MSc by Research – Details for projects in volcanology

Welcome to Bristol Volcanology Group and our projects available for an **MSc by Research (Geology)** in School of Earth Sciences at the University of Bristol.

The projects below are supervised by academic staff in the Volcanology research group and their collaborators. They offer access to our world class facilities and cover areas and questions in volcanology using techniques and fields such as:

physical volcanology, petrology, geochemistry, sedimentology, remote sensing, fluid mechanics and modelling, geophysical surveying, environmental impacts, hazard modelling and analysis

Within this cohort of MScR volcanologists for the academic year 2024-25 (full time) or 2024-2026 (part time), you will be actively involved in regular volcanology group activities and meetings including: reading group, discussion of current topics, seminars from guest speakers and internal members, career development events, and a yearly local field trip to nearby volcanic deposits. The School of Earth Sciences has a lively research culture, including local and international engagement and outreach and active participation in undergraduate teaching. MScR students will have the opportunity to participate in these wider activities, and other career development opportunities as appropriate during their MScR.

Further details about our volcanology research, people, and facilities can be found here.

Further details on applications, fees and scholarships, and qualifications can be found here. If you already have employment, caring responsibilities or other commitments, we encourage you to explore the part-time option available for our MScR program and to discuss this with a potential supervisor.

Supervisors have supplied some outline ideas to illustrate a general area of interest and provide ideas about how the project might develop. Your application will involve a project proposal so please do get in touch with supervisors whose project(s) you may be interested in, we encourage a flexible and open approach to project co-development. If you have your own idea, we encourage you to get in touch with appropriate members of our team too.

PROJECTS AVAILABLE:

1. **4 Explosions and A Lava Dome: the dynamics of the 1979 eruptions of La Soufrière, St Vincent**

Project Supervisors: Prof. Jenni Barclay and Prof. Alison Rust
Project partners/collaborators: Prof. Richie Robertson (*UWI SRC*); Prof. Steve Sparks
Key topics: *petrological and textural analysis applied to physical volcanology*

Project description: Unexpectedly La Soufrière, St Vincent erupted explosively on 13th April 1979. A sequence of explosions was followed by several months of dome growth. The magmatic remnants from this eruption have been implicated in governing dynamics of the initial stages of the 2020-2021 eruption too. Bristol University has some of the only remaining samples from this eruption, carefully collected and catalogued by Steve Sparks, and contrasting samples from the recent eruption.

This project would use these curated samples to take a fresh look at these samples to uncover the drivers behind this behaviour. Students could explore the causes of the eruptive transitions, the drivers behind the initial eruption, or look for further clues as to its longevity in the subsurface plumbing system. This would be done via careful analysis of the microlite population, electron microprobe analysis of glass and mineral composition, and exploring the vesicularity and physical properties of the samples.

Skills and knowledge gained: Students will learn how to interpret petrological, geochemical and textural information to understand the thermobarometry and dynamic evolution of erupting melts, and relate that to eruptive style. As well as numerous analytical techniques this would involve using existing modelling codes to interpret vesicle and crystal size distributions.

Skills starting point: This would particularly suit those with a degree in Earth sciences or related discipline who have been introduced to and enjoyed igneous petrological analysis

Suggested further reading: This paper details analysis and interpretation of the 2020-2021 explosions that demonstrates some of the techniques that could be used.
https://www.lyellcollection.org/doi/10.1144/SP539-2022-291
This is an excellent contemporary paper analysing the 1979 explosive sequence.
https://www.sciencedirect.com/science/article/pii/0377027382900695

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2. Explosive-Effusive transitions during the 2.6-2.3ka Pululahua Volcanic Complex

Project Supervisors: Dr. Samuel Mitchell and Prof. Alison Rust
Project partners/collaborators: Anais Vasconez-Muller, Francisco Vasconez (*Instituto Geofisico Ecuador*); Katharine Cashman (*University of Oregon*)
Key topics: *volcanic hazards and risk, petrology, geochemistry, physical volcanology*

Project description: The Pululahua Volcanic Complex, Ecuador, is a site of effusive and explosive silicic volcanism throughout the Holocene, which could be potentially hazardous to nearby populations in the event of future eruptions. One particularly explosive phase throughout 2.6-2.3 ka was previously interpreted as a single caldera-forming eruption. It is now better understood as a cycle of varying effusive-explosive and explosive-effusive transitions through dome forming and collapse events, with intermittent Vulcanian and sub-Plinian eruptions. Samples of numerous pumice-fall and ash deposits collected during fieldwork in 2020 and 2023, and a detailed overview field study published in 2022, comprise a solid foundation to look in more detail at the dynamics and variety of these eruptive transitions.

