

Subglacial and phreatomagmatic eruptions

30 minutes in paradise of fragmentation

Ármann Höskuldsson, Magnus Tumi Guðmundsson
And team futurevolc



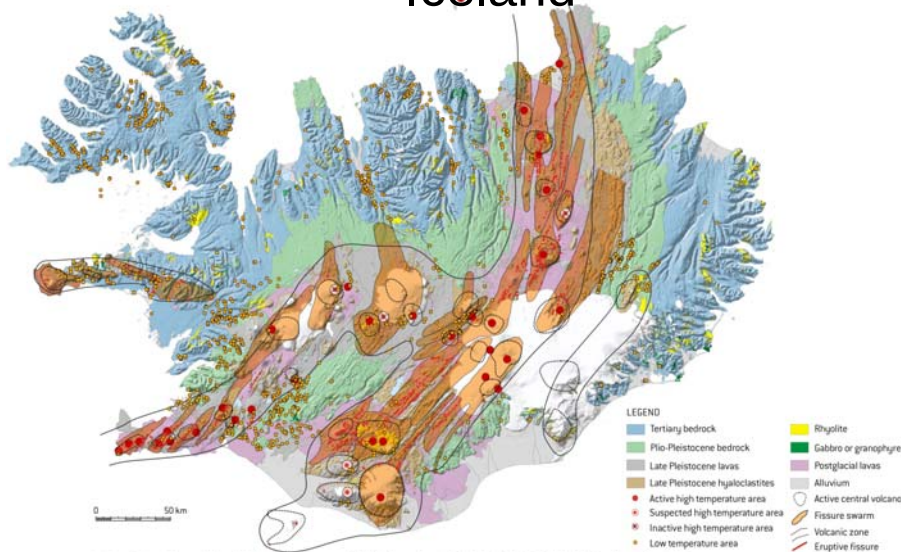
armh@hi.is

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NordVulk, Institute of earth sciences

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Iceland



Based on Geological map of Iceland by Haukur Jóhannesson and Kristján Sæmundsson 1999. Iceland. 1:1,000,000. Icelandic Institute of Natural History.
Haukur Jóhannesson and Kristján Sæmundsson 1998. Geological map of Iceland. 1:500,000. Bedrock. Icelandic Institute of Natural History [2.ed.]
Haukur Jóhannesson and Kristján Sæmundsson 1998. Geological map of Iceland. 1:500,000. Tectonics. Icelandic Institute of Natural History.

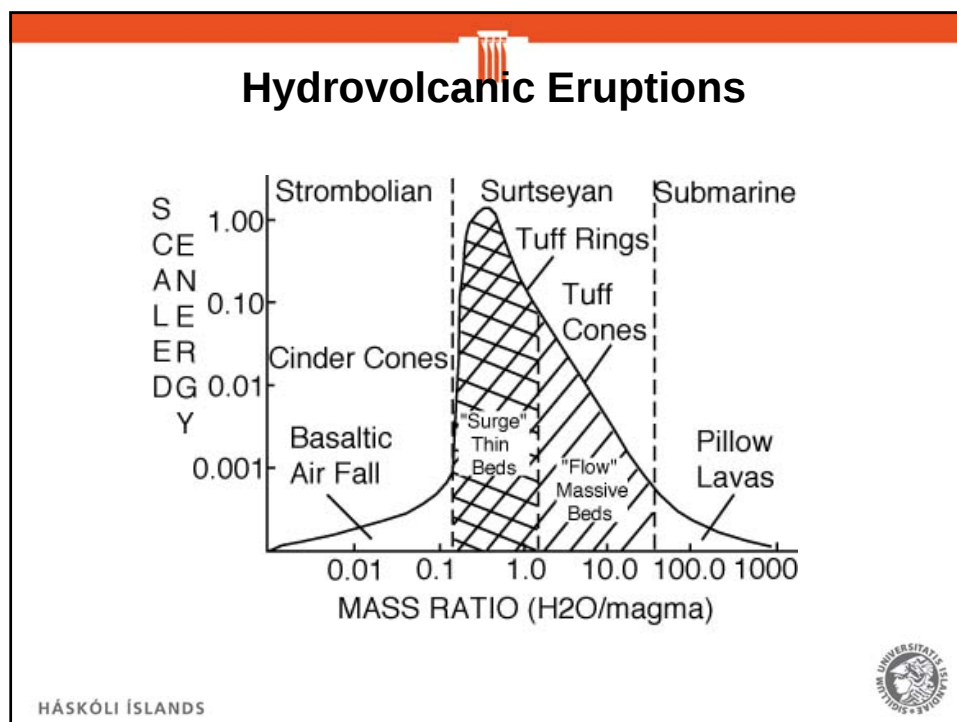
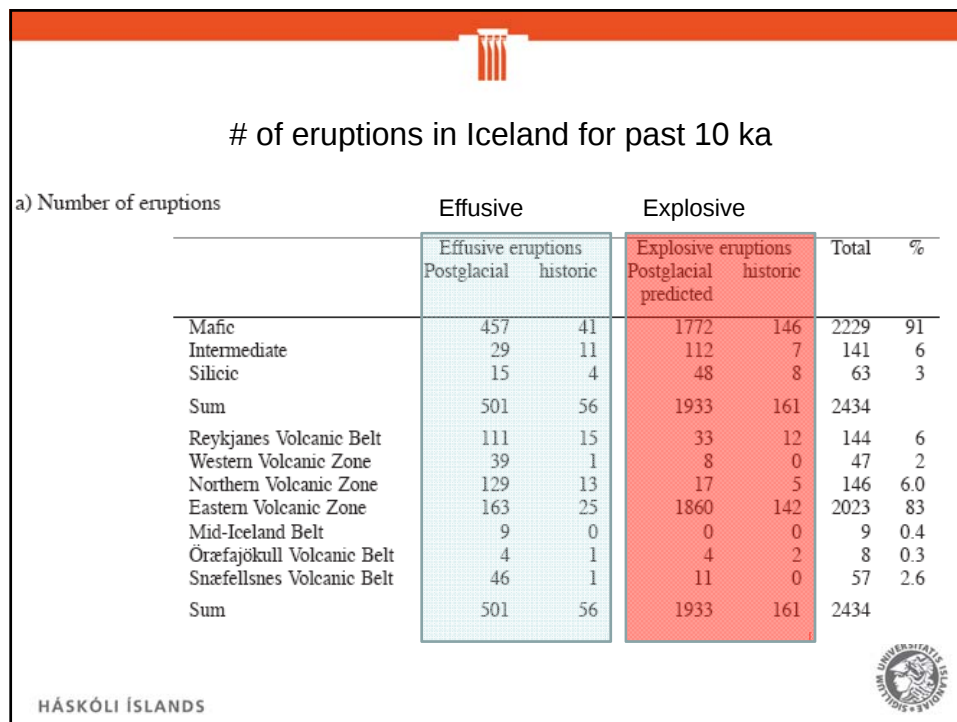


