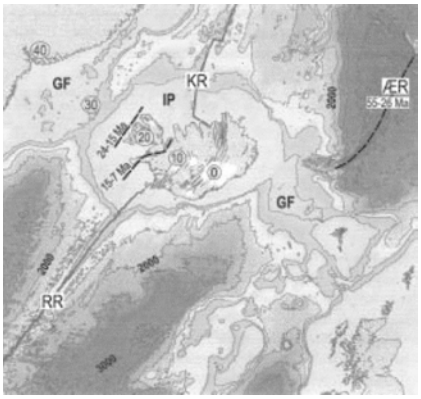
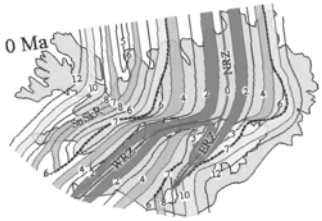
Iceland can be considered volcanologist “heaven”

1) Sub-aerial continuation of the Mid-Atlantic Ridge
2) Intersection of a mantle plume with a spreading ocean ridge
3) Volcanism associated with tectonic rifting
4) Sub-glacial volcanism
5) Tertiary flood (plateau) basalts
6) Bi-modal volcanism
7) Submarine volcanism
8) 18 historically active volcanoes
9) Eruptions roughly every 5 years



Kolbeinsey ridge (KR)
Reykjanes Ridge (RR)

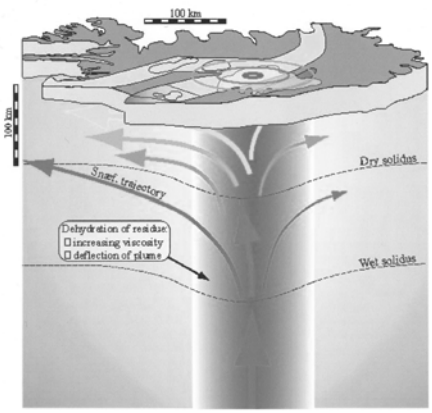


1. The North Atlantic opened about 54 Ma separating Greenland from Europe.
2. Spreading was initially along the now extinct Agir ridge (AER).
3. The Icelandic plume was under Greenland at that time.
4. The Greenland – Faeroe ridge represents the plume track during the history of the NE Atlantic.
5. During the last 20 Ma the Icelandic rift zones have migrated eastward, stepwise, maintaining their position near the plume
6. The plume center is thought to be beneath Vatnajökull

North Rift Zone – currently active
East Rift Zone – currently active
West Rift Zone – last erupted about 1000-1300 AD
[Also eastern (Oræfajökull) and western (Snæfellsnese) flank zones]

Rift zones comprise en-echelon basaltic fissure swarms 5-15 km wide and up to 200 km long. Over time these fissures swarms develop a volcanic center, eventually maturing into a central volcano with a caldera and silicic volcanism

Tertiary volcanics > 3.1 Ma
Late Tertiary to Early Quaternary 3.1 – 0.7 Ma
Neo-volcanic zone <0.7 - present



Schematic representation of Iceland's mantle plume.

The crust is about 35 – 40 km thick

Iceland's mantle plume has been tomographically imaged down to 400 km. Some claim even deeper, through the transition zone, and down to the core – mantle boundary.

LAVA PRODUCTION

Historical eruptions since 900 AD			
	Lava km^3	Tephra km^3	Percent
BASIC	25	6	74
INTERMEDIATE	7	1	19
SILICIC	0.3	2.8	7
TOTAL	32	10	100

Production Rate = 42 km^3/1100 yrs = 0.04 km^3/year

How does this compare with Hawaii?

