The Eyjafjallajokull eruption of March-May 2010

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Abstract

The March-May 2010 volcanic eruption in southern Iceland brought volcanoes to the attention of the general public, as north-westerly winds carried a cloud of volcanic ash across Europe and caused major disruption to air travel. This article describes that eruption, looks at the historical background, and asks what whether we can expect to see more such disruption in the future.

Introduction

On the 20th of March 2010, a volcanic eruption began in the area of Fimmvörðuháls in southern Iceland, with lava erupting from fissures in spectacular 'fire fountains'. By Icelandic standards, this was not particularly unusual; in fact, it was considered a welcome tourist attraction, attracting thousands of visitors a day, as described by the Iceland Review Online (www.icelandreview.com). Then, on the 14th of April, the site of the eruption abruptly moved from its first, ice-free location, to the ice-capped central crater of nearby Eyjafjallajökull volcano. Here, when the magma rising up beneath the volcano reached the surface, it melted the ice in the crater. The interaction of the hot magma with ice-cold water caused a reaction rather like that between hot oil and water; it exploded, throwing a column of volcanic ash and steam almost ten kilometres into the air. At the time, the prevailing winds were north-westerly, and so they carried the ash south-eastwards over Europe, where it caused widespread disruption to flights for several weeks, and stranded thousands of people away from home. Suddenly, volcanic eruptions – not usually considered a major hazard in the UK – were of interest to just about everyone. But what is the story behind the eruption?

Volcanic Iceland

Iceland is a unique volcanic island. It lies on the Mid-Atlantic Ridge, the great chain of underwater volcanoes that runs through the North Atlantic Ocean, along which the Eurasian and North American plates are moving apart at about 2.5 cm per year – or roughly the rate your fingernails grow. But Iceland also sits atop a mantle plume, where hot magma upwells from deep in the Earth's mantle. The interaction of these two types of volcanism, over the last 15 million years or more, has created the island of Iceland.

The majority of volcanism in Iceland occurs along volcanic rift zones that cut through the centre of the island. The single North Volcanic Zone, running broadly southwards from the north coast, gives way to two north-east – south-west rift zones (the East and West Volcanic Zones) in southern Iceland. Within these volcanic rift zones are numerous individual volcanoes, which tend to have the classic volcano profile of a broad cone with a summit crater or craters. In Iceland, though, many of these volcanoes are capped by glaciers.

Modern techniques for dating rocks tell us that the oldest lavas on Iceland are some 15 million years old, and that volcanic eruptions in Iceland have been going on ever since. However, by far the best record of Iceland's volcanic past comes from the last 1,100 years, since the first settlers arrived in Iceland from Europe. Written records have been studied in conjunction with careful fieldwork that has identified the products of individual eruptions, preserved in Iceland and further afield. Over this

time period, more than 200 volcanic events have been identified, some of them lasting for months or even years (Thordarson and Larsen, 2007). Thus, on average, there is roughly one volcanic eruption in Iceland every five years.

Eyjafjallajökull: the March to May 2010 eruption

On the 20th of March 2010, a swarm of earthquakes preceded the onset of a volcanic eruption at Fimmvörðuháls, on the north-east side of Eyjafjallajökull in southern Iceland. This eruption was in an ice-free area, and so lava was erupted from fissures without ever coming into contact with water. The lava was basaltic in composition, and so had a relatively low viscosity; it formed spectacular fire fountains and lava flows, similar to the eruptive style commonly seen on Hawaii – and like Hawaii, tourists were attracted to see the volcano. This eruption produced very little volcanic ash, and so had little effect beyond its local area.

That first phase of eruption ended on the 7th of April. Then, late at night on the 13th of April, a swarm of earthquakes was recorded directly beneath the summit of Eyjafjallajökull itself. Magma was rising up to be erupted directly from the volcano's central crater. This second phase had two important differences to the first phase of eruption. Firstly, the magma that was now being erupted was slightly more silica-rich in composition, meaning that it was more viscous than the basaltic lava, and contained more dissolved gas. Secondly, the crater where magma was now erupting was filled with ice. On contact with the hot magma, the ice melted and vapourised, producing steam, whilst the magma was cooled rapidly to produce many tiny glassy particles of volcanic ash. These explosive reactions generated a cloud of steam and volcanic ash that rose many kilometres into the sky above the volcano, whilst meltwater flowed outwards from the crater, flooding the river valleys below.

On the 14th of April, Icelanders woke up to a rising volcanic ash cloud, and floods in southern Iceland. But this was not really unusual; standard emergency plans were followed, including breaking a channel through the main road below the volcano, so that floodwaters would not destroy a bridge that would be difficult to repair. Scientists at the Icelandic Met Office and the University of Iceland swung into action, using their seismic and GPS networks as well as fieldwork to monitor and study the eruption. Some people were evacuated from the areas immediately around the volcano, and local farms suffered significant damage; but for many people in Iceland, it was simply 'business as usual'. For those of us outside Iceland, though, there was something different about this eruption: the prevailing north-westerly wind, which carried the ash cloud south-eastwards towards northern Europe. On the 15th of April, UK airspace was closed, because the existing regulations stated that planes should not fly through any concentration of volcanic ash.

