Iceland: The Restless Land
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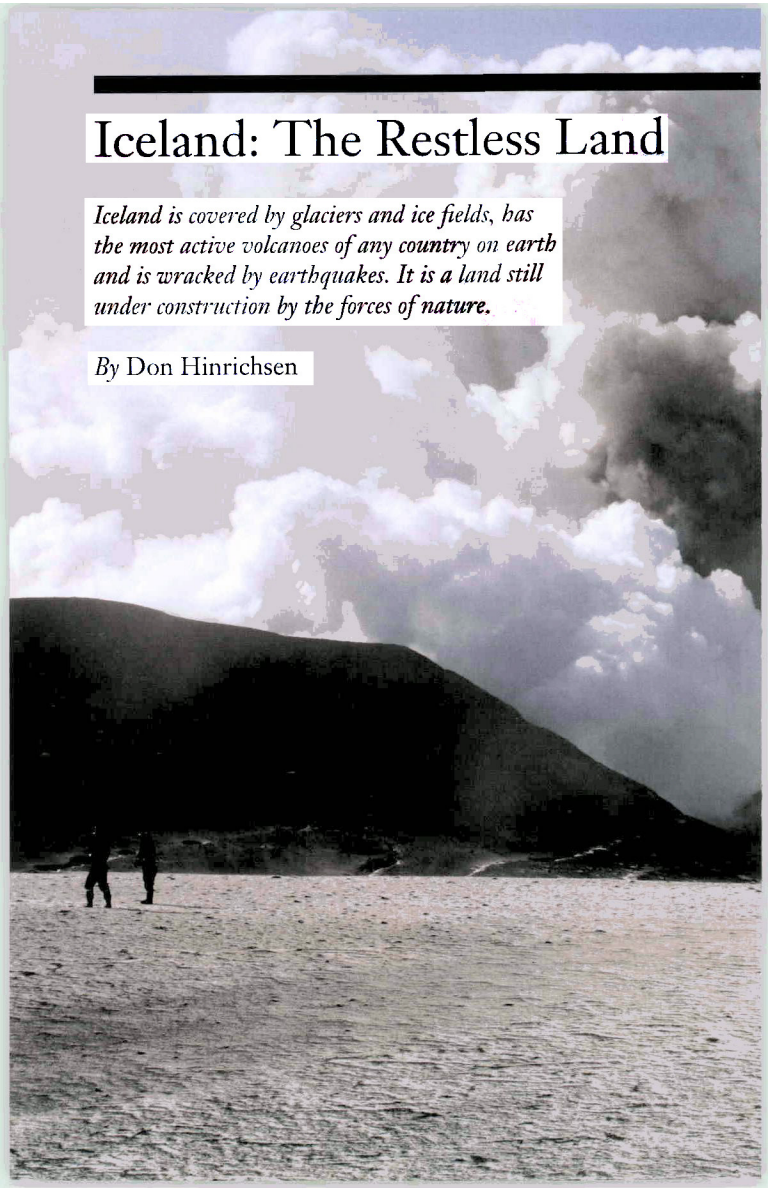
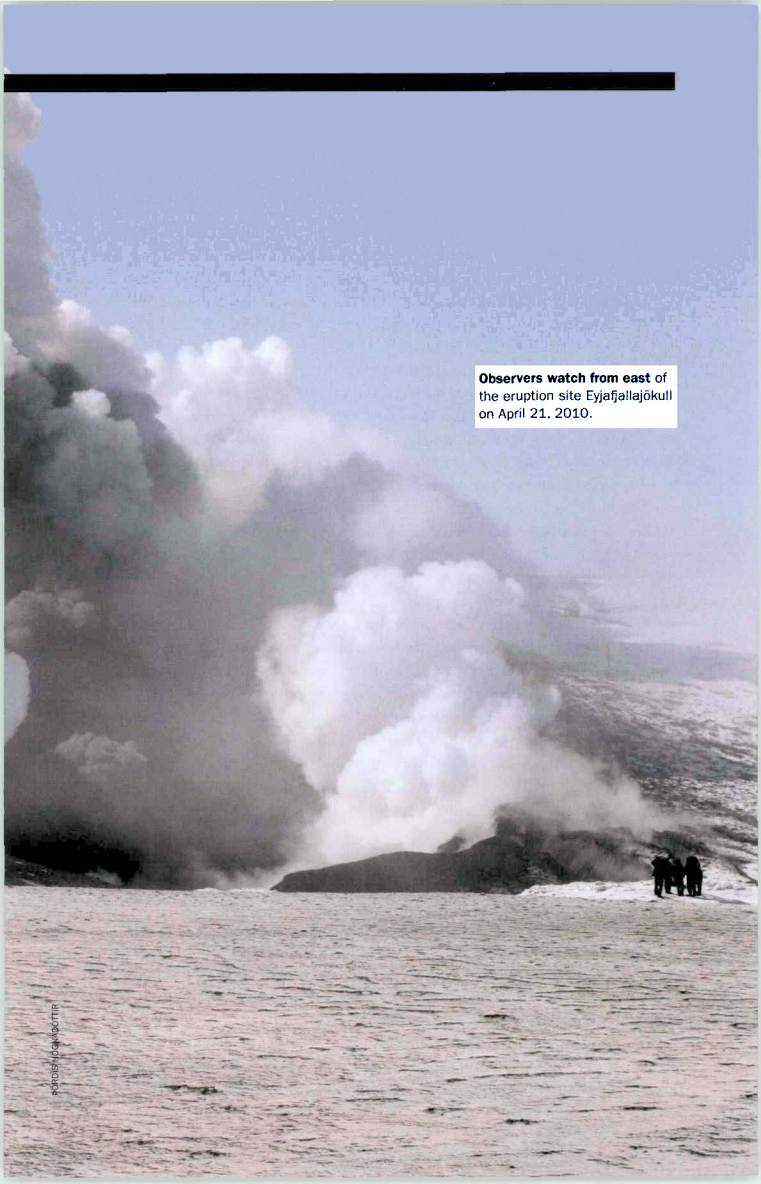
Iceland: The Restless Land

