Metals in magmas

Overview
Volcanic emissions have short-term and potentially long-term effects on the environment. In addition to CO₂, with its well-known impacts on climate, volcanic gases are major environmental sources of many trace metals. In the cases of Hg and Cd they may account for up to 50% of naturally occurring emissions (Mather, 2015). Understanding the release of these, often toxic, trace metals from volcanoes followed by their transport in volcanic plumes is therefore very important. Many of them impact human health and are important signals in archives, such as ice cores, of volcanic activity and environmental impacts. Recent work on Hg has shown that volcanogenic trace metals have great potential in global chemostratigraphy, and might thereby help unravel in finer detail links between past episodes of large-scale volcanism and their global environmental consequences (e.g., Sanei et al., 2012; Percival et al., 2015). Understanding metal volatility and release from magmas is also important due to its role in the formation of many ore deposits. On a larger scale, trace metal volatility from silicate melts is key to understanding their use as tracers of igneous/magmatic processes and wider processes associated with the composition, evolution and differentiation of silicate planets (e.g., Norris & Wood, 2017).

Methodology
Our understanding of trace metals in magmas has been held back by the challenges of tracking their behaviour using established methods such as melt inclusions. This is in part due to the challenges of making spot measurements of elements that are in very low natural abundances. To overcome these difficulties we will use experimental approaches to complement measurements on natural samples.

Our experimental approach will involve use of a specially-constructed furnace in Oxford (Norris & Wood, 2017). In this apparatus the molten sample, doped with the trace metals of interest, can be continuously stirred at high temperature (up to 1900K) in an atmosphere of known composition (fixed partial pressures of CO₂-Ο₂-H₂-S₂). The ability to control the atmosphere enables us to simulate a wide range of conditions relevant to volcanic degassing. The sample is quenched rapidly by opening the bottom of the furnace and allowing the sample to drop into a large volume of water. After quenching to a glass the elemental loss is determined using a combination of electron microprobe and Laser-Ablation ICP-MS methods. Analysis enables determination of the extent of volatile loss (e.g., of Hg, Cd and so on), which gives us the relative volatilities of the elements of concern. By stirring the melt we avoid development of a diffusional layer at the melt/atmosphere interface so that the loss rates of individual elements are directly related to their individual partial pressures above the melt. In this way we can determine elemental loss rates above a vigorously convecting molten body.

Although experimental in focus this project will also include field training for context maybe to Masaya volcano in Nicaragua which currently has an active lava lake.
Timeline
Year 1: Doctoral training courses (10 weeks), literature review, laboratory training, laboratory training.

Years 2 and 3: Experimental runs and sample characterisation (e.g., microscopy, LA-ICPMS), data compilation, geochemical model development, field visits and 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 are leaders in experimental petrology, volcanology and the application of geochemical tracers to volcanic systems. The supervisory team also have a wealth of field experience.

As part of this project you will learn how to plan and carry out experiments and field sampling, 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 techniques. 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


Further Information
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