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Sources of Late Miocene to Holocene Magmas, Changes in Subduction Geometry, and Removal of Crustal and Mantle Lithosphere Beneath the Southern Puna Plateau in the Central Andes

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Latest Miocene to Holocene magmas of the southern Puna plateau of the Central Andes provide a record of mantle and lithospheric processes beneath the plateau. The overall eruption pattern and temporal changes in magma distribution and chemistry can be reconciled with the period of lower crustal and continental lithosphere delamination proposed by Kay et al. (1994) following a subdued episode of transient shallow subduction. Late middle to late Miocene shallow subduction would coincide with the subduction of the Juan Fernandez Ridge on the Nazca plate beneath the southern Puna. A transient shallow subduction episode sets the stage for Pliocene lower crustal and lithospheric delamination by thinning the continental lithosphere and accelerating the formation of eclogite in a thickened mafic lower crust.

In detail, post-7 Ma magmas in the Salar de Antofalla and Cerro Galan region of the southern Puna are basaltic andesitic (53-55% SiO_2) to andesitic (58-63% SiO_2) lava flows erupted from mono to polygenetic centers and dacitic to rhyolitic ignimbrites. The mafic flows typically erupted along faults and can be distinctive for their glassy nature, acidic plagioclase and quartz xenocrysts, and high Mg numbers and Cr and Ni contents at a given SiO_2 content. The andesitic flows are notable for being more Cr-rich than CVZ magmas at the arc front. Their high Cr contents can be explained by mixing of mafic and silicic magmas, and their quartz and feldspar xenocrysts as phenocrysts of the silicic magmas. Their characteristics fit with rapid mixing of mantle-derived basalt ($\sim$80%) and accumulated lower crustal melt fractionating at mid crustal

depth ($\sim$ 20%). Mid-crustal mixing is supported by seismic data further north that is interpreted to show magma accumulation at mid-crustal depths (e.g., Chmielowski et al., 1999; ANCORP, 2003).

Importantly, the mafic lavas in the central Salar de Antofalla region show a temporal change from more arc-like La/Ta ratios (36 to 55) at $\sim$ 6.6 to more intraplate-like ratios (20 to 35) after 3 Ma. Contemporaneous La/Ta ratios in $\sim$ 5 to 4.3 Ma glassy andesites are 45-78 and in glassy dacites are $>$ 64. These ratios are extreme as shown by comparing with southern CVZ arc magmas with La/Ta = 27-36 at$\sim$ 53% SiO_2. Voluminous backarc Cerro Galán region ignimbrites show a similar arc to intraplate-like trend with La/Ta ratios of 27-42 at $\sim$ 6.6 to 4 Ma and of 14-28 after $\sim$ 2.4 Ma. These ratios are also higher than those near the arc front ($\sim$ 20 in $<$ 2 Ma Cerro Blanco ignimbrites). Parallel changes in mafic and silicic magmas fit with modification of the lower crust by underplating of mantle-derived magmas with a changing chemistry. Low Ba/La ratios (most $<$ 15) in all show little influence of slab-derived fluid mobile elements. The temporal changes in the backarc magmas fit with a changing influence for a subducted component under the southern Puna. An eastward expansion of $\sim$ 15 to 8 Ma andesitic to dacitic stratovolcanoes and dome complexes into the backarc is consistent with the subducted component being related to a moderately shallowly dipping Nazca plate. The disappearance of the subducted component in $<$ 3 Ma central Salar de Antofalla magmas along with other regional characteristics is in accord with delamination of the lower crustal and mantle lithosphere as the subducting slab steepened.