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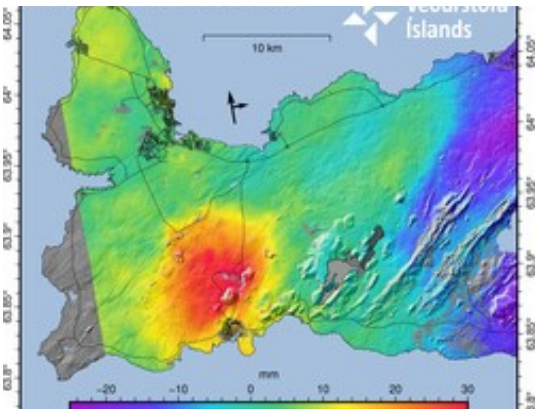
IN THIS EDITION:

Mt. Keilir (left), Litli-Hrútur (right). Summer 2023.

In our newsletter you can read about topics related to geography, geology and our natural environment. Comments are welcome!

NORTH ATLANTIC VOLCANISM

In this winter edition of the GeoNewsletter, we will focus on the ongoing volcanic activity on Reykjanes Peninsula, Southwest Iceland. A long period of rest came to a halt in 2021. The outburst of the Fagradalsfjall volcanic system in 2021 (Geldingadalir) was followed by several eruptions, in 2022 (Meradalir), summer 2023 (Litli-Hrútur) and winter 2023/2024, north of Grindavik, reaching the coastal town in January 2024. It seems that the prediction of earth scientists, that a new cycle of volcanic activity in Reykjanes Peninsula has started, has come true. And we are 'lucky' to have been a witness to that, in time and space, by flying above the area in the summer of 2022 and 2023. In this newsletter you can read about the experience of flying above a volcano, an update about the ongoing activity in Reykjanes in the winter of 2023/2024 and the eruption in 2022.



Top: Crustal uplift in the Svartsengi region (Nov. 2023, see page 5), Reykjanes, Southwest Iceland. Credits IMO. Bottom: Aerial view of the Litli-Hrútur eruption in the summer of 2023. Photo: Viktor Emil Óskarsson.

Flying around the volcano

Litli-Hrútur Eruption 2023

July 12. The Litli-Hrútur eruption, two days old. Photo: Viktor Emil Óskarsson.

In the summer of 2023, there was another volcanic eruption in Reykjanes, South West-Iceland. Previous eruptions in this area, defined as the Fagradalsfjall volcanic lineament, were in 2021 and 2022. This eruption was preceded by thousands of earthquakes, whose epicentres were concentrated in Fagradalsfjall, located between two historically active volcanic complexes: Svartsengi and Krýsuvík. Svartsengi is well known to tourists for the location of the Blue Lagoon, where one can swim in a lava field filled with water heated by geothermal energy; the region of Krýsuvik is known for its many fumaroles and bubbling hot springs.

A number of earthquakes were well felt in Reykjavík, 30 km from Fagradalsfjall, where the 2021 and 2022 eruptions had also occurred (Geo-Newsletter 2023/3). The series of earthquakes in the summer of 2023 turned out to be, as earth scientists had predicted (though they kept a guard up), the harbinger of the eruption, which began as a fissure eruption in the late afternoon of 10 July.

I joined a flight on July 27th, a beautiful sunny day, with Mýflug Air. Because of the severe turbulence I became curious how it is as a pilot to fly in a area under these circumstances. Viktor Emil Óskarsson, the pilot on that flight, was willing to talk about what it is like to conduct tourist flights over an area with an active volcano.

Read the interview on the next pages.

Below: 22 July. The advancing lava front with the crater. The glowing lava wall of A'A'-lava, with degassing plumes of sulphur, is creeping in a SSE-direction at a speed of 40m/day, covering the edge of the 2022 lava field (Meradalir eruption: the dark part in the foreground with the yellow sulphur deposits). In the last week of July output decreased. The volcanic activity ceased in the first week of August. Photo (in NNE direction): Annemieke van Roekel.

A pilot's experience

Interview with Viktor Emil Óskarsson, pilot at Mýflug Air. Questions and article by Annemieke van Roekel. Original publication in Dutch in Gea Magazine 2023/3.

July 15. The eruption starts as a long fissure. After a few days, one crater remains active; it will probably go down in history as the Litli-Hrútur crater. Photo: Viktor Emil Óskarsson.

How does the volcano affect turbulence?

