The Neogene Los Frailes Ignimbrites and Evolution of the Andean Crust and Mantle Beneath the Altiplano

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The chemistry of the andestic-rhyodacitic Los Frailes Ignimbrite Complex records the last 25 million years of crustal thickening and delamination under the Andean Altiplano. The strongly peraluminous character of these ignimbrites indicates a metapelitic crust, while seismic velocities reveal a predominantly silicic lower crust at present. Geochemical data and modeling suggest the ignimbrites are ~50:50 mixtures of enriched mantle and crustal-derived melts based on δ18O ratios of quartz phenocrysts (+9.73-11.09‰) and Sr-Nd AFC calculations that assume an enriched mantle melt with 500-950 ppm Sr; 25-30 ppm Nd; δ18O=+5.8‰, 87/86Sr=0.7055 and 143/144Nd =0.51260. Sr and Nd isotopic ratios in the ignimbrites are 0.710-0.713 and 0.5121-0.5123. The AFC calculated crustal end-members have δ18O=+13-16‰, 87/86Sr=0.730-0.750 at 95-160 ppm and 143/144Nd =0.51190 at 25-40 ppm. Evidence for melting and mixing near the Moho comes from steep HREEs (Sm/Yb=4-12) and high Sr ppm (400-650). Negative Eu/Eu* (0.6-0.9) anomalies require subsequent mid to upper crustal plagioclase fractionation, and cordierite in some reflect pre-eruption crystallization in the uppermost crust. Temporal trends in trace element ratios track a pattern of general and episodic crustal thickening related to crustal shortening since 25 Ma that is inferred from steepening HREE ratios. Two temporally distinct decreases in Sm/Yb ratios could correlate with discrete delamination events at 12-10 Ma and 4-2 Ma just prior to the major eruptions of the 8-7 Ma Livicucho/Condor Nasa and 2-1 Ma Los Frailes ignimbrite. A shift to more enriched isotopic compostions at 12-10 Ma could be related to delamination related loss of the mantle lithosphere and basal crust that both contaminates the mantle wedge and exposes mantle melts to more isotopically enriched crust. The voluminous ~1.5 Ma Los Frailes ignimbrite is linked with seismic evidence for missing lithosphere related to the latest delamination event.