						
Appr. 75% basalt - 17% Rhyolite, dasít and andesite						
Table 5 Volume of erupted magma according to rock type and volcanic regions						
Rock type	Lava	Tephra	Tephra (DRE)	Total	Total (DRE)	% DRE
Basalt	50	44	19	94	69	79
Andesite	11.5	4.5	2	16	13.5	16
Rhyolite and dacite	0.5	11	3.5	11.5	4	5
Sum	~62	~60	~25	~122	~87	
Volcanic zones						
Reykjanes Volcanic Zone and West Volcanic Zone	11	1	0.5	11.5	11.5	13
North Volcanic Zone	1	3	1	4	2	2.5
East Volcanic Zone	50	49	21	99	71	82
Öræfajökull and Snæfellsnes Volcanic Belts	0.2	6.5	2	6.7	2.2	2.5
Sum	~62	~60	~25	~122	~87	
Four most productive volcanic systems						
Katla	18	15 ^a	6–7 ^a	33	25	36
Grímsvötn	15	14 ^b	6 ^b	29	21	30
Hekla	11	6	2	17	13	19
Bárdarbunga–Veidivötn	5	13	5	18	10	15
Sum	49	48	19–20	97	69	
Note: volume estimates for the Grímsvötn Volcanic System are based on the assumption that average DRE volume of 20th century eruptions within and outside the Grímsvötn caldera (≈ 0.04 and 0.3 km^3 , respectively; Gudmundsson (2005) is representative for the activity in historical time (see text for further details). ^a Includes jökulhlaup-transported deposits. ^b Includes subglacial deposits.						
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Single vent phreatomagmatic			
Classification of basaltic volcanoes in Iceland			
Eruption characteristics		Circular (central vent or short fissure)	Examples
Environment	Eruption type		
Subaerial magmatic	Effusive–less explosive (flood lava)	Lava shield	Skjaldbreiður,
	Effusive	Spatter ring (eldborg)	Kollóttadyngja
	Effusive–explosive	Scoria cone	Eldborg at Mýrar,
Subaerial phreatomagmatic	Explosive	Tephra (tuff) cone, tephra (tuff) ring	Búrfell in Heimörk
			Eldfell, Grábrók
		Maar	Hrossaborg, Hverfjall ?
Subglacial and submarine	Effusive	Pillow lava cone	Grænavatn, Víti
	Effusive–explosive	Móberg cone seamount	?
	Effusive–explosive–effusive	Table mountain	Keilir Jólnir
Modified from Thorarinnsson (1981). ? : no examples are known			
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Fissure vent phreatomagmatic eruptions			
Classification of basaltic volcanoes in Iceland			
Eruption characteristics		Linear (long fissure)	Examples
Environment	Eruption type		
Subaerial magmatic	Effusive-less explosive (flood lava)	Mixed cone row	Laki, Eldgjá
	Effusive	Spatter cone row	Tröllagígur, Threngslaborgir
	Effusive-explosive	Scoria cone row	Vikraborgir, Valagjá
Subaerial phreatomagmatic	Explosive	Volcanogenic chasms	
		Tephra (tuff) cone row, tephra (tuff) ring row	Vatnaöldur, Veidivötn ^a
		Maar crater row	?
Subglacial and submarine	Effusive	Pillow lava ridge	Kverkfjallaráni
	Effusive-explosive	Móberg ridge or submarine ridge	Sveifluhals, Eldeyjarsbodi
	Effusive-explosive-effusive	Table mountain (ridge-like)	Bláfjall
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Production in historic time			
Volume of erupted magma according to rock type and volcanic regions			
Rock type	Lava		Tephra (DRE)
Basalt	50		19
Andesite	11.5		2
Rhyolite and dacite	0.5		3.5
Sum	~62		~25
Volcanic zones			
Reykjanes Volcanic Zone and West Volcanic Zone	11		0.5
North Volcanic Zone	1		1
East Volcanic Zone	50		21
Öræfajökull and Snæfellsnes Volcanic Belts	0.2		2
Sum	~62		~25
Four most productive volcanic systems			
Katla	18		6–7 ^a
Grímsvötn	15		6 ^b
Hekla	11		2
Bárdarbunga–Veidivötn	5		5
Sum	49		19–20
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Sub-glacial eruptions



Volcanology: JAR610G
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Ármann Höskuldsson: Flow-Surge



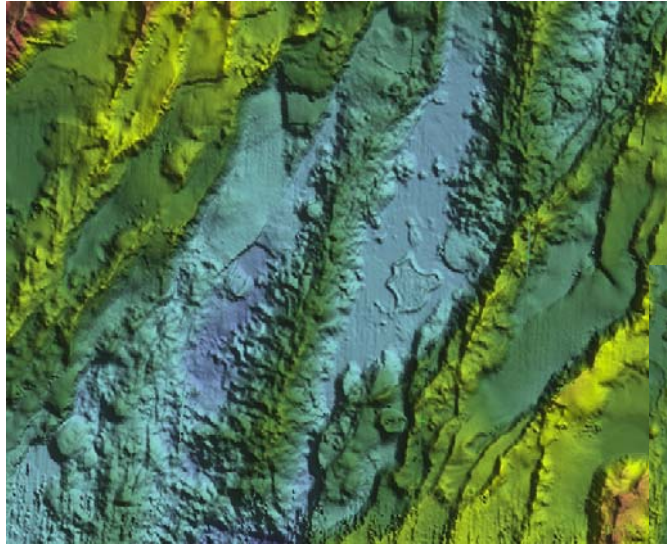
Non explosive hydrovolcanics



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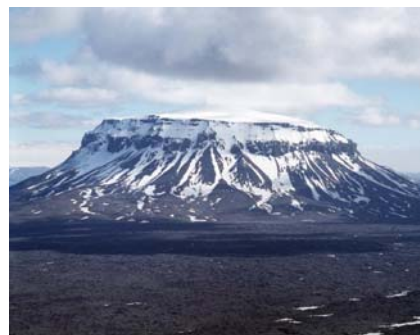
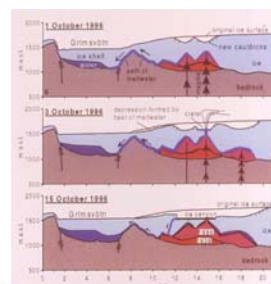
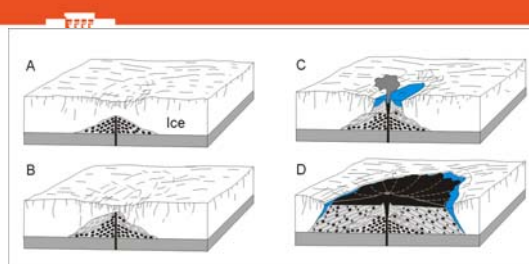


