Degassing mechanisms in silicic magmas (Ref-IAP2-18-111)

Durham University, Department of Earth Sciences
In partnership with Glasgow University (SUERC)

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Key Words
1. Volcanology
2. Fieldwork
3. Analytical geochemistry
4. Fluid dynamics experiments

Overview

Silicic volcanoes can produce the most devastating eruptions on Earth. The high-viscosity magmas involved may erupt explosively, affecting large areas and producing a global impact on climate, or effusively, producing relatively short-range lavas, with only local impacts. This project seeks to identify the principal causes for that fundamental difference in eruptive behaviour at the Earth’s surface.

Recent detailed observations of large rhyolitic eruptions demonstrate that these two eruption styles may occur simultaneously at the same vent location (Figure 1). These observations show that explosive eruptions often penetrate otherwise effusing lavas through fracture networks, and leave behind a welded remnant of their opening and closing, that is then rafted down-flow. Importantly, these venting and welding processes demonstrate that the erupting system is variably open- and closed- to the atmosphere. This has a wide range of physical and geochemical implications and yet is only poorly understood.

The main goals of this project are to:

1. Combine field observations at a range of scales, with novel laboratory experiments to reconstruct the range of physical processes controlling degassing through fractures at silicic volcanoes.

2. Use argon and iron in volcanic glass as geochemical markers of the degree to which the uppermost parts of the silicic volcanic plumbing system is open to mixing with air during eruption.

While fracture networks are open, atmospheric air can enter the uppermost magmatic conduit, and change the oxidation state of iron, as well as diffusing into the melt. These processes are underexplored, but will provide key insights into the depths to which the shallow volcanic system is ‘chemically open’. This information will help to better pose experimental and numerical studies of vent opening and sealing, which are currently over-simplified.

Methodology
The student will take a multidisciplinary approach to tackle this project, necessarily involving the development of a range of cutting-edge skills.

The student will use samples from silicic, rhyolitic eruptions worldwide, some of which will be collected as part of a fieldwork campaign. The principal focus will be on both obsidian lavas and obsidian pyroclasts from the 2011-2013 eruption of Cordón Caulle (Chile), similar products from the 700 year old eruptions of Mono Craters (U.S.), and the drill core products through Obsidian Dome (U.S.).

The student will use Fourier Transform Infrared Spectroscopy (FTIR) to measure the dissolved water concentration in the glass. Electron microprobe will be used to measure major element chemistry in the same samples of glass. Maps and transects of water and mobile elements such as lithium will test the extent to which the domains of glass are in equilibrium.

The student will use high-resolution gas-source mass spectrometry techniques to measure argon isotope ratios and abundances and X-ray absorption near edge structure XANES (microfocus spectroscopy beamline i18 at Diamond Light Source synchrotron) techniques to measure iron oxidation state in the same samples of glass.

In concert, these techniques will allow the student to test the extent to which atmospheric chemical components diffused into the glass. Using the drill-core data from Obsidian Dome, for which depths can be accurately assigned, will allow the student to find the depths to which the open-system degassing model extends in the conduit.

Finally, these results will be used to underpin an experimental campaign to measure the welding timescale in the open-system fractures as a function of depth in the conduit, calibrated using the analytical measurements described above. This project is also a collaboration with Dr Hugh Tuffen, Lancaster University.

### Timeline

**Year 1:** Fieldwork, sample collection, sample preparation, and microprobe work. Application to Diamond Light Source synchrotron.

**Year 2:** Analytical geochemical work at SUERC (Glasgow), and in collaboration with Gardner (Texas).

**Year 3/3.5:** Experimental campaign based on the results of the analytical work in year 2. Simple mathematical modelling of the results, bolstering interpretations.

### Training & Skills

The student will receive detailed training in all areas of physical volcanology, but in particular in:

- Analytical techniques for the determination of argon isotopes, oxidation state, dissolved water concentrations in glass, and spatially resolved major-element chemistry.
- The mathematical modelling of diffusion in obsidian to extract best-fit timescales for physical processes involving mass transfer.
- High-temperature experimental techniques for recreating aspects of the physics of silicic eruptions in the laboratory.

The student will join the Durham Volcanology Group; a dynamic collaborative research environment with 8 staff and approximately 20 postdocs and postgraduate students. Co-supervision will extend this group to Glasgow and Lancaster Universities. Additional collaboration with Dr Stephanie Flude (University of Oxford) and Prof James Gardner (University of Texas at Austin, U.S.) will widen further the opportunities for knowledge exchange and support from a range of volcanologists worldwide.

### References & Further Reading


### Further Information

Please contact fabian.b.wadsworth@durham.ac.uk for more information.