Viktor: "The turbulence around a volcano is directly related to the boiling magma in the cone, and to the lava flows. This causes the air to heat up and rise far up into the atmosphere. The wind direction determines where turbulence is felt. In case of northerly winds, I choose to fly north of the volcano in a WE-direction; in south winds, I fly south of the crater. This way, I avoid the turbulence as much as possible."

Are the lava flows and new lava fields also a major heat source?

Viktor: "The main heat source is the boiling magma in the cone. From here the heat spreads. But the lava flows and lava fields also create a lot of heat."

How high did we fly?

Viktor: "We flew at 1,500 feet (about 450 metres, ed.) above sea level, about 800 feet (about 250 metres, ed.) above the volcano. This is exactly according to government rules."

How do you deal with the smoke, both from the volcano and from burning vegetation?

Viktor: "We always try to stay out of the smoke because it can affect the performance of the engine. The hot smoke can reduce the efficiency of the engine."

When is a flight cancelled?

Viktor: "Besides the usual factors, such as wind speed, cloud cover and visibility, the aspect of gas pollution now plays an additional role. The presence of gases can significantly reduce visibility, which can get decreased to as low as 500 meters."

How do you personally experience flying around the volcano?

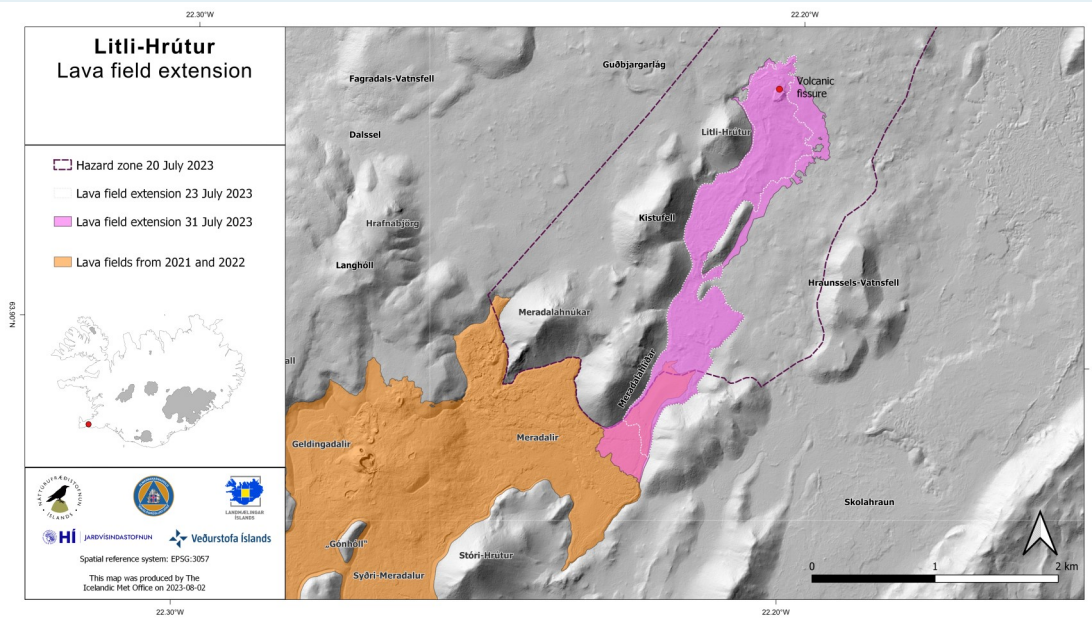
Viktor: "I love flying around the volcano. I never get tired of it, even though I have made countless flights over it. I also love how the passengers react and enjoy it. I always fly so that all passengers can see as much as possible. I tilt the wings and incline the plane so that we have more time near the volcano, a kind of horseshoe manoeuvre."

July 13. What started on 10 July as a tens of metres long fissure with elongated lava fountains soon grew into a hundreds of metres long fissure eruption, developing into a more centred lava flow, fed from some central craters. Photo: Viktor Emil Óskarsson.

Acknowledgement

Many thanks to Viktor Emil Óskarsson, pilot for Mýflug Air, for his explanation, personal impression and photo series (A-D). My sightseeing flight (of over half an hour) took place on 27 July 2023 in a Cessna 206 operated by Mýflug Air, from Reykjavík Domestic Airport.

The figures in this article come from daily updates from the (very informative and accessible) website of the Icelandic Met Office (IMO, vedur.is), the national media (such as ruv.is) and the University of Iceland (jardvis.hi.is).



