Conduit controls on magma evolution in dykes and sills: implications for PGE mineralisation

Supervisors: Dr Mike Stock (TCD), Prof. Marian Holness (University of Cambridge), Prof. Jens Andersen (Camborne School of Mines), Prof. David Chew (TCD)

Closing Date

Midnight, 9 January 2022

Funding Status

Fully funded project

Eligibility

EU, EEA, Swiss and UK students only

About the project

Magmas within dykes and sills undergo physical and chemical changes as they cool, crystallise and assimilate surrounding country rock material. As the morphology and orientation of conduits impact their cooling rate and fluid dynamic regime (e.g. convective vs non-convective), conduit structure must exert a first-order control on the magma evolution. This not only has a fundamental impact on magma transport in the Earth's crust but may play a critical role in the formation of conduit-type mineral deposits, where assimilation and local fluid dynamic variations could contribute to the saturation and concentration of sulphide minerals. Conduit-type Platinum Group Element (PGE) deposits are particularly important in this regard, as they constitute some of the largest deposits of these "critical metals" on Earth (e.g. Norilsk, Russia).

Despite its importance, the relationship between the conduit structure, fluid dynamic regime and the physicochemical evolution of magmas along dykes and sills remains poorly constrained. This is partly due to a lack of study sites where individual conduits can be tracked laterally over large distances or where morphologically diverse conduits have been fed by a common magma source, facilitating direct comparison. This knowledge gap has major implications for our fundamental understanding of crustal magma transport and severely limits exploration for conduit-type mineral deposits.

This project will use Palaeogene dykes and sills in the north of Ireland to study changes in physical and chemical processes along magma conduits. These dykes are well exposed and can be tracked across Ireland using airborne geophysical data, collected as part of Geological Survey Ireland's Tellus survey. The Irish Palaeogene intrusions represent one of the most prospective sites for PGE mineralisation in Europe and dykes associated with the Antrim flood basalt province are geologically analogous to those in the Norilsk deposit. Specifically, the project will:

- Date conduits for regional correlation and calculate the distance between outcrops and their magma source using airborne geophysical data.
- Quantify fluid dynamic and cooling regimes along and between conduits, using textural analysis, conduit widths and thermal modelling of metamorphic aureoles.
- Correlate fluid dynamic and cooling regimes with the amount of assimilation and sulphide exsolution along and between conduits, quantified through isotopic analysis,

sulphide modal abundance and trace element signatures of sulphide-saturated crystallisation in silicate minerals.

- Investigate along-strike variations in sulphide entrapment and PGE enrichment in conduits by relating sulphide abundance/PGE concentration with conduit orientation and petrography.

By tracking chemical and physical processes along Irish Palaeogene magma conduits, the project will improve our fundamental understanding of crustal magma transport and the formation of conduit-type mineral deposits, helping to better target future exploration.

The student will undertake several field seasons in the north of Ireland to sample the Palaeogene dykes and sills and collect structural measurements. Full training will be provided in all necessary analytical and modelling techniques at Trinity College Dublin, University College Dublin and international partner laboratories, including SEM, LA-ICP-MS, stable isotope mass spectrometry, Ar-Ar dating and XRF. This PhD forms part of the SFI *Critical-Ireland* project. The student will work closely with other members of the *Critical-Ireland* team to integrate their results and achieve the projects broad objective of understanding the fundamental magmatic processes which generate PGE mineralisation. Results will be communicated to industry through the iCRAG consortium.

We seek an enthusiastic and motivated individual to undertake this project within the active Geochemistry research group at Trinity College Dublin. The applicant should have a strong background in Earth or physical sciences, including a BSc, MSc or MSci in a relevant subject. No specific laboratory or modelling experience is required but the applicant should have some prior knowledge of igneous petrology and geological fieldwork. Experience in geochemical analysis and/or data manipulation is desirable.

For all enquiries, please contact Dr Michael Stock, Michael.Stock@tcd.ie.

Application procedure

To apply, the following documents should be submitted to Michael.Stock@tcd.ie in advance of the closing date:

- A personal statement, demonstrating the applicants experience and motivation for undertaking this project (max. 2 A4 pages).
- The applicants CV.
- Two academic references (these can either be submitted by the applicant or confidentially by the referees).

Shortlisted applicants will be invited to interview in February 2022 and will be informed of the outcome within one week. On receiving an offer, the successful applicant will be required to submit supporting documentation (e.g. degree transcripts) to the TCD Academic Registry.

Funding notes

This studentship is fully funded for 4 years by a Frontiers for the Future Project grant, supported by Science Foundation Ireland and Geological Survey Ireland. It is open to EU, EEA, Swiss and UK applicants only.

The project start date is September 2022 (or earlier by negotiation).

References

- Barnes, S.J., and Robertson, J.C., 2019. 'Time scales and length scales in magma flow pathways and the origin of magmatic Ni-Cu-PGE ore deposits', *Geoscience Frontiers*, 10, 77-87.
- Holness, M.B., Farr, R., and Neufeld, J.A., 2017. 'Crystal settling and convection in the Shiant Isles Main Sill', *Contributions to Mineralogy and Petrology*, 172, 7.
- Lindsay, J.J., Hughes, H.S.R., Smyth, D., McDonald, I., Boyce, A.J., and Andersen, J.C.Ø., Andersen, 2019. 'Distinct sulfur saturation histories within the Palaeogene Magilligan Sill, Northern Ireland: implications for Ni–Cu–platinum group element mineralisation in the North Atlantic Igneous Province', *Canadian Journal of Earth Sciences*, 56, 774–789.
- Naldrett, A., 1997. 'Key factors in the genesis of Noril'sk, Sudbury, Jinchuan, Voisey's Bay and other world-class Ni-Cu-PGE deposits: Implications for exploration', *Australian Journal of Earth Sciences*, 44, 283–315.