Experimental constraints on the Altiplano-Puna Magma Body: a dacite factory in the Central Andean Volcanic Zone

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The Altiplano-Puna Magma Body (APMB) is a regional sill-like zone of partial melt, some 17 km deep in the crust, which is thought to be the source of much of the magmas erupted in the Andean Central Volcanic Zone historically. The extent of the APMB ultra-low velocity zone has been imaged seismically and with magnetotellurics but petrological knowledge of this magma body is lacking. We present phase equilibria experimental data using an andesitic starting composition from a magmatic inclusion sampled in lavas from Uturuncu, a dacitic composite volcano in SW Bolivia. The natural andesites are porphyritic with plagioclase and orthopyroxene typically the most abundant phenocrysts. Experiments have been performed between 500 and 1100 MPa, 920 to 980℃ at volatile-saturated and -undersaturated conditions with oxygen fugacity buffered around Ni-NiO.

Volatile-saturated experiments crystallise amphibole, clinopyroxene, orthopyroxene and spinel but plagioclase, the most abundant phase in Uturuncu andesitic inclusions, is absent. In volatile-undersaturated runs plagioclase is common along with amphibole, clinopyroxene, orthopyroxene and spinel. Phase assemblages are not expected to exactly match those in natural andesitic inclusions which have crystallized at lower pressures prior to eruption. At pressures and temperatures representative of APMB conditions (e.g., 950℃, 800 MPa) residual melt in andesite experiments is dacitic with major element compositions similar to those of whole-rock lava and dome rocks erupted at Uturuncu.

We propose a conceptual model where basalts are intruded into the base of the APMB. Subsequent fractional crystallization of these basalts combined with crustal assimilation produces volatile-undersaturated, plagioclase-rich andesitic magmas with 6 to 16 vol% plagioclase phenocrysts. Residual melt of these andesites is dacitic and buoyantly rises from the APMB periodically.

Complimentary phase equilibria experiments on Uturuncu dacite compositions indicate pre-eruptive storage conditions between 50 and 150 MPa at temperatures around 870℃. H_2O and CO_2 concentrations measured in plagioclase-hosted melt inclusions from Uturuncu dacites are 3.2±0.7 wt% and <100 ppm respectively. If these concentrations reflect pre-eruptive volatile compositions then dacite magmas would be volatile-saturated at such shallow storage levels consistent with the equilibrium phenocryst assemblage. We envisage that ascending dacite magmas become volatile-saturated and crystallize extensively at this level. The resulting increase in magma viscosity causes the magmas to stall. Eruptions are likely triggered by intrusion and mingling of hotter, less evolved andesitic magmas sourced from the APMB as evidenced by inclusions in dacite lavas.