Vanadium isotopic composition of garnet-clinopyroxene pairs from kimberlite-hosted mantle xenoliths

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Prevailing mantle oxygen fugacity (fO_2) is hotly debated, since current fO_2 proxies have large uncertainties of at least half an order of magnitude. Thus, new approaches to quantify fO_2 are sought.

Vanadium (V) is a moderately incompatible, immobile transition metal with multiple valence states (+2, +3, +4, +5). Previous studies have shown that V concentrations in magmatic rocks can respond to variable fO_2 [1], however this approach is hindered by uncertainties in mantle source concentrations and degree of melting. Variations in the stable isotope compositions of multi-valent elements may also respond to fO_2. Theoretically, heavier stable isotopes preferentially enter sites with stiffer bonding environments (i.e. lower coordination and higher valence states). Hence, V stable isotopes could be used as a redox proxy, but the effects of coordination and oxidation state must be evaluated.

Here we present V stable isotope data for natural mineral separates. Garnet and clinopyroxene in chemical and textural equilibrium were picked from fresh, well-characterised, lherzolitic, mantle xenoliths from the Diavik diamond mine in the central Slave craton, Canada [2]. Co-ordination of V in both garnet and clinopyroxene is VI-fold; therefore, valence state should be the primary variable affecting bond strength. Determined bulk fO_2 ranges from -2.38 $\Delta \log fO_2^{[FMQ]}$ to -3.36 $\Delta \log fO_2^{[FMQ]}$ [2]. The measured garnet-clinopyroxene inter-mineral fractionation factor is negligible. Neither garnet nor clinopyroxene $\delta^{51}V$ in this suite co-vary with garnet $Fe^{3+}/\sum Fe$ or bulk fO_2. However, bulk rock $\delta^{51}V$ ranges from -1.08 to -1.73, positively correlating with fO_2, suggesting an additional redox-sensitive phase. The Diavik xenoliths are kimberlite-hosted, and given the significant difference in $\delta^{51}V$ between the main mineral hosts of V and bulk powders, the effect of host contamination needs further examination. This variance underlies the ambiguity inherent to using rock powders without mineralogical context.

[1] Canil, D. (1997) *Nature.* **389**, p. 842-845
[2] Yaxley et al. (2017) *Sci. Reports.* **7** (30)