As Eyjafjallajökull continued to erupt explosively, the airspace closures continued on, day after day, leaving thousands of travellers stranded away from home. By the 20th of April, the volcanic eruption had decreased in intensity, but the real key to the reopening of UK airspace was the agreement of tolerance levels of volcanic ash through which planes could continue flying. Although the main closures were over, disruption continued for some weeks as the eruption progressed. It was not until late May, when the explosive volcanic activity had largely ceased, that air traffic was really able to get back to normal.

Further information about the eruption can be found at http://www.bgs.ac.uk/research/highlights/icelandic_ash.html, including a cut-out cardboard model of Eyjafjallajökull that has even appeared on Blue Peter.

So have we seen disruption like this from Icelandic volcanoes before?

The Eyjafjallajökull eruption of March to May 2010 was neither large or unusual by Icelandic standards. During the 20th century, there were some 26 separate eruptions in Iceland (Thordarson and Larsen, 2007). Some of those were not explosivein nature: like the first phase of the 2010 eruption, they had little effect beyond their immediate area. However, the majority of those eruptions included at least some explosive activity, and would have produced volcanic ash clouds.

In 2004, a brief eruption of the Grimsvötn volcano produced an ash cloud which was carried eastwards over Scandinavia, leading to diversion and grounding of some flights. At the time, newspapers carried quotes saying that the disruption would have been much worse had the winds being north-westerly. Six years later, it was just such north-westerly winds that grounded so many flights across Europe. The prevailing weather is key to whether Icelandic volcanoes affect other parts of Europe.

In the latter years of the 20th century, when air travel boomed, it seems that Europe was lucky. The majority of eruptions in Iceland during that time were relatively small in scale, and the weather conditions were such that the ash was not carried south-eastwards into the main area of intra-European and trans-Atlantic air traffic. Historically, though, things have been rather different.

Eyjafjallajökull is a small volcano by Icelandic standards, but it lies close to a rather larger volcano named Katla. Katla has historically been much more active than Eyjafjallajökull, with around 20 eruptions over the last 1100 years (Sturkell et al., 2010). The last two eruptions of Eyjafjallajökull occurred in 1612 and 1821-1823, and each was followed within a few months by an eruption at Katla. The last major eruption of Katla, in 1918, was a large explosive eruption – perhaps similar in size to the 1980 eruption of Mount St Helens in the USA. Katla has not erupted since 1918, but some other Icelandic volcanoes – such as Hekla and Grimsvötn – had several explosive eruptions during the 20th century.

Really large explosive eruptions, producing more than 1 km^3 of volcanic ash (that is, larger than the Mount St Helens 1980 eruption) occur in Iceland, on average, once every 1000 years (Thordarson and Larsen, 2007). As recent events have proved, though, it's not just these largest eruptions that can affect the UK and the rest of Europe: if the weather conditions are right, ash from even quite small eruptions can be carried over the UK. In fact, study of ash layers in British lake sediments and peat bogs has shown that, over the last 1000 years, ash from at least ten different Icelandic eruptions has fallen in the UK.

However, the largest Icelandic eruptions have not been explosive eruptions. During recorded history, there have also been a number of very large flood lava eruptions. These eruptions are dominated by large-scale lava flows and fire fountaining, with some explosive activity producing volcanic ash. Such very large eruptions may continue for months or even years. The most well-studied example is the most recent, the 1783-1784 Laki eruption in the Grimsvötn volcanic system. This eruption lasted for eight months and produced nearly 15 km^3 of lava. During this process, large amounts of gas were

ejected into the atmosphere, including abundant sulphur dioxide (SO_2). In the atmosphere, the SO_2 reacted with water to produce many tiny droplets of sulphuric acid, creating a 'dry fog' that spread across most of Europe. This dry fog had two effects: firstly, it blocked out the sun's rays, so that the winter of 1783-1784 was one of the hardest of the eighteenth century (Thordarson and Self, 2003); and secondly, the acid droplets were precipitated as acid rain, damaging crops and causing sickness in livestock. In Iceland, a devastating famine was caused by the volcanic pollution.

What will happen in the future?

Iceland is an active volcanic island, and its volcanic eruptions are a natural force, uncontrollable by mankind. We can expect that eruptions such as that at Eyjafjallajökull in March-May 2010 will continue to happen every few years – and if the winds are blowing from the north or north-west during the eruption, we are likely to see more ash clouds over the UK and Europe. Eventually – perhaps during this century, perhaps not – it is likely that there will be another much larger eruption in Iceland, probably a flood basalt eruption like Laki. When this happens, the UK is likely to experience volcanic pollution, climatic changes, and disruption to air travel over a period of months. Iceland's volcanic eruptions are a force that we must continue to reckon with.

References

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Figure Captions

Figure 1: The main volcanic zones in Iceland (NVZ – North Volcanic Zone; WVZ – West Volcanic Zone; EVZ – East Volcanic Zone), together with the location of volcanoes mentioned in the text.

Figure 2: Photographing Eyjafjallajökull during the eruption. BGS Photo P731589, ©NERC

Figure 3: Downwind of the erupting volcano, Icelandic roads and houses were covered in a thick layer of volcanic ash. BGS Photo P731764, © NERC

Figure 4: Upwind from Eyjafjallajökull, some areas of Iceland were unaffected by ashfall, but provided spectacular views of the erupting volcano. BGS Photo P731715, © NERC.