subducted sediments or (2) low-temperature processes during sedimentation and diagenesis. A positive co-variation of $\delta^{186/184}W$ with SiO_2 is observed when only considering rocks with canonical W/Th arguing for some W isotope fractionation during fractional crystallisation. Other parameters like $f(O_2)$ or residual rutile, however, have little effects on $\delta^{186/184}W$ values.

Our results demonstrate that fractional crystallisation and addition of subduction zone components appear to significantly affect stable W isotope compositions of igneous reservoirs. Hence, stable W isotope measurements represent a promising geochemical tool to better constrain the cycle of W in modern and ancient igneous reservoirs.

[1] Kurzweil *et al.* (2018) *Chem. Geol.* **476**, 407-417.