The Laki Fissure eruption, 1783-1784

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In 1783, a mysterious dry fog enveloped the continent of Europe, blood-red sunsets were reported throughout the summer, and many reported a sulfuric smell, breathing difficulties and sore eyes. The Europeans were unaware that this was the result of a devastating event unfolding in Iceland. Many other phenomena were recorded throughout the year, including earthquakes and unusually frequent thunderstorms, leading to 1783 being dubbed an annus mirabilis, a year of awe. What could have caused these phenomena? Could these phenomena possibly all be connected?

1. Iceland—The land of ice and fire

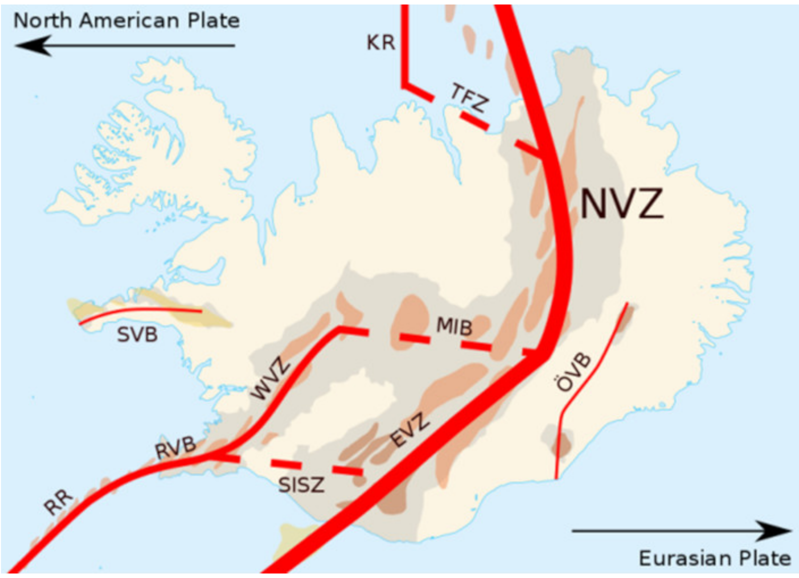

Figure 1. Iceland's location on two tectonic plates. The location of the Mid-Atlantic Ridge is shown here as a bold red line. The major volcanic zones are also indicated. [Source: Psiĥedelisto (add fault lines), Chris.urs-o (iceland outline) [CC BY-SA (https://creativecommons.org/licenses/by-sa/3.0)]

On June 8, 1783, it began. In the highlands in southeastern Iceland, a **volcano** erupted. A **27-kilometer-long fissure** tore through the landscape, beginning an eruption, which would last until February 7, 1784.

Iceland is often referred to as a land of "ice and fire." It's home to many volcanoes and, due to its location in the North Atlantic and its proximity to the Arctic Circle several glaciers. Geologically speaking, Iceland is very young. It formed over the past 24 million years, due mainly to two geological phenomena: Firstly, the fact that it is located at a diverging plate boundary, also known as a constructive plate boundary, as new crust is created here by the **Mid-Atlantic Ridge**. Iceland, perched upon both the Eurasian plate and the North American plate (Figure 1), grows by about two centimeters a year, one centimeter to the east and one to the west. Secondly, that it is located on top of a **mantle plume**, which is also known as a hot spot: A mass of relatively hot and therefore less dense mantle materials rise up from the Earth's mantle towards the surface where it produces volcanism.

