Fire & Ice
Stone & Sea

Geographic Overview

Iceland is the youngest landmass on Earth, and the second largest island in Europe, exceeded only by Great Britain. It has a greatest east-west extent of about five hundred kilometers. North-south its greatest extent is three hundred and seventy-five kilometers. Iceland's total surface area is one hundred and three thousand square kilometers. Roughly one ninth is inhabited. The remainder is covered with mountains of ice and desolate plains of lava and ash. The highest point of this wasteland is two thousand one hundred and nineteen meters at Hvannadalshnjukur, on the great Vatnajokull glacier. Vatnajokull is the largest ice mass in the world outside of Greenland and Antarctica. Iceland has several other large glaciers including Myrdalsjokull, Hofsjokull, and Langjokull. Iceland has a heavily indented coastline with many long fjords.

Geological Overview

A mid-oceanic ridge is an ocean floor structure composed of a series of submarine hills that rise toward a mountainous central zone. In the center of this zone is a comparatively narrow trench called an axial rift. Iceland sits astride the Reykjanes ridge. This ridge is an extension of the mid-Atlantic ridge, and is a constructive plate margin between the Eurasian plate and the (North) American plate. As these plates grow apart, molten material from beneath the Earth's crust wells up, forming the features of a mid-oceanic ridge. We attribute the formation of the Icelandic basalt pile to a mostly stationary volcanic zone located along this ridge.

The structure of Iceland is predominantly volcanic, and up to sixteen million years old. We divide this structure into four stratigraphic groups based on paleomagnetic reversal patterns. These are the Tertiary phase, the Plio-Pleistocene phase, the Upper Pleistocene range of rocks, and a Postglacial phase from 13000 years ago to the present (Saemundsson, 139).

Tertiary rock, from 16 million to 3.1 million years old, constitutes about half of the surface of Iceland. It includes the plateau basalts that dominate eastern Iceland. The basalt beds are typically uniform, and are generally between 5m and 15m thick. These layers are separated by thin beds of ash, tephra, and other clastics from volcanic activity (Saemundsson, 139).

Plio-Pleistocene rock of age 3.1 million to .7 million years covers about 25 percent of Iceland. There is no real stratigraphic break between tertiary and Plio-Pleistocene beds, but the Plio-Pleistocene rocks are more varied. The basalt beds are separated by detritus beds, the result of fluvial, or fluvioglacial, action. Pillow lavas, various breccia and hyaloclastite are interstratified with the basalt, indicating subglacial volcanism. During this phase the topography of Iceland, up to this point flat basalt plains, must have changed dramatically. Subglacial volcanism creates an uneven surface, with long ridges and conical hills. Glacial erosion would have begun as well (Saemundsson, 142).

The Upper Pleistocene phase, from .7 million years old to the end of the last glaciation, covers about 30000 square kilometers of Iceland. It is divided from the underlying Plio-Pleistocene phase by a thick layer of volcanic material indicative of the development of massive volcanic systems on the island. The Upper Pleistocene beds themselves show an alternation between subglacial eruptions and more typical lava flows, indicating interglacial periods. Rock from the Upper Pleistocene can be connected to existing volcanic systems which are either still active or dormant, rather than extinct (Saemundsson, 147).

The Postglacial phase consists of landforms produced after the end of the most recent glaciation. These include lava beds, pyroclastics, and fluvioglacial and fluvial soils. The pattern of volcanism is consistent with earlier phases, with over twenty active volcanic systems covering one tenth of the surface. At the beginning of this phase the sea level rose, covering lowland areas with clay, silt and gravel (Saemundsson, 150).

