Chemical and Isotopic Evidence for Modification of the Central Andean Arc Mantle by Crust Removed by Forearc Subduction Erosion

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The removal of forearc crust and mantle by forearc subduction erosion is widely discussed, but direct chemical evidence for subduction erosion linked to modification of the mantle wedge is rare. A clear case for such a change in the arc mantle comes from differences in the character of primitive, mantle-derived basalts that erupted near each other in the southernmost Andean Central Volcanic Zone near 27°S latutude. These ~ 24 Ma near-backarc (Segerstrom) and < 1.5 Ma arc (Incahuasi and San Francisco) basalts erupted before and after ~ 50 km of eastward frontal arc migration between 8 to 3 Ma. Arc migration is postulated to be related to subduction erosion in this part of the Chilean margin where forearc subduction erosion was first proposed.

The primitive nature of the 24 Ma and < 1.5 Ma arc basalts is shown by their high Mg (>9%), Cr (> 600 ppm) and Ni (> 200 ppm) contents and primitive olivine (>FO82) and clinopyroxene (>EN46) phenocrysts. Limited effects of crustal contaminants in the < 1.5 Ma basalt (~ 53% SiO_2) can be compensated in a model that removes ~ 18% of a nearby Pliocene rhyolitic ignimbrite (Laguna Verde). After removal of this rhyolite, the < 1.5 Ma basalt remains isotopically enriched, has a steeper REE pattern with more LREE enrichment, and has higher Th, Ta, alkali and alkaline earth contents relative to the ~ 24 Ma basalt. The best evidence for crustal contamination in the mantle wedge comes from an increase in $^{86}Sr/^{86}Sr$ from 0.7038 to 0.7055 that cannot be modeled by intracrustal contamination due to Sr mass balance considerations. Strong support for contamination of the mantle source comes from modeling $\delta^{18}O$ values in olivine from the basalts ($\delta^{18}O$ ~ 6 and 7) and quartz ($\delta^{18}O$ ~ 9) from the rhyolite (data from Gerhard Woerner). After correction for intracrustal contamination, both basalts have $\delta^{18}O$ near 5.8. Isotopic and trace element modeling fit an increase in $^{86}Sr/^{86}Sr$ ratio explained by source contamination in the mantle followed by intracrustal assimilation. A role for subducted sediments in producing the source contamination in the mantle can be eliminated due to a near lack of continental detritus being shed into the Andean trench in the last 11 Ma and a nearly constant pelagic sediment source on the incoming Nazca plate.

Supporting evidence for chemical effects in arc magmas comes from the extreme La/Yb and La/Ta ratios that occur only in 8 to 3 Ma volcanic rocks that erupted as the frontal arc migrated.