This project will use a variety of macro- and micro-analytical techniques to assess physical and geochemical triggers and timescales by looking at crystal geochemistry, and microtextures of crystals and vesicles in ash and pumice throughout the sequence.

Skills and knowledge gained: Physical properties of porous/crystalline rocks, geochemical analysis of crystals and volcanic glass, image manipulation analysis. Knowledge acquired will be interpreted to consider future hazards and risk around the volcano, possible GIS use to generate hazard maps.

Skills starting point: Would suit someone with strong geology background with skills in crystal identification, rock description, an interest in physical volcanology and igneous petrology. *****We strongly encourage students with Latin American/Hispanic background to apply**.***

Suggested further reading: https://link.springer.com/article/10.1007/s00445-022-01590-4 - 2022 field study of Pululahua 2.6-2.3ka complex

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3. **Dynamics and forecasting of rapid, concentrated settling from volcanic ash from umbrella clouds: An experimental approach**

Project Supervisors: Dr. Samuel Mitchell and Prof. Alison Rust
Key topics: *volcanic hazards and risk, physical volcanology, sedimentology, remote sensing*

Project description: The settling of volcanic ash (tephra) from volcanic clouds is usually modelled considering particles as "isolated" at negligible concentration. However, particle-particle interactions at higher concentrations in more proximal regions may lead to rapid settling of greater ash masses closer to source, and/or the settling of much finer particles cohered to larger particles. For this to be considered in modeling, we require experimental validation of key parameters and processes.

The researcher will conduct experiments in the fluid dynamics laboratory to simulate settling of concentrated ash mixtures from umbrella clouds, recording sedimentation rates and settling velocities over a range of grain sizes and initial ash cloud concentrations. Experiments will be recorded using a high-speed camera and high-resolution mass logging instrumentation. The researcher will interact with staff at the Met Office to explore the implications of the experimental findings for tephra sedimentation models.

Skills and knowledge gained: designing, developing, and running analogue particle-fluid laboratory experiments, use of compressed air flow, high-speed camera and laser boxes. Image analysis by software and coding. Working alongside Met Office partnership to generate a report of findings and possible model input parameters.

Skills starting point: This project would suit someone with an earth sciences, physics or engineering background. A strong interest in conducting laboratory experiments is key. Maths and coding skills (MATLAB, Python) are also desirable but can be learned during the project.

Suggested further reading:
https://www.frontiersin.org/articles/10.3389/feart.2021.640090/full - similar experiments from a 2021 study, but within water

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4. **Ash in the water: Impact of tephra on light attenuation in seawater and fertilization in the photic zone**

Project Supervisors: Dr. Samuel Mitchell and Dr. Erica Hendy
Project partners/collaborators: Alba Gonzalez-Vega, Eugenio Fraile-Nuez, Jesus M. Arrieta (*Spanish Institute of Oceanography – Canary Islands*); Dr. Jonathan Teague (*University of Bristol*)
Key topics: *volcanic hazards and risk, geochemistry, physical volcanology, environmental impacts*

Project description: Many volcanic eruptions can deposit ash into marine environments, especially at ocean island systems or submarine volcanoes. However, the impacts of volcanic ash on processes and biological response in water are highly variable amongst several case studies. Key observations may include reduced visibility and light attenuation, seawater "fluorescence" or the initiation of phytoplankton blooms. Despite this, there has been little experimental validation of ash impacts within seawater.

This project will take samples of volcanic ash with variable: chemical composition, componentry (glass vs. crystals), mineral assemblage, grain size and shape, to see how these properties impact attenuation across the UV-vis-IR spectrum. Experiments using hyperspectral cameras will measure how tephra attenuates wavelengths in range key to chlorophyll and carotenoid absorption to see if certain properties have a greater impact. A case study will focus on the 2021 Tajogaite eruption, La Palma, alongside the Spanish Institute of Oceanography – Canary Islands.

Skills and knowledge gained: The researcher will work in a highly interdisciplinary multinational group using case study data and samples, and will build off previous work in both the fields of volcanology and oceanography. The project will include SEM analysis, hyperspectral camera equipment, laboratory experiments, and potentially seawater fertilization and nutrient analysis experiments.

Skills starting point: A background in either earth science, oceanography, marine science is ideal. An interest in interdisciplinary research between oceanography, marine biology and volcanology is desirable. Some experience with image analysis and interest in laboratory experiments is also desirable.