Lava field extension in 2023. When the western crater wall collapsed in the night of 19 July, the lava flow changed direction and flowed southward (around 9 m^3/sec). There it filled the valleys and covered a small part of the 2022 lava field (marked in orange). Credits: IMO.

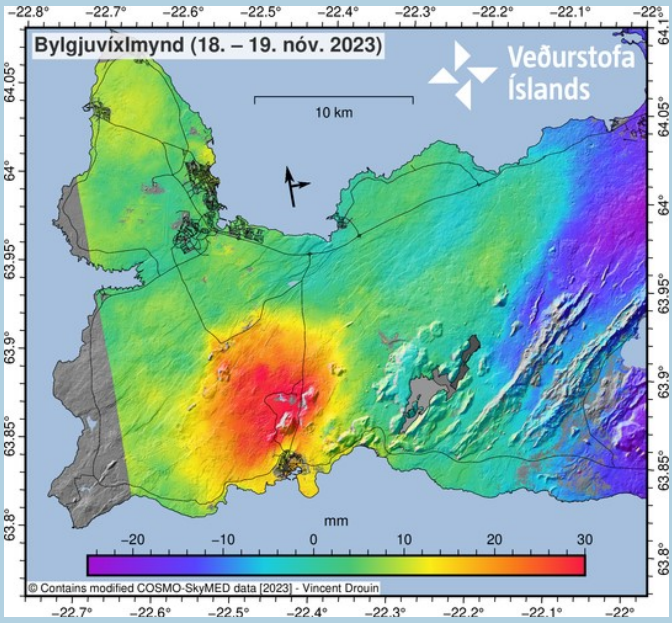
“Christmas-eruption”

Soon after the eruption of Litli-Hrútur ended, in August 2023 (as is described in the first article in this GNL-edition), a new magma tunnel formed in the area of Fagradalsfjall. This was based on GPS-measurements until October 2023. Satellite measurements from this period indicated an expansion of magma at a depth of about 10 km and seemed to show similarities to the run-up to previous magma intrusions in Fagradalsfjall.

By the end of October, another earthquake swarm began, which lead the authorities to decide to evacuate the town of Grindavik November 10th, as the chance of an eruption was deemed plausible. December 18 an eruption did finally happen at Sundhnúksgíga. Although the eruption was initially intense and the lava output large, the strength quickly diminished. This “Christmas-eruption” lasted for only three days, from 18-21 December.

The road to Grindavik in the middle, with the Blue Lagoon on the right (where steam vapours escape from the geothermal plant). The “Christmas-eruption” (18-21 December) took place where geologists had predicted it to happen. Google Earth.

COSMO-Skymed interferogram (18/19 November 2023). The orange/red area around Svartsengi is indicative of a deep inflation (>5 km). The same process of inflation is repeating itself in the beginning of January 2024. Credits: IMO.



Curbing the lava flow

North of Grindavik, a 4 km long structure is being build to protect Grindavik from a possible new lava flow. The 'wall', which should be ready in January, aims to change the direction of the lava flow. Whether it is successful or not will depend on the type of lava: the relatively liquid Pahoehoe-lava, or the more viscous a’a-type. The a’a-lava is, because of its viscosity, more difficult to stop and redirect. The area of the Christmas-eruption is, one month later, still very hot, as can be seen on this photo of the Icelandic news website, as steam is rising from the fresh lava fields. Since the eruption ended on December 21st, the land around it (Svartsengi region) started to inflate again and didn’t stop since, prof. Thor Thordarson says in an interview with volcanologist Valentin Troll on Troll’s YouTube-channel. This might be interpreted as deeper magma moving to shallower levels of about 5 km, stretching the walls and the roof of this storage zone, so increasing the pressure.

