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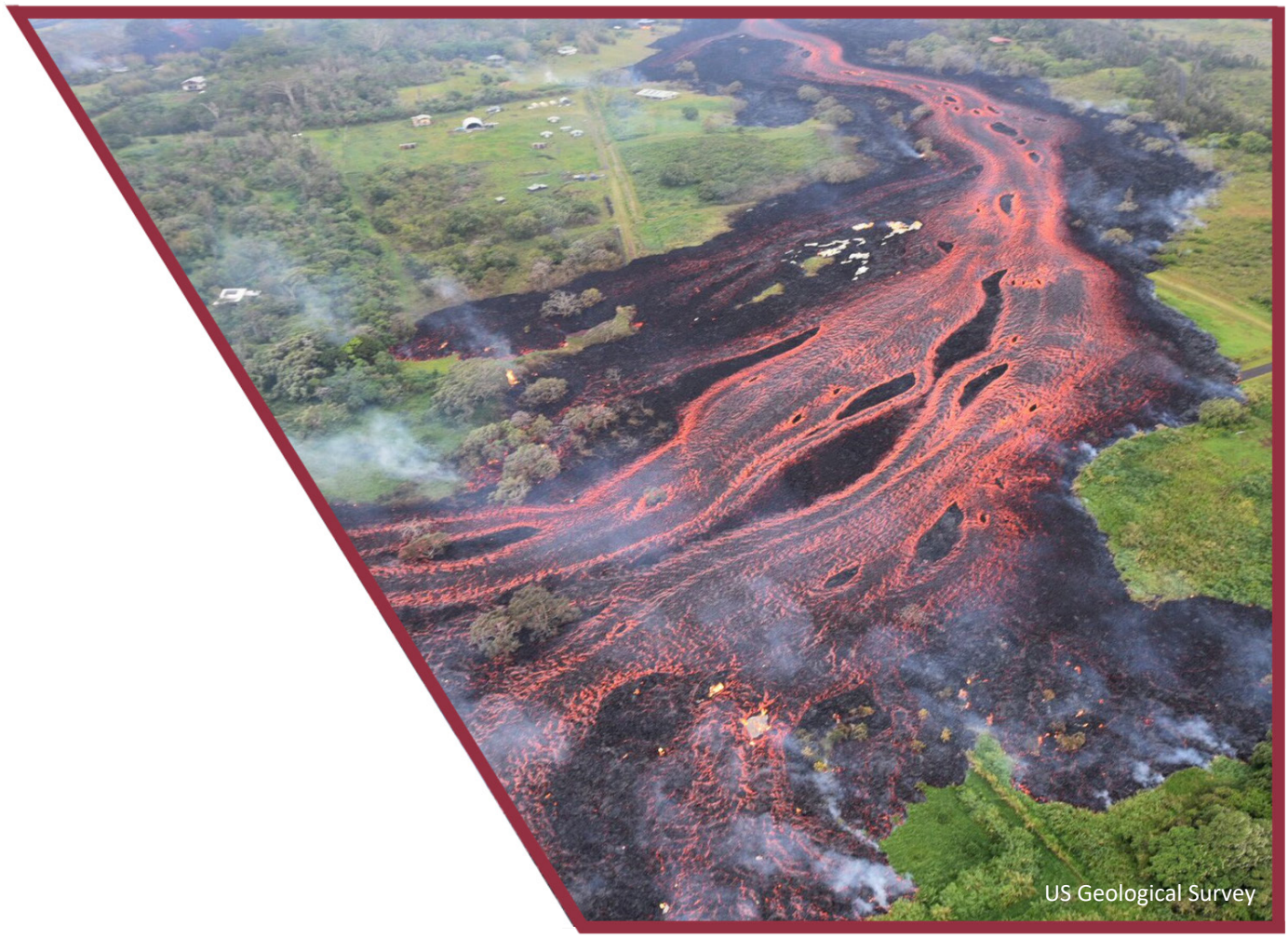
An active volcano in the neighbourhood



Hawaii: suddenly a crevice appears in the garden behind the house, first steam and toxic gases escape, then fire-liquid lava follows and buries whole districts under it. This is exactly what the inhabitants of the small community of Leilani in the southeast of Big Island, the largest of the Hawaiian Islands, experienced in May 2018. Volcano Kilauea (19.4069, -155.2877) has been erupting continuously for several weeks on the main Hawaiian island. Lava is currently escaping from 22 fissures, which has also reached the sea in the meantime, where it also produces toxic gases in a reaction with the water.