Reykjanesridge



- Depth 3000 m
- Lavas, pillows
- Explosives deposits

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Volcanic landforms resulting from subglacial eruptions



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Explosive hydrovolcanics



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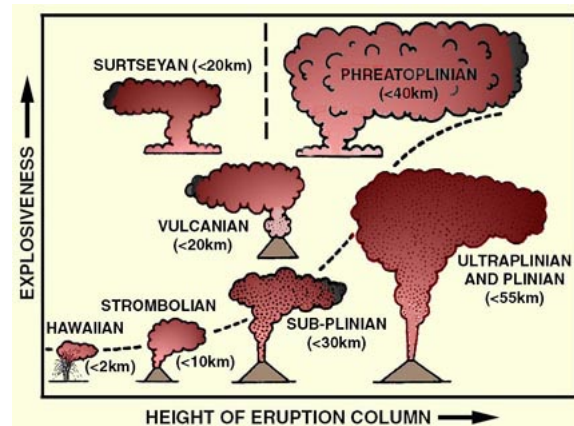
Breaking the surface



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Walker diagram



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Heimaey 1973 morgning of January 21



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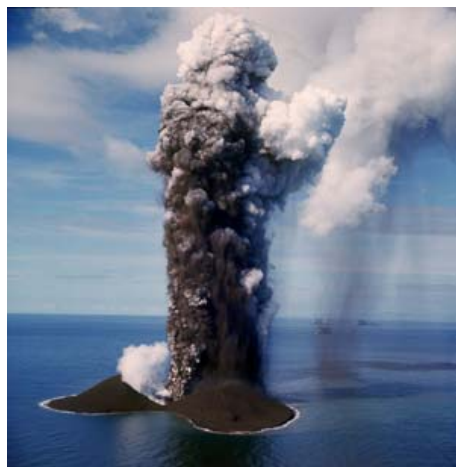
Heimaey 1973 two weeks later



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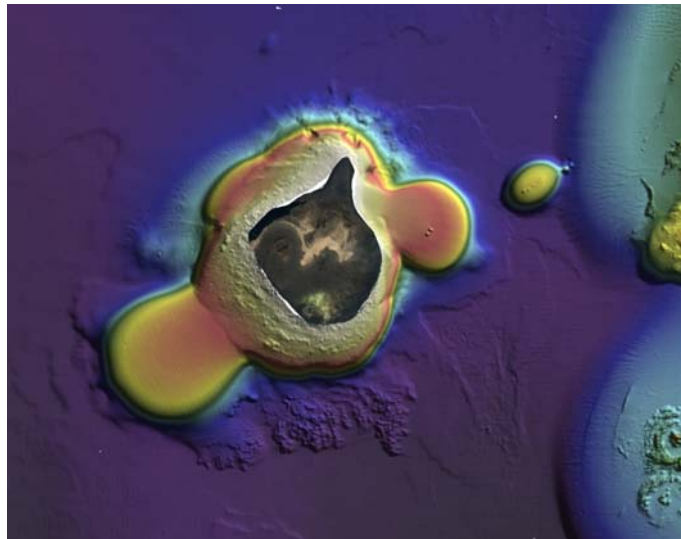
Surtsey 1963-67



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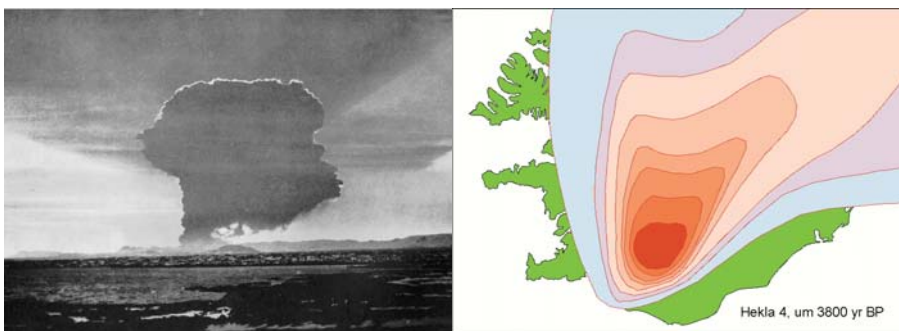
Jólnir, Surtsey, Syrtlingur and Surtla



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Plinian phreatomagmatic –



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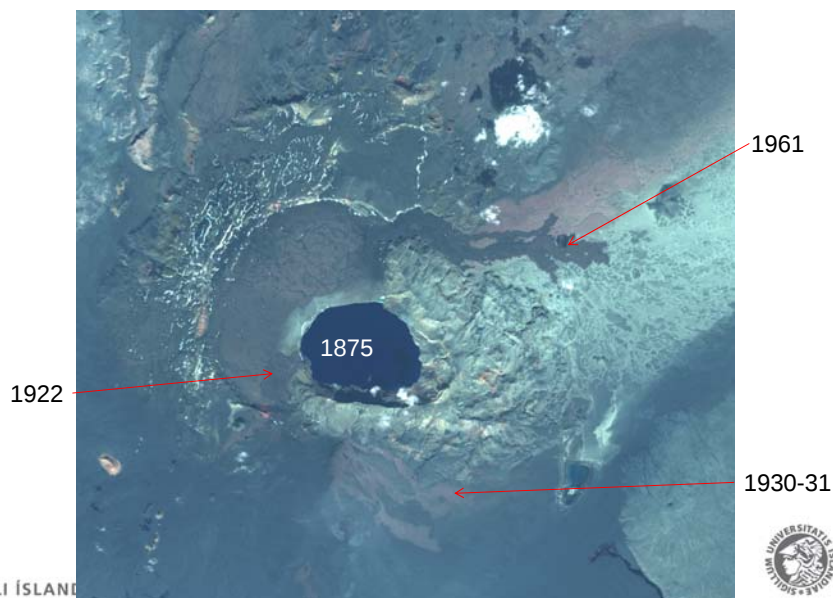
Askja volcano



