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Growth and evolution of long-lived, large volcanic clusters in the Central Andes: The Chachani Volcano Cluster, southern Peru

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ABSTRACT

In the Central Andes, large (> 500 km^2) and long-lived (1–5 Ma) volcanic clusters (LVCs) are less explored and their eruptive history and magmatic regimes less understood than smaller, short-lived (<0.5 Ma), individual stratocones. The Chachani-large volcanic cluster (C-LVC) sizeable volume (*c.* 290 km^3) consists of twelve edifices forming the 1.06–0.64 Ma group of stratovolcanoes and the 0.46–0.05 Ma group of domes coulees and block-lava flow fields. Both groups overlie pre-Chachani lavas and tuffs 1.02–1.27 Ma, and together they have buried large nested craters or a caldera associated with the *c.* 1.62–1.66 Ma Arequipa Airport ignimbrite. The C-LVC evolved from: (i) homogeneous compositions of the pre-Chachani and Chachani basal eruptive units to (ii) relatively wide compositional variations (53–67 wt% SiO_2) between mafic andesite and dacite at moderate eruptive rates (0.27–0.41 km^3/ka) for the 'Old Edifice' group, and finally to (iii) narrower (57–64 wt% SiO_2) andesitic compositions coinciding with extrusive activity at 2.5 times lower eruptive rates (0.12–0.15 km^3/ka) for the 'Young Edifice' group. The large compositional variations in the Old Edifice group are related to strongly contrasting resident and recharge magma compositions of hybridized lavas. In contrast, the narrow compositional range and lower eruption rate during the second half of the C-LVC eruptive history represent a trend towards more homogeneous, andesitic magma composition with time. Mineral texture and compositional studies provide evidence for disequilibrium and magma mixing in the C-LVC shallow (5–20 km depth range) magma reservoirs. These temporal changes in magma composition document that the transcrustal magma systems of the C-LVC evolved and matured with time by a combination of processes: fractional crystallization, crustal contamination and magma mixing/mingling with variable rates of mafic recharge. This resulted in a shift in time to a steady state, monotonous (andesite) regime as a result of coupling between compositional parameters and thermal conditions, density constraints, and the viscosity/crystallinity of erupted magmas.

1. Introduction

The Central Volcanic Zone (CVZ) of the Andes is an excellent natural laboratory in which the interactions between magma genesis and crustal evolution can be explored (e.g., Wörner et al., 2018). These interactions have led to four main constructional volcanic types: (1) andesitic and dacitic composite stratovolcanoes, (2) large volcanic clusters (LVCs) that have erupted relatively wide compositional ranges from mafic andesites to dacites, (3) voluminous rhyodacitic ignimbrite fields, and (4) scarce, volumetrically insignificant, basaltic or basaltic andesitic, monogenic fields.

Studies of individual composite volcanoes in the Andean CVZ over

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