

Volcanic matrix geochemistry records deep drivers of copper fertility in the Central Andes

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The green energy transition is driving a rapid increase in the demand for copper. Most of the world's copper accumulates in porphyry systems in magmatic arcs, yet porphyry copper deposits represent only the tip of the iceberg – the final, shallow portions of vertically extensive, complex magma systems that span the entire crust. Precursory processes occurring at depth in these systems are inferred to control the endowment of shallow mineralised intrusions. For example, deep garnet fractionation is considered to oxidise the melt, allowing the transport of copper to upper crustal levels.

Here, we access deep fractionation across the Central Andes, Earth's most fertile continental arc, with laser ablation mass spectrometry of volcanic matrix (in situ LA-ICP-MS groundmass rasters). We focus on volcanoes in the main arc (Lascar stratovolcano, Cerro Overo monogenetic cone) as well as in anomalous settings that may enhance copper fertility, including an arc kink (Socompa stratovolcano, El Negrillar monogenetic field) and the back-arc (Tuzgle stratovolcano). The volcanic matrix has relatively evolved basaltic trachyandesite to rhyolite compositions with typical MgO of 1-5 wt.%, indicating that primary melts do not erupt, and instead are strongly modified through the crust. Trace element data reveal that the volcanoes located in anomalous settings record garnet fractionation. In contrast, the main arc volcanoes dominantly record amphibole signatures.

Our work shows that isolating melt records using volcanic matrix can improve proxies for magma generation, differentiation and filtering relative to bulk rock compositions. We aim to develop fertility indicators for copper exploration in arc systems.