

Fieldwork at Erebus – an overview

One thing I really enjoy about working on Erebus volcano, Antarctica, is seeing the huge range of research that can happen on one volcano. Erebus is one of the few volcanoes in the world that hosts an active lava lake – meaning that the lake is not a disconnected pool of lava, but is connected by a conduit to a magma source. The volcano is almost 3800 m high, consisting of a wide, flat caldera and the summit cone inside it. Scientists go to Erebus to study the volcano itself, but also its ice caves and the extremophile bacteria that survive in the warm volcanic soils.

The work of the Erebus volcanologists can be very broadly classified into: the ‘monitoring’ type work – taking measurements in real time; more traditional field geology studying rock outcrops; and the experimental petrology, which involves recreating volcanic conditions in the lab. Here’s an overview of just some of the techniques that were being used during my trips to Erebus.

Real-time measurements

Developments in technology over the past couple of decades have been a real advantage to volcanologists, not just in terms of what we can measure, but also in terms of where and how we can measure it. At Erebus, we have a generator sending power to the crater rim, allowing instruments to be set up. Laptops and mini computers can be used to control the instruments, and – when everything is working – we can monitor some of them remotely. The ability to monitor how gas and heat output or the shape of a feature changes over time is useful for understanding patterns in volcanic behaviour and for forecasting what will happen next.

Infrared spectrometry

Whereas the only way to take gas measurements in the past might have been through collecting samples and taking them to a lab for analysis, we can now measure how gases change from second to second. My work at Erebus was mainly at the rim of the volcanic crater, studying the gases in the volcanic plume. I used a technique called infrared spectroscopy. The instrument measures infrared radiation from a source on the other side of the volcanic plume. The gases between the source and the instrument will absorb the radiation, at different frequencies depending on the types of molecules – so looking at what is left (the measured radiation) and the absorption patterns tells me which gases are present, and in what amounts.

Thermal camera

Also up at the crater rim is a thermal infrared camera. This takes 2D images of the heat emitted by the lava lake. The thermal camera can show us how the surface of the lake is moving, and how its heat output changes over time. We can find interesting patterns, like cyclic increases in the speed of lake movement and in the heat output, which correlate to changes in the gas composition of the plume.

‘Gas boxes’

While the infrared spectrometer and thermal camera are mounted on heavy tripods, some instruments are more portable. The multigas boxes contain a range of chemical sensors to measure gases, including some that the infrared spectrometer cannot detect. We are constantly moving them to the

areas where we can smell the volcanic plume most strongly. Of course, this isn't always reliable because the wind direction can change! Sometimes we have these up at the crater rim – other days, when the plume is 'grounded' (coming down the flanks of the volcano) we can have these partway up the volcanic cone.

Filter pack

Another portable instrument is the filter pack, which measures acid gases (such as HF and HCl), and collects fine particles. This is also moved around to find an area where the plume is relatively dense, and a pump sucks air through a series of filters – one of which traps the particles, and successive ones which are treated with basic chemicals. While most of the other instruments are connected to computers that collect the data, the filter papers must be collected (carefully!) and analysed later.

LIDAR terrestrial scanning

One instrument which is used all over Erebus is the LIDAR, which gives 3D images of different sites, including the crater of the volcano, but also the ice caves and towers (of 'Frozen Planet' fame). The instrument fires a laser, which is reflected off surfaces and returns to the scanner. Based on the amount of time it takes to return, and the known speed of the laser, it is possible to map the point on the surface where the reflection occurs. Thousands of such points form a point cloud in three dimensions.

A single scan can take a long time but, using LIDAR, people working on Erebus have been able to get dimensions for the crater and the lava lake, and see how it has changed from year to year.

Ultraviolet spectrometry

The ultraviolet spectrometers are usually set up near the hut. They measure UV radiation and, like the infrared spectrometer, use the absorption of radiation by gas molecules to measure the flux of a gas – usually sulphur dioxide - in the plume. There are a few different ways these can be used: having two spectrometers a fixed distance apart, a single spectrometer that scans through the plume - or driving on a snowmobile (carrying a spectrometer) along the plume!

Ultraviolet camera

One new instrument that was used for the first time at Erebus last year is a UV camera. This was set up at the hut alongside the UV spectrometer. The UV camera also measures sulphur dioxide, but in the form of a 2D image of the plume – so a series of images can show us how the plume moves and how concentrations of SO₂ change.

Seismic and infrasound

Detectors to measure vibrations are situated all around the flanks and rim of the Erebus cone. Seismic and broadband detectors are used at volcanoes all around the world. They can be used to detect magma movement - at Erebus they often pick up bubble explosions and ice quakes as well.

Understanding volcanic history

More traditional geological techniques can still be of use to understanding a volcano's history. The past volcanic activity is a key piece of information in trying to figure out how a volcano works and

what it might do in the future. Techniques for these types of analyses are still evolving – at Erebus last year, we had a student mapping lava flows and collecting samples to recalculate the ages of the flows, using newer helium and chlorine isotope dating methods.

Mapping and stratigraphy

Geologists at Erebus have studied where different types of lava flows have been deposited, and how different types of volcanic deposits are layered (their stratigraphy). This gives us information about the sequence of events in a single volcanic eruption or the order in which different eruptive episodes happened. Together with chemical and petrographic analyses, is an important part of putting together the history of the volcano.

Rock and tephra sampling

Maps and stratigraphic columns can give us a general picture of volcanic history, but they're of much more use when combined with petrographic studies to get smaller scale information. For example, the crystals that are present, or the shapes of ash particles - can tell a great deal about the origins of the magma, the processes that happened in the volcanic conduit, and the type of eruption that happened. Samples of ash and rock can be analysed for chemical composition and radiogenic isotopes, giving information about the composition of past eruptions and helping to constrain when they happened.

Experimental insights

Experimental petrology

Another way geologists can learn about what is happening *inside* the volcano is by performing experiments in the laboratory. On Erebus, scientists collect a multitude of samples, gathering as many different types of lava rock as possible. Once back home in the lab, the scientist can put that sample into a machine that recreates the high-pressure and high-temperature conditions that exist in magma chambers several kilometres beneath the Earth's surface. Essentially, they can recreate a magma chamber under controlled conditions and observe how the magmas behave when those conditions are tweaked. This kind of work can help answer questions like, "What was the temperature of this rock before it was erupted?"