# Deciphering the climatic forcing of major volcanic eruptions from minor isotopes (Ref IAP2-18-171)

## University of St Andrews, School of Earth and Environmental Sciences

## In partnership with Department of Earth Sciences, Durham University

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| **Supervisory Team** | • **Dr Andrea Burke, University of St Andrews**<br>• **Prof Kevin Burton, Durham University**<br>• **Dr Robert Steele, University of St Andrews**<br>• **Dr Mark Claire, University of St Andrews** |
| **Key Words** | 1. **Volcanoes, climate, isotopes, mass spectrometry, ice cores** |

## Overview

Sulfate layers in polar ice cores provide a high-resolution and continuous record of global volcanism through time (e.g. Gao et al., 2008; Sigl et al. 2015). The study of these sulfate layers can provide important insights into the frequency and climatic forcing of volcanic eruptions. However, a key requirement to accurately interpret these records is the ability to distinguish whether a sulfate layer is due to a local eruption (proximal to the ice sheet) or from a large tropical eruption (with associated greater climate forcing potential).

Multiple sulfur isotope analyses can be used to identify if the ice core sulfate was formed in the stratosphere, thus providing a means to identify large tropical eruptions (e.g. Baroni et al., 2007;2008). However there are still many uncertainties regarding the mechanism of fractionation and interpretation of minor sulfur isotopes (see e.g Gautier et al., 2018). The aim of this studentship would be to develop a new technique for measuring quadruple sulfur isotopes (32, 33, 34, 36) on small samples by coupled collision cell MC-ICP-MS. This technique will be applied to volcanic sulfate deposited in ice cores to distinguish between different mechanisms proposed for the signal observed in ice.

Recent work (Lin et al 2018) suggests that there is an altitude dependence of $\Delta^{33}S$ in stratospheric sulfate, which if true would provide a means of constraining the plume height of past volcanic eruptions. The student will test this on known volcanic eruptions recorded in ice cores, and where possible on sulfate aerosols collected from volcanic plumes. The student will then apply the technique to key volcanic events over the past 200,000 years as recorded in ice cores.

## Methodology

This project will be in close collaboration with Prof Tim Elliott and Dr Chris Coath at the University of Bristol, where the student will use the bespoke, state-of-the-art collision cell multi-collector inductively coupled plasma mass spectrometer, or Proteus. Preliminary data measured on sulfate from ice cores shows impressive potential of this analytical technique which would allow unprecedented resolution of minor sulfur isotope measurements in small ice core samples.
Ice cores will be sampled from repositories in Grenoble and Copenhagen, and aerosol samples will be provided by Prof Kevin Burton (University of Durham), and sulfate concentration will be measured by IC at the University of St Andrews. Multiple sulfur isotopes will be measured by MC-ICP-MS at the University of St Andrews in the STAiG laboratories, and by collision cell MC-ICP-MS at the University of Bristol in the BIG laboratories.

## Timeline

Year 1: Literature review, ice core sampling, training in clean laboratory methods and mass spectrometry at the STAiG laboratory at the University of St Andrews. Method development on the collision cell MC-ICP-MS in Bristol.

Year 2: Ice core sulfate concentration by ion chromatography and $\Delta^{33}S$ isotope measurements by MC-ICP-MS at St Andrews. $\Delta^{36}S$ isotope measurements at University of Bristol. Analysis of data, and draft initial paper(s). Develop application of technique to aerosol samples.

Year 3 to 3.5: Finish ice core sample measurements and make measurements on volcanic aerosol emissions, finalize data sets, prepare written manuscripts and write thesis.

## Training & Skills

The student will gain specific training in geochemical laboratory techniques including ion chromatography, mass spectrometry, and clean lab chemistry, as well as training and expertise in volcanology, climate science, atmospheric chemistry, and isotope geochemistry. The student will be trained and work with a state-of-the-art, bespoke collision cell MC-ICP-MS. The student will also be trained in the use of Matlab to process and analyse data. Furthermore, over the course of the PhD the student will gain transferable skills such as scientific writing, statistics and data analysis, and problem-solving, as well as time management and working towards a long-term goal.

## References & Further Reading


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