Iceland is covered by glaciers and ice fields, has the most active volcanoes of any country on earth and is wracked by earthquakes. It is a land still under construction by the forces of nature.

By Don Hinrichsen





Observers watch from east of the eruption site Eyjafjallajökull on April 21, 2010.

ICELAND IS A VIOLENT AND YOUNG LAND BY GEOLOGICAL standards. It has around 150 volcanoes and about 40 of them have been active over the past few centuries. On average, Iceland experiences a volcanic eruption every five years. Since the Middle Ages, one-third of all the earth's lava flows have occurred on this tiny island in the North Atlantic, hugging the Arctic Circle.

Iceland is a land still under construction, shaped by ice and fire. The reason this island nation is periodically rocked by violent volcanic eruptions and accompanying earthquakes is because it straddles the Mid-Atlantic Ridge—a 10,000-mile crack in the Atlantic Ocean floor caused by separation of the North American and Eurasian tectonic plates. The western part of the island sits on the North American plate, while the eastern half rests on the Eurasian plate. The island's subterranean geology is constantly at war and on the move, with the two massive plates either crashing into each other or pulling away.

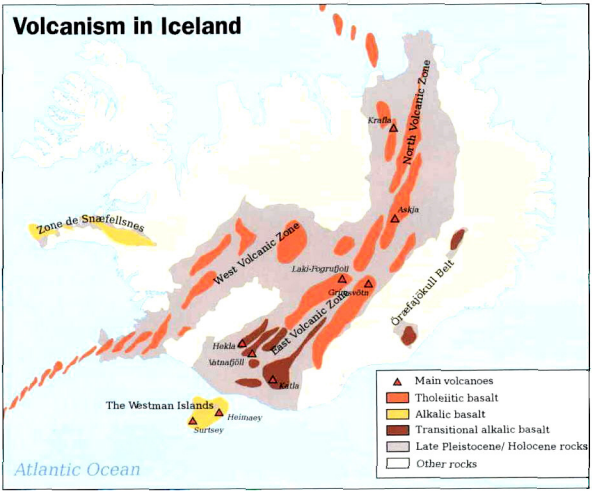
Basically, the island sits atop vast lakes of magma. When the plates pull apart, fissures open up sending magma and ash to the surface. Once the intense pressure built up during times of dormancy is released, the resulting volcanic explosion can be catastrophic.

The most recent evidence of this was the volcanic eruption at Eyjafjallajökull beginning on April 14, 2010, which shut down most of Europe's air space over the course of several weeks. Though the volcano had been active since March 20, it had been spewing out fiery magma, Hawaiian-style, with little ash fallout.

