Tungsten isotope fractionation in subduction zones

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Subduction zones are fundamentally linked to the recycling of elements and the formation of contientnal crust. Tungsten, a moderately siderophile and strongly incompatible element, is fluid mobile in the sub-arc mantle [1], but little is known about its geochemical cycle. Using the newly developed W double spike technique [2], this study evaluates W stable isotope fractionation in subduction zones. A characteristic suite of samples from three subduction zones were chosen to trace W isotope fractionation. Samples from the volcanic front and rear arc of the Sangihe and Izu-Bonin arcs were chosen to evaluate W fractionation between fluid/melt slab components. Samples from SW Japan were chosen to evaluate processes related to subduction of a young, hot slab.

Our results show both heavy and light W isotopic fractionation relative to the average chondritic value ($\delta^{184/183}W = 0.027 \pm 0.007$) for bulk silicate Earth [2], ranging from $\delta^{184/183}W$ ~0.08 to ~0.00 (where $\delta^{184/183}W$ is the ‰ deviation from NIST SRM 3163). The heaviest $\delta^{184/183}W$ is observed in slab-fluid-rich samples from the volcanic fronts of the Sangihe and Izu-Bonin arcs. With increasing distance from the volcanic front, rear/back arc slab-melt-rich samples are characterized by lighter $\delta^{184/183}W$. Enriched alkali basalts from SW Japan, thought to be the product of mantle melting at a slab tear [3], have the lightest $\delta^{184/183}W$.

We suggest that the heavy $\delta^{184/183}W$ signature records fluid release near the volcanic front and/or the preferential partitioning of isotopically light W into rutile. Subsequent melting of rutile may occur in hot subduction zones, possibly accounting for the light $\delta^{184/183}W$ signature recorded in SW Japan. Our results indicate that W stable isotope systematics provide a powerful new tool for investigating fluid cycling and crust formation processes in subduction zones throughout Earth's history.

[1] König et al. (2011) GCA, 75, 2119-2136 [2] Krabbe et al. (2017) Chem. Geo., 450, 135-144 [3] Kimura et al. (2015) G3, 15, 691–739