Guatemala: People around the Volcan de Fuego (14.4747, -90.8850) are used to the regular eruptions of the volcano in their neighbourhood. The lava is viscous and usually flows only a few hundred meters. But on the morning of June 3, 2018, the volcano was hidden behind clouds so the people in San Miguel Los Lotes could not see the extent of the eruption and the ash cloud and were surprised by the resulting pyroclastic flow. The whole village was wiped out and the media are already talking about „a second Pompeii".

How long these outbreaks will last cannot be said, but we want to deal with some questions in this issue of K.A.R.L. Insights: What is the geological mechanism behind it? Can something like this happen elsewhere? What does this mean when assessing volcanic risks?

Hot Spots, Supervolcanoes and Stratovolcanoes

Hawaii is a Hot Spot

Deep inside the earth there is a temperature of about 5,000 degrees. Some of this heat dates back to the time when the earth was formed almost 5 billion years ago. Atomic decay processes - similar to a nuclear reactor - also ensure constant supplies, so that it will still take billions of years until the earth has completely cooled down. Like any hot body, the earth wants to release this thermal energy into its colder environment. The heat is transported from the inside to the outside by viscoplastic rock masses, which move upwards by only a few centimetres per year. Near the earth's surface they cool down and then sink back into the earth's interior, ready for the next round. This pattern doesn't recur in every case and everywhere: in some places, where the hot rock mush „shoots up" faster than any where else by perhaps only a few centimetres per year, the heat transport takes place particularly effectively.

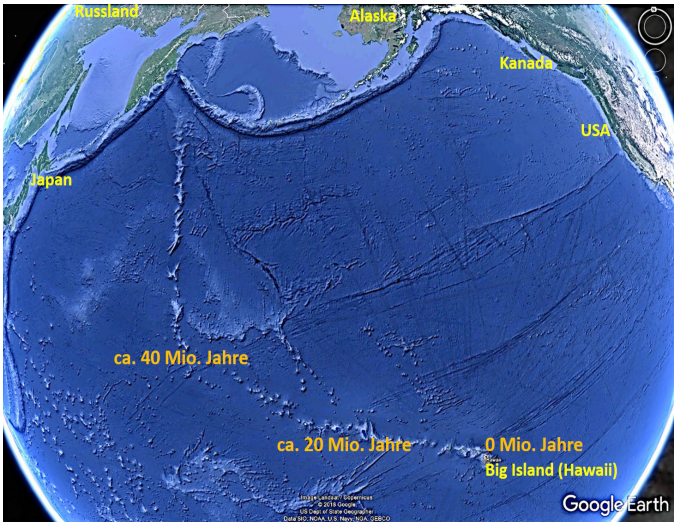


Fig. 1 The Hawaiian islands in the Pacific Ocean (source: Google Earth); fissure eruption in the middle of the residential area (Source: USGS)

These places are called hot spots or heat anomalies by geologists. On the surface of the earth, a hot spot acts like a cutting torch that is held against a steel plate from below: there it first becomes red-hot until finally a hole is formed and the flame penetrates upwards. If the plate moves slowly, the first hole will close again and a new one will be created elsewhere. The chain of the Hawaiian volcanic islands was created exactly in this way: the Pacific Ocean floor is slowly

but steadily moving northwesterly, but the hot spot remains stationary. Therefore, the oldest and long extinct volcanoes in Hawaii are at the northwestern end of the chain of islands, and Big Island at the other end is currently right above the hot spot. Here lies Kilauea, the most active volcano in the chain of islands. Because of the ongoing northwest migration of the pacific ocean plate, the volcanoes on Big Island will expire at some point and a new volcano will form further southeast. Actually, it is already in progress: southwest of Big Island, in the depths of the Pacific Ocean, the Lo'ihi is getting ready to ascend up to the water surface in the near future.

