Times Standard

# Not My Fault: Iceland – a unique place where a ridge and a hotspot collide

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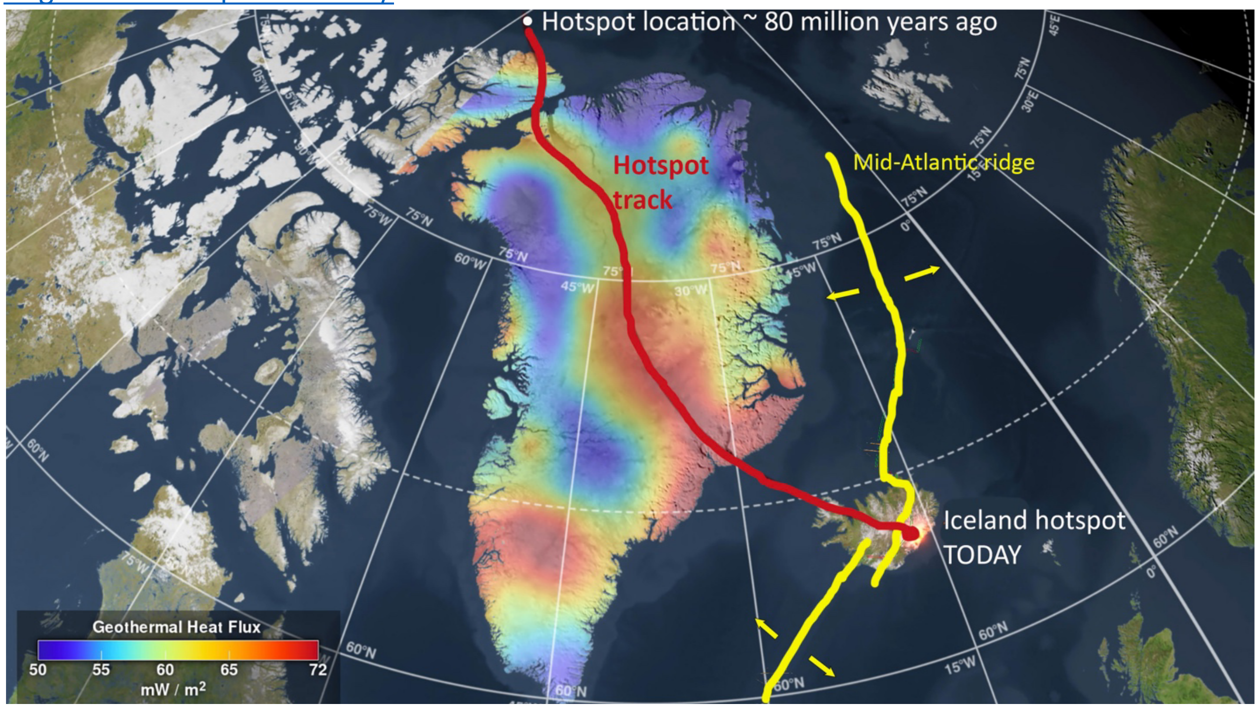


*Tectonic cartoon of Iceland showing the relative movement of the Iceland hotspot (red), and today's position of the Mid-Atlantic ridge (yellow). Heat flow contours and hotspot track from https://svs.gsfc.nasa.gov/4670 .*

I just returned from Iceland, a bucket list trip for me and a Mecca for geologists. Iceland, in the northern Atlantic Ocean between Greenland and Norway just south of the Arctic Circle, is unusual in many respects. A land of fire and ice, it is a laboratory for earth processes from the depths of the mantle to surfaces sculpted by glaciers, landslides, and monumental floods. And just to prove the point, an eruption began just hours before we landed. We could easily see the billowing gas plume from the airport, a warm welcoming sign.

To prepare for our trip, I spent a little time looking at web sites, journal articles, and field notes from geology friends and colleagues. I knew that Iceland owes its existence to two primary geologic tectonic processes: the Mid-Atlantic ridge and the Icelandic hotspot. But I knew little about the timeline of events, or how the evolution of the two created a land like no other on earth.

I'll start Iceland's story about 60 million years ago when two important geologic events occur. The Mid-Atlantic ridge grows to the north beginning to separate the North America and

Greenland away from Scandinavia, and the first evidence of what will become the Iceland hotspot emerges.

The Mid-Atlantic ridge is often where plate tectonics is introduced. Fifth grade students are shown maps of the supercontinent of Pangaea, the edges of the American continents, Europe, and Africa seamlessly meeting and then the great split when Europe and Africa broke away from the Americas creating the Atlantic. What they don't learn is how complex a split it was and how it continues to evolve.