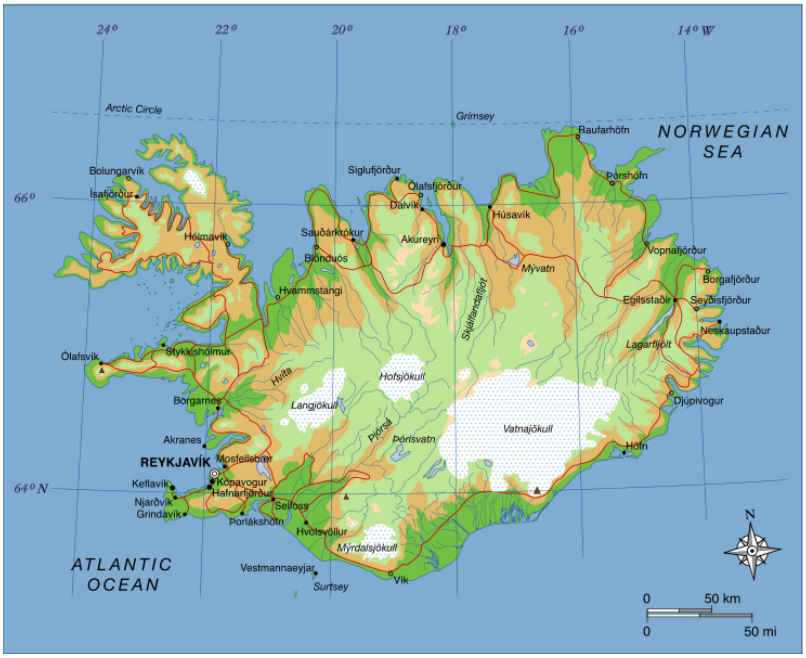

Figure 2. Iceland and the location of the Laki Fissure, indicated by a red line to the SW of Vatnajökull. [Source:Max Naylor [Public domain]]

Iceland is divided into various volcanic zones, which make up a third of Iceland's landmass (Figure 1). It is further divided into thirty volcanic systems, with a wide range of different volcano types. The Laki fissure eruption is located in a system called Grímsvötn. **Grímsvötn** is Iceland's most productive **volcanic system**, fed by a central volcano of the same name that is located underneath the Vatnajökull ice shield. This system on average produces one volcanic eruption every 2-7 years. [1]

Figure 3. The delta of the Skaftá river in southern Iceland. [Source: Bjoertvedt [CC BY-SA (https://creativecommons.org/licenses/by-sa/3.0)]]

This volcanic eruption **produced 14.7 cubic kilometers of lava**. [2] The event was composed of ten eruptive episodes, each one beginning with strong earthquakes, followed by explosive activity, resulting in a new fissure segment. The entire fissure consists of around 140 craters, vents, and cones in a SW-NE direction, all the way to the Vatnajökull ice sheet, Iceland's largest glacier (Figure 2). The total amount of lava produced **covers an area of 599 square kilometers**. [3]

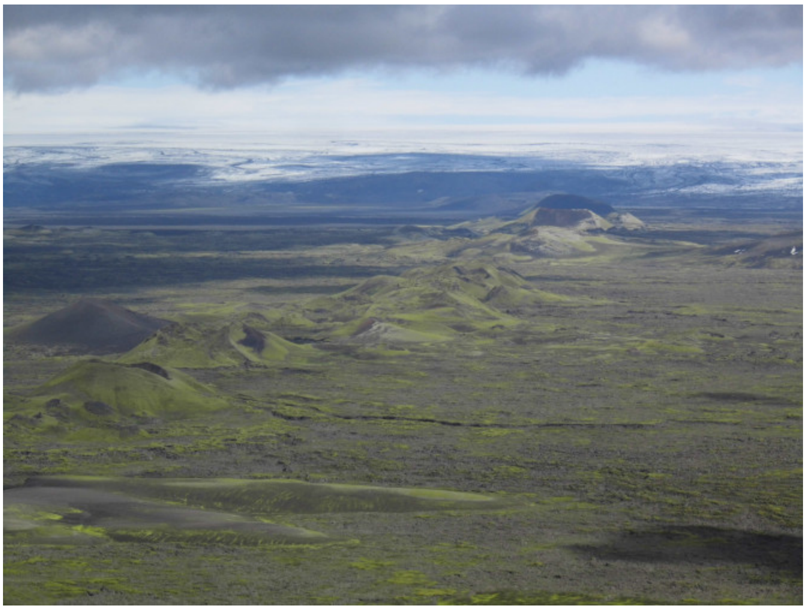

Figure 4. The NE part of the Laki Fissure, as seen from Mount Laki. In the distance, Vatnajökull is visible, Iceland's largest glacier. [Source: Photo © Katrin Kleemann]

The fissure is located at around 600 meters above sea level, whereas the coastal areas are much lower. Kirkjubæjarklaustur, a settlement on the southeastern coast, is located at 35 to 40 meters above sea level. So naturally, the large volumes of lava travelled downhill towards the coastal plains. The lava travelled, for the most part, via river beds, mainly through the Skaftá and Hversfljót, two glacial rivers that normally flow from Vatnajökull to the Atlantic Ocean. Skaftá (Figure 3), was devoid of water, lava lay in its stead. [4]

This volcanic eruption is known by many names: Its **Icelandic name, *Skaftareldar***, comes from the fact that the eruption took place in the *Skaftarfellssysla*, a region of Iceland, and that it replaced the Skaftá with lava. The crater row is also known as *Lakagígar*, meaning the craters of Laki. The name Laki comes from Mount Laki, a mountain of volcanic origin that did not actually erupt in 1783, located roughly in the middle of the fissure (Figure 4). In English, the eruption is mainly known as the Laki Fissure eruption. The term "Laki" was suggested by Norwegian geologist Amund Helland almost one hundred years after the eruption, it was also chosen for its brevity and easiness to pronounce. Sometimes, it is also referred to as the **Laki eruption**.

