Fagradalsfjall

THE STORY OF AN ERUPTION - A CASE STUDY

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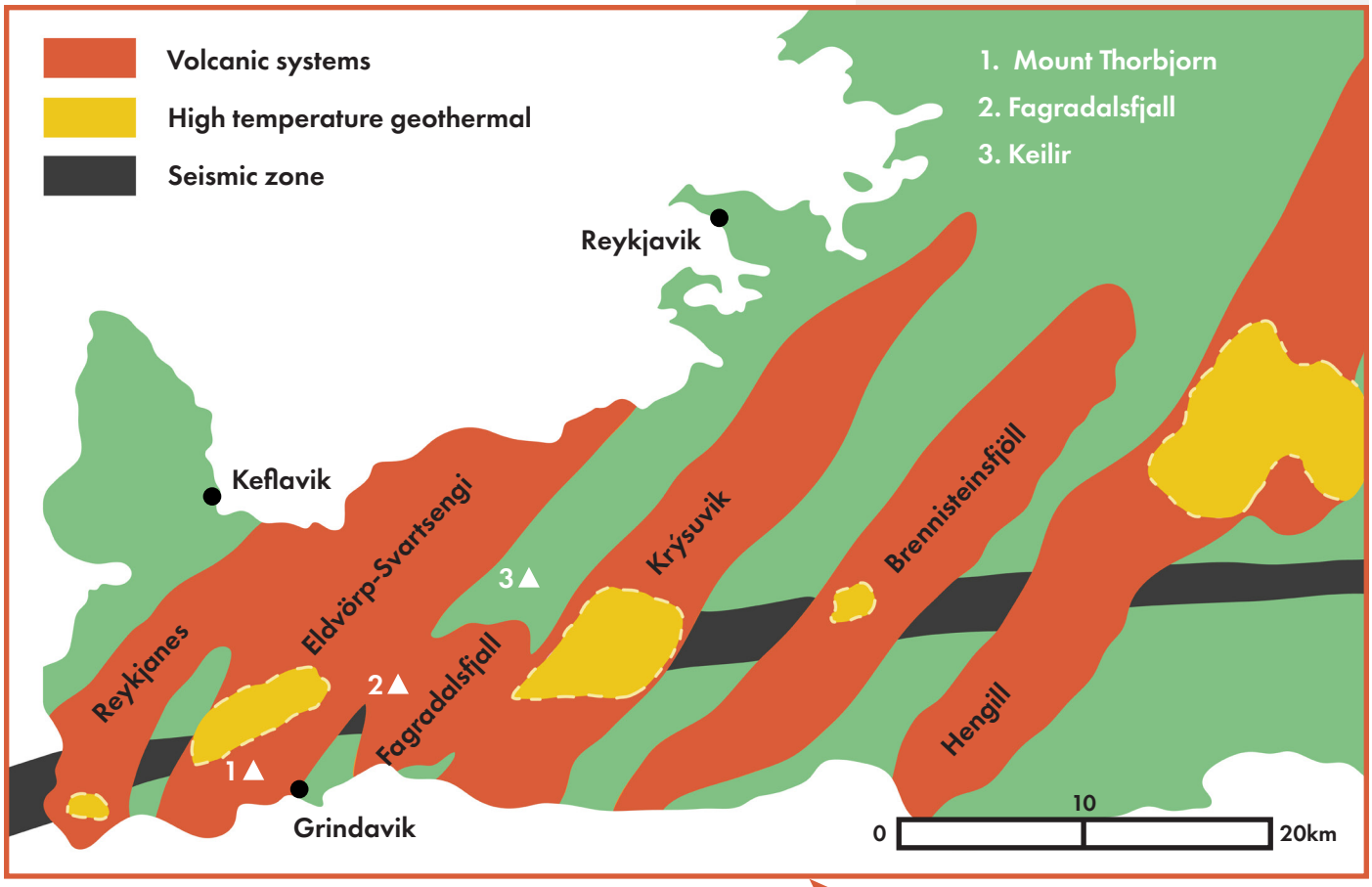
WHEN DID THE ERUPTION BEGIN?

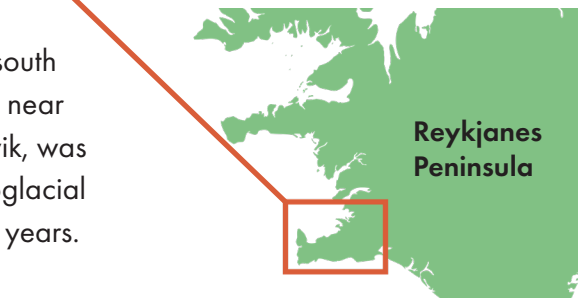
19th March 2021.

Volcanic systems on the Reykjanes Peninsula



WHERE WAS IT LOCATED?