Hawaii is not the only volcanic hot spot on earth. Geologists have now identified over 60 such hot spots, most of which are under water or in remote areas and are therefore relatively harmless. At this point, therefore, we will limit ourselves to just a few that could cause problems:

Eifel (50.4126, 7.2716): Let's start with the home of the KA: Located only about 100 km south of Cologne, the Eifel has been the scene of recurring volcanic eruptions for about 800,000 years. The area north of Koblenz is covered with smaller and larger volcanic cones. But the hot spot takes long breaks, because the last really violent eruption that threw ash as far as southern Sweden was 11,000 years ago. Nevertheless, nothing is extinguished here yet, because carbon dioxide emissions at Laacher See and an impressive geyser near Andernach show that there is no peace in the underground yet.

Fig. 2 Carbon dioxide emission at Laacher See (Source: Paus)

Etna (37.7511, 14.9965): Etna on Sicily is Europe's most active volcano. Every few years it attracts attention by breaking out. Nevertheless, due to its diameter of up to 30 km, the nearest settlements are far enough away from the main crater and are therefore not threatened should an eruption occur. However, it has an unpleasant characteristic: just like in Hawaii, crevices in the ground at Etna far away from the summit can suddenly rupture, and liquid lava can flow. Like parasites, the remains of these eruptions stick to the wide flanks of the mountain. During such an eruption in 1669, even parts of the port city of Catania were overrun by lava, 30km away from the main crater.

South-Australia (-37.8463, 140.7768): Here, about halfway between the cities of Adelaide and Melbourne, things currently seem to be as peaceful as in the Eifel, although the most recent eruptions were only 4,500 to 5,000 years ago. For the city of Mount Gambier, which lies directly next to the mountain of the same name, this volcano and the more remote Mount Schank are now a tourist attraction. However, there are no traces of major fissure eruptions, such as on Etna and Hawaii.

Fig. 3 Crater Lake at Mount Gambier, South Australia (Source: Paus)

Iceland (64.1502, -18.8961): The situation is quite different in Iceland, where hot springs, geysers and a constant trembling of the ground are part of everyday life. A volcanic eruption in 1967 created a new island off the coast (Surtsey), in 1973 there were eruptions on the Westmännar Islands for weeks and in 2010 a rift eruption at the volcano Ejafjallajökull blew up so much ash that air traffic had to be stopped in half of Europe. Even worse was the eruption of the Laki in 1773: sulphurous gases then blew as far as Central Europe and led to numerous casualties. Nowadays such an outbreak would cause our entire electronic communication network to break down, because acid rain and fog would lead to massive short-circuits in the transmitters.

Fig. 4 Outbreak on Heimaey, Iceland 1973 (Source: Ewerts)

Yellowstone (44.4182, -110.5719): Although no conical mountain can be seen, Yellowstone is one of the largest volcanoes on earth: after its last really extensive eruption 640.000 years ago, only a collapse crater of 80 km length and 55 km width remained, in which today the national park of the same name with its geysers and bubbling mud pools is located. Ejected material from this eruption can be found in half of North America, and dust and sulfuric acid are thought to have caused twilight and uncomfortable weather in the atmosphere for weeks or months around the world. In today's circumstances, that would be a global disaster. Geologists have found that such apocalyptic eruptions occur approximately every 600,000 years. So the next one is overdue. Nevertheless, there is no reason to panic: in view of such long periods, an outbreak is no more likely (or unlikely) today than at the time of the Roman Empire.

Supervolcanoes

Due to the global dimension of its eruptions, Yellowstone is also one of the so-called supervolcanoes. These are volcanoes that do not necessarily have to be fired by a hot spot, but occupy an outstanding position in terms of their risk potential. Two of these volcanic giants are to be discussed here:

Toba (2.6258, 98.7919): The Toba volcano on the Indonesian island of Sumatra left behind a 100 km long and 30 km wide burglary crater, which is now filled with water, during its last eruption some 74,000 years ago. This eruption had an explosive force of about one gigatonne TNT, whereby the Indian subcontinent was covered with an ash layer about 15 cm thick. One - albeit controversial - theory says that at that time mankind had passed through a „genetic bottleneck" and, especially in Africa, only a few thousand individuals survived the consequences of the Toba outbreak. After the devastating tsunami in the Indian Ocean in 2004, which was triggered by an earthquake off the coast of Sumatra, geologists were concerned that the Toba volcano could be awakened from its twilight sleep. So far, however, nothing of the kind has happened, fortunately it remains quiet.

