11 Million Years of Arc Volcanism at the Aucanquilcha Volcanic Complex, Northern Chilean Andes

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Volcán Aucanquilcha, at 21°S in northern Chile, lies near the center of a cluster of more than 10 major volcanoes that we refer to as the Aucanquilcha Volcanic Complex (AVC). This cluster records about 11 m.y. of mainly effusive, arc volcanism in the Central Volcanic Zone of the Andes where the continental crust is as thick as 70 km. The active arc at this latitude has two NNE-striking axes; Volcán Aucanquilcha lies on the western axis and Volcán Ollagüe lies 20 km to the east, on the border with Bolivia. We here summarize age, volume and composition data for the AVC to serve as a window into the history of the formation of a batholith.

The Aucanquilcha Volcanic Complex defines a geomorphological cluster with a radius of about 12 km. It is flanked on the west by the Loa Valley, which is underlain by Mesozoic rocks that are blanketed by the 5.6-Ma Carcote Ignimbrite. The complex is separated from Volcán Ollagüe to the east by the Salar de San Martin O Carcote, underlain by the Carcote Ignimbrite. To the north, the AVC is bounded by subdued topography that coincides with a westward stepping of the axis of active volcanoes. To the south, a broad pass separates the AVC from Volcán Chela (~5.8 Ma). Arid conditions since the Miocene have allowed for remarkable preservation of volcanic edifices.

Based on mapping and $^{40}Ar/^{39}Ar$ dating of volcanic rocks of the AVC, we estimate that 340 km^3 of magma has been erupted since 11 Ma (Fig. 1a), yielding an average volumetric eruption rate of 31,000 m^3 per year. Most of the volcanic products are andesite and dacite lavas, many of which are agglutinated. Pyroclastic rocks are not common. We include the Ujina Ignimbrite (9.3 Ma, ~2.5 km^3) with the AVC, because it occurs on the northern flank of the complex, but its source is uncertain. A major pyroclastic flow deposit occurs on the western side of Volcán Aucanquilcha, but does not account for much of the 45 km^3 that make up the edifice. To the east, Aucanquilcha has shed a large debris avalanche deposit. The volume estimate does not account for pyroclastic fall deposits, but we have made a modest reconstruction of pre-erosion volumes by using the relationship between volume and footprint of Volcán Miño, a little glaciated, well-preserved andesite cone, to reconstruct volumes of eroded cones based on their footprint. The correction amounts to less than 10% of the total estimated volume.

Viewed in more detail, the extrusion of magma in the AVC has occurred episodically (Figure 1). Growth of the cluster was fairly slow (~13,000 m^3/year) from 11 to about 8 Ma and was followed by an apparent hiatus in volcanism of about 2 m.y (Fig. 1a). This older set of about 7 volcanoes occurs on the northern and northwestern side of the AVC. Around 6 to 4 Ma, volcanism shifted to the south and west of the AVC and accounts for an additional 50 km^3 distributed over 4 major centers (Fig. 1a). Greatest productivity in the AVC occurred between about 3.5 and 2.5 Ma with lavas distributed on