2. The course of the eruption and the consequences for Iceland

This lava threatened many Icelanders, their animals, and property. A small number of churches and farmsteads fell victim to the lava. Icelanders were able to evacuate before the lava arrived. A very important local chronicler, who kept records on the events unfolding in Kirkjubæjarklaustur and what he could observe from a distance about what was happening in the highlands, is **Jón Steingrímsson**. He was a local reverend. He became famous for his autobiography and his "fire treatise," that described the events, and is well known as the "**fire priest**." On July 20, 1783, lava crept to within a few meters of his church, in Kirkjubæjarklaustur, as he began mass. After his sermon, known as the "fire sermon," the parishioners were astonished to find the lava in the same spot where it had been when mass began. Steingrímsson, it seemed to his parishioners, had prevented the lava from engulfing and consuming the church.

The eruption had produced large amounts of gases and ash too. The gases, particularly the fluorine, poisoned the fields, meadows, and ponds. 50% of all the cattle, 79% of the sheep, and 76% of the horses perished between 1783 and 1785, in addition to fish in ponds and other animals [5]. In Iceland, the eruption is also remembered by its consequence: The **famine of the mist**, or Móðuharðindin. The Icelandic diet at the time was mainly based on meat and fish, so the fallout of this eruption was catastrophic. By 1785, **roughly 20 percent of the Icelandic population had perished**—from hunger, malnutrition, or diseases.

Iceland was under a **Danish trade monopoly**, which meant that only certain Danish merchants were allowed to trade with Iceland at specific trading posts around the country. Usually, these merchants arrived in the spring and left in late summer or early autumn. News about the volcanic eruption reached Copenhagen in early September 1783, and so, the Danish king, Christian VII, decided to send a party to Iceland to survey the damage caused by the eruption. However, due to adverse weather conditions, the surveyors did not arrive until the spring of 1784. It took until the 1810s for the population in Iceland to get back to its pre-1783 levels.[6]

3. Impacts on the world outside of Iceland

3.1. Extraordinary weather phenomena and signs in the sky

What makes this eruption so extraordinary is that its impacts reached far beyond the borders of Iceland. The gas was transported to Europe via the jet stream, where it became observable as a **sulfuric-smelling dry fog**. The contemporaries in Europe were oblivious to the fact that a volcanic eruption had occurred in Iceland at the same time and was causing this unusual dry fog. The most worrisome feature of the summer of 1783 was perhaps the **"blood red" coloring of the sun** during sunset and sunrise. Stars and planets became invisible in the lower degrees above the horizon—very similar to the appearance of smog in large cities today.

In 2010, when Eyjafjallajökull erupted, the world was reminded of Icelandic volcanism and its almost global consequences: The plume of ash and gas was carried from Iceland towards Europe via the jet stream, grounding international air traffic for several days. Even before the onset of international aviation, Icelandic volcanic eruptions proved troublesome for the outside world.

Figure 5. The view from Benjamin Franklin's terrace in Passy on November 21, 1783. This was the first untethered and manned journey of a Montgolfière hot air balloon. Vue de la terrasse de Mr. Franklin a Passi by an anonymous engraver, Paris : Le Vachez : 1783. [Source: Bibliothèque nationale de France, département Estampes et photographie, FOL-IB-1. (In the public domain).]

In early June 1783, two brothers in Annonay, France, had demonstrated the first flight of a hot air balloon (Figure 5). Jacques and Étienne Montgolfier named this new invention in their honor, calling it a Montgolfière. The race to the skies had begun: This would not remain the last balloon to ascend into the skies in France in 1783. Other inventors, such as Anne-Jean Robert, Nicolas-Louis Robert, and Jacques Charles were working on a hydrogen balloon [7]. While the "**ballomania**" [8] took hold, these "flying globes" were not the only unusual phenomenon to occupy the skies and people's imaginations that year.

