The University of Oxford Department of Earth Sciences

EARTHSCIENCES

Understanding carbon dioxide emissions from Iceland: carbon budgets and their use for forecasting changes in volcanic behaviour

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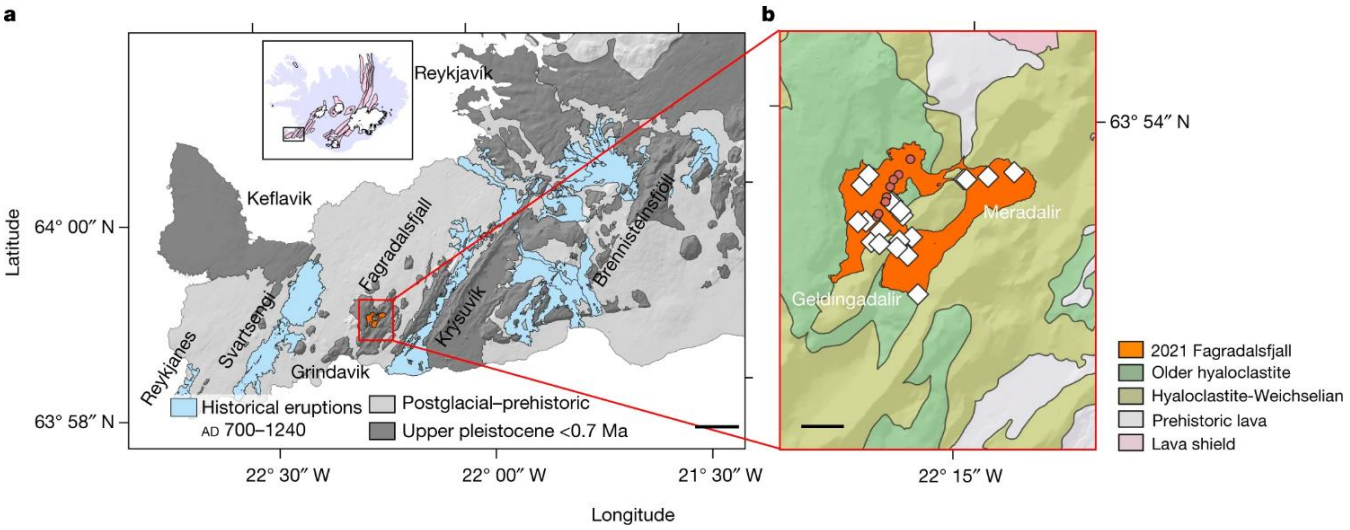
Key Words	**Volcanology, Carbon emissions, Forecasting**



Map of the Reykjanes Peninsula, showing the location of the lava fields from the 2021 Fagradalsfjall eruption (Halldorson et al., 2022).

Summary

Carbon dioxide exsolves from magmas deep within the Earth. Changes in carbon dioxide emissions measured at the surface may indicate changes within the magmatic system at depth, and provide clues to future changes in volcanic activity. Sub-aerial rifts associated with hotspots like Iceland are also significant, but poorly defined, contributors to global fluxes of deep Earth carbon degassing.

This project will study background carbon dioxide emissions from the Reykjanes Peninsula in Iceland, site of recent fissure eruptions and ongoing dyking episodes. The student will measure soil degassing fluxes at key locations and relate their measurements to structural and geo/hydrothermal features (e.g., faults, fumaroles) and ongoing changes in seismicity and deformation. By the end of the project, the aim is to develop a conceptual model of the links between active processes at depth, and diffuse carbon dioxide fluxes at the surface.

Methodology

Magmatism transports large quantities of carbon dioxide from Earth's interior to the surface. The solubility of carbon dioxide in magmas falls as pressure drops, so magma rising through the crust will release CO_2. What happens next is the focus of this project. In volcanic and geothermal areas, the influence of magmatic carbon can be detected by a variety of geochemical methods – including in the fluxes and compositions of diffuse 'soil gases', and high temperature gases, and by analysing dissolved inorganic carbon in crustal fluids.

Long-term monitoring of carbon dioxide fluxes in some volcanic systems suggests that changes in carbon flux at the surface may have use as a forecasting tool. The aim of this project is to conduct a detailed programme of field measurement, analysis, modelling and

interpretation in order to understand the processes that control the release of volcanic carbon dioxide from an active volcanic rift, in Iceland.

While there have been prior studies of carbon dioxide emissions from volcano-related settings in Iceland, much of this work has focussed either on geothermal systems; or on individual volcanic centres. This new work will fill a gap, with a focus on measuring diffuse emissions across an active rift, in a setting where seismicity and deformation are also being actively measured.

Timeline

Year 1: The student will join the diverse cohort of students from Oxford's Doctoral Training Partnership in Environmental Research (DTP; https://www.environmental-research.ox.ac.uk/) and will spend the first six months engaged in training (run by the DTP); reading and reviewing the wider literature, and preparing a detailed research proposal.

Preliminary work will include local field trials of the diffuse gas sampling equipment, and becoming proficient in data analysis, visualisation and interpretation; and a field campaign in Iceland in summer of Year 1.

Years 2 and 3: Following reconnaissance field mapping in the summer of year 1 the student will spend the winter seasons plotting and manipulating the field data in order to produce their first estimates of the region's degassing budget and establish hypotheses regarding structural and topographic control on fluxes to be tested in future field seasons. Areas of particular interest in terms of flux measurements will also be defined and revisited.

Year 4: The student will write up the results of the ongoing work as the research progresses; will present these results at workshops, meetings and conferences and in peer-reviewed publications. They will submit a thesis documenting their research during their 4th year of study.

Training & Skills

Funding for the studentship will be sought from Oxford's NERC doctoral training partnership in Environmental Research (DTP). The DTP provides a detailed programme of training in research and wider skills (including coding, computing, networking and presentation) over the first six months of the project, and continuing support for the full 4-year duration of the project.

This project will suit a student with strong fieldwork and numerical skills. Icelandic conditions can be challenging and a high-level of problem-solving ability will be required to make the right measurements to make the best estimates of degassing over this wide area drawing clues from structural, geodetic, seismic and geochemical datastreams. The student will benefit from the strong research environment in volcanology, petrology, geochemistry and geophysics in Oxford; and from the expertise in geodesy and volcano monitoring at Vedurstofa Islands, the Icelandic Met Office. Additional training directly relevant to the project will be provided in the field (Iceland), and in the laboratories, as required. The student will benefit from access to the modern laboratory, computing and library facilities in Oxford; and from the wider networking and training opportunities available within the UK, such as COMET (Centre for Observation and Modelling of Earthquakes, Volcanoes and Tectonics).

There will be ample opportunities for presenting research posters and talks, for writing scientific papers throughout the project. There will also be opportunities to participate as a demonstrator in field and class teaching, for which training will be provided.

References & Further Reading

Gudjonsdottir et al., 2020, Gas emissions and crustal deformation from the Krysuvik high temperature geothermal system, Iceland. JVGR 391, 106350.

Halldorsson et al., 2022, Rapid shifting of a deep magmatic source at Fagradalsfjall volcano, Iceland. Nature 609, 529.

Hunt et al., 2017, Spatially Variable CO_2 Degassing in The Main Ethiopian Rift, G-cubed 18, 3714.

Sigmundsson et al., 2022, Deformation and seismicity decline before the 2021 Fagradalsfjall eruption, Nature 609, 523.

Further Information

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