Major Processes

Volcanism

The history of Iceland might well be said to be the history of its volcanoes. Nearly every type of volcano found on Earth has a representative here. Of over two hundred volcanoes, thirty are presently active, including mount Hekla. Hekla is an example of the most common form of volcano on Iceland, the crater row. This type of basaltic volcano consists of a series of scoria or agglutinate cones straddling a lava fissure which may be many kilometers long. Another common type of volcanism on Iceland is the subglacial eruption referred to earlier. This is the eruption of a volcano that is covered by an ice cap. Iceland's most active volcano, Katla, is of this type. This sort of eruption produces massive flooding, sending enormous quantities of water, sand, and terminal moraine across the landscape. Fissure eruptions also occur. These volcanic events do not produce cones of any sort, but lava oozes from "fissure swarms" in quantities much greater than in a typical eruption. In addition, poisonous gases may be released. When Lakagigar fissure erupted in 1783-1784, more than 9000 people and seventy percent of the country's livestock perished due to these pollutants (Sanders, 142). Least common is the shield volcano familiar to students of Mediterranean volcanism. Skjaldbreidur is a classic shield volcano near Thingvellir.

Earthquakes

Due to its location on a plate boundary Iceland is subjected to a large number of earthquakes. These earthquakes can exceed magnitude seven. Lesser seismic events of magnitude four and five are associated with simple volcanism. The plate boundary earthquakes are concentrated in three areas. The Reykjanes Peninsula, where Reykjavik is located, has been relatively inactive in recent years. The South Iceland seismic zone has produced the heaviest quakes, magnitude 7 and 7.5, but these seem to occur only every fifty to one hundred years. The Tjornes Fracture zone on the north coast extends under the sea to the island of Grimsey, and has been quiet recently. All the zones show typical focal mechanisms that indicate classic strike-slip faulting (Einarsson, 166).

Wind Erosion

Wind erosion is not a problem typically associated with cool, humid island climates. However, it plays a significant role in shaping Iceland's landforms. Since the time of the settlement nearly half of the area then sporting vegetation has lost its soil cover entirely due to the action of wind and water. Of 20000 square kilometers of birch woods, only 1200 square kilometers are left. The vulnerability of the land to erosion is a combination of deteriorating climate, which has steadily cooled over the last thousand years, and the grazing action of man and his livestock. This is an example of how the people who live there can shape the geomorphology of a place.

Major Landforms

Glaciers

Glaciers are an integral part of the geomorphology of Iceland. The island was repeatedly glaciated during the last ice age. Even now eleven percent of its surface is covered by ice year round (Bjornsson, 203). Many glacier forms can be found here. The familiar cirque variety of alpine glacier, which forms in bowl shaped sloping valleys, can be found in the Trollskagi mountain range. This range radiates out from the Icelandic highlands and is home to over one hundred cirque and valley glaciers. Cirque glaciers are also found in the fjords of eastern Iceland. The plateau ice sheet variety of glaciation is exemplified by the Vatnajokull ice cap, which averages 420m deep, with a maximum thickness of 1000m (Bjornsson, 204).

Iceland's glaciers are very active due to its temperate climate. Velocities of glacier movement are commonly over one meter per day. The Hoffelsjokull coastal glacier has been observed to move as fast as 2.1m per day (Bjornsson, 205).

Glacier Erosion

Erosion by Iceland's glaciers is enormous. Valley glacier erosion is significant in southeastern Vatnajokull, where outlets are cut deep into the mountain range. Based on sediment loads, a rate of denudation of 3.2mm per year is estimated for Vatnajokull (Bjornsson, 208). The high sediment load results in large black-sand deltas on the southern coast. The glacier margins terminate on a broad lowland area and the heavily laden streams braid back and forth across the outwash plain.

Glaciers and the People

Iceland experienced a Climatic Optimum between 8000 and 2500 years before the present. At this time it was warmer and drier. Glaciation then was confined to small mountaintop ice caps. From the settlement in the 9th century up to the 13th century, glaciers were smaller than today. From the 14th century through the beginning of the twentieth the climate cooled continuously. Between 1600 and 1900 much cultivated land and many farms were covered by advancing ice. This advance was reversed by rising temperatures through the 1940s (Bjornsson, 206).

