EARTHSCIENCES

Multiparametric geophysics and geothermal resources

Primary supervisor:	Michael Kendall
Co supervisor(s):	• Jon Blundy • Petros Bogiatzis • Simon Stephenson (Ascension Earth Resources)
Research theme(s):	• Geophysics and Geodynamics • Geodesy, Tectonics, Volcanology and related hazards • Earth Resources
Eligible courses for this project:	• DPhil in Earth Sciences • Environmental Research (NERC DTP) • Intelligent Earth (UKRI CDT)

Overview

Geothermal fluids are rich in heat and can hold a wealth of valuable minerals. A key challenge is finding these fluid reservoirs and assessing important parameters such as porosity, permeability and conductivity. Geophysical methods offer valuable insights into the nature of such fluids, but the use of a single technique has inherent ambiguities and non-uniqueness in interpretation. Hence joint analyses of multiple datasets can derisk exploration.

The last decade has seen a rapid advancement in instrumentation. Autonomous seismic nodes are now broadband in frequency response can be deployed in large quantities for many weeks. Distributed acoustic sensing using fibre optic cables offers unprecedented sampling of the seismic wavefield. New instrumentation for resistivity surveying is dramatically improved depth of sounding and speed of surveying. As a result, there is a wealth of new data being acquired in geothermal settings.

This project will explore methods for integrating multiple types of geophysical datasets, including seismic, electrical and gravity. Ideally this can be posed as an inversion problem, and machine learning methods can be used to save a computational time. To start, this will be applied to data recently acquired on Ascension Island by the CASE partner Ascension Earth Resources. Little is known about the hydromagmatic system beneath the island, but geothermal test wells from the 1980s suggest promising geothermal resources.

Methodology

Oxford has recently acquired diverse datasets from a range of volcanic areas. This project would first concentrate on passive seismic data acquired recently on Ascension Island. Other datasets including the acquisition of new data will be also considered.

Microseismicity: small earthquakes offer insights into stress field, delineating faults and fluid movement.

Passive imaging: microseismic events can be used to tomographically imaging the velocity structure in volcanic environments. This project will also seek to integrate ambient noise tomography into joint body wave and surface wave imaging.

Resistivity: new methods in electrical resistivity tomography (ERT) provide complimentary methods for imaging compositional variations in lithologies and fluids.

Timeline

Year 1: field work training; deployment of instruments; data gathering; working with legacy datasets from Ascension Island; detecting and locating microseismic events.

Years 2 and 3: seismic and ERT methods will be used to imaging geothermal systems. Use of deep learning to locate seismic events.

Year 4: Data integration, thesis completion, papers for international journals/conference presentation.

Training & Skills

The project is best suited to a student with a background in geophysics, computational geology or physics. Student will join the vibrant Oxford geophysics group, receiving training in both softskills (e.g., project management, writing and presentation) and technical skills (programming, instrument deployment and servicing, etc.).

References & Further Reading

Gauntlett, M., T. Hudson, J. M. Kendall, N. Rawlinson, J. Blundy, S. Lapins, B. Goitom, J. Hammond, C. Oppenheimer and G. Ogubazghi (2023). "Seismic tomography of Nabro caldera, Eritrea: Insights into the magmatic and hydrothermal systems of a recently erupted volcano." Journal of Geophysical Research: Solid Earth: **128**(5): e2022JB025742.

Harmon, N., S. Wang, C. A. Rychert, S. Constable and J. M. Kendall (2021). "Shear velocity inversion guided by resistivity structure from the PI-LAB Experiment for integrated estimates of partial melt in the mantle." Journal of Geophysical Research: Solid Earth **126**(8): e2021JB022202.

Hudson, T. S., J.-M. Kendall, J. D. Blundy, M. E. Pritchard, P. MacQueen, S. Wei, J. Gottsmann and S. Lapins (2023). "Hydrothermal fluids and where to find them: Using seismic attenuation and anisotropy to map fluids beneath Uturuncu volcano, Bolivia." Geophysical Research Letters **50**(5): e2022GL100974.

Lapins, S., B. Goitom, J. M. Kendall, M. J. Werner, K. V. Cashman and J. O. Hammond (2021). "A little data goes a long way: Automating seismic phase arrival picking at Nabro volcano

with transfer learning." Journal of Geophysical Research: Solid Earth **126**(7): e2021JB021910.

Further Information

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