Understanding the evolution of large-scale continental magmatic systems: a case study of the Purico-Chascon volcanic complex in northern Chile

Dale H Burns, Shanaka L de Silva, Frank J Tepley

College of Earth, Oceanic, and Atmospheric Sciences, Oregon State University, Corvallis, OR, United States

E-mail: burnsd@geo.oregonstate.edu

The Purico-Chascon volcanic complex in northern Chile is a long-lived silicic magmatic system that records 800 ky of continental arc magmatism. Volcanism at the Purico-Chascon volcanic complex initiated 1.0 ma with the eruption of the 60-80 km^3 Purico ignimbrite. Following the ignimbrite eruption, activity became significantly less explosive resulting in a series of intermediate lava domes and flows (10 km^3 total), the youngest of which (Cerro Chascon) erupted 200 ka. In this study, we combine textural, major element, trace element, and isotopic data from individual crystals within the Purico ignimbrite and Cerro Chascon lavas to determine how the Purico-Chascon magmatic system evolved.

Plagioclase crystals from the Purico ignimbrite have high, restricted $^{87}Sr/^{86}Sr$ isotope ratios (0.7085-0.7089) similar to whole-rock isotope ratios from the same unit. In contrast, Cerro Chascon contains two isotopically distinct types of plagioclase. The first type of plagioclase is texturally and isotopically indistinguishable from crystals within the Purico ignimbrite. The second type has significantly lower $^{87}Sr/^{86}Sr$ ratios (0.7060-0.7072). Phase equilibria obtained from crystalline and glass phases (plagioclase, amphibole, olivine, pyroxene, glass) indicate that the crystals within the Purico ignimbrite grew in a single, shallow (100-200 MPa; 4-8 km), relatively low temperature (800-875 degrees C) magma reservoir. In contrast, crystals from Cerro Chascon appear to be derived from two distinct magmas. Some crystals appear to have grown in conditions identical to crystals from the Purico ignimbrite. However, other crystals, particularly those in basaltic-andesite magmatic inclusions, appear to be derived from a much deeper (350-550 MPa; 12-20 km deep), higher temperature (950-1050 degrees C) magma source. Lastly, Fo_{81-85} olivine within the lavas yield olivine-melt temperatures of 1200 degrees C consistent with an even deeper source, possibly within the lower crust.

The lack of compositional and isotopic heterogeneity, high $^{87}Sr/^{86}Sr$ isotope ratios, and phase equilibria indicate that the upper crust was a site of significant magma generation and storage during the early evolution of the Purico-Chascon magmatic system. In contrast, the magmatism that led to the eruption of Cerro Chascon appears to have been concentrated in the mid-crust, and only had minor interactions the upper crustal Purico magma reservoir shortly prior to eruption. In the regional context, the Purico-Chascon system appears to be the last major eruptive center associated with a regional magmatic flare-up. Thus, the changes observed in the Purico-Chascon magmatic system might reflect changes in the thermal structure of the crust in response to decreased mantle heat input associated with the waning of the flare-up.