Several extraordinary weather phenomena occurred throughout 1783**—the *annus mirabilis*, the year of awe**. Among them, a sulfuric-smelling dry fog that lasted for several weeks and that was observable from around June 16 in most parts of Europe and beyond. It was visible as far away as Labrador in today's Canada, Syria, the Lebanon, and even the Altai Mountains on the border to China. [9] It varied in density, winds from the northwest seemed to strengthen it, whereas winds from the south seemed to disperse it. During the summer of 1783, the contemporaries in Europe were left alone to **speculate about the fog's origin.**

The dry fog was mainly caused by **sulfur dioxide** (SO_2) that had been released during the eruption, the gases are believed to have reached an altitude of 9-12 kilometers. Above Iceland, the tropopause is at approximately 8-11 kilometers of altitude. The lower level of the atmosphere is called the troposphere and the level above is called the stratosphere. Generally, if volcanic gases only reach the troposphere, they are washed out within weeks and there is no long-term impact on the climate. If volcanic gases reach the stratosphere, they will remain in the atmosphere for longer and have lasting impacts on the climate, perhaps for up to three years. Scientists working on the Laki Fissure eruption are divided on whether most of the Laki gases were able to reach the stratosphere. Once the sulfur dioxide reached the tropospause, it was transported towards Europe via the polar jet stream, here the sulfur dioxide chemically reacted with the moisture, which produced sulfuric acid (H_2SO_4). An **unusual anticyclonic**

weather pattern above Europe, a quasi-stationary high-pressure cell, funneled the Laki gases down to the surface level, where it materialized as a sulfuric-smelling dry fog. [10]

In addition, the summer of 1783 was hot in north, west, and central Europe. This is particularly unusual, as normally cooling is expected after a large volcanic eruption. The heat wave was most likely related to this high-pressure cell. [11]

The dry fog was peculiar, long-lasting, and may have had some **negative impacts on vegetation and human health** in mainland Europe. A sticky substance was said to have formed on leaves of plants, it was called "**honey dew**." Particularly around June 24-25, in the Netherlands and Northwest Germany, almost over night, plants were heavily affected. Several **plants withered**, leaves changed their color or the trees lost their leaves altogether, but not all species were affected the same. At the same time, chemical reactions on metal were observed, structures rusted or turned green. The dry fog hit hardest those suffering from pre-existing **respiratory or heart issues**. In several regions, people complained about **sore eyes**. There are studies for England and France that analyze whether the heat, the dry fog, or several factors together may have caused a **higher than usual mortality rate** in the population. It remains unclear if it was indeed this fog that caused this, or an unrelated outbreak of another kind.

Other contemporary reports argued against the **fear mongering**: Reports from the eldest community members and close study of older chronicles suggested that similar events had occurred in the past and they were always followed by fertile years, indicating that there was nothing to worry about. Indeed, the **grape harvest of 1783** seemed to have been **extraordinarily successful**, most likely aided by the very warm summer.

The summer also saw a large number of **severe thunderstorms**, which brought with them frequent lightning that killed many people. The **practice of ringing church bells to reroute the storm clouds** when thunderstorms were approaching undoubtedly helped those figures (*clocher de tourmente* in French). The recent invention of the lightning rod and a sudden increase in their popularity throughout the summer of 1783, led to a law abolishing this practice in many regions [12].

3.2. Speculation about the cause of the unusual weather

Figure 6. The earthquake of February 5, 1783. The earthquakes caused severe damage and destruction in Messina (in the foreground) and Reggio Calabria (in the background), killing and injuring thousands of residents. [Source: Public Domain]

The possible explanations for the unusual weather of 1783 were numerous:

By far the most popular explanation for the presence of the dry fog was the **numerous earthquakes** that seemed to have occurred throughout the year: In February and March 1783, a seismic sequence of five very strong earthquakes shook Sicily and Calabria, causing an estimated 30,000 casualties (Figure 6).[13] Other earthquakes occurred throughout the summer: On July 6, an earthquake shook parts of France, and was felt in Franche-Comté, the Jura, Burgundy, and Geneva. This earthquake did not produce much damage, but it occurred when the dry fog was still dense and wide-spread. Another earthquake occurred on the night from August 7 to 8, affecting Northern France, and the areas between Aachen and Maastricht. Another major earthquake hit Tripoli, Lebanon, on July 30. [14] Many contemporaries believed they were living in a time of "**subterraneous revolution**" and there were reports of a "**newly emerged burning island**" that was discovered by fishermen in May 1783 off the coast of Iceland. This island was said to have been emitting smoke and surrounded by pumice, floating on the ocean surface, impeding sea travel. This island was called *Nyey* (“new island”) and was fussed over in the news during the summer and almost forgotten by the time continental Europe heard of the Laki Fissure eruption. [15]

