Percolative reactive flow - ore formation in a capsule

Primary supervisor:	*Dr. Elena Melekhova* *https://www.earth.ox.ac.uk/people/elena-melekhova*
Co supervisor(s):	*Prof. Jon Blundy* https://www.earth.ox.ac.uk/people/jon-blundy *Dr. Austin Gion* *https://www.earth.ox.ac.uk/people/austin-gion*
Key words:	sulphides, mineralisation, igneous petrology, volcanic arc
Research theme(s):	• Igneous petrology and volcanology • Earth Resources
Eligible courses for this project:	• DPhil in Earth Sciences

Overview

The student will use a novel experimental approach to simulate the generation of a wide spectrum of fluid and melt compositions that are responsible for building continental crust and forming porphyry ore deposits. We test a radical new concept of crystal-dominated transcrustal magmatic systems in which percolative reactive flow plays a major role in chemical differentiation.

Fluid percolation through a crystal mush pile as a potential mineralisation process has not been previously analysed. In this project the student will explore the hypothesis of percolative reactive flow as an ore-forming process, define the circumstances when it is most likely to occur, and apply this new understanding to explore for new metals resources.

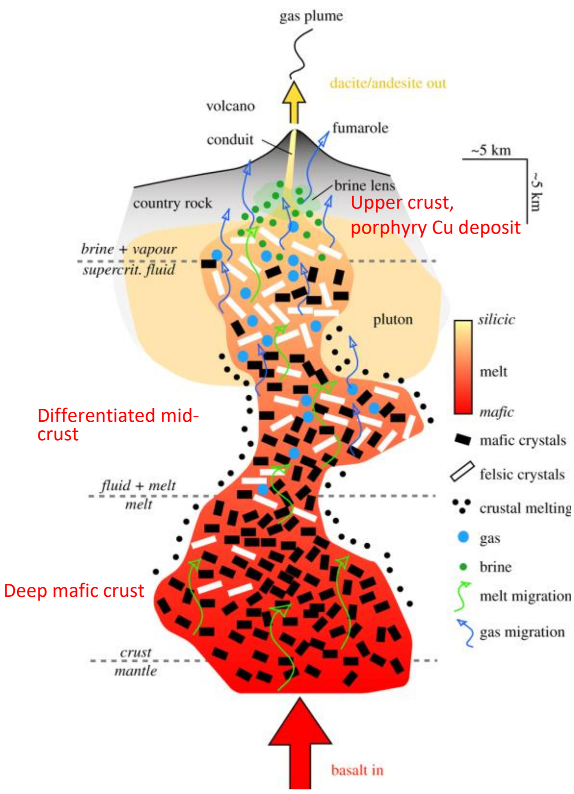

Figure 1. Schematic section through a transcrustal magmatic system (after Blundy et al., 2021). Ascent of melt (green arrows) and fluids (blue arrows) is decoupled and may be either steady-state (percolative) or episodic. Magma degassing could lead to the formation of a relatively shallow (<5 km) Cu-rich brine lens (greenshaded area), or, if conditions are favourable, the formation of a porphyry Cu deposit.

Methodology

The project will take a multidisciplinary approach, using classic petrography and petrology, geochemical analysis (including geochemical modelling) and potentially field work.

High-temperature and pressure laboratory experiments, appropriate for low crustal conditions will be used to test the hypothesis conveyed in the figure and text above. Juxtaposing different, sulphide bearing gabbroic rocks with a layer of silica rich fluid or H_2O-rich melt will be used to see how fast and how efficient the percolative reactive flow is for redistributing and depositing trace elements and metals, previously contained within gabbroic minerals, especially in sulfides.

Potential field work areas are Sierra Nevada, US or Famatinian arc, Argentina. Both areas represent exhumed magmatic arcs. The focus of the field work will be looking at the exposed crustal sections to relate the processes happening in currently active arcs. Collected samples form an exposed arc section will used to characterise their mineralogy and textures to provide an important test of the experimental and geochemical modelling results.

The geochemical modelling component will synthesise the laboratory and field work into a qualitative theoretical framework. This will be based on trace element portioning theory. The theory will be applied to experiments for validation and will then be extended to natural systems. Mismatch with natural rocks will motivate and constrain an elaboration of the theory to better capture the complex natural potentials.

Timeline

Year 1: Literature review and preparatory coursework. Identification of starting compositions for experiments and training in piston-cylinder experimental technique, preliminary experiments to verify experimental set-up.

Years 2 and 3: Experiments at low crustal conditions. Training in cold-seal experimental technique and experiments at low crustal conditions. Geochemical analyses of experimental run products, geochemical modelling. Field work. National and international conferences attendance.

Year 4: Data integration, thesis completion, writing up papers for international journals.

Training & Skills

The project requires a wide and interdisciplinary skill set. The training will aim to fill gaps in knowledge and skills. For example, the student might take a graduate-level course in scientific computing, microanalises techniques, experimental techniques.

The student will also learn through weekly project meetings with the supervisors and biweekly group meetings. A key focus will be on experimental techniques, geochemical modelling, scientific writing and illustration for publication.

Other courses on professional skills are available through the University. Attendance is encouraged.

References & Further Reading

Holwell, David A., et al. "Mobilisation of deep crustal sulfide melts as a first order control on upper lithospheric metallogeny." *Nature Communications* 13.1 (2022): 573.Cashman K., et al. (2017). *Science* 355.6331:eaag3055

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Sillitoe, Richard H. "Porphyry copper systems." *Economic geology* 105.1 (2010): 3-41.

Wilkinson, Jamie J. "Triggers for the formation of porphyry ore deposits in magmatic arcs." *Nature Geoscience* 6.11 (2013): 917-925.

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Further Information

Elena Melekhova elena.melekhova@earth.ox.ac.uk

Austin Gion austin.gion@earth.ox.ac.uk

Jon Blundy jonathan.blundy@earth.ox.ac.uk