<u>MSc by Research – Details for projects in volcanology</u>

Welcome to Bristol Volcanology Group and our projects available for an **MSc by Research (MScR 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, analogue experimentation, remote sensing, fluid mechanics and modelling, volcano deformation, geophysical surveying, environmental impacts, hazard modelling and risk analysis

Within this cohort of MScR volcanologists for the academic year 2025-2026 (full time) or 2025-2027 (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.

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 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.

The following projects are available for ***September 2025 entry** – *January 2026 entry may also be possible; however, September start is encouraged, to begin with the rest of the cohort. *Applications due <u>August 2025</u>.*

PROJECTS AVAILABLE:

1. ***Fragmentation of crystal-rich magmas – controls from crystal and vesicle size distributions***

Project Supervisors: Prof. Alison Rust and Prof. Jenni Barclay
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 explosive crystal-rich 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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2. *Fracture and deformation at active volcanoes: testing a better analogue material for Earth crust*

Project Supervisors: Prof. Alison Rust and Dr. Alexandra Morand
Key topics: *Analogue models; Volcano deformation*

Project description:
The interpretation of deformation at active volcanoes relies on our understanding of the complex process that appends beneath the surface. The physics of magma chamber can be investigated numerically or experimentally. Through scaling and careful choice of material, analogue modelling can reproduce in laboratory real-world processes. The Earth crust is generally modelled using gelatine (elastic response) or silica flour (brittle response), but they each represent an end member of the crust response. To push analogue modelling further, we need a material that reproduces both types of responses. The student will build laboratory-scale models of magmatic systems and test a mix of sand and gelatine. The surface deformation will be measured with high-resolution camera technology along with source pressure. The student will also link the results to numerical modelling and real-world observation to test the suitability of this mixed material to better represent the crust around magma chamber.

Skills and knowledge gained: Students will gain experience in building analogue models, in analysing time series and python coding (data processing and analysing).

Skills starting point: This would particularly suit those with a quantitative degree and with interest in Volcanology.

Suggested Further reading:

Gelatine vs Silica flour:
Bertelsen, H. S., Guldstrand, F., Sigmundsson, F., Pedersen, R., Mair, K., & Galland, O. (2021). Beyond elasticity: Are Coulomb properties of the Earth's crust important for volcano geodesy?. *Journal of Volcanology and Geothermal Research*, *410*, 107153. https://doi.org/10.1016/j.jvolgeores.2020.107153
Poppe, S., Wauthier, C., & Fontijn, K. (2024). Inversions of surface displacements in scaled experiments of analog magma intrusion. *Geophysical Research Letters*, *51*(8), e2023GL106805. https://doi.org/10.1029/2023GL106805
Initial set-up:
Biggs, J., et al., (2024). Fracturing around magma reservoirs can explain variations in surface uplift rates even at constant volumetric flux. *Journal of Volcanology and Geothermal Research*, *452*, 108129. https://doi.org/10.1016/j.jvolgeores.2024.108129
Sand mixed with gelatine:
Bureau, D., Mourgues, R., & Cartwright, J. (2014). Use of a new artificial cohesive material for physical modelling: Application to sandstone intrusions and associated fracture networks. *Journal of Structural Geology*, *66*, 223-236. https://doi.org/10.1016/j.jsg.2014.05.024

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3. ***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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4. ***Wetting and buoyancy of volcanic ash and pumice***

Project Supervisors: Dr. Pete Rowley
Project partners/collaborators: Dr. Samuel Mitchell (UoB Earth Sciences)
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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5. ***The risk to global shipping industries from volcanic activity***

Project Supervisors: Dr. Pete Rowley
Project partners/collaborators: Dr. Samuel Mitchell (UoB Earth Sciences)
Key topics: *volcanic hazards, environmental impacts, hazard modelling and risk analysis, GIS, geospatial data analysis*