That all changed when the volcano literally exploded, sending an ash (tephra) plume high in silicon content soaring up to 10 kilometers into the atmosphere. From there, it was transported eastward by the prevailing winds, reaching northern Europe on April 15. Since the plume contained highly corrosive particles of silicon (like shards of glass), as well as sulfuric acid, air traffic was halted for fear that jet engines would ingest the silicates causing the engines to flame out and stall. Airborne ash also scars aircraft windscreens, greatly reducing visibility. For some 15 days, the volcano grounded around 100,000 flights and eight million people, many of whom were unable to fly to or from Europe.

Airline pilots are very concerned about the possibility of encountering airborne ash. In 1982, a British Airways flight lost all four engines when it flew into an ash cloud over Indonesia.

Volcanic ash can cause severe damage. "This stuff is nasty," says Stewart John, a fellow at the Royal Academy of Engineering in the U.K. "It is extremely fine and if it gets into a jet engine, it melts and blocks up all of the ventilation holes that feed in cooling air. Jet engines operate at about 2,000 degrees C, and the metals can't take increased temperature and just shut down." The British Airways flight was lucky: after dropping 20,000 feet the pilot was able to restart one engine. "By repeatedly turning the engine over and having a clean air flow going through, he managed to blow the ash out," said John.



Iceland is a volcanic hot spot on the Mid-Atlantic Ridge—the dividing line between the Eurasian and North American continental plates. The map shows Iceland's various rock types as well as it's principal volcanoes.

What made the Eyjafjallajökull eruption far worse, in terms of its impact, was the fact that it occurred under a glacier, explained Dr. Matthew Roberts, a British glaciologist working at the Icelandic Met Office. As the magma and super heated ash sliced through the ice, it gave off tremendous quantities of steam and ash particles. By April 21, the volcano was spitting out 30 cubic meters of magma per second (equivalent to 75 tons per second). By the time the eruption subsided in early May, volcanologists calculated that it had pushed some 100 million cubic meters of tephra (ash) into the upper atmosphere.

The interaction of molten rock, magma and glacial ice caused the magma to cool very quickly, pulverizing it into tiny fragments of rock. "The updrafts of fine volcanic ash were being lifted into the sky by the enormous steam plumes that were created by the vast quantities of ice that's been melted," noted Dr. Roberts.

What triggered the massive eruption of magma and ash? Dr. Dave Rothery, a volcanologist at London's Open University, points out that "the proportion of gas—made up of water vapor, carbon dioxide and sulfur dioxide—in the first volcanic magma may have increased, compared to the original batch of magma when it started erupting in March."

The mixture of ice and water from the glacier turns quickly into steam when it meets super-heated magma, and the resulting ash is pumped skyward. "Once airborne, convection takes over and the plume, which is warmer than the surrounding air, rises rapidly," says Rothery. "How high the plume rises depends on the initial impetus from the expanding gas, plus its heat content. Eventually the plume cools, reaches neutral buoyancy, and then ceases to rise. It is then at the mercy of prevailing winds."

Coarse ash, more than one millimeter in diameter, falls back to earth quickly. However, fine ash particles, less than 0.1 millimeter in diameter, can stay airborne for a long time.

DR. ROTHERY OBSERVES THAT SO LONG AS THE ASH COLUMN remains below three kilometers in height, it poses little threat to air traffic. Problems arise when the ash plume reaches 7 to 10 kilometers or higher, as these are routine altitudes for jet aircraft flying between Europe and North America.

Volcanologists have also pointed to another worrying possibility; the last time Eyjafjallajökull erupted in December 1821, it was active for more than a year. Worse was to come. Once the initial eruption subsided, its neighbor, the more powerful Katla volcano, became active in June 1823. Experts fear that this latest activity could once again ignite Katla into a frenzy of eruptions.

According to Ármann Höskuldsson, a research scholar and scientist at the University of Iceland's Institute of Earth Sciences, history does not necessarily repeat itself. "So far there are no indications that Katla will also become active," he states.

If Katla did erupt it could be much worse than Eyjafjallajökull. The Katla volcano is the fourth largest in Iceland, consisting of an ice-covered caldera nine miles in diameter, but covering 220 square miles. The last time it erupted, in 1918, deadly gases released from the caldera poisoned animals and people as far away as northern Scotland.