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Askja

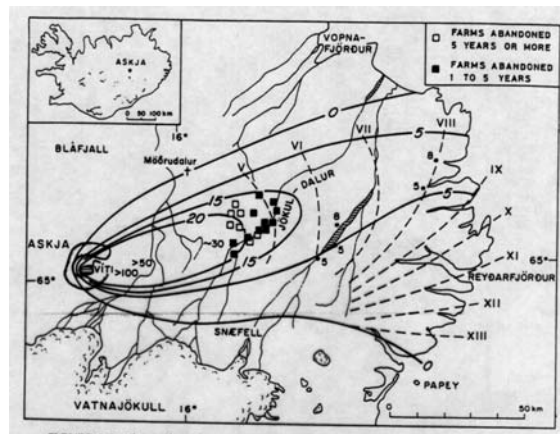


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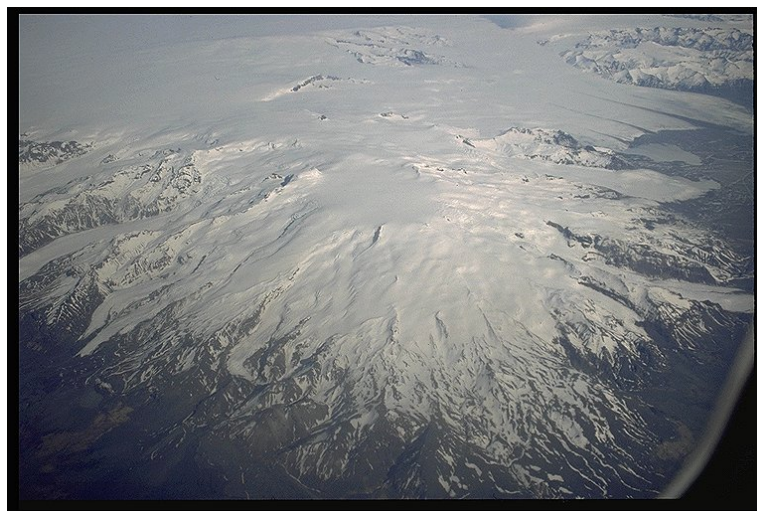
Dispersal of the airfall deposits from the Askja 1875 eruption



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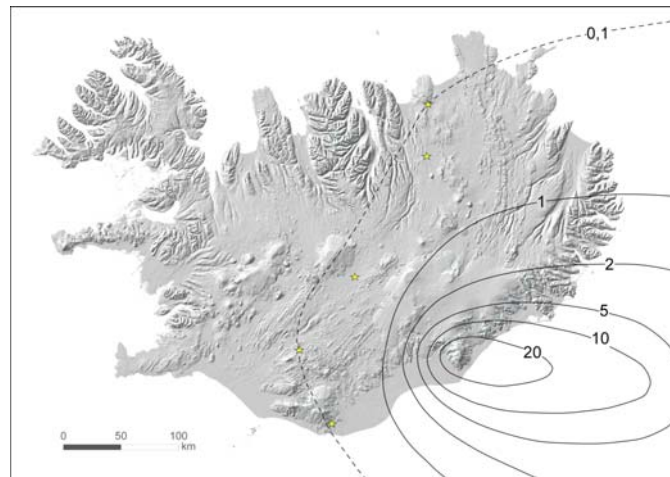
The Öräfajökull volcano, the giant in the east 1362 and 1727



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Öræfajökull 1362



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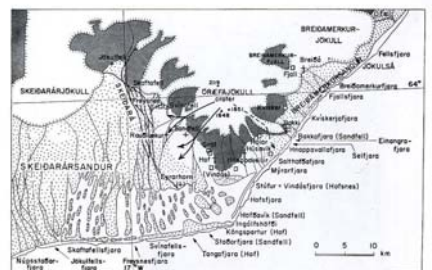


Fig. 15. Litledated to the 18th century. Topography according to the 1916 map. Inflow areas along 100 m are shaded. The courses of the 1362 jökulhlaup and the jökulhlaup from Kvíðajökull are shown very schematically. Long crosses: Main churches. Short crosses: Annex churches. The map also shows the present division of the shore.

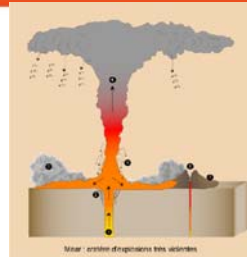


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Fissure eruptions



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Magmatic - Phreatomagmatic



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Vents going from land to water or water to land



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In lakes– tuff cone - Hverfjall



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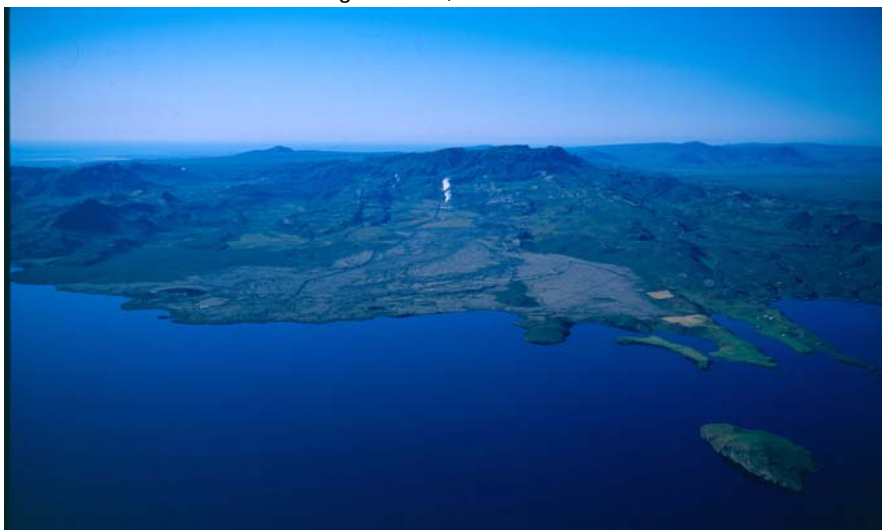
Hverfjall



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Lake Þingvallavatn, ~2000 BP



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High groundwater level – The case of Veidivotn eruption 1477



