Ti stable isotope fractionation during planetary and magmatic differentiation

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Titanium is a significant constituent of the silicate portion of planetary bodies and is a refractory, fluid immobile and incompatible element that has been widely used to trace partial melting and magma differentiation processes. However, to date, its stable isotope composition has received very little attention. Titanium is dominantly in 5-fold coordination in silicate melts and in 6-fold coordination in Ti-oxides, the main mineral phase incorporating Ti. As stable isotope partitioning theory suggests predicts that fractionation will be driven by changes in elemental coordination and bonding environment, it is likely that partial melting and magmatic differentiation processes will be accompanied by significant Ti stable isotope fractionation. Here we explore the potential of Ti stable isotopes as a tracer using a recently developed analytical method[1] to obtain ultra-high precision Ti stable isotope data (ca. 0.015‰ on δ^{49}Ti) on a range of terrestrial and lunar samples.

All primitive terrestrial basalts display values within analytical uncertainty regardless of geographical origin or geological context (δ^{49}Ti=+0.006±0.022, 95% c.i.). Mantle samples display similar values (δ^{49}Ti=+0.011±0.028, 95% c.i.) to basalts, indicating that partial melting does not cause fractionation of Ti isotopes. However, primitive lunar basalts extend to heavy δ^{49}Ti values (up to 0.087±0.015) that display positive and negative correlations with Mg and Fe isotopes, respectively. This is explained by the crystallisation of ilmenite in the late stages of the lunar magma ocean.

Differentiated terrestrial magmas also display extremely heavy δ^{49}Ti values (δ^{49}Ti up to 0.54±0.018‰) that are positively correlated with silica content. This is consistent with the progressive fractionation of isotopically light δ^{49}Ti into Ti-oxides during fractional crystallisation. Interestingly, adakitic magmas plot on this correlation, which suggests that fractionation of Ti-bearing oxides play a significant role in generating their distinct geochemical signatures.

[1] Millet and Dauphas (2014) *JAAS* **29**, 1444-1458.