

PhD Project Description

Exploring mineral and geothermal resources at active volcanoes

Supervisors

Lead Supervisor: Michele Paulatto

Co-supervisor(s): Ian Bastow, Matthew Jackson

Research Group

Plates, Mantle and Core (PMAC) and reservoir modelling (NORMS)

Project Summary

The demand for critical minerals is surging, driven by the energy transition and electrification of the transport sector. To keep up with demand, new discoveries of mineral deposits are needed however the rate of major mine development has slowed down in the last two decades. The hydrothermal systems of active arc volcanoes are an underdeveloped source of many critical metals, including copper. A new concept proposes that these metals can be extracted directly from high temperature ($>400^{\circ}\text{C}$) hypersaline brines that form above crystallizing magma reservoirs. The co-production of geothermal energy from the brines can be leveraged to produce copper with very low environmental impact.

This project focuses on developing geophysical methods and exploration strategies to find and image hypersaline brine lenses and characterize their reservoir properties (temperature, porosity, permeability, salinity) and geothermal potential (enthalpy, heat in place).

Research Context and Objectives

The candidate will start by designing strategies for collecting and processing geophysical data to image hypersaline brine lenses. Low porosity means that the brines are not easily imaged with seismic methods alone. Instead, the project will focus on combining seismic and electromagnetic methods to constrain the physical properties of the brines to target and derisk exploration drilling. Low electrical resistivity is the key indicator of hypersaline fluids. Low V_p/V_s is associated with vapour-dominated regions, which are low salinity and don't contain high metal concentrations. High V_p/V_s regions are more likely to contain liquid high-salinity and possibly metal-rich fluids.

The strategies to be tested will include a combination of local earthquake tomography, electrical resistivity tomography, controlled source EM and Magneto-telluric inversion. These strategies will be tested on synthetic datasets and existing datasets from the Andes and South East Asia.

The final part of the project will focus on developing multi-scale prospectivity indicators borrowing concepts from traditional porphyry copper exploration and geothermal exploration.

Collaborators and partners on the project:

The student will interact with the Rio Tinto Centre for Future materials, in particular with the Copper brines project, which aims to develop exploration and production strategies for copper-rich subvolcanic brines..

Further reading:

Paulatto, M., Hooff, E. E., Chrapkiewicz, K., Heath, B., Toomey, D. R., & Morgan, J. V. (2022). Advances in seismic imaging of magma and crystal mush. *Frontiers in Earth Science*, 10, 970131. <https://doi.org/10.3389/feart.2022.970131>.

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Department of Earth Science
and Engineering

Who are we looking for?

We are looking for students with an excellent background in geophysics, seismology or related disciplines and an interest in developing and applying advanced data analysis workflows. Skills developed will include programming, advanced geophysical inversion methods, and machine learning methods for seismology, with extensive training provided.

Successful applicants have a proven aptitude for analytical work and a genuine passion for research. The candidate will have the opportunity to develop their career and profile by presenting at international conferences and publishing in high-impact journals.