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At high groundwater levels

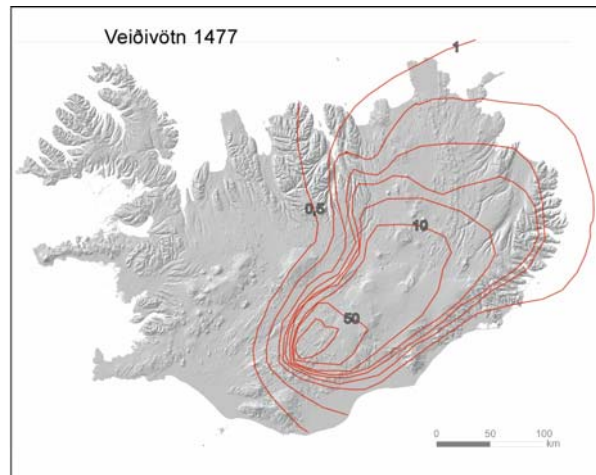


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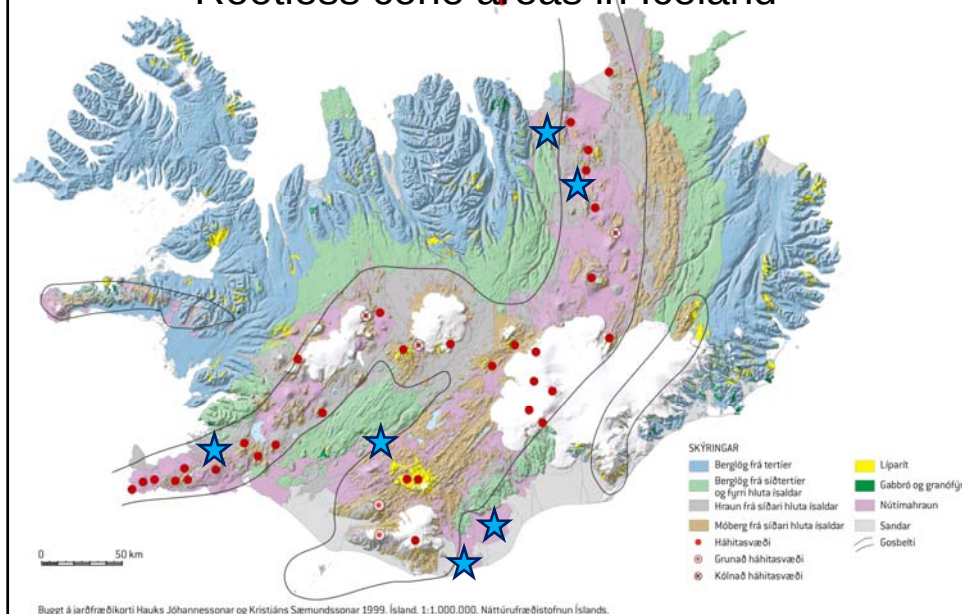
Forming widespread tephra covers



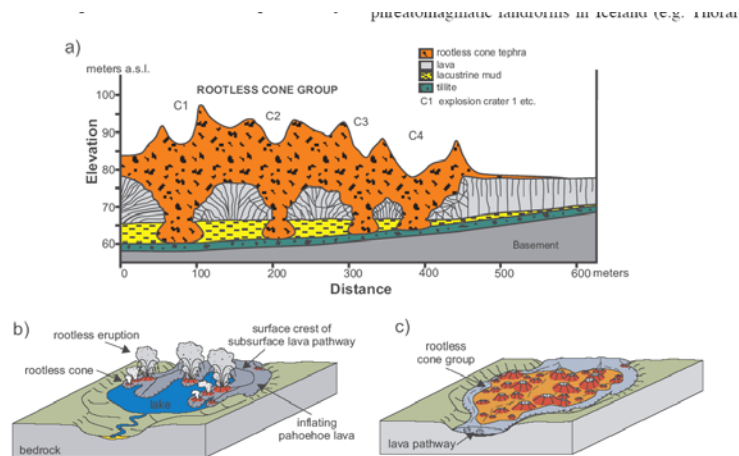
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Rootless cone areas in Iceland



Rootless cones



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Rootless cones, Myvatn



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Fimmvörðuháls 21/3



Basaltic eruption with minor ash production, limited water interaction

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Rootless explosion Fimmvörðuháls



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Eyjafjallajökull 2010



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015 991

14/4 2010 kl 15:49



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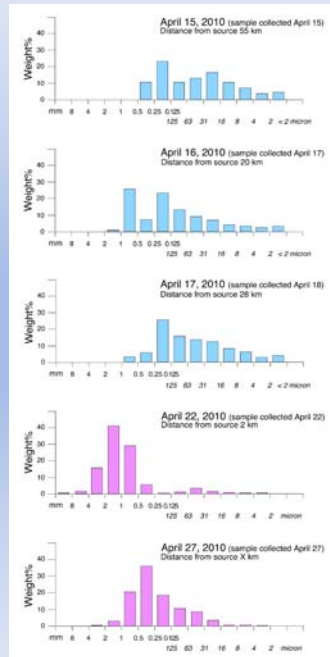


14-17 April – very fine grained ash – can float in the atmosphere over long distances

17 April

Periods of low activity (e.g. 20-28 April) – larger grain size

27 April



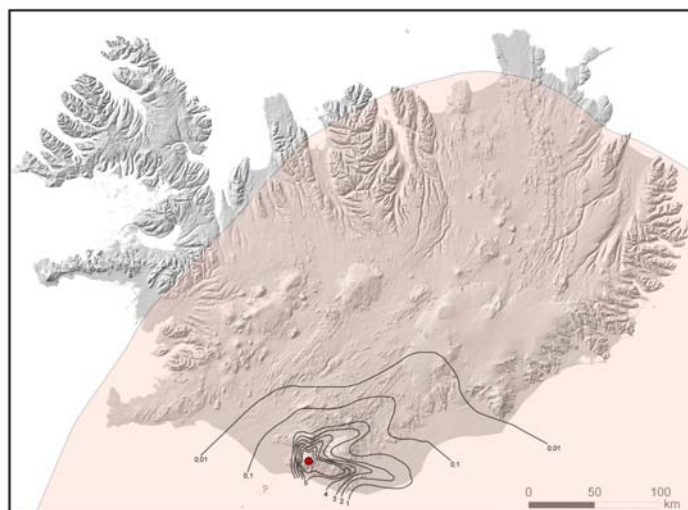
Eyjafjallajökull 2010



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Tephra cover Eyjafjallajökli 2010



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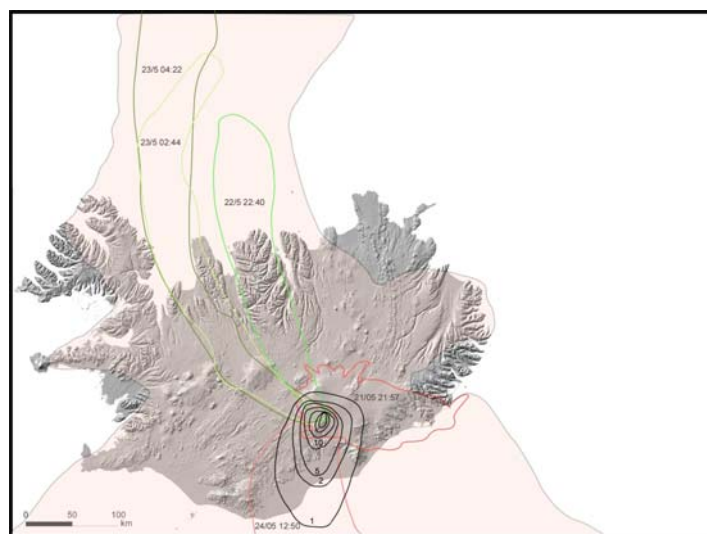


- Alternation of highly fragmented particles zones and vesicular scoria zones, indication of variations in water magma ratios.

