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A high field strength perspective on tungsten-182 variability in modern mantle melts

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Hafnium-182 is a short-lived ($t_{1/2}$ = ~9 Myr) radionuclide that undergoes double-beta decay to ^{182}W. It was extant for only ~60 Myr after Solar System formation. Variations in the ^{182}W/^{184}W ratio of natural materials record primordial metal-silicate and/or silicate-silicate differentiation processes. Recently, small (up to ~-25 ppm) deficits in ^{182}W/^{184}W (expressed as μ^{182}W) of modern ocean island basalts have been found to correlate with elevated ^{3}He/^{4}He, suggesting that “anomalous” source mantle reservoirs, common yet minor consitutents of many plumes, have remained less degassed than other mantle reservoirs whose derivative melts are characterized by normal μ^{182}W and lower ^{3}He/^{4}He. The μ^{182}W-^{3}He/^{4}He association has been suggested to result from core-mantle interaction, but early silicate differentiation and subsequent long-term isolation of some portion(s) of the lowermost mantle is a viable alternative explanation.

One geochemical aspect that has remained unexplored with respect to the origin of W anomalies is whether they can be correlated with anomalous enrichments in certain high field strength elements with similar silicate partitioning characteristics. Notably, the so-called “TITAN” anomaly (elevated Ti, Ta, and Nb) has been linked to melts with elevated ^{3}He/^{4}He. The Nb-Y-Zr system, which can be expressed as δNb, is a measure of Nb enrichment/deficit compared to a global array. Combining published and new μ^{182}W values, and trace element data for a globally-representative set of samples, we find that TITAN basalts occupy a restricted range in Nb-Y-Zr space, and that δNb and μ^{182}W may be correlated. This correlation may indicate that this component formed early in Earth history and remained largely isolated in the lower mantle. The near-ubiquity of this geochemical signature in plumes, however, remains unexplained, meriting further integrated studies to understand the role of early-differentiated reservoirs in mantle convection plumes.