Titanium isotopic fractionation during magmatic differentiation

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To better constrain the titanium (Ti) isotopic composition of the silicate Earth, and investigate the behavior of Ti isotope during magmatic processes, we report double-spike Ti isotope data for 92 terrestrial samples including 63 basalts (MORBs, BABBs, OIBs and continental basalts) and 29 highly differentiated igneous rocks from different localities worldwide. Among the bulk rocks analyzed, those with MgO SiO_2 below 54 wt.% have a narrow range of $\delta^{49/47}Ti_{OL-Ti}$ from −0.05 to 0.11, with an average of 0.04±0.06 (2SD, n=60), and no correlation between isotopic composition and degree of differentiation is seen. Together with Ti isotopic data for mantle-derived samples from literature, the new estimate suggests that the BSE has an average $\delta^{49/47}Ti_{OL-Ti}$ of 0.02 ±0.07 (2SD, n=147). By contrast, the other samples with SiO_2 above 54 wt. % show remarkably varied $\delta^{49/47}Ti_{OL-Ti}$ values (ranging from 0.06 to 1.93) that are significantly heavier than the mafic rocks. In particular, multiple SiO_2 vs. $\delta^{49/47}Ti_{OL-Ti}$ trends can be identified in these highly fractionated lavas. These correlations are interpreted as reflecting the result of preferential incorporation of light Ti isotopes into Fe-Ti oxides during fractional crystallization, leaving behind a melt that is enriched in heavy Ti isotopes. Modeling of Ti isotope fractionation between mineral and melt shows that variations in magnetite/(ilmenite+pseudobrookite+ rutile) are important for controlling Ti isotope fractionation. At an average SiO_2 content of 60.6 wt.%, the predicted $\delta^{49/47}Ti_{OL-Ti}$ value of the continental crust is 0.31±0.09(2SE, n=15). This study implies that crystal fractionation is the dominant mechanism that controls Ti isotope fractionation in evolved rocks and Ti isotopes may be used to study magmatic differentiation of high-silica magmas.

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