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Tephra cover Grímsvötnum 2011



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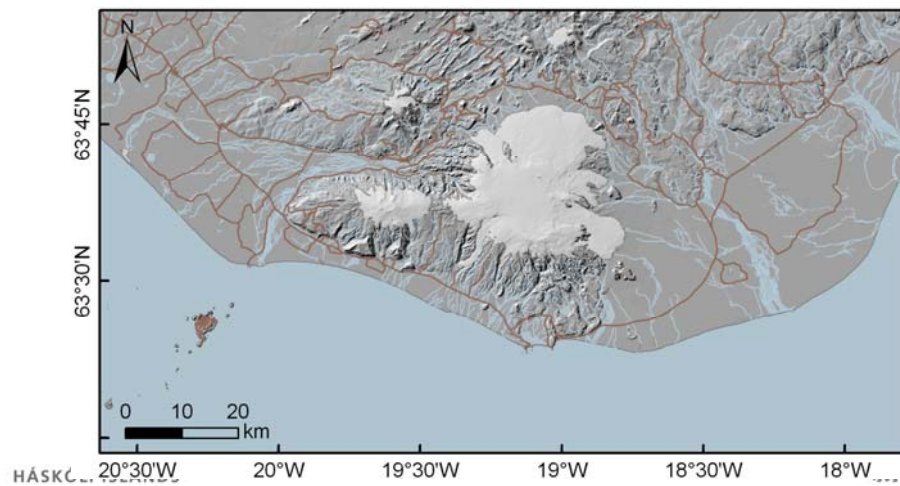
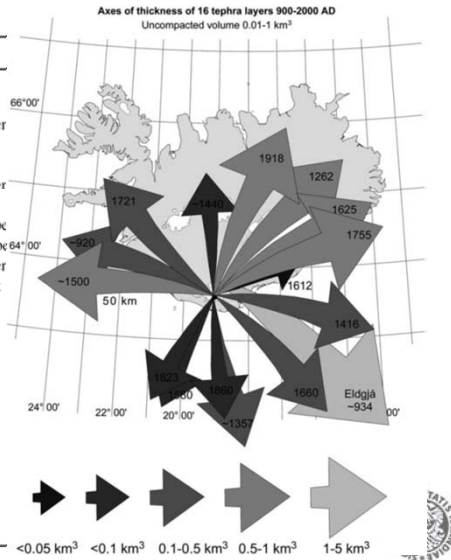


Figure 1 consists of two panels. The top panel is a topographic map of the Vatnajökull glacier system, showing elevation contours and various calderons. The map includes a scale bar (0 to 10 km) and a north arrow. The bottom panel is a cross-section of the glacier system, showing the profile of the glacier and the underlying bedrock. The cross-section is labeled with various calderons (TCR, C-1, C-15, C-24, C-23, C-11, C-12, SSC) and shows the glacier's extent and the underlying bedrock. The cross-section also includes a scale bar (0 to 10 km) and a north arrow.

Kötlugos og áttir gosmakkar

Historical eruptions on the Katla volcanic system

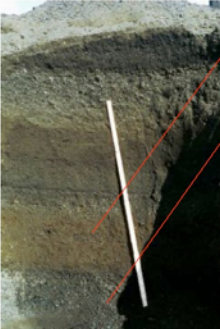
Katla volcanic system	Eruption year	Date
Katla	(1999)	18 July
Katla	(1955)	25 June
Katla	1918	12 October
Katla	1860	8 May
Katla	1823	26 June
Katla	1755	17 October
Katla	1721	11 May
Katla	1660	3 November
Katla	1625	2 September
Katla	1612	12 October
Katla	1580	11 August
Katla	~1500	
Katla	15 ca.	
Katla	~1440	
Katla	1416	
Katla	~1357	
Katla	1262	
Katla	1245	
Katla	~1179	
Katla	12 ca.	
Eldgjá	934/938	
Katla	~920	
Katla	9 ca.	



The Eldgjá 934 mixed fissure eruptions forming effusive and explosive deposits.



Eldgjá Tephra 934 att 30 km from source



Brown tephra rich in fines indicates fragmentation in phreatomagmatic phase

Black glassy coarse grained tephra with "achneliths" indicates fragmentation in magmatic eruption phase

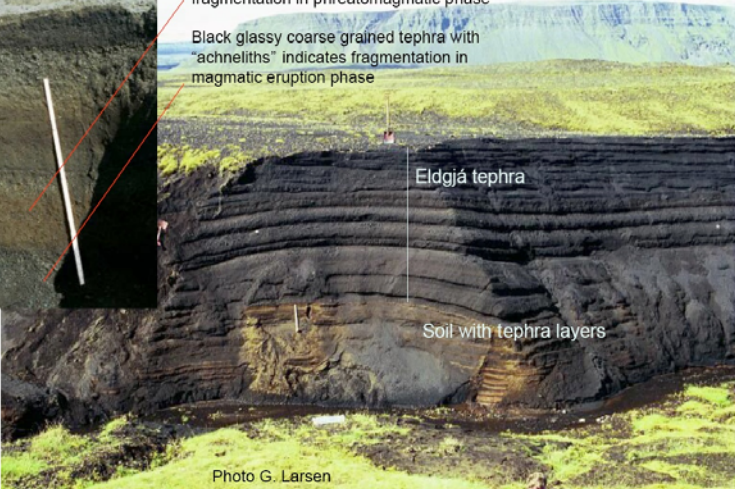


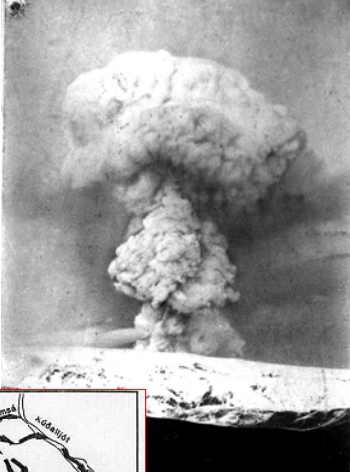
Photo G. Larsen

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Jökulhlaup and plumes carry tephra from source