Lava broke through the surface on the Reykjanes Peninsula, in the south west of Iceland. It was in a remote valley known as Geldingadalir, near the flat-topped mountain Fagradalsfjall. The nearest town, Grindavik, was about 6 miles to the south west. Fagradalsfjall formed during a subglacial eruption during the last ice age and has been dormant for 14,000 years.



WHAT HAPPENED?

Initially a 700m fissure (a linear vent) opened, with basalt lava flowing to both sides. There were dramatic lava fountains, at times reaching hundreds of metres in the air. Within a matter of hours a small crater formed, becoming the main vent for the flowing lava. The eruption was effusive and the magma had low viscosity so gas could escape easily and at the surface form lava flows rather than any explosive activity.

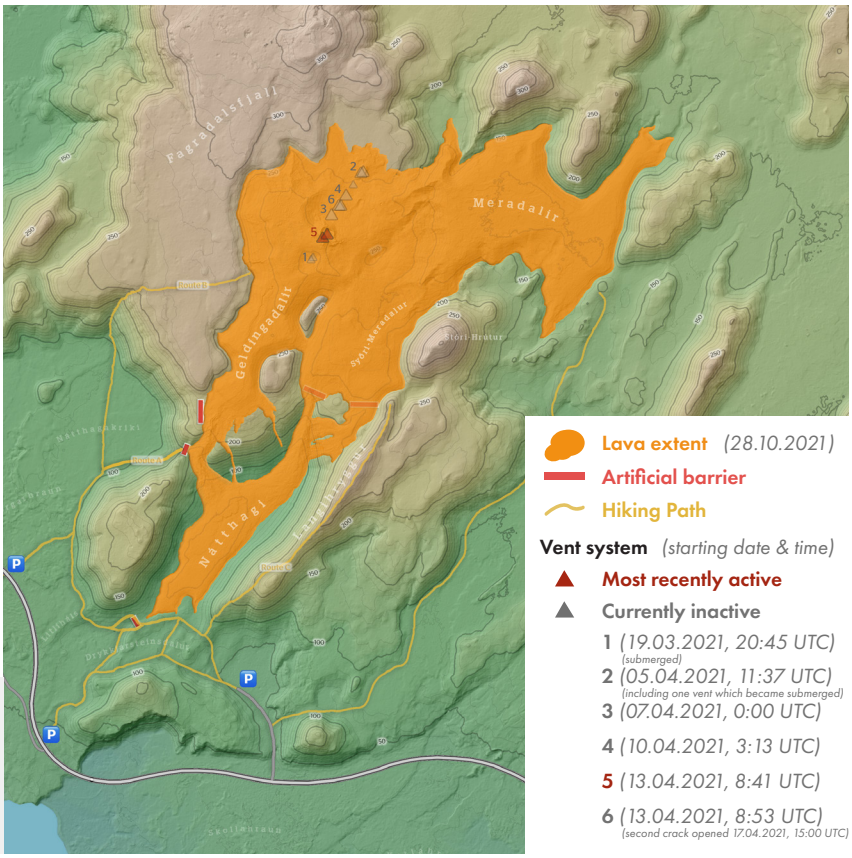
In the early stages of the eruption, 3 distinct spatter cones grew. As the eruption continued, multiple fissures opened and lava poured into Geldingadalir.

The rhythm of the eruption changed several times as new fissures opened and closed and the composition of the lava changed. There were periods of pulsating activity with fire fountains, periods of steady outflow of lava and quiet periods where no activity was seen on the surface or the tremor graphs.

A spatter cone is a steep sided volcanic cone, built up around a vent as escaping gases in the lava form lava chunks or blobs (spatter) that are thrown into the air. These blobs of spatter stick together as they land and pile up around the vent.

Each phase could last for just a matter of hours or for several days. A total of seven craters formed but over time the activity was focused around a single vent with the crater eventually reaching a height of 334m. The temperature (1,200°C) and chemical composition of the lava indicated it came from the mantle about 20km below the surface.

The eruption continued for 6 months until September 18th, since when there has been no further lava emitted. The lava produced amounted to 151 million cubic metres and covers an area of 4.8 km².



Map of the Geldingadalur Volcanic Eruption and its lava flows at Fagradalsfjall/Iceland, updated October 28th 2021

WHY DID IT HAPPEN?

Iceland frequently experiences earthquakes and volcanoes due to its position on a constructive plate margin. The Reykjanes Peninsula is part of the Mid-Atlantic Ridge, where two tectonic plates, The North American and the Eurasian, move away from each other.

As the plates diverge the land is stretched, causing linear fractures. Magma is able to make its way along these lines of weakness and if it reaches the surface and volcanic material is ejected, a volcano is formed.

WHO WAS AFFECTED?

Life, for those living in the region, had been extremely stressful and many had trouble sleeping prior to the eruption due to the almost constant shaking from earth tremors. Once the eruption began the lava flows posed little threat to residential areas and the activity had little effect on daily life, due to its out-of-the-way location and effusive style.