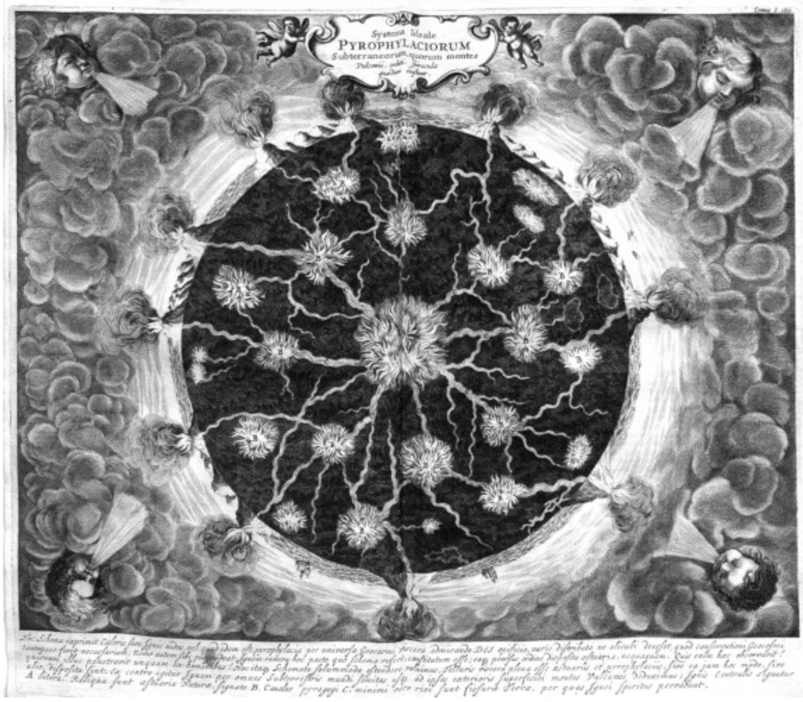

Figure 7. A map of the Earth’s fire canals (Subterraneus Pyrophylaciorum), which he believed to connect all the volcanoes in the world. This map is from Athanasius Kircher’s Mundus Subterraneus, 1668. [Source: Public Domain]

All of these reports of earthquakes gave credence to the idea of a “subterraneous revolution” connecting the “upheaval” in Iceland, Calabria, and the Lebanon with one another. It was believed that volcanoes around the world were connected by subterraneous canals (Figure 7). There also were reports of a dry fog that occurred just before the first earthquake in Calabria, thus spreading fear that this dry fog might only be a harbinger for a large earthquake that was to come. The idea to connect earthquakes and the dry fog was probably also aided by the fact that the various hundreds of aftershocks in Calabria and Sicily occurred while the dry fog was still visible in southern Italy.

There also were reports of “**fire spitting mountains**” that had erupted in three different parts of **Germany**: The most famous one being the Gleichberg in Thuringia. The reports were surprisingly accurate in describing the process of a volcanic eruption and it is debatable whether these were genuine explanation attempts to describe the origin of the dry fog locally or whether they were clever hoaxes to spread fear. [16] The reports were later retracted after people had visited these areas only to realize the extinct volcanoes hadn’t inexplicably sprung back to life. The idea of volcanic eruptions, though, fit very well with the above-mentioned theory of a subterraneous revolution.

Figure 8. Henry Robinson, "An accurate representation of the meteor" as seen at Winthorpe, Nottinghamshire, England, on 18 August 1783. [Source: Henry Robinson / The Trustees of the British Museum. This image is in the online collection of the British Museum. (CC BY-NC-SA 4.0).]

On August 18, 1783, another phenomenon made people turn their heads skyward: A very bright and unusually long-lasting meteor, called "**the Great Meteor of 1783**" was visible from Ireland, Scotland, England, France, Belgium, and the Netherlands (Figure 8). At the time, an extraterrestrial origin of meteors was not yet widely accepted: There was no clear distinction between meteors and comets. Meteors were believed to be either produced by vapors in the atmosphere or by electricity in the upper atmosphere, similar to the phenomenon of the northern lights. [17] Benjamin Franklin, the American ambassador to the United States, naturalist, and inventor, who was in Paris at the time, speculated whether "the tails of these great burning balls" **might have caused the dry fog**.

