The precursors of porphyry copper deposits: geophysical imaging of magmatic/hydrothermal systems in the Andes

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Project Highlights:

- Geophysical imaging of volcanic and hydrothermal systems associated with Chilean volcanoes
- Comparison with extinct magmatic systems associated with large porphyry-copper deposits
- Develop strategy for maximising prospectivity of undercover copper deposits

Overview:

The demand for copper is forecast to grow between 50% and 300% by 2050, driven by the energy transition and electrification of the transport sector. To keep up with demand, new discoveries of large copper deposits are needed – however, the rate of major discoveries has slowed down in the last two decades. The largest known copper deposits, like Escondida in Chile, are high-grade hypogene porphyry (HGHP) deposits, formed by precipitation of copper from hydrothermal fluids associated with large silicic magma bodies. Major undiscovered deposits are likely to be found under cover, i.e. with no surface outcrop, therefore finding such large deposits requires a system approach, i.e. an understanding of the magmatic/hydrothermal system, tectonic conditions and geologic history of fertile porphyry settings.

This project will focus on collating and expanding a database of geophysical constraints on active and extinct volcanic systems in the Andes. One area of focus will be the Lazufre volcanic field (Chile), an explosive silicic volcanic complex where a magmatic-hydrothermal system has been imaged using seismic and magneto-telluric (MT) methods (Unsworth et al., 2023). The system may be an active analogue for porphyry-copper deposits. The aim is to characterise the magmatic-hydrothermal systems at Lazufre and other volcanoes in the Andes using seismic tomography and MT methods and to compare their structure to that of extinct systems that host known HGHP deposits (Comte et al., 2023; Leon-Rios et al., 2024).

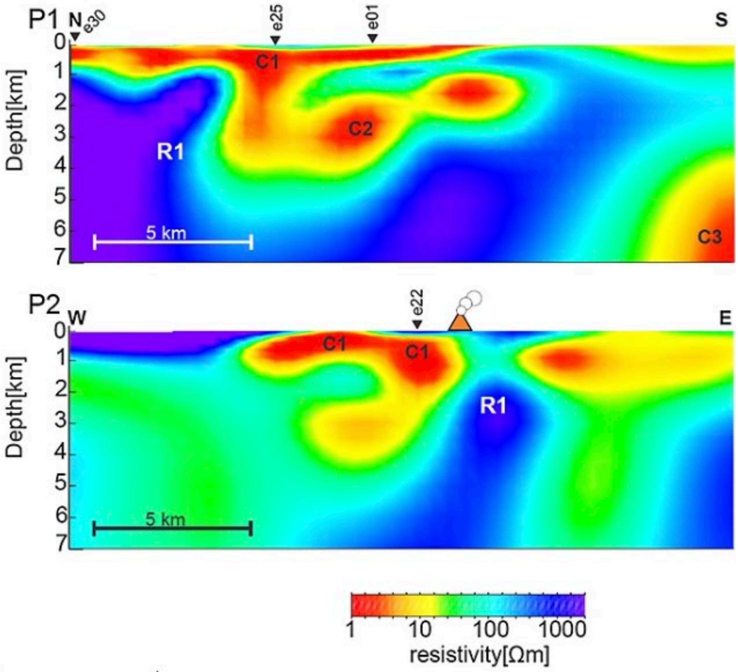

Figure 1: Cross sections of electrical resistivity models through the Lazufre volcanic complex (Unsworth et al., 2023)

Methodology:

The candidate will first collect and analyse existing published geophysical models for Chilean volcanoes including local and regional models of seismic velocity, seismic anisotropy and electrical resistivity. The database will be expanded to include a new model for Lazufre. The candidate will process the existing local earthquake catalogue and will invert P and S arrival times to constrain the Vp and Vp/Vs distribution. Low Vp/Vs is associated with hydrothermal alteration and solidified silicic bodies while high Vp/Vs is associated with active magma reservoirs and solidified mafic plutons. Further analysis of melt-sensitive seismic constraints such as seismic anisotropy will complement this imaging work.

Analysis of deep crust and Moho architecture at the regional scale using teleseismic receiver functions, and their joint inversion with surface waves, will provide new constraints on the magmatic plumbing systems that acted in the past to develop some of the large HGHP deposits discovered further west in the Chilean Andes. Comparison of the seismic velocity and electrical resistivity at Lazufre and other active volcanoes with the structures observed in the region of these HGHP deposits will help understand the tectonic and magmatic processes that control HGHP formation and help direct more targeted geophysical exploration in Chile and elsewhere.

Possible Timeline

Year 1: Analyse local earthquakes from Lazufre to determine seismic velocities, Vp/Vs ratio and seismic anisotropy.

Year 2: Joint inversion of seismic data with MT data to further characterize the magmatic and hydrothermal system

Year 3: Comparison with regional models and other active and extinct systems

Training and skills:

TARGET researchers will participate in a minimum of 40 days training over the 3.5 years of study composed of:

- an annual one-week workshop dedicated to their year group, and tailored to that cohort's needs in terms of skills development – *for the first three years of their study*;
- an annual all-TARGET workshop with cross-year interactions, advanced training and opportunities to specialise in particular areas – *all years of study*;
- a number of one-day workshops;
- additional online events and in-person workshops attached to relevant conferences.

The student will be trained in the theory of geophysical inversion and its application to the exploration of magmatic systems and mineral deposits.

Partners and collaboration (including CASE):

CASE partnership funding is being sought from BHP. This PhD project will be associated with a large BHP-funded research project to study the formation of porphyry copper deposits using geophysics and numerical modelling. Participation in geophysical fieldwork in Chile may be possible depending on the success of this related funding.

Further details:

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Please visit https://target.le.ac.uk/ for additional details on how to apply.

Unsworth et al., 2023, https://doi.org/10.1130/GES02506.1

Comte et al., 2023 https://pmc.ncbi.nlm.nih.gov/articles/PMC10133302/

Leon-Rios et al., 2024, https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2023GC011197