Project description:
Approximately 90% of global trade is reliant on marine shipping, with this set to only grow in coming years. However, a large portion of the worlds' maritime trade passes within 100 km of active volcanic systems, presenting potential risk to multiple areas of the shipping industry. This risk has never been quantified, but historical losses have been documented, and there are still no maritime protocols in the face of volcanic hazards. In this project, the researcher will combine geospatial datasets of volcanic systems and their hazards, and the density and prevalence of different shipping industries across the ocean. The researcher will explore, in detail, case study areas around the world with high risk, and/or risk to specific shipping sub-industries e.g. commercial, fishing, tourism. The project will work with financial risk and insurance industry partners to better inform how we prepare maritime operations in the eventuality of marine volcanic hazards.

Skills and knowledge gained: The researcher will develop a strong skillset is using GIS and geospatial data analysis to tackle contemporary issues that bridge the physical and social sciences, and economics. The researcher will be able to work with larger quantitative datasets to present and turn them into digestible, visual datasets to convey findings and conclusions.

Skills starting point: This would suit those with a degree in earth science, geoscience, maritime/nautical science, geology, data analysis, GIS or statistics. An interest/experience in GIS, geospatial data analysis, and working with large quantitative datasets is very desirable. This would also suit someone with interests in natural hazards, maritime science, economics and/or geopolitics.

Suggested Further reading:
https://www.sciencedirect.com/science/article/pii/S0964569123003939
https://www.matec-conferences.org/articles/matecconf/abs/2021/08/matecconf_istsml2021_01019/matecconf_istsml2021_01019.html - Risks and legal analysis of 2021 Suez Canal blockage

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6. ***Surface waves in dense granular currents***

Project Supervisors: Dr. Pete Rowley
Project partners/collaborators: Dr. Rebecca Williams (University of Hull), Dr. Natasha Dowey (Sheffield Hallam University)
Key topics: *granular currents, density currents, physical volcanology, experimental modelling*

Project description:
Dense granular currents are important geophysical processes, which are found in a range of natural settings including pyroclastic density currents. The unsteadiness of these currents is critical in controlling their interaction with topography and substrate, and therefore in controlling their propagation and hazard potential. Little is known about the dynamic conditions within pyroclastic density currents, but preliminary work has suggested that surface waves, including standing waves, may be present in certain conditions.
This project will develop a range of flume experiments using gas-fluidised granular currents to explore the conditions under which different surface waves develop and evolve, to construct a phase diagram which will enable informed interpretation of resulting bedforms for the first time.

Skills and knowledge gained: Fluidised granular currents are important in both geophysical and industrial processes, and this project will give you high level understanding of how to work with them and their underlying physics. You will develop experimental methods, and use a range of video and image analysis tools to quantify morphological evolution through time.

Skills starting point: This would suit someone with an undergraduate degree in Earth Sciences, Physics, Maths, or Engineering with an interest in granular flow, volcanology, flow dynamics and/or sedimentology. This project will involve considerable experimental laboratory work handling dry powders (possibly including volcanic ash) and compressed air.

Suggested Further reading:
Rowley, P., Giordano, G., Silleni, A., Smith, G., Trolese, M., & Williams, R. (2023). Stationary surface waves and antidunes in dense pyroclastic density currents [Preprint]. Earth ArXiv. https://doi.org/10.31223/X5TW8V
Rowley, P. J., Roche, O., Druitt, T. H., & Cas, R. (2014). Experimental study of dense pyroclastic density currents using sustained, gas-fluidized granular flows. Bulletin of Volcanology, 76(9). https://doi.org/10.1007/s00445-014-0855-1

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7. *Dyke induced graben subsidence*

Project Supervisors: Professor Juliet Biggs and Dr. Timothy Davis
Key topics: *Numerical models, ground deformation*

Project description:
Dykes are a crucial role volcanic process, providing pathways for magma to reach the surface. These structures often result in fissure eruptions, such as those in Southwest Iceland. Dyking in volcanic rift zones can cause surrounding normal faults to slip, leading to graben subsidence above the dyke. Quantifying these interactions is essential for interpreting dyking behaviour.