Figure 9. The United States delegation at the Treaty of Paris: John Jay, John Adams, Benjamin Franklin, Henry Laurens, and William Temple Franklin, as depicted by Benjamin West. The British delegation refused to pose, which is why the painting was never completed. [Source: Benjamin West [Public domain]]

Benjamin Franklin further speculated, in May 1784, that there also was a connection between the dry fog and the extremely cold winter of 1783/1784. The **winter had been extraordinarily cold**, not only in Europe, but also in North America. In Europe, there was **heavy snow**, which resulted in **major floods** along several central and western European rivers in February and March of 1784. In Germany, the water levels of late February 1784 produced the highest or second highest flood markers ever recorded for some regions. [18] In North America, the winter was unusually long, was rich in snow, and even froze the Mississippi river at New Orleans and created ice floes in the Gulf of Mexico. [19] The severe winter conditions made it difficult to assemble enough congress members in Annapolis in order to have a quorum to ratify the Treaty of Paris, which ended the American Revolutionary War (Figure 9). Once the quorum was reached and the treaty was ratified, it was difficult to get a passage across the Atlantic Ocean in order to bring it to Paris to exchange it with the ratified treaty of the British. [20]

While the debate about the origin of the dry fog was primarily inspired by the **Enlightenment** and the thirst for a rational explanation, there also were some religious arguments made.

3.3. Speculation about a connection between the dry fog and icelandic volcanism

A handful of contemporary naturalists considered a **connection between the dry fog and volcanic eruptions in Iceland**. Most suggested that there might be a connection between the unusual weather phenomena of the summer and either the Nyey eruption or the eruption in the Skaftárfellsysla region when they learnt about them in the news in early to mid-September of 1783. The first to propose such an idea was Jacques Antoine Mourge de Montredon, a French naturalist, who presented his findings in front of the Société Royale des Sciences de Montpellier on August 7, 1783. Christian Gottlieb Kratzenstein, a German naturalist and professor for physics at the University of Copenhagen also connected Icelandic volcanism, with which he was familiar, with the dry fog. Swiss naturalist H. Guerin also came to a similar conclusion, his findings were published in *Neue Zürcher Zeitung* on November 5, 1783. Johann Rudolf von Salis-Marschlins, also a Swiss naturalist, published his findings on the topic in *Der Sammler: Eine gemeinnützige Wochenschrift für Büntgen* in mid-November 1783. Belgian botanist and baron Eugène de Poederlé published a text about his observations made in Brussels in early 1784.

In May 1784, Benjamin Franklin, who had suggested the dry fog might have been caused by the meteor, also suggested alternatively that Icelandic volcanoes—either Nyey or Hekla—might have been responsible. [21] However, all this speculation remained just that for a long time.

4. The search for the origin of the dry fog

When the news of an Icelandic volcanic eruption reached Denmark, the mystery about the dry fog was not lifted. It was only in **1794**, that Icelandic naturalist and physician **Sveinn Pálsson discovered the Laki Fissure** in the highlands. Pálsson described his discovery in his manuscript, which he sent to Copenhagen, but remained unpublished for financial reasons. In 1879, Icelandic geologist Thorvaldur Thoroddsen stumbled upon the manuscript at the Royal Library in Copenhagen and subsequently published part of it in 1879. Norwegian geologist Amund Helland also took an interest in this and upon Thoroddsen's suggestion visited the Laki Fissure in 1881, he also drew a map of the craters and lava fields. Thoroddsen visited the fissure in 1894. [22]

In **1883**, another volcanic eruption made global news: In the Dutch East Indies, a volcano called **Krakatau** produced the loudest noise ever recorded, ejected large amounts of gas and ash, and triggered a tsunami. The eruption is estimated to have killed 35,000 people. Despite Krakatau's distance from Europe, the news about the eruption spread fast–thanks to the advent of telegraphy. [23]

This large volcanic eruption inspired several scientists into action, who collected information from professional and amateur weather observers from all around the world. They realized for the first time that volcanic eruptions can have impacts on the sky and weather phenomena far, far away from the actual volcano. In the aftermath of the 1883 Krakatau eruption, colorful sunsets and vibrant colors of the sky were observed in Europe and North America. Thus, **in the 1880s, the dots between the Laki Fissure eruption and the strange haze of the summer of 1783 could finally be connected**. [24]