Iceland's volcanoes have had devastating, and far-ranging, impacts throughout the country's history. The second largest lava flow ever recorded on earth occurred at the Laki volcano (known in Iceland as the Lakagigar crater) in the summer of 1783. In all, some 12 cubic kilometers of ash and lava poured out of the volcano, covering 580 square kilometers of land. So much ash was released that hundreds of thousands of sheep and cattle perished from poisonous fumes. The ensuing famine killed about 10,000 people, 20 percent of the country's population at the time. The ash cloud from the eruption blanketed Europe and Western Asia, decreasing the amount of sunlight reaching crops and reducing food stocks.

The history of Iceland is literally bound up with its unique and convulsive geology. The country is criss-crossed by volcanoes in a broad band from west

ÞÓRDÍS HÖGNADÓTTIR

Steam and ash erupting from Eyjafjallajökull on April 21, 2010.

Blowing Their Tops: Major Icelandic Eruptions During Recorded History

(Iceland was settled around A.D.874.)

Katla	934	spewed out 18 cubic km of lava, the largest lava flow recorded
Hekla	1104	largest explosive eruption recorded for this volcano
Öræfajökull	1362	massive explosive eruption
Krafla	1724-1729	repeated eruptions along the 80-km-long Krafla fissure system
Grimsvötn-Laki	1783-1785	lava flows inundated 580 square km; poisonous fumes killed 20 percent of the total population
Askja	1875	a major explosive eruption resulted in the formation of the caldera Öskjuvatn
Katla	1918	at 1,512 meters, one of Europe's highest volcanoes. This eruption caused major flooding due to the melting of the glacier Myrdalsjökull
Hekla	1947-1948	11-month *eruption*, major lava flow with 24,000 tons of carbon dioxide emitted into the atmosphere
Surtsey	1963	submarine explosion off the southern coast of Iceland formed a new island, called Surtsey
Eldfell	1973	seven-month eruption on the island of Heimaey. 80 percent of the town was buried under lava
Grimsvötn	1996	major eruption causing a glacial burst and massive flooding
Grimsvötn	2004	eruption blasted ash up to 12 km into the atmosphere

to east. The entire island is a product of volcanism and is covered with new and ancient lava flows. The predominant rock formations are all volcanic basalts, the oldest of which date back 14 million years. The island is a mere baby in geologic time and is still growing in size.

The most famous active volcano on Iceland is Mount Hekla. It has erupted 18 times since 1104, the last time in 2000. Other active volcanoes include: Grímsvötn, Katla, Askja and Krafla. Katla has erupted some 20 times since the settlement of Iceland. In all, there have been 125 major land-based eruptions since the island was settled in A.D. 874 and at least 13 submarine eruptions off the coast.

The numerous active volcanoes and hot springs are just the surface manifestations of a fiery subterranean environment. The same geological

The rising volcanic cloud above Eyjafjallajökull on April 24, 2010.

activity that creates volcanoes provides an endless supply of geothermal energy. Currently, Iceland meets over 80 percent of its total energy needs from geothermal power and hydropower—both renewable sources of energy.

Now Iceland is in the forefront of researching and developing geothermal fields down to five kilometers. The first deep-bore test well was sunk in late 2008 near the Krafla caldera in a very intense, high-energy geothermal field. But after just 2,000 meters, drilling halted as it encountered molten rock. At this depth, superheated water and steam reach temperatures of 450-600 degrees Celsius. Water does not turn to steam at these temperatures because of the great pressure at such depths.

"The deeper you go down into geothermal fields, the energy per borehole increases by a factor of 5 to 10," says Ólafur Flóvenz, General Director of Iceland GeoSurvey. "In other words, there is 5-10 times more energy per mass unit contained in deep wells than in conventional boreholes."

Iceland has identified 20-30 such high-temperature geothermal fields, every one of them linked to active volcanic belts. Whether they can all be exploited for deep geothermal energy is unclear. The volcanism that continues to shape this stark and rugged landscape is constantly changing, constantly in flux. Lying atop perhaps the most active fault line in the world, Iceland is a victim of its own geography as well as a beneficiary. Ultimately, the unpredictable nature of volcanism will have a major role in determining the island's future.

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Don Hinrichsen is an internationally recognized environment writer and has undertaken numerous assignments for various United Nations agencies. He is the author of *Coastal Waters of the World: Trends and Strategies* as well as countless newspaper, magazine and journal articles.