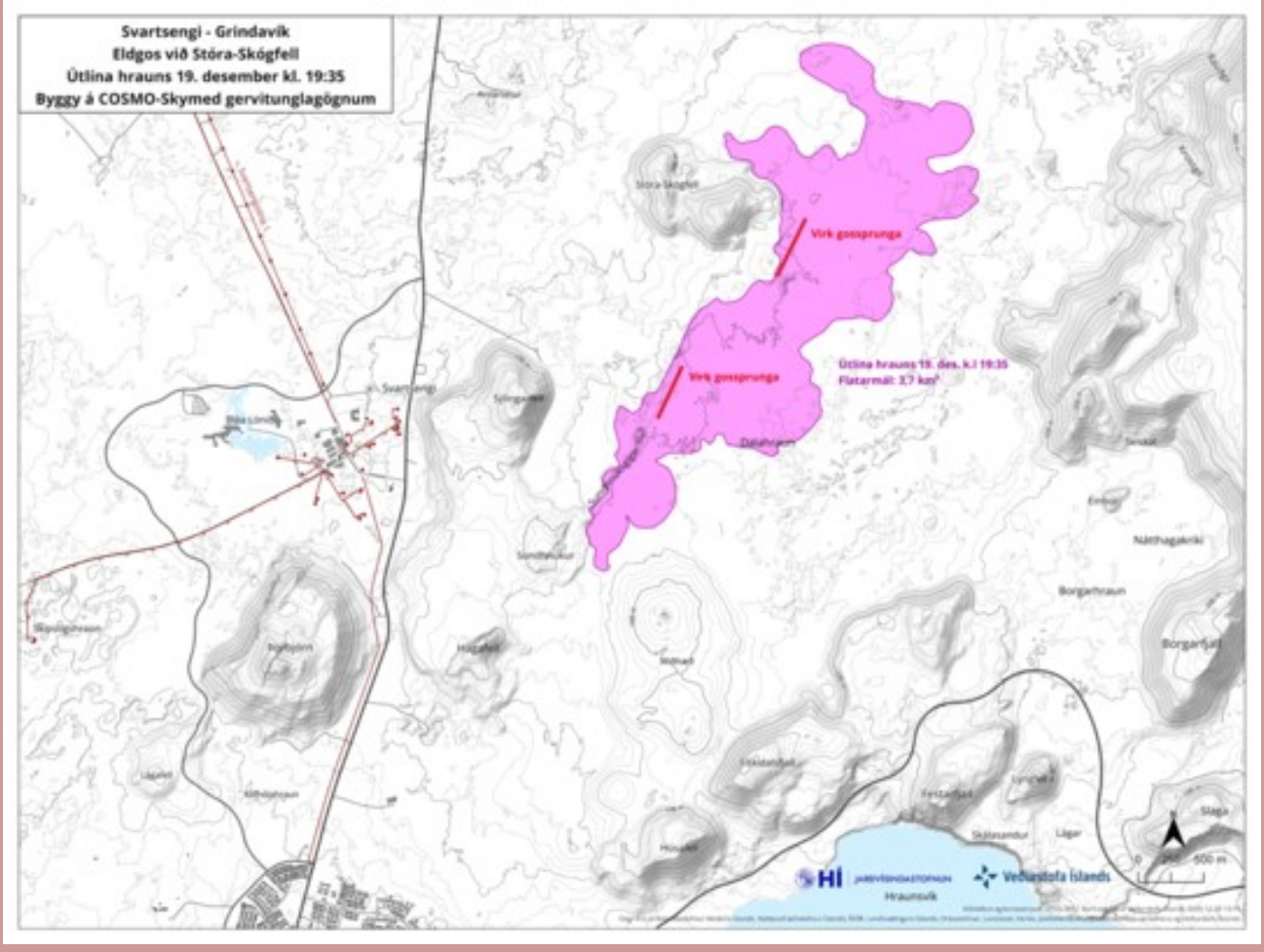
The eruption in December started as a line with lava fountains, finally concentrating to three main vents along a 4 km line. The amount of lava is about half of the lava that was erupted during the Litli-Hrútur eruption, in the summer of 2023. According to Troll, the issue of this last eruption is not the size, but the distance to settlements.

Size versus intensity

Size and *intensity* should not be confused here, according to Thordarson. In the beginning, the discharge was 50-100 m3/second, and the output peaked within a couple of hours to 350-400 m3/second. After that, it dropped, according to the volcanologist. As the output rate was high, but it lasted only about six hours, one could conclude that the intensity (output rate) was high, and the total volume was low.

If another eruption will happen, Thordarson expects it to be similar, but starting slower and lasting a little longer.
You may read the latest news on the website of IMO.

