Durham University

MSc by Research (Volcanology)

Exploring deep supply and mingling dynamics of mafic magma at Soufrière Hills Volcano, Montserrat

Supervisors: Dr Martin Mangler; Dr Madeleine Humphreys (Earth Sciences)
External Collaborators: Dr Thomas Christopher (Montserrat Volcano Observatory)

Background:

The sizes and shapes of crystals in igneous rocks reflect the conditions during their nucleation and growth. Therefore, studies of crystal textures can help disentangle magma dynamics at depth and reconstruct magmatic histories leading to eruptions. Specifically, changes in crystal size and shape depend on undercooling conditions (e.g., cooling rate) and crystal number density [1]. Combining crystal size and shape information can therefore yield important constraints on pre-eruptive magmatic conditions such as cooling rates.

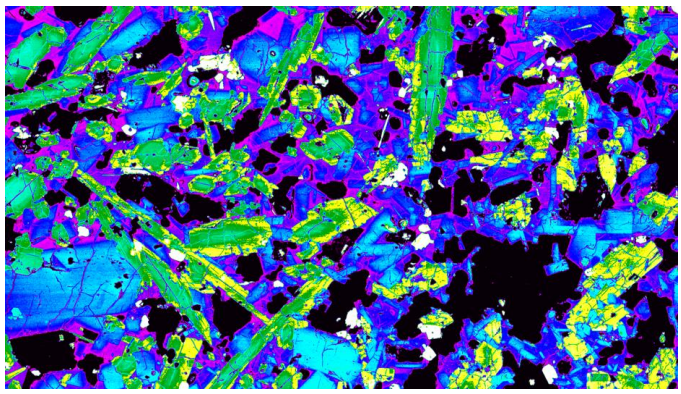
In this project, the student will investigate size-shape distributions of plagioclase microlites in mafic enclaves found in volcanic rocks from Soufrière Hills Volcano (SHV), Montserrat, with the aim of better understanding the role of mafic recharge in driving eruptions and gas emissions at the volcano.

Mafic enclaves at Soufriere Hills Volcano (SHV), Montserrat

Soufrière Hills is an active stratovolcano on Montserrat (West Indies), which entered a protracted dome-forming eruption in 1995 [2]. Although lava extrusion stopped in 2010, the eruption is not considered over because continued emission of large quantities of SO2 gas suggests that mafic magma from depth may still be intruding into the shallow magma reservoir beneath SHV. Mafic recharge can drive eruptions through supply of heat and volatiles, which pressurise the magma reservoir. To improve interpretation of present-day monitoring data, it is therefore crucial to better understand the nature and dynamics of the interaction between basaltic recharge melts and the silicic magma reservoir beneath SHV. Luckily, the rocks erupted at SHV between 1995 and 2010 offer a unique opportunity to study such magma mixing and mingling processes in situ: mafic enclaves [3].

Project Aims and Methods:

The student will examine plagioclase sizes and shapes in mafic enclaves in 1995-2010 SHV rocks in order to reconstruct magma recharge dynamics through time. Building on new concepts of how crystal shape evolves with size [1] and using 1D thermal modelling [e.g., 4], the student will quantify shape and size variations as a function of cooling rate in small enclaves with chilled margins that quenched in situ. These methods will then be applied to enclaves that represent fragments of larger bodies, to place constraints on the residence times and minimum dimensions of mafic magma intruding deep under SHV.



False-colour scanning electron microscope image showing textures of plagioclase (blue) and amphibole (green-yellow) in a mafic enclave erupted in early 2010. Image approx. 1.5 mm across.

Training and skills development:

- Scanning electron microscopy
- Quantitative textural analysis
- Writing and presentation skills *via* weekly volcanology group meetings
- Work within the vibrant Durham volcanology group
- Opportunity to demonstrate to undergraduate students in practical classes.

Pre-requisites:

The successful candidate will have:

- good petrographic observation skills
- strong quantitative skills

Research costs:

Research costs associated with this project will be met through the associated NERC project on crystal shapes in magma mushes.

References and further reading

[1] Mangler et al. (2022) *Contrib. Min. Pet.*
[2] Wadge et al. (2014) *Mem. Geol. Soc. Lond. 39, 1-40*
[2] Plail et al. (2014) *Mem. Geol. Soc. Lond. 39, 343-360*
[4] Holness (2014) *Contrib. Min. Pet. 173(8), 1-18*

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