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Resolving changes in arc magma volatile budgets over Myr timescales leading up to porphyry Cu formation

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The crustal-scale magmatic systems of Andean-style arcs produce thick volcanic deposits and abundant plutons that are emplaced into the crust. They can also generate spatially- and temporally-restricted, economically-important porphyry Cu deposits. These deposits are formed at the magmatic-hydrothermal transition and require significant amounts of volatiles and metals to be concentrated in the sub-volcanic environment. Thus, understanding the magmatic and tectonic processes acting within an arc segment and their effect on the volatile budgets of crustal magmas could be essential for identifying the constraining factors controlling the potential of a magmatic system to produce a porphyry deposit.

In this study we examine the magmatic evolution of the Rio Blanco-Los Bronces district, ~30 km northeast of Santiago, Chile, which is host to the Earth's largest resource of Cu. Eocene to Early Miocene volcanic rocks were intruded by the Miocene San Francisco Batholith that, in turn, partially hosts intrusions related to the Late Miocene to Early Pliocene Rio Blanco-Los Bronces porphyry deposit cluster. We apply a combination of whole-rock, apatite and zircon geochemistry and zircon geochronology to the intrusive rock suite of the district to provide temporally-constrained geochemical information over the entire duration of batholith assembly and ore formation.

U-Pb geochronology reveals incremental assembly of the San Francisco Batholith by individual magma batches over >14Myr (~18 – 4 Ma), with ore formation occurring in discrete pulses in the last 3 Myr before cessation of intrusive activity within the district. Progressive changes in the trace element chemistry indicate crustal thickening and deeper magma evolution within the arc segment as a result of the subduction of the Juan Fernandez ridge. A temporal shift to elevated SO_3 and Cl contents is recorded by zircon-hosted apatite inclusions from the intrusions with highest values occurring in porphyry intrusions directly associated with the ore forming events. These data suggest variable volatile budgets of magmas during zircon crystallisation and hint at crustal-scale controls on the porphyry ore-forming potential of an arc segment.