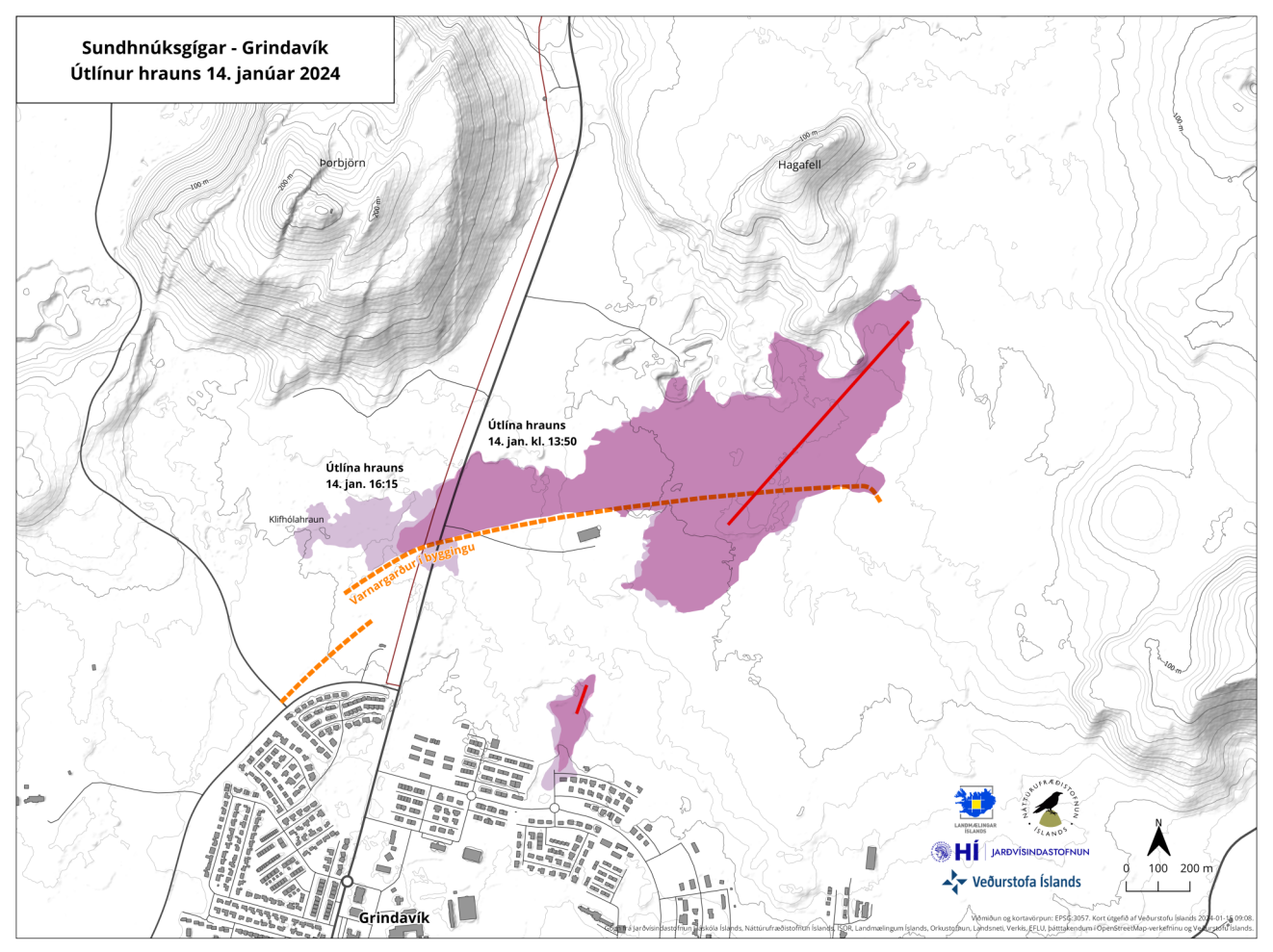
The new lava field as observed on December 19th. Most of the lava output happened on the first day of the eruption. This "Christmas eruption" had a high intensity, but was fairly low in total output. Credits: IMO/HI.



Update eruption January 2024

Only eight hours after we put this GeoNewsletter online, there was another eruption in the area of Grindavik. In the early morning of January 14th a new fissures appeared.
The construction that was supposed to protect Grindavik from a lava flow functioned to divert the lava. However these protective barriers were not sufficient, as a second fissure opened south of the wall. The lava creeped downhill and three houses on the northern edge of the town were put into ashes the first day of the eruption.
RÚV television controlled five webcams, providing a view that covered the entire fissure. Also many drones gave an interesting view, notwithstanding the dramatic effect on the population.
The next day, the lava flow from the southern fissure stopped and the other lava flows decreased. The very last developments can be read on the website of IMO.

