Completing the molybdenum isotope mass balance in subduction zones

ALLISON T. GREANEY[1], ROBERTA L. RUDNICK[1] , STEPHEN J. ROMANIELLO[2], ARIEL D. ANBAR[2]

[1]Department of Earth Science, University of California – Santa Barbara, Santa Barbara, CA 93106
[2]School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85281

Continental crust and arc basalts generally have higher δ^{98}Mo than MORB, chondrite, and the upper mantle, which span the range of ~0.0‰ to -0.22‰ [1]. By contrast, several ocean island and intraplate basalts record isotopically lighter signatures than MORB and the primitive mantle (down to -0.59‰) [1]. These discrepancies have been attributed to fractionation that occurs in the subduction zone: slab fluids are proposed to carry heavier Mo isotopes to the mantle wedge, thereby leaving the light isotopes in the slab [2]. If this process indeed occurs, recycling of isotopically light slabs into the deep mantle may explain light signatures observed in some intraplate basalts.

To determine the Mo isotopic signature of slabs, we studied a suite of eclogites from the Koidu kimberlite complex in Sierra Leone that were interpreted to represent partially melted residues of Archean oceanic crust [3]. Whole-rock [Mo] and δ^{98}Mo must be reconstructed from *in-situ* laser ablation and mineral separate data, as kimberlite has contaminated grain boundaries of these samples. Pyroxene, garnet, and rutile were analyzed to determine whole rock compositions. Sulfides are strongly altered to secondary pyrite, making analyses of primary Mo in sulfide impossible.

Average whole-rock [Mo] abundances of reconstructed eclogites range between 0.04 and 0.38 ppm (mean = 0.13 ppm), and mass balance indicates that rutile contains, on average, 88% of the whole-rock [Mo]. Molybdenum falls in line with the LREE on primitive mantle-normalized diagrams, indicating that Mo mimics the behavior of LREE during slab dehydration and melting. The LREE are depleted by 60% (Nd) – 85% (La) relative to Archean basalts [4], suggesting ~ 70-80% of Mo is removed from the slab during dehydration and melting. Rutile separates from three eclogites record very light Mo isotopes (-0.61 to -0.69‰), with an estimated bulk eclogite δ^{98}Mo signature of -0.59‰. These data provide independent evidence for Mo isotope fractionation in subduction zones, and support the hypothesis that isotopically light slabs may be recycled into OIB mantle sources.

[1] Liang et al. (2018) *GCA* **199**, 91-111; [2] Freymuth et al. (2015) *EPSL* **432**, 176-186; [3] Barth et al. (2001) *GCA* **65**, 1499-1527; [4] GeoRoc compilation