This project will use mechanical modelling to explore the relationships between dyking, fault slip, and surface deformation. The student will investigate whether graben subsidence magnitude is proportional to dyke opening or pressure. They will also quantify how graben profiles vary with fault geometry and dyke depth, revealing insights about the dyke's proximity to the surface and the potential for eruption.

Working in non-dimensional space, the results will apply to laboratory and real-world contexts. By integrating model outcomes with satellite observations, this research will enhance our ability to monitor and forecast volcanic activity through improved interpretation of dyking processes.

Skills and knowledge gained: Running and implementing numerical geomechanics codes. Proficiency in developing and implementing mechanical models to analyse geological processes. The ability to use non-dimensional scaling to ensure results are generalizable across laboratory and real-world scenarios. Experience in running numerical inversion software to explore how different parameters influence surface deformation patterns. Skills in interpreting and integrating satellite observations of graben deformation to link theoretical models with real-world data.

Skills starting point: Proficiency in programming languages like Python, MATLAB, or similar. A fundamental understanding of tectonic processes, dyking faulting and surface deformation. Some mathematical competence/interest.

Suggested Further reading:
Rubin, A., & Pollard, D. D. (2017). Dike-induced faulting in rift zones of Iceland and Afar. Geology, 16(5), 413-417. This has some foundation knowledge for the project. Don't be scared of the mathematics.
Wright, T.J., Ebinger, C., Biggs, J., Ayele, A., Yirgu, G., Keir, D. and Stork, A., 2006. Magma-maintained rift segmentation at continental rupture in the 2005 Afar dyking episode. Nature, 442(7100), pp.291-294. This shows an example of the graben deformation above a dyking episode from InSAR data.

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8. *Satellite-based remote sensing to study lava flow emplacement and development*

Project Supervisors: Prof. Juliet Biggs and Dr. Edna Dualeh
Key topics: *remote sensing, lava flow mapping*

Project description:
Monitoring lava flows is essential for mitigating volcanic hazards, but traditional ground-based observations are often limited by hazardous conditions or inaccessible during eruptions. Synthetic Aperture Radar (SAR), an active sensor, can overcome these challenges and limitations of other sensors (e.g., optical) as it can acquire observations regardless of time of day or cloud coverage. SAR backscatter is controlled by the ground surface properties (e.g., roughness, local gradient and dielectric properties), which are changed during eruptions providing information about the deposits and processes. However, SAR backscatter is still underexploited in volcano monitoring.

The project will use high-resolution SAR data to examine the extent and surface characteristics of volcanic deposits during ongoing eruptions. By building on existing methods for mapping lava flows from SAR backscatter, the student will test the applicability of these techniques at volcanoes either in different environmental settings or with different eruption styles and correlate with observations from other sensors.

Skills and knowledge gained: Student will gain experience in image analysis and processing of remote sensing data and coding skills.

Skills starting point: This would suit those with a degree in earth sciences, geoscience, geospatial sciences or equivalent degree who have an interest in the use of remote sensing for volcano monitoring.

Suggested Further reading:

Poland, M. P. (2022). Synthetic aperture radar volcanic flow maps (SAR VFMs): A simple method for rapid identification and mapping of volcanic mass flows. *Bulletin of Volcanology*, *84*(3), 32.
Dualeh, E. W., Ebmeier, S. K., Wright, T. J., Albino, F., Naismith, A., Biggs, J., Ordoñez, P.A., Boogher, R.M. and Roca, A. (2021). Analyzing explosive volcanic deposits from satellite-based radar backscatter, Volcán de Fuego, 2018. *Journal of Geophysical Research: Solid Earth*, *126*(9), e2021JB022250.