Orange dots: protective barriers. Dark purple colour: fresh lava early afternoon January 14th; light purple: two hours later. Red lines: fissures. Source: IMO /HI.



Southwest Iceland awakens from long hibernation

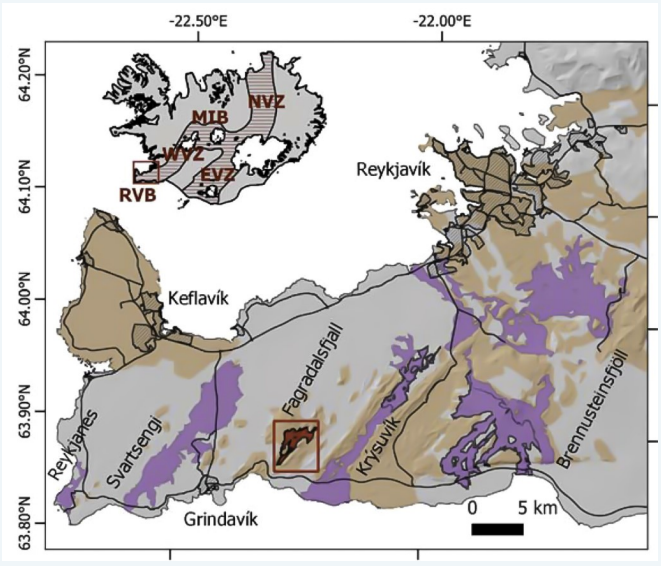
After almost eight hundred years of volcanic silence, there were eruptions again in 2021 and 2022 on Reykjanes Peninsula, in the extreme southwest of Iceland. In the valleys of Fagradalsfjall and adjacent Meradalir, where both eruptions occurred, there had been no volcanic activity for even 3000 years.

Article by Annemieke van Roekel. Link to original publication in Dutch in Gea 2022/4.

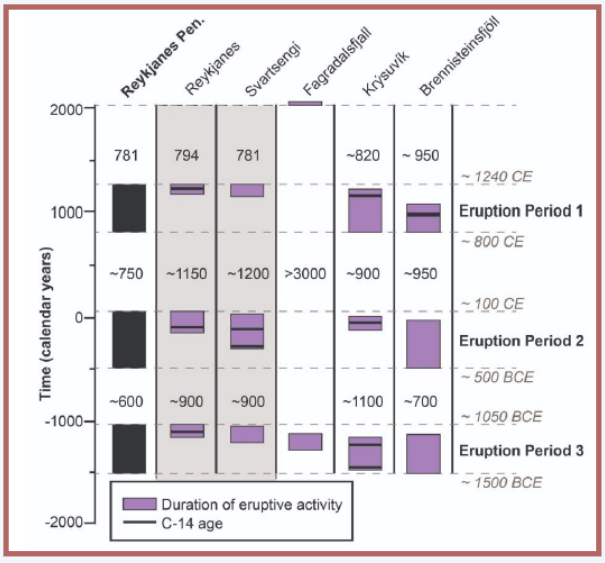
The moss-covered lava fields in the Fagradalsfjall volcanic zone date back to the Pleistocene. Photo: Annemieke van Roekel.

What we call "Iceland" is the subaerial part of an active volcanic platform in the middle of the Atlantic Ocean. Its position above sea level is the result of seafloor spreading of the Mid-Atlantic Ridge in combination with the presence of a hotspot. This hotspot has been active for a little less than 70 million years and is now presumed to be located under the Vatnajökull glacier.
The main active fault systems on and around Iceland run from the southwest (Reykanes Rift-RR) via a kind of forkshape to the north, to disappear under water again with the Kolbeinsey Ridge (Fig. below left).

What is special about the Reykjanes Peninsula is that the transition from the central Iceland plume plateau to the Mid-Oceanic Ridge comes ashore here! Reykjanes, like parts of Central Iceland, is characterized by so-called 'fissure swarms': concentrations of spreading zones.



The main spreading zones in Iceland. Reykjanes Peninsula with the (historical) eruption zones. Brownish: Late Pleistocene <0.7 Ma; grey: Postglacial/prehistoric; purple: historical eruptions 700-1200 AD. Inset: 2021 Fagradalsfjall eruption zone. Source: Bindeman et al, 2022.