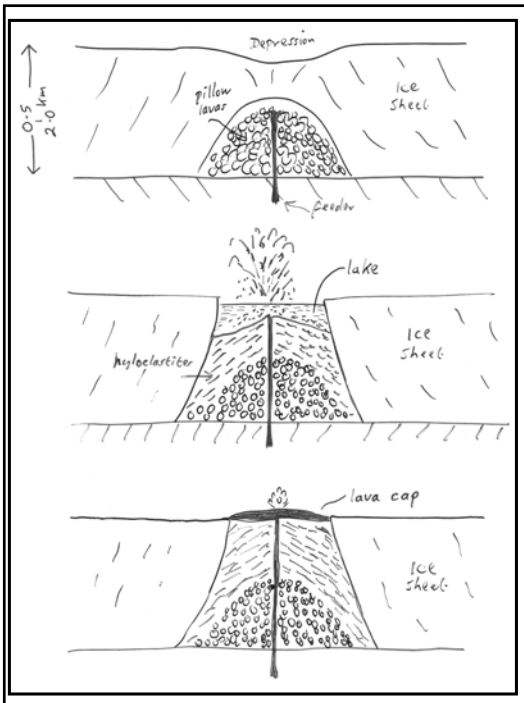
Sub - Glacial Volcanism

Iceland was completely covered by thick (500 – 2000m) ice sheets about 3 – 5 million years ago. Eruptions under ice produce:

a) Pillow lavas – deep
b) Hyaloclastites – shallow
c) Lava flows – once the eruption has breached the ice cover.

Sub-glacial pillow lavas and hyaloclastites Ölfusvatjna

Herdubreida is a classic example of a sub-glacial volcano. A table mountain composed of pillow lavas and hyaloclastites and capped by horizontal lava flows. How did it form?



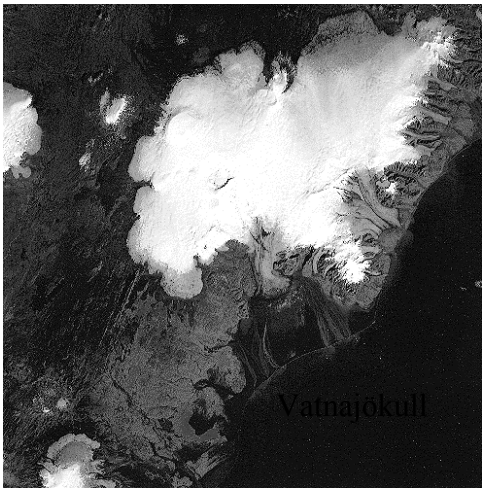
Burfell - fissure eruptions under ice produce long ridges known as moberg ridges

Bláfjàll – central eruptions under ice produce tuyas (table mountains).

Present day sub-glacial activity

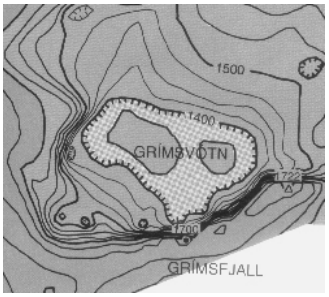
Katla – under Myardalsjökull
Grimsvötn – under Vatnajökull

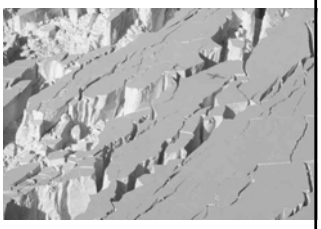
Jökull is an ice cap

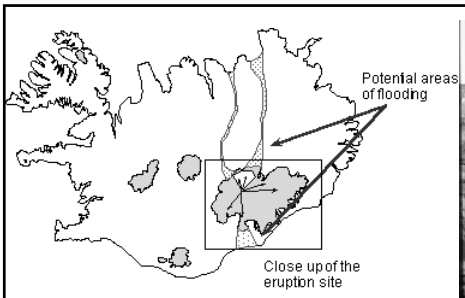


Eruptions under ice caps result in giant floods called jökullraups. Melt water discharge from these devastating floods range from 1000 – 40,000 m^3/sec. For comparison the discharge from the Amazon river is about 10,000 m^3/sec!

