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The Ti isotope composition of the Andean lower continental crust: Implications for lower crustal foundering and the co-evolution of crustal and mantle geochemistry

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Mass-dependent fractionation of titanium (Ti) isotopes is a useful tracer of magmatic and planetary differentiation. During melt chemical differentiation, the crystallization of Fe-Ti oxides preferentially removes the lighter isotopes of Ti, thereby producing derivative melts with isotopically heavy (*i.e.*, more positive δ49/47Ti) compositions. This process is thought to take place on a crustal scale, as the average δ49/47Ti of the upper continental crust is elevated relative to the mantle and less evolved crustal materials such as mafic enclaves and xenoliths bearing Fe-Ti oxides (*e.g.*, [1]). Following this reasoning, it has been proposed that the isotopically light complement to the upper continental crust resides within oxide-enriched cumulates in the lower continental crust. This assumption has been leveraged to speculate that lower crustal foundering (*i.e.*, gravitationally-driven recycling of dense lower crustal cumulates into the mantle) has imparted an isotopically light signature to the mantle that can be traced through time (*e.g.*, [2]).

To test this assumption, we measured the Ti isotopic composition of gravitationally unstable lower crustal cumulates formed via fractional crystallization of hydrous arc magmas from the Northern Andean Volcanic Zone in Colombia. These arclogites, brought to the surface as xenoliths by a Quaternary volcanic eruption, are dominantly garnet pyroxenites (±amphibole) that record P-T conditions indicative of equilibration in the Andean lower crustal root, and represent the density-unstable portion that will likely founder into the mantle on geologic timescales. Contrary to prevailing hypotheses that suggest these arclogites would be isotopically light, we find the density-unstable portion of the Andean arc lower crust to have relatively unfractionated δ49/47Ti compared to the mantle. These results are supported by the mineralogy of the samples, because the crystallization of arc magmas at high pressures favors garnet, pyroxene, and amphibole crystallization over Fe-Ti oxides, suggesting that Ti isotopic variability is limited to the middle and upper continental crust. Variability in mantle Ti isotopic values with time is thus more likely due to the extraction of isotopically heavy Ti isotopes through repeated melting events, rather than lower crustal foundering.

[1] Storck et al. (2023) *Chem Geol*, V. 617

[2] Deng et al. (2023) *Nature*, V. 621