The main hazard from the eruption was the potential danger of toxic gases, in particular sulphur dioxide, which, even in small quantities, can irritate the lungs of those with respiratory conditions. This was a threat to those hiking to the crater and those living downwind of the eruption site.

There was some concern that the lava flow might threaten to overflow the nearby coast road making it impassable as well as destroying fibre optic cables providing internet connection to the area and connecting the country with Europe.

The eruption came at just the right time for Iceland's tourist industry. In 2019, nearly 2 million tourists visited Iceland. With the onset of Covid19 travel restrictions, this number dropped to only 478,00 in 2020. Once travel restrictions started to ease, tourists flocked to the eruption site, as the volcano posed relatively little danger and it was relatively easy to get close to. It was a popular tourist attraction, with around 400,000 visitors, keen to witness this natural phenomenon. This was a boost for the struggling tourism industry as demand rose for hotels, restaurants, transport, tour guides and sightseeing flights. In 2021, whilst still below pre pandemic levels, tourist numbers reached almost 690,000.

Study Notes

WAS ICELAND PREPARED FOR THIS ERUPTION?

Iceland has an extensive volcano monitoring system and it is not unusual for earthquakes to be detected on the Reykjanes Peninsula. However, in December 2019, when the peninsula experience an earthquake swarm (a sequence of many, mostly moderate or small earthquakes in a relatively short period of time, without a specific main shock) scientists started to pay closer attention, as such swarms can precede a volcanic eruption.

GPS devices detected inflation of the Earth's surface just to the west of Mount Thorbjorn, to the north of Grindavik. Scientists believed that magma was forcing its way into cracks and fissures in the crust and gathering about 4km below the surface.

Scientists at the Icelandic Meteorological Office (IMO) increased monitoring of the area by setting up more seismographs and GPS devices. Frequent earthquakes were detected over the next few months, the largest of magnitude 5.2 and a total uplift of land of 7 to 8 cm was recorded. The authorities declared a state of uncertainty and raised the aviation code to yellow.

A meeting was held for local residents of Grindavik where the Department of Civil Protection, scientists and first responders reviewed safety protocols and evacuation procedures and residents were encouraged to make a plan of action in case an eruption occurred.

However, by the end of April there was a significant decrease in seismic activity and the uplift of land stopped. Scientists warned that there was still the possibility of renewed activity in the near future, either at Thorbjorn or elsewhere on the Reykjanes Peninsula.

Study Notes

The lull in activity lasted until July 2020 when the Reykjanes Peninsula was rocked by another earthquake swarm, the largest of which was magnitude 5. This time activity was focused on Fagradalsfjall, about 6 miles north east of Grindavik. Data from InSAR (Interferometric synthetic aperture radar), a satellite-based radar, clearly showed land deformation in the Fagradalsfjall region.

In October, another large earthquake, measuring magnitude 5.6 was recorded, originating about 7km west of Lake Kleifarvatn, followed by 1,700 tremors in the following 24 hours.

WHAT WAS THE RESPONSE TO THE ERUPTION?

As soon as it was clear that an eruption had started, the Department of Civil Protection and Emergency Response raised their alert level to Emergency, the highest level. Roads in the area were closed and air traffic was temporarily halted, whilst the Icelandic Met Office prepared an ashfall prediction. The airport soon reopened as the tephra was small and ashfall was expected to be minimal to non-existent. Residents in Þorlákshöfn, on the south coast, were advised to close windows as the wind direction might carry toxic gases towards them.

On the following day, once the extent of the eruption was clear, the readiness level was lowered to Alert and the aviation colour code lowered to orange.

Computer modelling and meteorological surveys were used to track toxic gases and warn residents downwind to keep windows and doors closed, and to avoid going outside.

The eruption became a major tourist attraction. Search and rescue teams monitored the site and created paths for people to walk on more safely. Business Iceland had created a marketing campaign to attract foreign tourists to the ongoing eruption.

Authorities experimented by constructing protective barriers to impede the flow of lava into the Natthagi Valley from where it might proceed towards the road and fibre optic cables and cause damage to infrastructure. The initial height of the barriers was 4m, but this was raised to 8m. Although the lava flow collected high enough to flow over the barriers, it did not breach them, proving the effectiveness of the design. As a precaution, the data provider quickly buried the fibre optic cable 2m underground to protect from any advancing lava flow.

Plans were drawn up to decide what infrastructure might need to be protected if the eruption continued for many more months, evaluating whether the cost of defence or the cost of doing nothing will be higher. Structures were designed to provide protection for the town of Grindavik and nearby Svartsengi power station, should the lava flow head towards them.

In October, as no further lava had been emitted since September, the readiness level was lowered from Alert to Uncertainty and on December 3rd the Uncertainty phase was lifted.

3 months on from the last lava emission the eruption was officially declared over, although scientists continued to monitor the area closely, as data still indicated magma movement below the surface.

Study Notes