Grimsvötn September – October 1996

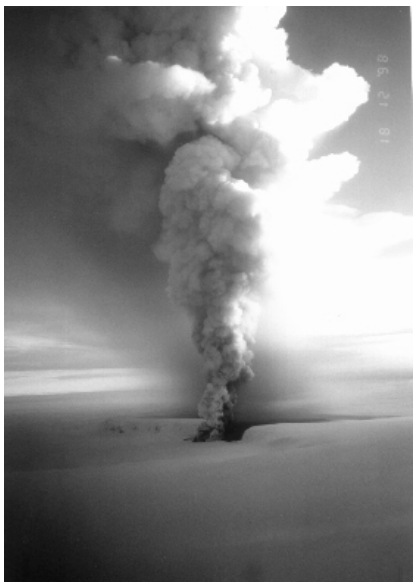






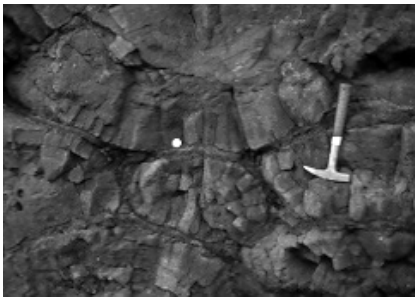
Maximum discharge rate was estimated at 45,000 m^3/sec. Resulting in 10 km of road washed away and loss or damage to three bridges. Estimated cost US$10 – 15 million.

Again in 1998!



The Western Volcanic Zone

The Reykjanes Peninsula is the continuation of the Mid-Atlantic Ridge. No current volcanic activity, but abundant evidence of spreading (faulting), exposed pillow basalts and hydrothermal activity.



Although the last eruption in this region occurred about 1300 AD there is abundant evidence of hydrothermal activity in the form of steam vents and boiling mud pools. Source of hydrothermal energy

The Western Volcanic Zone is home to the eponymous Geysir.

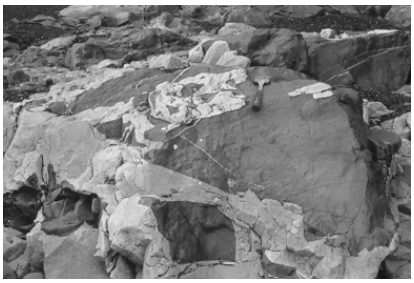
Cracking and rifting near Thingvellir

Thingvellir – site of the 900 AD Icelandic Parliament

Tertiary Volcanism

1. Initiated about 50 Ma at the opening of the N. Atlantic.
2. Located on E. and W of Iceland
3. Oldest lavas on Iceland are 18 Ma.
4. About 10 km exposed.
5. Quart tholeiite flood basalts
6. Erupted from fissures

Bi-Modal Volcanism



Net-vein complex

Composite dike

Tertiary Central Volcanic Centers are characterized by eruption of contemporaneous basaltic and silicic magmas. How can this be?

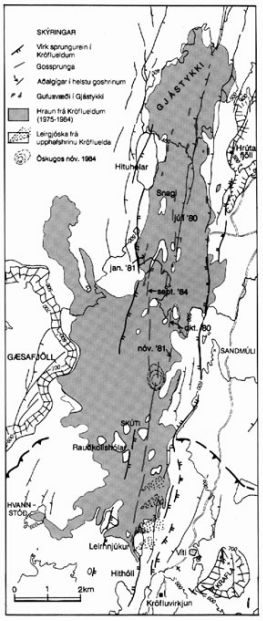
1. Fractionation of parental basaltic magma?
2. Melting of thick (35-40 km) crust?

The North Rift Zone

Krafla Region – historical eruptions have occurred in 1724-1729 (the Mývatn Fires) and again in 1975-1984 (Krafla eruptions)

Vitti – a phreatomagmatic explosion crater formed in 1724. In the background are the fissures and lava flows of the Krafla 1981 eruption

The Mývatn eruption occurred along 11 km of fissures and produced 0.5 km^3 of lava.



The Krafla eruptions occurred in 1975, 1977(2), 1981 and 1984 from fissures fed from a central magma chamber. Each eruption was followed by episodes of rifting and re-inflatiuon of the reservoir (estimated at ~ 0.015 km^3/yr). Total volume erupted was ~ 0.3 km^3.

The 1981 flow on the 1975 flow

The Krafla area is a source of hydrothermal power.

