**Andesite Genesis: A Sumatran Case study**

## Supervisors

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## Project Background

Andesitic volcanism is typically associated with subduction zones. The petrogenesis of andesite remains contentious with models for the generation of andesitic melts from mantle melting to mixing of basaltic and rhyolitic magmas in the continental crust (see Gómez-Tuena et al., 2014 for review). The debate revolves around whether andesitic melts are 1) primarily derived from the mantle and are contaminated by material from the subducting slab; or 2) whether the contamination of the magma occurs during the magma ascent through the overriding plate after the magma has left the source.

Studies of andesites in arc settings have shown that many samples are in fact composed of a crystal cargo with a polygenetic origin, thus revealing that a single liquid line of descent is improbable (e.g. Davidson et al., 2005; Saunders et al., 2010). Traditional geochemical methods often involve the powdering of the whole sample, hence resulting in an average chemical composition. This can mask subtle geochemical signatures that could be used to identify and untangle the different magmatic processes that have occurred. In order to unravel the complex evolution of these samples, detailed crystal-specific studies are required as individual crystals have the ability to record the magmatic evolution within their growth structure (Figure 1). By investigating mineral textures and geochemistry using in situ microscopic techniques, the clues that are held in multiple crystal populations can be pieced together to determine the complex evolution of the magmatic system.

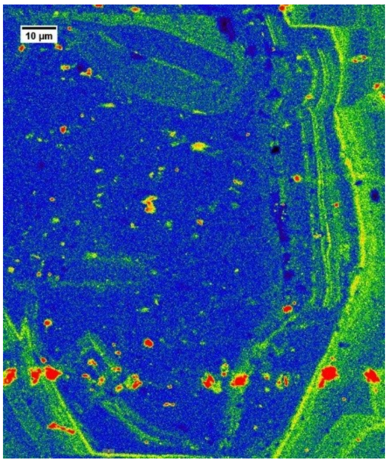


Figure 1: False colour image of Dy in a zoned apatite.

Indonesia, situated between the Pacific and Indian plates is one of the most volcanically active countries on Earth with over 120 active volcanoes, over half of which are known to have erupted in the last 400 years. The Sunda Arc is composed of tectonically contrasting segments. The western and central segment (Sumatra and Java) is an oblique subduction regime beneath relatively thick (25 km) continental crust, compared to Eastern Java, which is subducting beneath normal oceanic crust (~7 km). A unique sample set from 16 andesite volcanoes sited along the Sumatra section of the Sunda Arc is available for this study. Previous research on these samples has characterised the bulk rock chemistry, providing an essential framework from which detailed petrological studies can now be conducted.

This project aims to investigate the genesis and evolution of andesite magmatism along the Sumatra arc by characterising the textural and chemical characteristics of zoned crystals (including olivine, plagioclase, pyroxene, and apatite). The presence of apatite in some samples provides an ideal opportunity to investigate the role of fluids (including halogens) on the partitioning behaviour of rare-earth-element within the subduction system. Furthermore, where appropriate the timescales of magmatic processes would be interrogated through diffusion chronometry techniques to not only provide insights into the processes that are involved but also the timescales of andesite genesis.

**Key Research Questions**
The fundamental research questions that would be addressed during this study are;

- Does the evolution and timescales of andesite genesis vary along the Sumatra Arc?
- Through unravelling the chemical zonation of andesites, can we determine the source of contamination to andesite melts (e.g. mantle or crust)?
- Does the presence of halogens affect the chemistry of the Sumatran andesites by inhibiting crystallisation?

**Methodology**
The project will use a combination of in-situ micro-analytical techniques to characterise the zonation of crystals within Sumatran andesites including scanning electron microscopy (SEM), electron probe microanalysis (EPMA) and potentially a range of other in-situ techniques that may include laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS) & secondary ion mass spectrometry (SIMS) to characterise the chemical and textural composition of samples. Modelling of data would involve the use of ImageJ, mathematical diffusion models and geochemical modelling to process and interpret the data.

| Preliminary work plan | |
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| 0-3 months | Background reading/literature review. |
| 3-6 months | Sample preparation. Initial characterisation of samples. |
| 6-9 months | Preparation of 1st year report |
| 6-36 months | Analysis of samples by in-situ micro-analytical techniques |
| 18-24 months | Preparation of first manuscript |
| 36 months | Completion of analytical collection by the end of 3rd year at the latest |
| 36-42 months | Preparation of thesis for submission and subsequent manuscripts |

**Training**
A comprehensive training programme will be provided comprising of both specialist scientific training and generic transferable and professional skills. The scientific training would include the preparation of samples for analysis, the use of a range of in-situ micro-analytical techniques as outlined above. The student would also learn data processing techniques for both textural images and a geochemical database.

**Requirements**
Applicants should have a good first degree in Geology or related subject. The ideal candidate would be enthusiastic about magmatic processes and have good numerate skills with the ability to model geochemical datasets. Experience in some relevant analytical techniques would be advantageous but is not essential.

**References**
Gómez-Tuena, A., Straub, S.M., Zellmer, G.F., (2014). An introduction to orogenic andesite and crustal growth. The Geological Society of London, Special Publications, 385: 1-13. Davidson, J.P., Hora, J.H., Garrison, J.M., Dungan, M.A. (2005). Crustal forensics in arc magmas. Journal of Volcanology and Geothermal Research, 140:157-170. Saunders, K.E., Morgan, D.J., Baker, J.A., Wysoczanski, R.J., (2010). The magmatic evolution of the Whakamaru supereruption, New Zealand, Constrained by a micro analytical study of plagioclase and quartz. Journal of Petrology, 51: 2465-2488.

**Project Summary:** Insights into the evolution of arc andesites from crystal zonation and diffusion chronometry