Black-sand Deserts

Fluvioglacial outwash is the deposition of erosional material carried by melting glacial ice. In Iceland there are extensive outwash plains near Vatnajokull and Myrdalsjokull where massive flooding often occurs. Icelanders call this jokulhlaup, which means 'glacier bursts'. These jokulhlaup commonly deposit 30 million tons of sediment. During the 1934 eruption of Grimsvotn 150 million tons were transported (Bjornsson, 208). This sediment comes to rest on vast plains, producing what Icelanders call a *sandur*, a 'black-sand desert'. These are vast fields of sand, ash and tephra that are too porous to retain any water. In this arid soil no vegetation can take hold. As a result of repeated jokelhlaup the interior of Iceland is virtually barren. A classic example is Myrdalssandur, which covers 700 square kilometers. Others include Solheimasandur and Skogasandur. These places are so lifeless that NASA astronauts came to Iceland to train for their lunar landings.

Geothermal Land Forms

The 500 kilometer width of Iceland sits directly over the Reykjanes mid-oceanic ridge. Due to this location it is bathed in elevated heat flow typical of a constructive plate margin. As a result Iceland has an abundance of Hot Springs. These springs range from 20°C up to boiling. In areas of active volcanism steamfields may form, where super-heated vapor escapes from numerous vents. Near scenic Thingvellir the mountain Hengill is adorned with great plumes of geothermal steam (Sanders, 197).

Because of the humid, cool oceanic climate, Iceland receives a great deal of precipitation. As we say in our discussion of *sandur*, the bulk of this precipitation percolates down to the bedrock. Once there it flows down faults, gathering the regional heat flow from the constructive plate margin. In hotter areas the cooling igneous intrusions of active volcanic systems may heat the water (Fridleifsson, 176).

Hot springs may be the conventional variety that simply bubbles forth. The Deildatunga spring, at Reykholtsdalur in western Iceland, releases 180 liters of boiling water every second (Fridleifsson, 180). Springs may also manifest in explosive eruptions we call geysers. Geysers all over the world derive their name from the great Geysir (pronounced like blazer) at Haukadalur in the south of Iceland. Its largest eruptions reached heights of 70m and continued for up to ten minutes. Geysir has a 20m deep vertical pipe. At a depth of 10m the pressure creates a boiling point of 120°C. When the water is occasionally super-heated by an additional 5 or 6°C, it can instantly flash to steam. Since the volume of steam at that depth is almost twenty times that of water, it creates an explosion that throws the remainder of the water column up into the air (Fridleifsson, 184).

Geothermal Heat and the People

Geothermal energy is an important component of the economy of Iceland. In this case the geomorphology of the place has shaped the people who live there. A third of the energy consumed in Iceland comes from geothermal sources, with nearly seventy percent of households geaothermally heated. In the Westman Islands a pilot project is extracting heat from a partly molten lava flow. It serves the electrical needs of a town of 5000 people.

Geothermal steam and water serve a variety of purposes beyond home heating. Nearly 150000 square metres of greenhouses are heated this way, growing fresh vegetables and flowers that could never survive in the open. Fish hatcheries and fish drying facilities, hay drying plants and candy manufacturing are all served by geothermal heat (Fridleifsson, 189). The small lake in the center of Reykjavik is kept heated all year round for the comfort of the fish there. Various projects are in place to expand geothermal heat to industrial uses, but hydropower resources on the island have so far served all of the country's real needs.

Conclusion

Iceland is a realm of ice and fire, stone and sea. The volcanoes and hot springs are an ever present reminder of the fiery rift that gave birth to the island. The glaciers that ebb and flow over the years warn of the danger should that subterranean fire ever dim. The Icelanders have harnessed the geothermal heat of the island to nurture their culture. In doing so they have made the fundamental nature of Iceland the defining reality of its people.

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