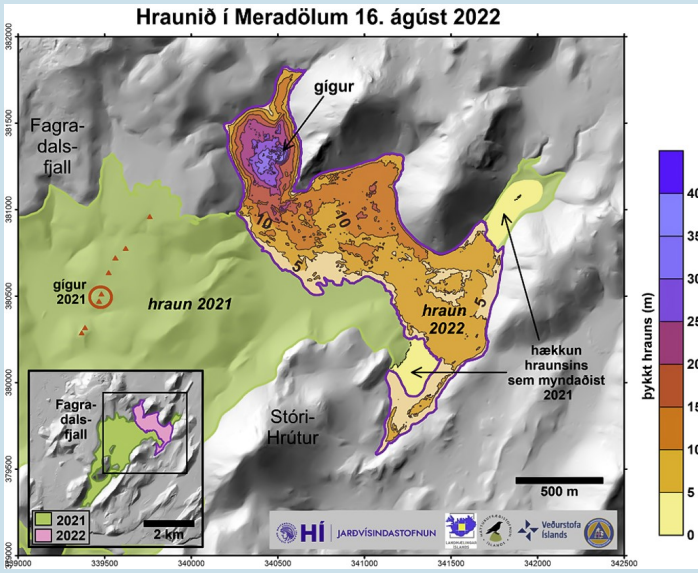
Volcanic activity on Reykjanes Peninsula over the past 4000 years in the five volcanic zones, pictured in the image left. The activity has a cyclical character. The Fagradallsfjall complex was inactive for a longer period than the other four zones. Source: Bindeman et al, 2022.

In August 2022, the Meradalir Valley filled with fresh lava as the Fagradalsfjall complex became active again within one year. Over the course of 2.5 weeks, a new cone formed; the eruption began as a fissure volcano. Photo: Valentin Troll, on Aug. 15. With permission.

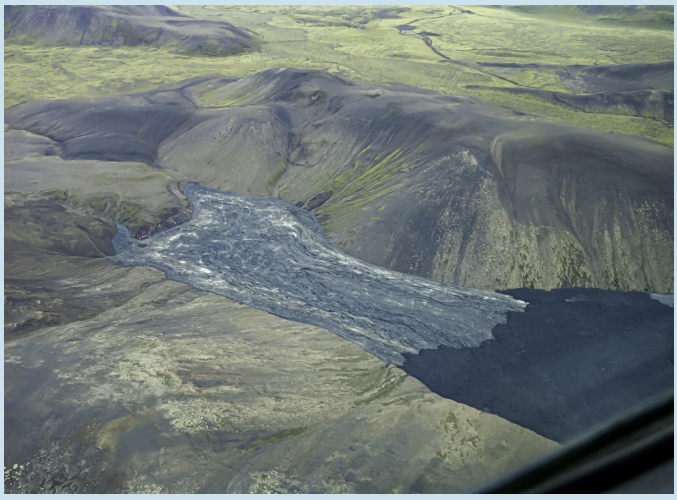
Once on land, the Mid-Ocean Ridge on the Reykjanes Peninsula merges into the Reykjanes Volcanic Belt (RVB); here – from west to east – five parallel, broadly SW-NE running fissure swarm zones are visible: Reykjanes, Svartsengi, Fagradalsfjall, Krýsuvik and Brennisteinsfjöll.

The Fagradalsfjall volcanic complex was the longest inactive on the peninsula for about 3000 years; the area was volcanically active during the Weichselian, under a complete cover of glaciers, and also during the Holocene, when Iceland was not yet inhabited.

The volcanic activity in all five volcanic fissure swarm zones of Reykjanes shows a cyclicity of 500 years per millennium. If we extrapolate that cyclicality, the eruptions of 2021 and 2022 could mark the start of a new period of volcanism on Reykjanes Peninsula. At least that is what volcanologists think (Bindeman et al., 2022). Valentin Troll, a volcanologist at Uppsala University and specialist in oceanic islands, collected and analyzed rock and gas samples from both eruptions. He expects more eruptions on Reykjanes Peninsula in the coming decades, probably small and harmless like this year's, and very attractive to tourists. The next eruption could take only a year or two to come.



The lava from the 2022-eruption has flowed over the lava from 2021, as can be clearly seen on this aerial photo (below) and the figure above (arrow on the far right). Photo: Annemieke van Roekel.



