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Anomalous vanadium isotopes in Baffin Island lavas: Evidence of core-mantle exchange?

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Mantle plumes with higher $^3He/^4He$ than the upper mantle imply solar-like gases captured during planetary accretion are preserved in the deep Earth, possibly in the outer core [1]. We hypothesize that, if mantle plumes entrain core-derived helium, that they might also incorporate vanadium (V) from the core. Most mantle-derived peridotites, komatiites, ocean island basalts, and mid-ocean ridge basalts have invariant $\delta^{51}V$ (−0.856 ± 0.020 ‰ [3], where $\delta^{51}V = ([^{51}V/^{50}V)_{sample/}{}^{51}V/^{50}V)_{standard}] - 1) \times 10^3)$ values that are heavier than chondrites (−1.089 ± 0.029 ‰ [3]). Assuming that bulk Earth is chondritic, the core must have lighter $\delta^{51}V$ (−1.39 ± 0.10 ‰ [3]) values to satisfy mass balance constraints [3]. Therefore, V isotopes are a potential tracer of core-mantle exchange. We analyzed the V isotopic composition of 26 lavas from Baffin Island, Canada, which have the highest known $^3He/^4He$ ratios of any measured terrestrial igneous rock (up to 65 times the atmospheric ratio [4]). These lavas have $\delta^{51}V$ values that are statistically lighter than the bulk silicate Earth, consistent with a core contribution. Bulk mixing calculations reveal that approximately 20–60% bulk core is required to explain the offset. Such high core fraction is inconsistent with major element, trace elements, and other core-sensitive isotopic tracers in Baffin Island lavas, including tungsten [5] and osmium [6] isotopes. Alternatively, chemical fractionation across the core-mantle boundary might occur via exsolution of precipitating oxides out of the core, or isotope diffusion. Lastly, it is also possible that V stable isotope fractionation occurred during fractional crystallization of spinel or assimilation of crustal rocks could have affected the V isotope signatures.

[1] Jackson et al. (2020) PNAS 117, 30993-31001. [2] Stuart et al. (2003) Nature 424, 57–59. [3] Nielsen et al. (2020) Geochem Perspec Lett., 35-39. [4] Horton et al., (2022) Goldschmidt. [5] Jansen et al., (2022) EPSL 585, 1-13. [6] Dale et al. (2009) EPSL 278, 267-277.