Íslensk Stórgos – Dæmisögur

Þorvaldur Þórðarson

Goslisti

- Skaftáreldar 1783-84
- Eldgjá 934-40
- Öræfajökull 1362

- Nornaeldar 2014-15
- Grímsvötn 2011/10ka
- Eyjafjallajökull 2010

Stærstu hraungosin frá því land byggðist

Gos	Hvenær	km^3
Eldgjá	934-38	20
Skaftáreldar	1783-84	15
Hallmundarhraun	10. öld	8
Frambruni	fyrir 13. öld	4
Dyngjusandshraun	**2014**	**1,1– 1,2**

Stærstu sprengigosin frá því land byggðist

Gos	Hvenær	km^3
Vatnaöldur	870	5
Öræfajökull	1362	10
Veiðivötn	1477	11
Askja	1875	3

Rúmmál reiknað sem nýfallin gjóska

Byggt á: Þorvaldur Þórðarson og Guðrún Larsen, 2007; mælingum Náttúruváhóps Jarðvísindastofnunar á gosinu 2014

Skaftáreldar (8 júní 1783 - 7 febrúar 1784)

Annað stærsta flæðibasaltgos jarðar á sögulegum tíma

Mestu náttúruhamfarir Íslands

Hraun = 14.7 km^3
Gjóska = 0.4 km^3
SO_2 = 120 Mt
H_2SO_4 = 200-240 Mt

Thordarson, et al., 1993, 2001, 2003; Self et al 2004

Samtímaheimildir: Eldrit um Skaftárelda

Höfundar	Eldritin
Jón Steingrímsson (1728-1791)	1. Lítið ágrip um nýja eldsuppkomu í vestariparti Skaftafellssýslu (1783). 2. Einföld og sönn frásaga um jarðeldshlaupið í Skaftafellssýslu ... (1783). 3. Fullkomið skrif um Síðueld (1788).
Sæmundur M. Hólm (1749-1821)	Om Jordbranden paa Island i Aaret 1783 (1784).
Magnús Stephensen (1762-1833)	Kort beskrivelse over den nye Vulcans ildsprudning i Vester Skaptafields-Syssel paa Island i Aaret 1783 (1785).
Sveinn Pálsson (1762 -1840)	Historia ignis in oriente Islandiae erumpentis anno 1783, quad innotuit in tractu Skagafjördensi; complectitur historia in se et effectus varios (1784)
Johan C. Sünckenberg (1757-1806)	Skrivelse til den islanske handels Direction (1783).
Jón Eiríksson (1728-1787)	Efterretning om ilds-udbrydelsen i Vester Skaptafells-Syssel i Island (1783).
Jón Pétursson (1733-1801)	Om ildrögens Kiendeligste Virkninger paa Nordlandet i Island, 1783. (handrit tapað).

Sveinbjörn Rafnsson, 1984; Thordarson 2003

Skaftáreldar 1783-84

Samtímaheimildir

Framlag Jóns Steingrímssonar

Lýsingar Jóns Steingrímssonar I

Eldrit Jóns Steingrímssonar eru einstœðar heimildir um annað mesta hraungos jarðar á sögulegum tíma og hann lýsti framvindu gossins frá degi til dags.

Eldritin eru jafnframt ein merkasta eldgosalýsing mannkyns-sögunnar. Sem slíkt stendur það jafnfœtis, ef ekki framar, lýsingum Pliní yngra af gosinu í Vesúvíus 79 e.kr.

Thordarson, 1991; 2003

Fullkomið Skrif um Síðueld – Forsíða

Lýsingar Jóns Steingrímssonar II

Þrátt fyrir trúarlegt ívaf eldritanna lítur Jón á öll ferli jarðeldsins raunsæisaugum og telur þau stjórnast af náttúruöflunum, þó að vísu undir yfirstjórn almættisins. Hann lýsir atburðum eins og hann sá þá, ótruflaður af grillum lærðra manna.

Lýsing Jóns nær yfir jarðskjálfta, öskufall, hraunrennsli, og áhrif þess á samfélagið.

Eftir skrifum hans má rekja framvindu gossins, opnun gossprungunnar frá suð-vestri til norð-austurs og kortleggja framrás hraunsins.

