Amphibole fractional crystallization in the lower crust: implications for Nb-Ta fractionation in the continental crust

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Most geologic processes should not lead to fractionation of Nb from Ta. However, the Earth's major silicate reservoirs exhibit subchondritic Nb/Ta values. Nb/Ta of primary mantle melts from different tectonic settings compiled from GEOROC yield values clustering around 17. In contrast, Nb/Ta in more evolved arc volcanics correlate negatively with SiO_2 and show progressively lower values, reaching upper continental crust estimates (~13). This global trend suggests that differentiation processes in magmatic arcs control the decrease in upper crustal Nb/Ta. Understanding processes that govern fractionation of Nb from Ta in arcs should provide key insights into continental crust formation and differentiation. While Ti-rich phases (rutile, titanite and ilmenite) have D_{Nb}/D_{Ta} <1 and thus cannot explain the observed trend, biotite and amphibole could significantly lower Nb/Ta values in the evolved liquid during fractionation from mafic to intermediate magmas. Experimental studies have suggested that amphibole Mg# inversely correlate with D_{Nb}/D_{Ta} and amphibole could effectively fractionate Nb from Ta. Abundant amphiboles crystallized during magmatic differentiation, now exposed in partially preserved lower to middle crustal sections [e.g. Chelan complex; Talkeetna arc (TA); Ivrea-Verbano Zone (IVZ)] allows for testing the magnitude of amphibole-driven crustal Nb-Ta fractionation. We examined mineral major and trace element composition of amphibole gabbros with 10-30% amphibole from mid-lower crustal sections in the IVZ and TA. Our data show that amphiboles with Mg# ranging from 60 to 75 have suprachondritic Nb/Ta values (>30) and host up to ~95% of the whole rock Nb, suggesting that amphibole fractional crystallization is a viable mechanism for the fractionation of Nb from Ta in the continental crust.