10 Km

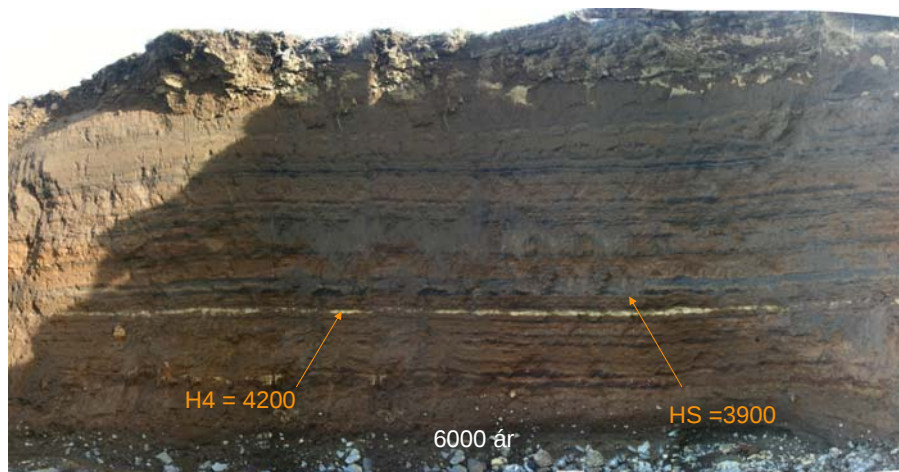
1918

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Tephra past 6000 years, soil section



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Past 112 years

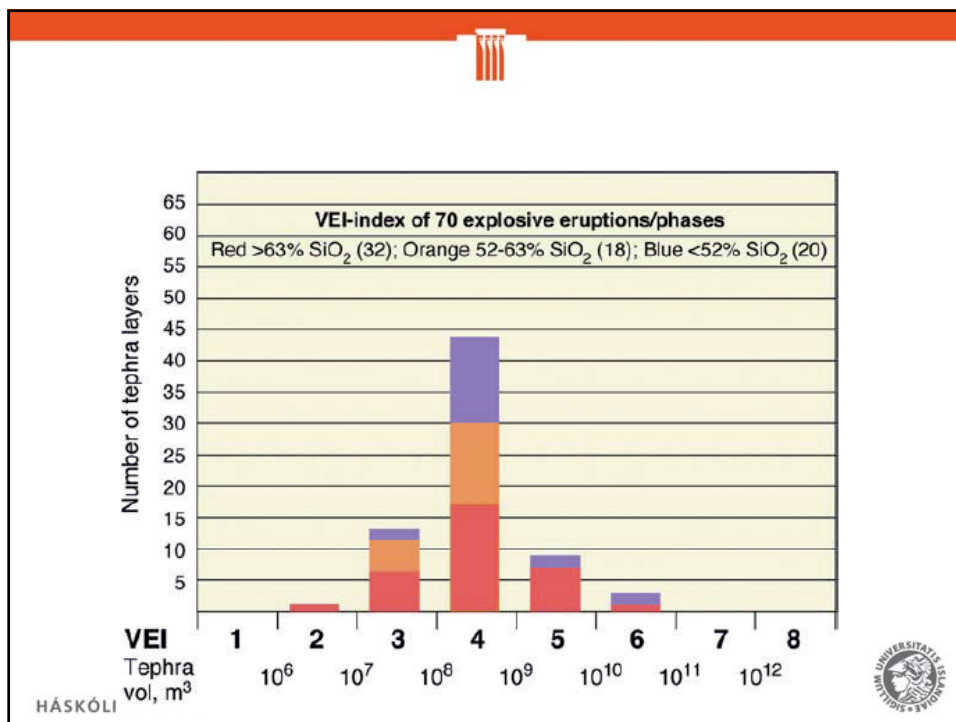
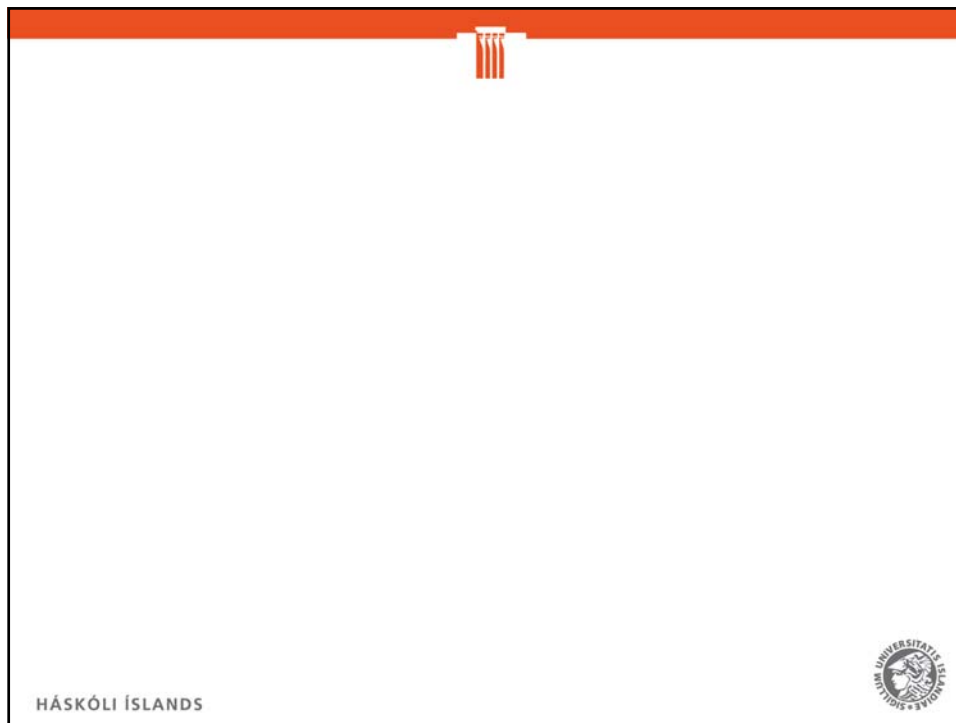
2011 Grímsvötn
2010 Eyjafjallajökull
2010 Fimmvörðuháls
2004 Grímsvötn
2000 Hekla
1998 Grímsvötn
1996 Gjalp
1991 Hekla
1984 Krafla
1983 Grímsvötn
1981 Krafla 2 gos.
1981 Hekla
1980 Hekla
1980 Krafla 3 gos.
1977 Krafla 2 gos.
1975 Krafla
1973 Submarine 5 km of the coast.
1973 Heimaey
1970 Hekla
1963-1967 Surtsey 6 gos.
1961 Askja
1947 Hekla
1938 Grímsvötn
1934 Grímsvötn
1933 Grímsvötn
1929 Askja
1927 Askja
1926 Norðaustan Eldeyjar.
1924 Askja
1923 Askja
1922 Askja 2 gos.
1922 Grímsvötn
1921 Askja
1918 Katla
1913 Austan Heklu
1910 Þórðarhryna
1903 Þórðarhryna
1902 Grímsvötn

