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Spatial and temporal relationships between granites and porphyry copper deposits in northern Chile

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Chile is the leading copper producing country in the world, hosting ∼30% of known worldwide copper reserves. Subduction-related magmatism in Chile has been ongoing since at least Mesozoic time, with progressive inland migration of the magmatic arc from the Jurassic coast eastward to the active western cordillera in the high Andes.

Porphyry copper deposits (PCDs) in Chile are spatially and temporally related to emplacement of shallow, felsic to intermediate composition plutons that sourced the ore-forming magmas and mineralising fluids. However, not every such intrusion in Chile is associated with a mineralised deposit, suggesting that there are other controls on whether or not an intrusion hosts a PCD. Models for porphyry copper formation typically assume emplacement of these felsic to intermediate intrusions at shallow crustal levels (5–15 km depth) [1], but absolute constraints on emplacement depths for both mineralised and barren systems are lacking.

In order to explore the relationship between granite emplacement depths and occurrences of PCDs in northern Chile, we have created a geospatial database that compares the age, geochemistry, and depth of mapped felsic to intermediate plutons (e.g. granites, tonalities, and diorites) with the locations of known PCDs, as well as major fault zones and volcanic centres.

Emplacement depths have been calculated from published geochemical analyses using existing calibrations of the Al-in-hornblende barometer, which is widely used for calc-alkaline granitic rocks [2]. We are also developing a new experimental calibration of the barometer using a combination of piston cylinder experiments (5, 7, and 10 kbar), externally heated pressure vessel experiments (0.5–2 kbar), and electron microprobe analyses on a granitic sample of the Lluta batholith, collected in northern Chile.

This improved Al-in-hornblende barometer, calibrated for shallow intrusions, will provide a viable alternative to estimating depths of PCD formation from fluid inclusions, which is often hampered by alternations between lithostatic and hydrostatic pressure. Furthermore, the results of this study will be broadly applicable to investigating the potential links between intrusion depth, PCD formation, and parameters such as regional tectonic patterns and fluid/melt interactions.

References:
[1] Sillitoe, 2010, Porphyry Copper Systems, Ec. Geol., 105, 3–41.
[2] Anderson et al., 2008, Thermometers and Thermobarometers in Granitic Systems, Rev. Min. Geochem., 69, 121–142.