In some spots, the new lava (2022) has remobilized portions of the older 2021 lava, where it has reheated the (sometimes still warm) interior lava of older pahoehoe flows. As a result, it has become vicious again and set in motion. Pressure from the reactivated ancient lava flow has broken the solidified crust of 2021 pahoehoe lava. Below right: Close-up of broken pahoehoe lava. An intriguing phenomenon, according to Valentin Troll, and "a unique opportunity to study lava flows in such rapid succession. In the rock record we would not be able to distinguish this sequence and would see this as one eruption. The 2022 eruption has even led to new eruptions in the old lava field. Plumes of smoke, however, did not always indicate new eruptions. Sometimes the sparse vegetation was on fire." Photos: Valentin Troll, with permission.

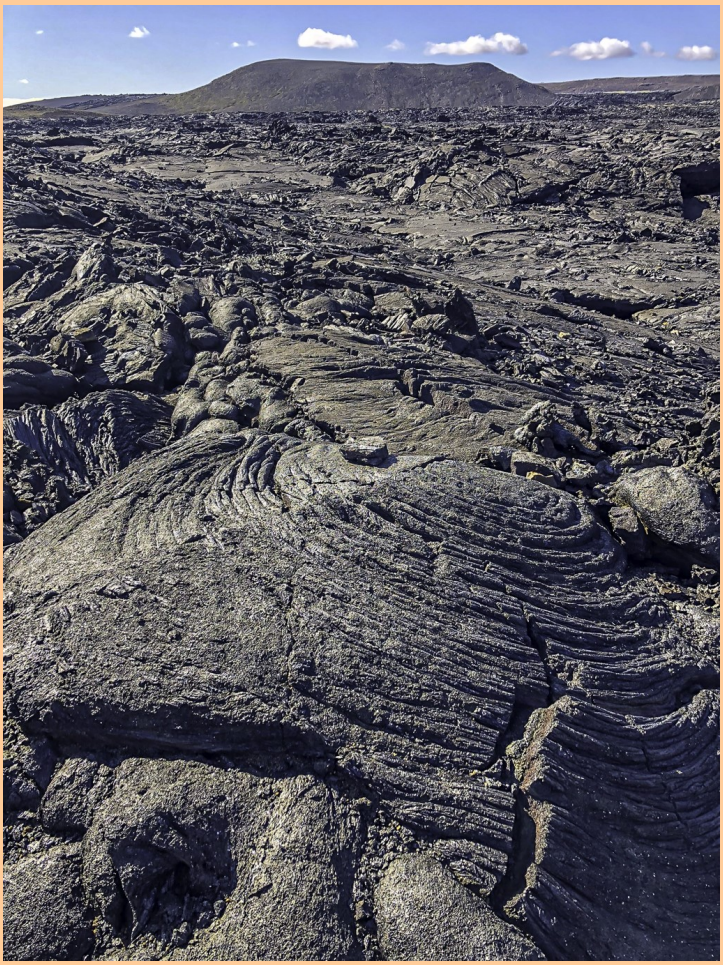
However, Reykjanes Peninsula is vulnerable to volcanic activity due to potential damage to infrastructure. The area around Fagradalsfjall swelled a few millimetres due to rising magma, and the swelling decreased after the eruption. This land deformation is measured with InSAR technology, using radar from satellites.
Troll: "At a distance of about 6 km from the active zone, there is both an important geothermal power plant and the tourist attraction 'Blue Lagoon'. An eruption of 1000 years ago is known in which the lava flowed all the way to the north coast, where the highway between Reykjavik and the international airport now runs. This makes this part of Iceland especially vulnerable to volcanic activity.

This photo series aims to give a picture of the volcanic activity in the summer of 2022, when the (later named) Meradalir volcano erupted for 2.5 weeks, after starting as a 100 -meter long fissure volcano. Just like in 2021, the natural phenomenon attracted many volcano enthusiasts.

Sources and reading suggestions

- Bindeman, I.N., Deegan, F.M., Troll, V.R. et al. Diverse mantle components with invariant oxygen isotopes in the 2021 Fagradalsfjall eruption, Iceland. Nat Commun 13, 3737 (2022). https://doi.org/10.1038/s41467-022-31348-7. Incl. supplementair materiaal.
- Thordarson & Höskuldsson (2022). Iceland. Dunedin Press.
- Interview with Valentin Troll, September 8, 2022.
- www.youtube.com/@ValTroll

Top: The active cone of the Meradalir eruption. Photo: Ellen Everts.
Below: Pahoehoe Lava from the 2021 eruption, solidified in beautiful ropy structures. Photo: Phiny van Roekel.



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Spring 2024:

- Special issue about Italy (bilingual)

Summer 2024:

- La Palma's growing pains

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