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9. *Unlocking Volcano Mysteries: Global Volcano Classification for Improved Satellite Monitoring*

Project Supervisors: Prof. Juliet Biggs and Dr. Weiyu Zheng
Key topics: *Volcano classification, remote sensing, environmental analysis*

Project description:
Satellite data provides the opportunity for global monitoring of volcanic activities. InSAR (Interferometric Synthetic Aperture Radar), a satellite-based technique effective for detecting and tracking volcanic deformation, offers a unique perspective on the Earth's surface and tracks volcanic activity from space – something once thought impossible. However, the unique environmental and geological characteristics of each volcano can significantly affect InSAR data coherence, and consequently, the quality of processing.

In this project, you will develop a classification system for volcanoes using environmental and geological datasets, including geographic location, snow and vegetation cover, historical eruption patterns, and coherence statistics derived from InSAR data. This classification will optimize InSAR processing strategies by assigning them to the specific conditions of each volcano. Your work will contribute to the development of more effective tools for monitoring volcanic risk and improving global volcanic hazard mitigation efforts.

Skills and knowledge gained: Students will learn how to process and interpret real-world data (including satellite data), apply statistical and geospatial analysis techniques, and use the findings to improve our understanding of volcanic hazards.

Skills starting point: This would suit those with strong data analysis skills, particularly those with a background in Earth sciences or geography. An interest in remote sensing, environmental processes, and volcanic hazards is essential for success in this project.

Suggested Further reading:

1. A review of satellite-observed volcano deformation and the internal processes:
Biggs, J., & Pritchard, M. E. (2017). https://doi.org/10.2113/gselements.13.1.17

2.A report about satellite volcano remote sensing:
Pritchard, M.E.,et al., 2022,https://doi.org/10.3133/sir20225116

3. An overview of capabilities and limitations of InSAR in monitoring volcanic deformation:
Ebmeier, S. K., et al., 2018, https://doi.org/10.1186/s13617-018-0071-3.

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10. *Pumice and plastics: Applying volcanology to the distribution of oceanic microplastics*

Project Supervisors: Dr. Lewis Alcott and Prof. Alison Rust
Project partners/collaborators: Dr. Samuel Mitchell (UoB Earth Sciences)
Key topics: *physical volcanology, oceanography, hazards, environmental impacts, plastic*

Project description:
Microplastics are now a globally inescapable contaminant, especially within our oceans, where modern day concentrations are greater around areas of tourism and/or higher population densities. The impact of microplastics on ecosystems is calling for a better understanding of how they are distributed among our oceans and coastlines. This project aims to determine whether the volcanic ejecta, pumice, can be used as a proxy for microplastic distribution in surface waters, as like plastic, pumice can be buoyant in water. This project will determine the spatial relationship between microplastics and pumice – how they float, "floc" together, and break apart. The student will: 1) test the physical properties of plastics and how they compare to pumice; 2) conduct floating experiments of pumice and plastics in a wave tank; and 3) potentially conduct field surveys along the coastlines and beaches of Santorini, Greece, to assess onshore and offshore microplastic within and surrounding grafting pumice.

Skills and knowledge gained: The student will develop a range of skills including design and running of analogue experiments, analytical techniques such as pycnometry and scanning electron microscopy, image analysis, and potentially field surveys of plastics and coastal water sampling. The student will combine these datasets for an interdisciplinary, multiskilled research thesis.

Skills starting point: This would suit those with a degree either in earth or marine sciences, geography or environmental science. A general interest in marine science, oceanography, contemporary issues such as ocean pollution, and/or volcanic hazards is desirable. An interest in developing multiple hands-on skillsets is critical.

Suggested Further reading:
https://msurjonline.mcgill.ca/article/view/187 - Review of pumice raft formation
https://link.springer.com/article/10.1007/s00227-023-04203-6 - Pumice ingestion in seabirds... and relationships with plastic ingestion

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