The University of Oxford Department of Earth Sciences

EARTHSCIENCES

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Magmatic volatiles: the behaviour of noble gases and halogens in subduction-related volcanic systems

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Overview

Reconstructing magma-source volatile composition, degassing, and interaction of magmas with the hydrosphere underpins our understanding of major scientific questions such as the role of volatiles in eruptive processes (partial melting, crystallisation and gas phase formation), the impact of deep volatiles on the Earth's surface, and the role that such systems play in sustaining a habitable planet. Noble gases (He, Ne, Ar, Kr and Xe) and their isotopes provide excellent geochemical tracers and have the potential to make significant advances in our understanding of these processes. Before the full potential of using noble gases as tracers in magmatic systems can be realised we need to be able to link their behaviour with major species such as water, CO_2 and the halogens (F, Cl, Br, I). This project will aim to investigate this in a subduction zone setting and will operate in the wider context of a major, NERC funded (£8m) initiative to investigate the deep geological volatile cycle and its impact on the Earth's habitability.

The emission of a gas plume from Villarrica, one of the most active volcanoes in the Southern Volcanic Zone of Chile and a source of recycled volatiles.

Methodology

Despite the application of noble gases to tracing the recycling of volatiles and identifying magma-source compositions (e.g., Hilton et al., 2002, Holland and Ballentine, 2006), we lack a basic understanding of how noble gases behave during magma crystallisation and eruptive processes. In part, this has been due to difficulties in measuring the low abundances of noble gases found in the majority of volcanic samples. We now have the analytical capacity to measure these samples for both noble gas concentrations and isotopic compositions due to recent developments in multi-collector mass spectrometry (Oxford). The focus of this project will be to trace the behaviour of the noble gases, together with halogens and other major volatiles as magmas evolve via crystallisation and degassing. This will provide a significant contribution to our understanding of the behaviour of noble gases and volatile elements in volcanic systems. To achieve this, the project will focus on a number of well-characterised volcanic systems (e.g. Mocho-Choshuenco, Hornopiren, Apagado) in the Andean Southern Volcanic Zone (SVZ). This project will compliment a larger project investigating the recycling of volatiles through subduction zones, where the Southern Andean convergent margin represents the 'hot' subduction zone endmember.

Fieldwork/sample collection will be conducted and collected samples will be characterised via microscopy and electron microprobe (EPMA). Noble gas concentrations and isotopic compositions will be measured on the Helix MC+ Noble Gas Mass Spectrometer (Oxford) and halogen concentrations will be determined via neutron irradiation noble gas mass spectrometry (NI-NGMS) (Manchester)/synchrotron micro-XRF (DIAMOND).

Timeline

Year 1: Doctoral training courses (10 weeks), literature review, fieldwork planning, fieldwork/sample collection in Chile, sample characterisation and laboratory training.

Years 2 and 3: Further sample characterisation (e.g., microscopy, EPMA), sample preparation (e.g., mineral separation), sample analysis (noble gas concentrations/isotopic composition, halogen concentrations), data compilation, geochemical model development, presentation of research at a national conference.

Year 4: Data integration, thesis completion, papers for international journals, presentation of research at an international conference.

Training & Skills

The supervisory team in Oxford/Manchester are leaders in volcanology, noble gas geochemistry and the application of geochemical tracers to volcanic systems. The supervisory team also have a wealth of field experience in the Southern and Central Andes and are actively researching the recycling of volatiles through the Andean convergent margin.

As part of this project you will learn how to plan and carry out a field sampling campaign, and how to characterise and prepare these samples for a variety of geochemical analytical techniques. A significant portion of this project will be lab based and will involve advanced training on state-of-the-art noble gas mass spectrometry in both Oxford and Manchester, and potentially synchrotron micro-XRF at the Diamond Light Source. You will also receive training and guidance in how to model and interpret data, how to present scientific results, and how to write scientific papers for publication.

References & Further Reading

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Further Information

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