5. The Laki Fissure today

Figure 10. A photo from the center of the Laki Fissure. [Source: Chmee2/Valtameri [CC BY-SA (https://creativecommons.org/licenses/by-sa/3.0)]

Today, Iceland is an independent country with a population roughly seven times the size it was in 1783. Iceland performs well in many indices that measure quality of life, happiness, and equality. Iceland is far from the marginal country it was 250 years ago. In the last few decades, **Iceland has become a popular tourist destination** and Iceland is welcoming record numbers of tourists each year. This of course has some **environmental consequences**.

The **Vatnajökull National Park** was established in 2008 and now also **incorporates the Laki Fissure** (Figure 10). The increase in tourism to Iceland also leads to an increasing number of visitors to the fissure. The Laki Fissure is difficult to reach. From Kirkjubæjarklaustur it is an eight hour round trip on a four-wheel bus. Although only 50 kilometers from the village, traversing bumpy dirt roads, kn

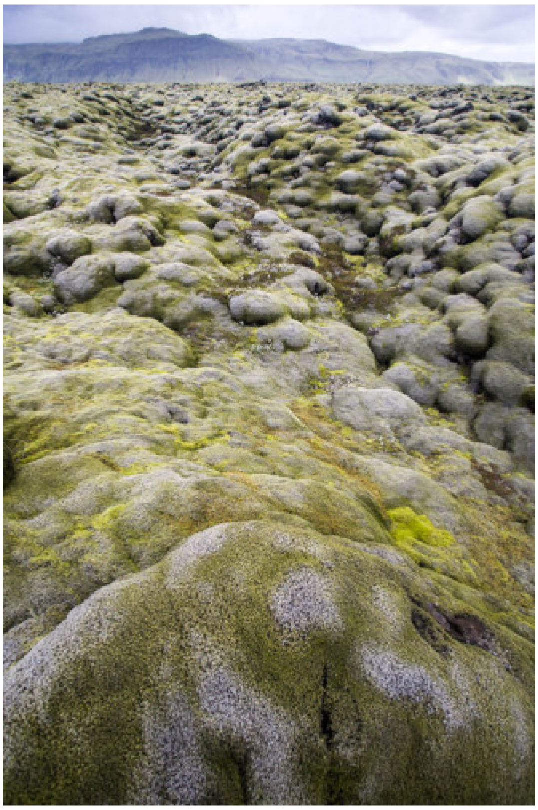

Figure 11. The moss on the lava fields that were produced by the 1783-1784 eruption. [Source: Onioram [CC BY-SA (https://creativecommons.org/licenses/by-sa/4.0)]]

own as F-roads, takes time. Additionally, the journey requires the fording of several rivers. [25]

Sadly, not all tourists respect nature, some leave rubbish behind and others leave the designated pathways. On the *Skaftáreldahraun*, the Laki lava field, a **very delicate sort of moss** is growing, painting the hills around the Laki Fissure with a lush light green (Figure 11). This moss, due to the altitude and high latitudes, is very sensitive and takes decades to grow. If it is stepped on, it turns brown and dies. Several warning signs educate visitors and the efforts of volunteer conservationists have led to wooden paths being built that visitors can step on. [26]

Large flood lava events such as the Laki Fissure eruption have a **recurrence time of 300-1000 years.** However, in Iceland, the next volcanic eruption is never far away: On average, **Iceland sees a volcanic eruption every 3-5 years**. Today, Iceland monitors its volcanoes carefully and gives locals and travelers a warning to evacuate once the threat of a volcanic eruption is imminent. It is important to understand the consequences of Icelandic volcanic eruptions on Europe and the northern hemisphere so that we may act accordingly in the future.

6. Messages to remember

The Laki Fissure eruption of 1783 shows that volcanic eruptions can have impacts on regions far away from the actual volcano.

Sometimes, these effects might be fairly long lasting, even perturbing weather patterns to the extreme.

This extreme event during the Little Ice Age shows how contemporaries dealt with sudden and extreme weather changes, these lessons may become very useful in our own present and future in a warming world.

Notes et références

Cover image. The southwestern part of the Laki Fissure in Iceland, as seen from Mount Laki. [Source: Photo © Katrin Kleemann. (Used by permission).]

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