Suggested further reading:
https://www.frontiersin.org/articles/10.3389/fmars.2015.00014/full - an important observational and ground-truthed study of biological interaction of ash within water

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5. From the Volcano to the Sea: Long-range impacts of lahars in Guatemala

Project Supervisors: Prof. Jeremy Phillips and Prof. Matthew Watson
Project partners/collaborators: Dr Alex Guerra (*Institute for Climate Change, Guatemala*)
Key topics: *lahar impacts, flow modelling and environmental change*

Project description: Fuego is a persistently-active volcano in Guatemala that for many years has been erupting with small explosions every few tens of minutes, ramping up to a much larger paroxysmal eruption every few months. This results in continuous deposition of pyroclastic material around the volcano, which is mobilized as lahars during the rainy season and transport of sediment to the coastal plain, with associated impacts on agriculture and coastal ecosystems. Critical to understanding and mitigating these impacts is quantification of both the dynamics and rate of sediment transport over volcanic and coastal topographies over distances of up to 50 km.

This project will use the dynamic flow model *LaharFlow* (www.laharflow.bristol.ac.uk) to compute sediment transport, and associated patterns of erosion and deposition, with the aim of understanding the fundamental mechanisms by which volcanic sediment causes landscape change, and to provide a quantitative basis for potential mitigation of sediment impacts.

Skills and knowledge gained: Students will learn how to use state-of-the-art modelling tools, and how to post-process and interpret their results, and apply them to situations of environmental change and hazard impacts.

Skills starting point: This would particularly suit those with well-developed quantitative and data processing skills, with a degree in Earth sciences or other quantitative science, who have an interest in fundamental physical processes and environmentally relevant research

Suggested Further reading:
This paper provides a good overview of volcano-landscape interactions
www.annualreviews.org/doi/pdf/10.1146/annurev-earth-060313-054913

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6. Wetting and buoyancy of volcanic ash and pumice

Project Supervisors: Dr. Pete Rowley and Dr. Samuel Mitchell
Key topics: *marine volcanism, physical properties of volcanic ash*

Project description: The interaction of moisture with tephra is of increasing interest due to its clear impacts on pyroclastic density current behaviors, sedimentation, and post-eruption sediment strength. The wetting process also has impacts on the transition of volcaniclastic particles through the air-water interface when runout encounters lakes and oceans. This ultimately will exert controls on the development of submarine volcaniclastic density currents, and the timescales of pumice and ash rafting.

This project will enable you to design and execute novel experiments which explore how different shapes and particle size distributions of volcaniclastic material experience wetting, and the impacts that has on physical characteristics such as buoyancy, cohesion, adhesion, and friction. Using time series imaging and optical microscopy you will explore how floating volcanic ash wets and sinks, how the thickness of rafted ash impacts settling and sedimentation rates, and whether shape parameters impact the wettability of tephra at different grainsizes.

Skills and knowledge gained: Students will gain experience in experimental design, particle characterisation, and both optical and electron microscopy. Image analysis and physical characterisation methods will be applied as required by the project, and will very in scope depending on project design.

Skills starting point: This would particularly suit those with a science or engineering background who have experience in either sedimentary processes, properties of soils or granular materials, or wetting.

Suggested further reading:
The following paper demonstrates how moisture in pyroclastic materials impacts their flowability. https://link.springer.com/article/10.1007/s00445-023-01682-9
The second paper explores some of the controls on the buoyancy of pumice, and how that impacts raft lifecycle.
https://www.sciencedirect.com/science/article/abs/pii/S0012821X16306896

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7. **Stratigraphic controls on phreatic explosions**

Project Supervisors: Dr. Pete Rowley and Dr. Samuel Mitchell
Project partners/collaborators: Dr. Rebecca Williams (*University of Hull*), Dr. Natasha Dowey (*Sheffield Hallam University*)
Key topics: *Volcanic stratigraphy, sedimentology, and granular physics*

Project description: Following the deposition of volcanic sediments the intrusion of groundwater, or the escape of primary gases can lead to phreatic explosions, which form pit craters in the deposit tens to hundreds of meters in diameter. These phreatic explosions represent a secondary hazard in active volcanic areas, as well as a mechanism for remobilizing sediment and generating complex internal stratigraphies in the deposit.