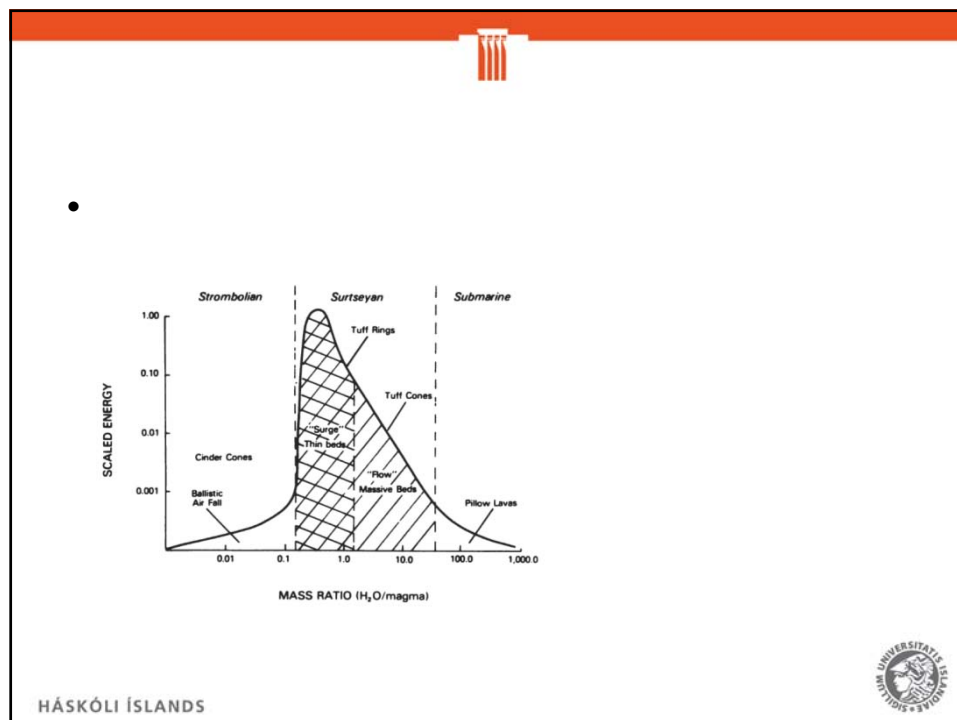
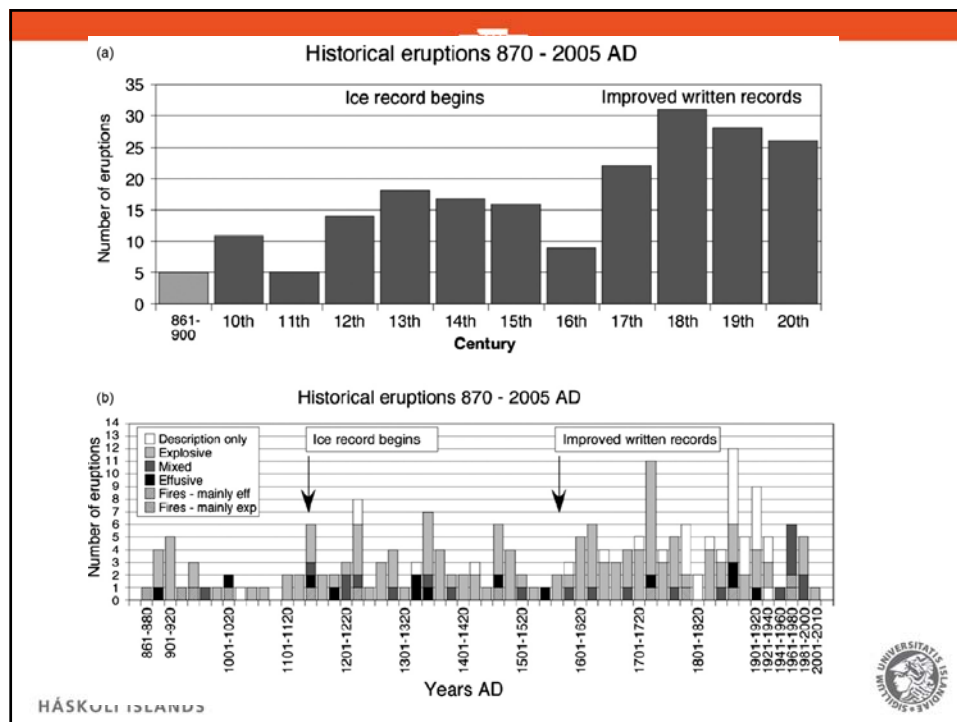


Total	48
Averag.	2.3 years

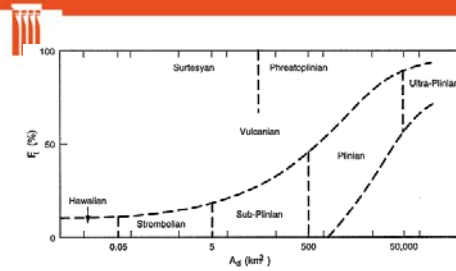
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Frequency of eruption in Iceland and recurrence time



V_{DRE} km^3	Recurrence time Years
<0.01	5–10
0.01–0.05	5–10
0.05–0.1	10
0.1–0.5	10–20
0.5–1.0	50
1–5	100
5–10	500
>10	500–1,000

VEI	Recurrence time Years
1	10
2	10
3	10–20
4	30–50
5	100–200
6	500–1,000

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Hekla, 1947



Grímsvötn 2011



Historic plinian:

Grímsvötn 2011 subplinískt

Katla 1625 and 1755

Askja 1875

Öræfajökull 1362

Hekla 1104

Veiðivötn 1477, 871

Prehistoric: Snæfellsjökull 3, Öræfajökull 3, Hekla 5, Askja 2, Krafla 1

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The Krafla fires 1975-1984

Rifting event resulting in a 10 m displacement of the plates



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