Campi Flegrei (40.8273, 14.1394): A smoking volcanic vent in the middle of the city, countless other remains of eruption craters of various sizes and ages as well as areas where the ground has risen and sunk by up to 8 metres within decades: these are the Campi Flegrei, a densely populated area that begins just west of the city of Naples and extends as far as the island of Ischia. Geologists have found the remains of a huge eruption 37,000 years ago, which can be compared to the largest historically known eruptions (Tambora 1815, Krakatau 1883). A similar eruption would now devastate large parts of the western Mediterranean and wipe the city of Naples off the map. However, it is more likely that another volcano will do this: Vesuvius east of Naples; a stratovolcano that has been sealed since its last eruption in 1944 and will eventually regain air with an explosion.

Fig. 5 Sulphur vapours on the Campi Flegrei near Naples (Source: Paus)

Volcan de Fuego is a Stratovolcano

Volcan de Fuego is one of the volcanoes along the Pacific Ring of Fire, a volcanic belt that surrounds the Pacific Ocean from three sides. Volcanism is triggered by the subduction of oceanic plates (e.g. Pacific plate, Nasca plate) under continental plate (e.g. Eurasian, Australian or South American plate). Through the conical mountains with steep flanks and one or more summit craters, stratovolcanoes look like they are out of a picture book. But each of them carries more risk than the volcanoes described above, because they erupt much more frequently than the supervolcanoes and develop higher destructive power than the hot spot volcanoes. Mostly the intervals between the eruptions last only decades or centuries; sometimes also some millennia, rarely however still longer. In addition, stratovolcanoes tend to explode suddenly, pouring hot ash and rock avalanches over their surroundings for miles.

Fig. 6 View of Popocatepetl volcano (Source: Paus)

Among the most dangerous stratovolcanoes are currently Vesuvius (Italy, 40.8223, 14.4289), Tambora (Indonesia, -8.2462, 117.9905) and Popocatepetl (Mexico, 19.0236, -98.6225). These three volcanoes have the potential to wreak immense destruction far beyond their immediate surroundings. And not in a few tens or hundreds of thousands of years, but possibly soon.

Assessment of volcanic risk

Volcanoes are as diverse as the risks they pose. Sudden and „unannounced“ eruptions are just as possible as weeks of threatening rumbling in the mountain, which triggers large-scale evacuations of the surrounding area but is not followed by an eruption. Also, nobody can predict today whether tomorrow, next year or the next decade one of the supervolcanoes will make itself felt or whether a hot spot will decide to be active. Unexpectedness is the name of the game. This is how it happened in 1943 in western Mexico: from one day to the next, a crevice in the earth was ruptured in a field of maize from which gas and ashes burst. A few days later, lava followed and soon buried the nearby village of Paricutin, after which the newly formed mountain was named. The eruption lasted nine years, then the volcano went silent again. The emergence of Paricutin (19,4931, -102,2516) shows amazing parallels to the events in Hawaii in 2018, although there is no hot spot and certainly no super volcano in this area. The Paricutin belongs to a 40,000km² Michoacan-Guanajuata volcanic field, which comprises more than 900 monogenetic cinder cones, i.e. volcanoes that erupt only once or only within a short period of time and then remain silent forever. When and where the earth will re-open in this area is uncertain.

The further away the site is from the volcano, the less likely it is that damage will be caused by ejected rocks or lava flows. Damage caused by volcanic ash, on the other hand, can still occur several hundred kilometres around the site. It is therefore not easy to understand the risk of volcanism. With K.A.R.L. we use a combination of different information and data sources, such as volcanic type, eruption history, removal of potentially endangered sites from the eruption centre and the site-specific sensitivity of buildings, means of production and goods to the consequences of volcanic activity. However, it is still not possible to predict volcanic eruptions, but in this way the risk of suffering damage from volcanism can be limited and quantified quite well.

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