

Multiple saturation thermobarometry of volcanic magmas

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Research theme(s):	• Geophysics and Geodynamics • Geodesy, Tectonics, Volcanology and related hazards • Planetary Evolution and Materials • Earth Resources
Eligible courses for this project:	• DPhil in Earth Sciences (3-4 years) • Interdisciplinary Life and Environmental Science Landscape Award (ILES�A)

Overview



Mount Shasta (California) one of several volcanoes to be investigated in this project

Constraining the source depths of magmas has implications for crustal evolution, geothermal energy, formation of hydrothermal ore deposits and volcano monitoring. Existing mineral-based thermobarometric methods lack the requisite accuracy to constrain magma source depths and, more problematically, relate to the depths of crystallisation, which are invariably shallower than the original source. Consequently, it is very difficult to establish the depths within the crust and mantle where chemical differentiation and magma generation take place. In this project we will explore a new method of magmatic thermobarometry that uses the concept of liquidus multiple saturation to establish when an erupted magma was

last in equilibrium with its polyminerale source [1]. Although the concept of multiple saturation is well established in petrology, its application to active volcanic systems is in its infancy [2]. This project will use experimental and numerical methods to determine magma source depths at four volcanic contrasting volcanic settings: the Main Ethiopian Rift, the Aleutians island arc, Trans-Mexican Volcanic Belt and the Cascades (USA). The results will be integrated with geophysical, heat-flow and monitoring data to generate images of the sub-volcanic magmatic architecture. The project involves high pressure and temperature experimental petrology and machine-learning approaches to multiple saturation thermobarometry [3] and builds upon new understanding of chemical differentiation process in transcrustal magmatic systems [4].

Methodology

The project is rooted in high temperature and pressure experiments using the well-appointed piston cylinder and cold-seal laboratories in Earth Sciences. Experimental run products and natural samples will be analysed by electron microbeam methods. It is anticipated that some fieldwork to recover samples of erupted material will be carried out. The project will suit a numerate student with a good grounding in igneous petrology, thermodynamics and volcanology. Field experience will be valuable.

Timeline

Year 1: Training in cold seal experimental techniques. Experiments on Aluto (Ethiopia) rhyolites. Introduction to numerical methods for determining multiple saturation.

Years 2 and 3: Training in piston-cylinder experimental techniques. Experiments on Cascades and Mexican dacites and andesites, and Aleutians basalts.

Year 4: Integration of experimental results with geophysical and monitoring data. Thesis completion. Writing up papers for international journals/conference presentation.

Training & Skills

Training will be provided in experimental petrology methods, electron microbeam analysis and phase petrology.

References & Further Reading

- [1] Blundy, J., 2022. Chemical differentiation by mineralogical buffering in crustal hot zones. *Journal of Petrology* 63, egac054
- [2] Melekhova, E., Blundy, J., 2024. Generation of mantle-derived basaltic andesites in volcanic arcs. *Earth and Planetary Science Letters* 641, 118791
- [3] Weber G., Blundy, J., 2024. A machine learning-based thermobarometer for magmatic liquids. *Journal of Petrology* 65, egae020
- [4] Cashman, K.V., Sparks, R.S.J., Blundy, J., 2017. Vertically extensive and unstable magmatic systems: a unifying view of igneous processes. *Science* 355, 1280

Further Information

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