This project will use laboratory experiments to explore how different stratigraphies, incorporating grainsize distribution changes, control how sediment packs are able to degas, and to quantify the impacts of different layer properties and thicknesses on the scale and failure stresses of eventual gas-driven eruptions. This will help us understand the processes at work in natural deposits, and therefore the larger scale gas flux, permeability and strength conditions.

Skills and knowledge gained: Students will gain experience in experimental design, particle characterisation, and granular mechanics experiments using compressed air. The use of high-speed video recording and analysis, digital pressure logging apparatus, and electron microscopy are likely to be parts of the finalised plan.

Skills starting point: This would particularly suit those with a science or engineering background who have experience in either sedimentary processes, properties of soils or granular materials.

Suggested Further reading:
The following paper demonstrates how cohesion in pyroclastic materials impacts their flowability. https://link.springer.com/article/10.1007/s00445-023-01682-9
The second paper provides some background on the processes and ahzards of phreatic explosions. https://appliedvolc.biomedcentral.com/articles/10.1186/s13617-016-0053-2

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8. Fragmentation of crystal-rich mafic magmas – controls from crystal and vesicle size distributions

Project Supervisors: Prof. Alison Rust and Dr. Samuel Mitchell
Project partners/collaborators: Katharine Cashman (*University of Oregon*); Amanda Lindoo (*Durham University*)
Key topics: *petrology, geochemistry, physical volcanology*

Project description: How magma breaks apart during explosive eruptions controls the size distribution of the resulting fragments, which in turn affects heat transfer and settling speeds, and so how far particles travel. By analysing the size and shape of the fragments themselves *and* their internal textures (size, shape and abundance of bubbles, crystals and glass), volcanologists can gain insights into the history of magma as it flows up the conduit, through fragmentation, to cooling. This project will take samples collected from subaerial and submarine explosive crystal-rich mafic eruptions to analyze the textures of the erupted products, relating back to observations and eruptive style. The analysis will focus on assessing how the bubble and crystal contents of the magmas influenced the fragmentation. The researcher will use imaging techniques such as scanning electron microscopy (SEM), CT scanning and imagery analysis.

Skills and knowledge gained: Processing and analysing microanalytical microscopy images, granulometry of volcanic tephra, instruments to determine particle shape, size, and density. Interpreting images of volcanic textures to understand eruption dynamics with application to broader processes in volcanology. Ideal experience for those looking towards a PhD in physical volcanology/petrology.

Skills starting point: Would suit a student with keen interest in volcanic eruption processes and dynamics. A strong geology/earth sciences background with good petrology and geochemistry grades is desirable. Optical microscopy and igneous rock experience is important. Image processing and analysis is a bonus.

Suggested further reading:
https://link.springer.com/article/10.1007/s00445-022-01555-7 - recent short review paper on magma fragmentation

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9. Experiments on the flow and trapping of bubbles in magma mush

Project Supervisors: Prof. Alison Rust and Dr. Samuel Mitchell
Key topics: *physical volcanology, petrology*

Project description: It is increasingly recognized that mature magmatic systems can contain substantial volumes of 'mush'. It is important to understand how exsolved volatiles migrate through (and are trapped in) these crystal-rich, melt-bearing regions in the crust, for both 1) monitoring volcanoes, and 2) understanding how sub-volcanic ore deposits form. You will conduct laboratory experiments with 3D printouts of the geometries of a set of real magma mush rocks that have been imaged in 3D by X-ray tomography. There will be some technique development, testing printing materials and resolution. You will then do experiments studying the flow of analogue melt (e.g. water or syrup) and an analogue exsolved volatile phase (e.g. air) through the 3D-printed mushes. You will study the permeability of the mushes, and the 'relative permeability' of the analogue melt and volatile phases. The end products of some experiments will be scanned with X-rays to image the geometry of trapped bubbles. The results will feed into models of volatile migration in magmatic systems.

Skills and knowledge gained: 3D printing of volcanic rock textures; CT scanning of rocks; running analogue laboratory experiments using a variety of fluids. It is also feasible to do some numerical modelling related to permeable flow if of interest to the student.

Skills starting point: Should have a background in Earth Sciences or other physical science or engineering. No prior experience in laboratory experiments or imaging techniques required.

Suggested further reading:
Sparks, R. S. J., et al. "Formation and dynamics of magma reservoirs." *Philosophical Transactions of the Royal society A* 377.2139 (2019): 20180019.
Degruyter, Wim, et al. "How do volatiles escape their shallow magmatic hearth?." *Philosophical Transactions of the Royal Society A* 377.2139 (2019): 20180017.

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