Pangaea, the supercontinent where all of the known continents were connected, began to break apart over 200 million years ago. But it didn't split all at once. The central Atlantic began to form first, rotating North America away from Northern Africa. At first it was probably just a cleft in the earth like today's Rift Valley in Africa. It slowly grew both to the north and south.

The last part of the Atlantic to open was the northern section that now separates Greenland and Scandinavia. By 60 million years ago, the rift had penetrated the last remaining connection between Europe and the Americas.

All of the world's oceans were formed by rift zones that have left a 40,000-mile-long global network of underwater mountains. These are magnificent peaks, soaring nearly two miles above the surrounding sea floor, but almost never penetrating the ocean surface. In most places, you would need to dive more than a mile to touch the top.

There are nine places where the Mid-Atlantic ridge breaks the sea surface: a scattering of small islands like the Azores and one big one - Iceland. Iceland is the enigma, with an area of nearly 40,000 square miles, it is more than 40 times larger than all the Azores put together. Why is Iceland so big?

Enter the second player in the Iceland geologic saga, a hotspot. Hotspots are areas of hotter than average heat flux from the deep interior. They are long-lived features that likely exist for 100 million years or longer and are fixed within the mantle compared to the far more mobile outer surface.

Since J. Tuzo Wilson first suggested the existence of hotspots in 1963 by looking at the Hawaiian Islands. Since then, at least fifty hotspots have been identified and some geoscientists suggest the number is much higher. Iceland is one of the most well-studied hotspots and has likely existed for at least 80 million years. But it hasn't always been beneath Iceland. Like Hawaii, the outer surface of the earth has been slowly moving over it, leaving a track similar to that recorded by the islands in Hawaii.

Volcanic deposits in Greenland suggest that by 60 million years ago, a hotspot was under Greenland. A study published five years ago by a team led by Yasmina Mantos used the magnetic signature of Greenland rocks to trace out the slow movement of Greenland to the northwest as it moved over the hotspot. Greenland wasn't the only thing moving; the entire Mid-Atlantic ridge system was moving too, slowly getting closer to the hotspot. Roughly 25 million years ago, hotspot and ridge began to interact.

The result was literally earth changing. The added heat input of the hotspot to the ridge put the system out of equilibrium and volcanic layer after layer accumulated around the hot spot/ridge juncture far more quickly than spreading could move it apart. A great basalt platform spread out over the area getting thicker and thicker. The ocean crust around ridges is only a few miles thick in most places around the world. Iceland's crust today is about 25 miles thick beneath the center of the island – the thickest ocean crust anywhere in the world.

As the crust thickened, the structures in Iceland grew more complex. Magma moving to the surface had time and space to evolve and change. Mid-ocean ridges are basically all basalt with nearly identical compositions. Hot spots in the ocean like Hawaii have a little more variability but are also almost entirely basalt. The relatively fluid basalt lava flows out in sheet after sheet constructing the broad smooth shield shape of Mauna Loa.

Iceland's largest volcanoes don't look like Hawaii's and don't behave like them either. Most of Iceland is still made of basalt, but roughly a quarter of the volcanic products contain more silica, making them stickier and more explosive. Most of the volcanoes in Iceland are stratovolcanoes – more like Mt. Shasta than Mauna Loa. Stratovolcanoes sometimes produce smooth runny lava flows, and sometimes blasting bits of molten rock miles into the air.

Iceland's newest eruption may be marking yet another chapter in the island's complex history. For each of the last three years, small eruptions have occurred on the Reykjanes Peninsula only 19 miles from Reykjavik. We could see a gas plume extending a few hundred feet into the air from the airport when we landed.

So far, the eruption has posed little hazard; lava flows are restricted to a small uninhabited area and no ash has been produced. Access is restricted due to toxic gas emissions. But this area had been quiet for over 800 years prior to 2021 and it's not at all clear how this new activity will last or if this is a prelude to larger events.

Next week: past Icelandic eruptions give a clue to what could happen in the future.
Note: for updates on the current eruption, visit the Icelandic Met Office
https://en.vedur.is/about-imo/news/earthquake-activity-in-fagradalsfjall-area.

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Lori Dengler is an emeritus professor of geology at Humboldt State University, an expert in tsunami and earthquake hazards. The opinions expressed are hers and not the Times--Standard's. All Not My Fault columns are archived online at https://kamome.humboldt.edu/taxonomy/term/5 and may be reused for educational purposes. Leave a message at (707) 826-6019 or email Kamome@humboldt.edu for questions and comments about this column. Downloadable copies of the North Coast preparedness magazine "Living on Shaky Ground" are posted at https://rctwg.humboldt.edu/prepare/shaky-ground.