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Batholith Formation in Continental Arcs from Volcanic Zircon Geochronology and Trace Element Geochemistry

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The study of zircon from young volcanic systems provides important insights into the construction of granite plutons because zircon uniquely records the physical and chemical conditions in magmas at high fidelity and temporal resolution. We comprehensively investigated zircon geochronology and geochemistry of volcanic rocks from the Altiplano-Puna Volcanic Complex (AVPC) in the Central Volcanic Zone of the Andes between ∼21 and 24° S to constrain the pace and processes of magmatic addition in continental arcs. The APVC comprises multiple nested caldera systems which episodically sourced large-volume (>10^3 km^3) ignimbrites of dacitic-rhyolitic composition. Between ignimbrite flare-up pulses, and during the prevailing waning stage (since ca. 2 Ma), lava domes and small-volume ignimbrite shields erupted, which are compositionally similar to, but texturally often more mature than large-volume ignimbrites. The presence of rare andesitic banded pumice or blebs in lava indicates that upper crustal magma reservoirs are recharged from a mid-crustal hot zone. The scarcity of zircon xenocrysts in APVC rocks implies that zircon is undersaturated in the andesitic recharge, and predominantly crystallized in differentiated upper-crustal reservoirs. Volcanic rocks from high eruptive flux episodes have zircon age spectra dominated by neoformed zircon and lack antecrysts from ancestral eruptions of the same caldera (Kern et al., 2016; Kaiser et al., 2016). By contrast, low-flux episodes produced zircon age spectra extending back for 100's of ka prior to eruption with a high abundance of antecrystic zircon (Tierney et al., 2016). Based on thermochemical modelling of zircon age spectra, high-flux episodes are characterized by runaway growth of magma reservoirs at elevated recharge rates, whereas slightly lower recharge rates lead to pluton formation at high (up to 75 : 1) intrusive to extrusive rates. APVC zircon trace element compositions show remarkable homogeneity over time, suggesting that most zircon crystallized in a temperature-buffered crystal mush. Rare aphyric high-Si eruptions (e.g., as represented by the Toconao ignimbrite) punctuate the dominantly crystal-rich intermediate ignimbrite record of the APVC (e.g., Atana). Based on zircon compositional similarity between high-Si and coeval intermediate ignimbrites, high-Si rhyolites are interpreted to form via interstitial melt extraction from an upper-crustal magma mush. APVC volcanic zircon compositions are also very similar to zircon from plutonic rocks of the Sierra Nevada arc, excluding rare low-T zircon in Sierra Nevada plutons. Broad compositional similarities in volcanic and plutonic zircon underscore that thermochemical magma storage conditions in the APVC may be typical for continental arcs in flare-up mode. We propose that a differentiated upper-crustal batholith has accumulated underneath the APVC since ca. 10 Ma with subequal additions during low- and high-flux eruptive episodes.

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