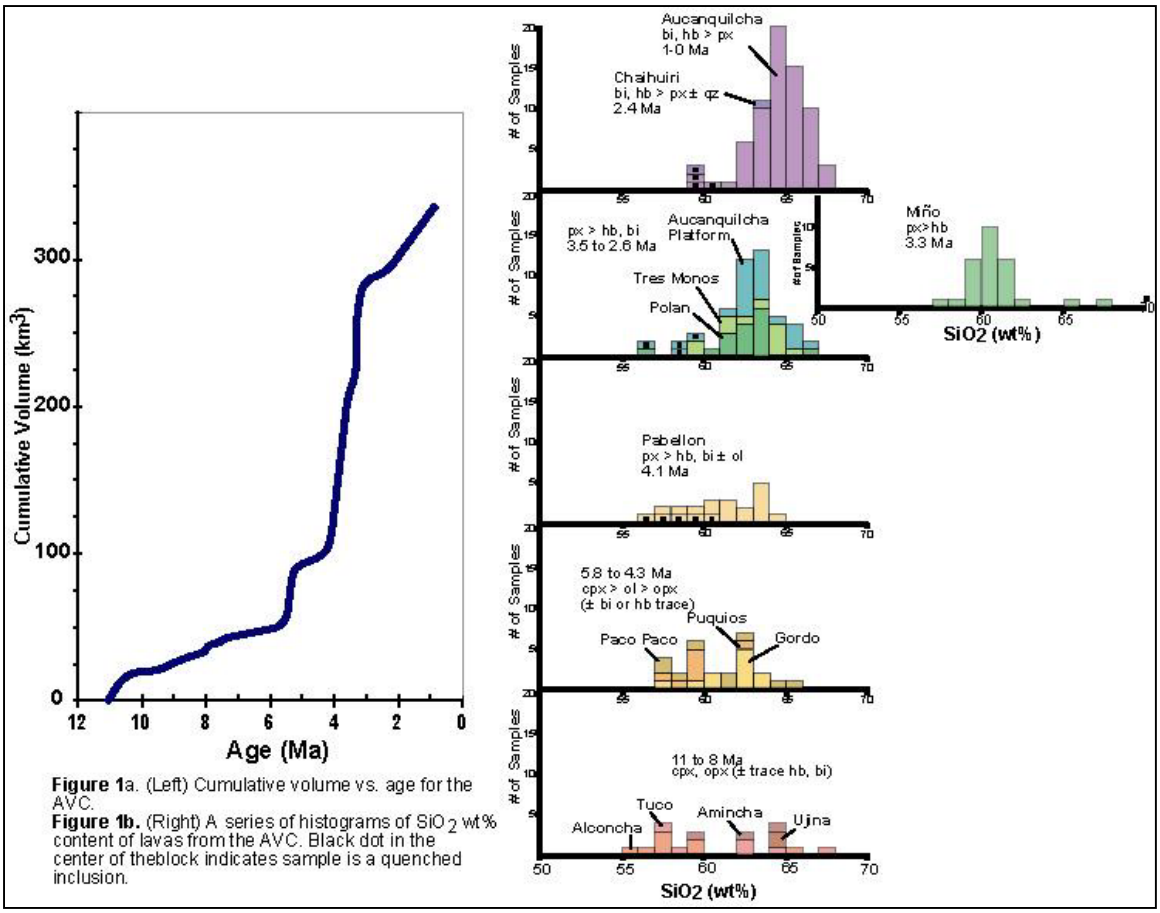

Figure 1a. (Left) Cumulative volume vs. age for the AVC.
Figure 1b. (Right) A series of histograms of SiO_2 wt% content of lavas from the AVC. Black dot in the center of theblock indicates sample is a quenched inclusion.

all sides of the complex and vents mainly along as east-west ridge that makes up Cerro Polán and Polán Viejo and along a prominent north-south ridge that makes up Cerro Tres Monos. These centers, and possibly others now buried by Volcán Aucanquilcha, created a large platform of lavas on which Volcán Aucanquilcha is built. Volcán Miño, which is included toward the young end of this major volcanic episode, stands slightly to the west of the rest. The volumetric eruption rate during this episode was about 180,000 m^3/year, nearly 6 times the overall average production rate (fig. 1a). Volcán Aucanquilcha ranges in age from about 1 Ma to a few hundred thousand years. Mild fumarolic activity ranks it as an active volcano. It is made of overlapping domes and flows that define an east-west ridge that lies on strike with the Polán-Polán Viejo alignment and perpendicular to the Tres Monos alignment. For Volcán Aucanquilcha itself, the volumetric eruption rate is about 45,000 m^3/year.

Compositionally, the AVC rocks are a typical continental, medium- to high-K "andesite" suite, ranging between 55 and 69 wt. % SiO_2 (fig. 1b). The AVC conforms to regional, strongly crustal radiogenic isotopic compositions. εNd, from –1 to –8, correlates with increases in $^{87}Sr/^{86}Sr$ from 0.7051 to 0.7068. While each volcano has its own compositional range, mineralogy and textures, there is an overall compositional evolution. From 11 to about 4 Ma, volcanism was compositionally variable, crudely bimodal, with few lavas between 60 and 63 wt. % SiO_2 (fig. 1b), and had dry mafic silicate assemblages (clinopyroxene, orthopyroxene, olivine). In time, volcanism becomes more unimodal at individual centers. The major 3.5-2.5 Ma volcanic episode was more silicic, ranging from 60 to 65 wt% SiO_2, and peaking between 62 and 64 (fig.

1b). In this group, biotite and amphibole are common but are subordinate to pyroxenes. The present culmination, Volcán Aucanquilcha, is composed mainly of silicic dacites (64-66 wt % SiO_2) and biotite and hornblende dominate over pyroxene. Volcán Miño stands physically and compositionally separate. It is made of remarkably monotonous hornblende andesite that clusters around 60-62 wt% SiO_2 and so fills the compositional gap defined by the early volcanism (fig. 1b). The persistence of andesitic magma with dacite is indicated by magmatic inclusions. At Cerro Pabellón (~ 4 Ma), andesite occurs both as lavas and as inclusions in dacite lavas. Thereafter, compositions below 60 wt% SiO_2 occur only as inclusions (except at Volcán Miño – see fig. 1b).

We interpret the long-term temporal compositional trends of the AVC to reflect tapping of long-lived episodic magmatic reworking of the crust. The petrologic history of individual volcanoes reflects assembly of subvolcanic plutons with lifetimes of a few 100,000 years to as long as a million years, which together make a major batholith under the AVC. As the crust is successively reprocessed, individual centers become more homogeneous in composition. The trend toward higher silica and more hydrous assemblages suggests that the plutonic complex stalled at successively shallower and cooler crustal levels.