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

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Mantle plumes with higher $^3\text{He}/^4\text{He}$ 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 $\delta^{51}\text{V}$ ($−0.856 ± 0.020 \permil$ [3], where $\delta^{51}\text{V} = ([^{51}\text{V}/^{50}\text{V}]_{\text{sample}}/[^{51}\text{V}/^{50}\text{V}]_{\text{standard}} − 1) × 10^3$) values that are heavier than chondrites ($−1.089 ± 0.029 \permil$ [3]). Assuming that bulk Earth is chondritic, the core must have lighter $\delta^{51}\text{V}$ ($−1.39 ± 0.10 \permil$ [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 $^3\text{He}/^4\text{He}$ ratios of any measured terrestrial igneous rock (up to 65 times the atmospheric ratio [4]). These lavas have $\delta^{51}\text{V}$ 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.