**The fluid dynamics of magma replenishment in precious metal-enriched layered intrusions**

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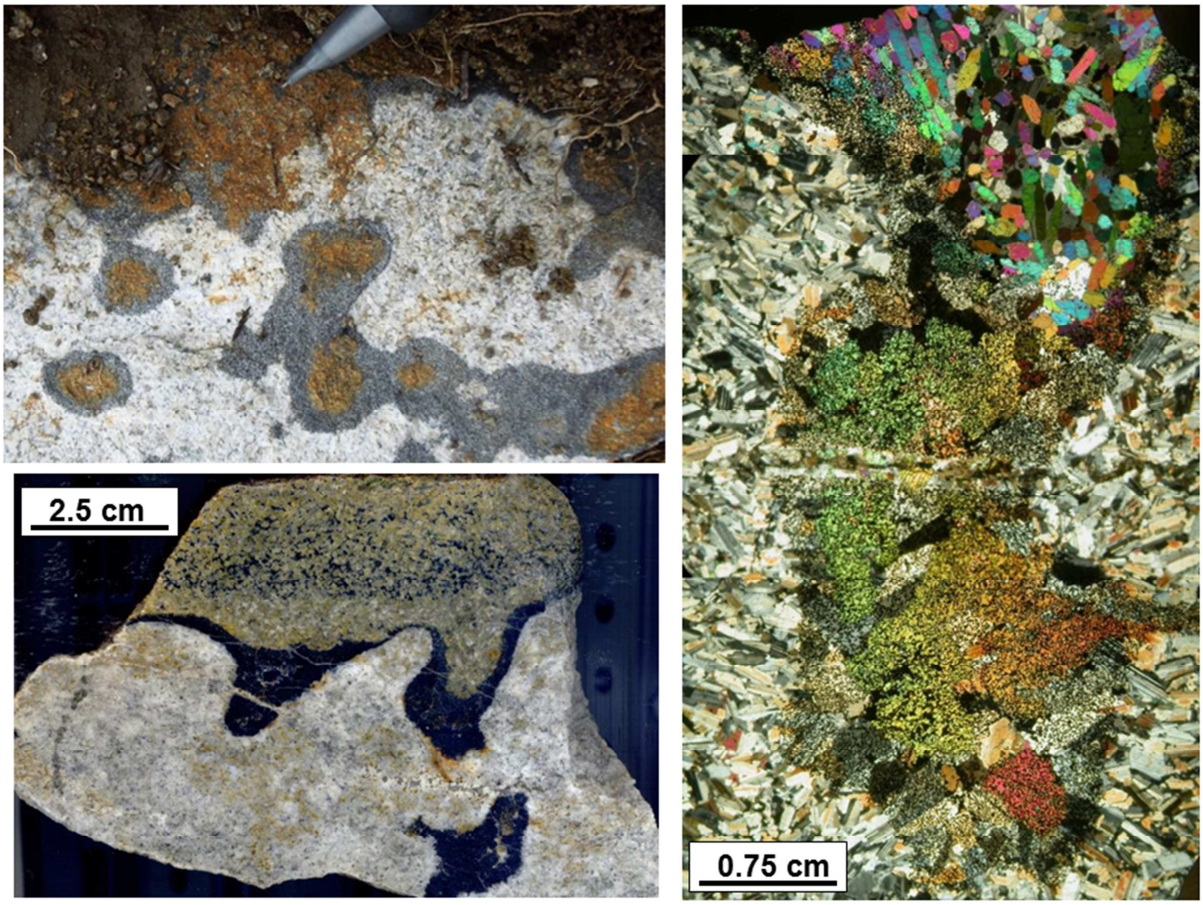
**Introduction:**

Layered intrusions are fossilised magma chambers and are also the source of the bulk of the world's platinum-group metals (PGM). The precious metals in the largest known deposit on Earth, the Bushveld intrusion (South Africa), are concentrated into discrete layers called 'reefs' that represent laterally extensive sites of new magma replenishment into the chamber. In the Bushveld, as well as other intrusions enriched in the PGM, reefs typically have a complex and irregular (non-stratiform) geometry. They are not continuous with the layered crystal pile below (i.e., the footwall), which they erode and cross-cut down into. One important feature of particular interest are 'potholes'; metre-to-tens of metres diameter depressions in the footwall rocks. In addition to exerting a significant influence on the way that reefs are mined in the Bushveld intrusion, potholes also place constraints on the fluid dynamics of the environment in which the reefs formed. Advancing our understanding of the genesis of these enigmatic features thus has the potential to improve exploration for precious metals in layered intrusions, as well as lead to a more fundamental understanding of the mechanisms of PGM mineralisation in magmatic systems.

**Project Summary:**

The formation of potholes has been previously attributed by other workers to thermochemical erosion of the footwall by the hot replenishing magma. A striking observation is that in the Rum layered intrusion (Scotland)[1], which is orders of magnitude smaller than the Bushveld, similar pothole structures are associated with PGM reefs[2]. However, in the case of Rum (see Fig. 1), the potholes are mm-cm in diameter, commensurate with the smaller size of the latter intrusion compared to the Bushveld. This project will utilise a multi-disciplinary approach to constraining the fluid dynamics of precious metal reef formation. The primary goal is to use the natural occurrence of potholes at two significantly different length-scales (in the different intrusions) to elucidate their formation. Fluid dynamic analogue experiments and numerical modelling will be carried out in the Manchester Centre for Nonlinear Dynamics (see http://www.mcnd.manchester.ac.uk/pictures.php) to examine the effects of deformation and melting on the footwall, and to constrain the intensive parameters of the system. The experimental and modelling work will be grounded in field observations and petrological data collected on reef samples. In this way, the project will test whether thermochemical erosion, Rayleigh-Taylor instabilities, or a combination of both processes can explain the formation of potholes.

*Methodologies and training:* This project will suit a numerate candidate with a strong background in mathematics, physical sciences or geoscience with an enthusiasm for




experimental and numerical work. The project is supervised by a team of researchers with a broad range of expertise in different aspects of the project. Training will be provided in the experimental and numerical protocols. The successful candidate will also receive training in data collection in the field and on various procedures for measuring and collecting petrological data on igneous rocks.

*Figure 1. Top left: Plan view of the pot-holed surface of the PGM-enriched Unit 7-8 layer in the Rum layered intrusion, Scotland. Note pen-tip for scale. The pale-coloured lithology is anorthosite, the black is PGM-bearing chromitite, and the brown-coloured rock is peridotite. Bottom left: Cross section through the sequence described above, illustrating the potholes associated with the Unit 7-8 boundary on Rum. Note the package of chromitite that has apparently become detached from the overlying pothole. Right: Thin section image of the right-hand pothole from the last image. Note the way that many of the brightly-coloured tabular olivine crystals in the top part of the structure look as though they may be aligned with the sides of the pothole, perhaps suggesting they were reoriented during deformation of the crystal pile.*

## References

[1]O'Driscoll, B., Emeleus, C.H., Donaldson, C.H. and Daly, J.S. 2010. Cr-spinel seam petrogenesis in the Rum Layered Suite, NW Scotland: cumulate assimilation and in situ crystallisation in a deforming crystal mush. Journal of Petrology, 51(6), 1171-1201.

[2]Campbell, I. H. (1986). A dynamic model for the potholes of the Merensky Reef. Economic Geology, 81, 1118-1125.