Spatter cone along the 1981 fissure

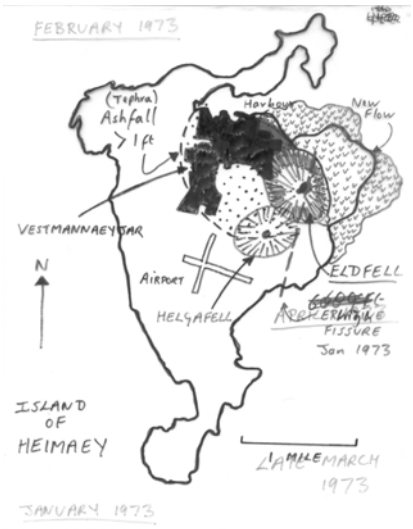
The Heimaey Eruption

Iceland, January to June, 1973

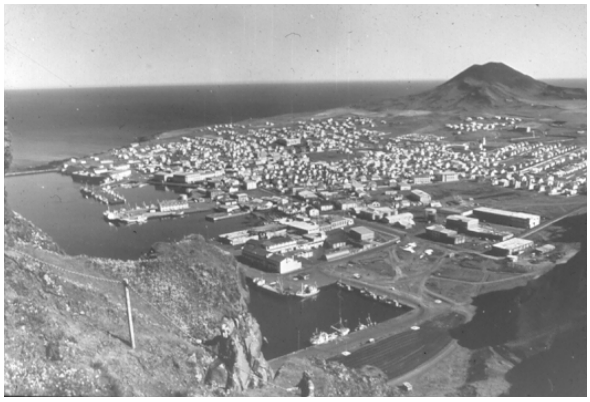
Eruption rate about 0.5 x 10^6 m/hr (initially)

- January - February
  - Fires started by incandescent bombs.
  - Ash buries houses - roofs collapse due to weight of (wet) ash.
- March
  - Aa lava flow, about 130 ft thick, moving at 10-30 ft/day destroys homes and fish canneries and threatens to block harbor.
- March - April
  - Massive effort pumping sea water onto flow front and interior of flow diverts flow and saves harbor.

The Heimaey Eruption



April, 1973

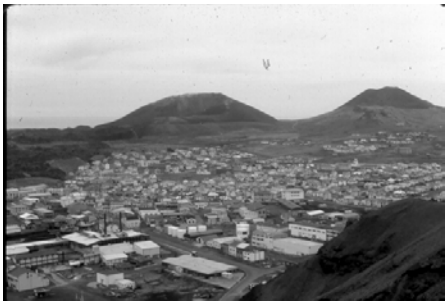


The town of Vestmannaeyjar on the island of Heimaey, prior to the eruption, with the 900 year old volcano Helgafell in the background

The eruption begins, behind the town, from fissures as a typical Hawaiian style of eruption. With time it becomes more strombolian, bombarding the town with bombs and blanketing it with ash.

A single vent builds up the cone of Eldfell, producing a thick blocky/aa flow that invades the town and harbor.

If the harbor were to be blocked, then the economy of the island, which depends on fishing, would be ruined.



The town afterwards, with the new volcano Eldfell in the background. The huge aa flow provides protection for the harbor as well as a source of geothermal energy.

SURTSEY

Surtsey erupted explosively in November 1963. Initially there were continuing phreatomagmatic eruptions as basaltic magma reacted with seawater. Eventually, once the vent was sealed from the sea, the eruptions became more Hawaiian in style. Surtsey represents the southward propagation of the Eastern Volcanic Zone

Surtsey Today

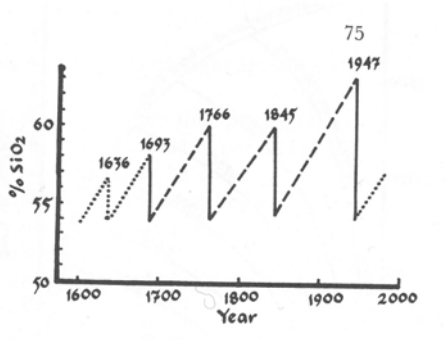
Heimaey from Surtsey

Hellisey

Remnants of former volcanoes

Hekla

Hekla is Iceland's most active volcano, erupting 17 times since 1158 AD and producing about 8 km^3 of lava and 7 km^3 of tephra. The ash is widely spread (sometimes reaching Europe) and potentially toxic because of a high fluorine content (causes fluorosis)



Hekla is unusual in that the initial stages are often silicic and explosive, resulting in sub-Plinian eruptions that evolve into fissure eruptions of basaltic magma. The size of the eruption and the silica content of the first material erupted appear to be a function of the repose period, indicating the evacuation of a zoned magma chamber.

What produces the zoning?

The last eruption of Hekla occurred in 2000, prior to that it erupted in 1991. So, with a repose period of only 9 years, can you predict the nature of the 2000 eruption?