Þá er merkileg sú tilraun hans hvort eldurinn gæti brætt berg:

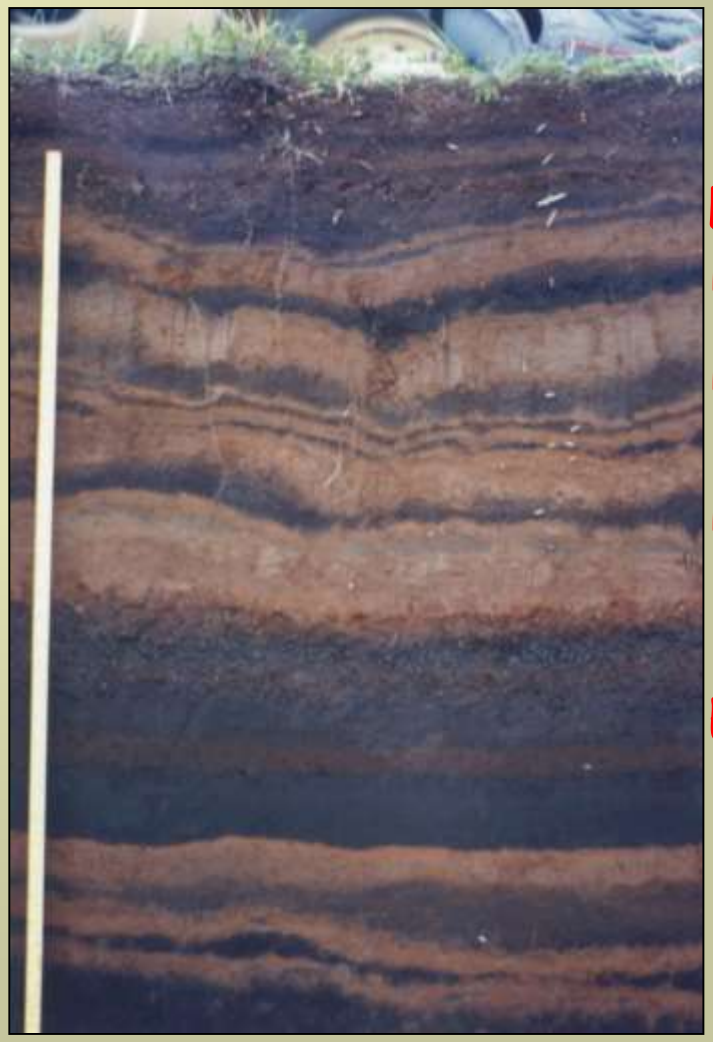
"Þessa prófun brúkaði ég fyrir meðal að hugstyrkja og yfirbevísa fólk um það, að aldeilis væri óhætt vorum byggðarfjöllum og hálsum fyrir eyðileggingu þessa elds."

Glöggskyggni og raunsæi Jóns Steingrímssonar I

Jón tengir öskulög í jarðvegi réttilega við eldgos.

"Ég lít til og meina helzt hér í Vestri-Skaftafellssýslu, …., hafa 14 sinnum að þessu meðreiknuðu og enn oftar jarðeldar uppkomið og gjört hér ýmsar eyðileggingar og umbreytingar. Þó hafa öskuföll úr þeim misjafnt yfir fallið því sumstaðar má hér telja 5, en sumstaðar 11 sandlög í jörðinni."

(Jón Steingrímsson, 1788)



Glöggskyggni og raunsæi Jóns

Jón lýsir nornahárum sem eru þær fyrstu sem vitað er um á prenti.

"… þau voru svartblá og íglittin, að lengd og digurð sem selshár …"

(Jón Steingrímsson, 1788)

Pele's hair

cow dung bomb

Einnig lýsir Jón kleprabombum

„því að þar er að sjá grjótslettur, sem hafa fallið úr lofti ofan á jörð; sumar eru aflangar og snúnar saman, sem kúahlöss"

(Jón Steingrímsson, 1788)

Thordarson, 1991, 2003

Samtímakort

Þorvaldur Þórðarson

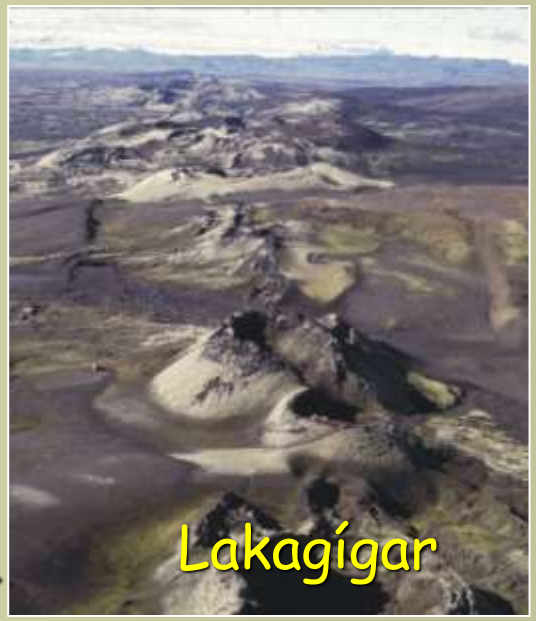
Sæmundur Hólm

Sveinn Pálsson

Magnús Stephensen

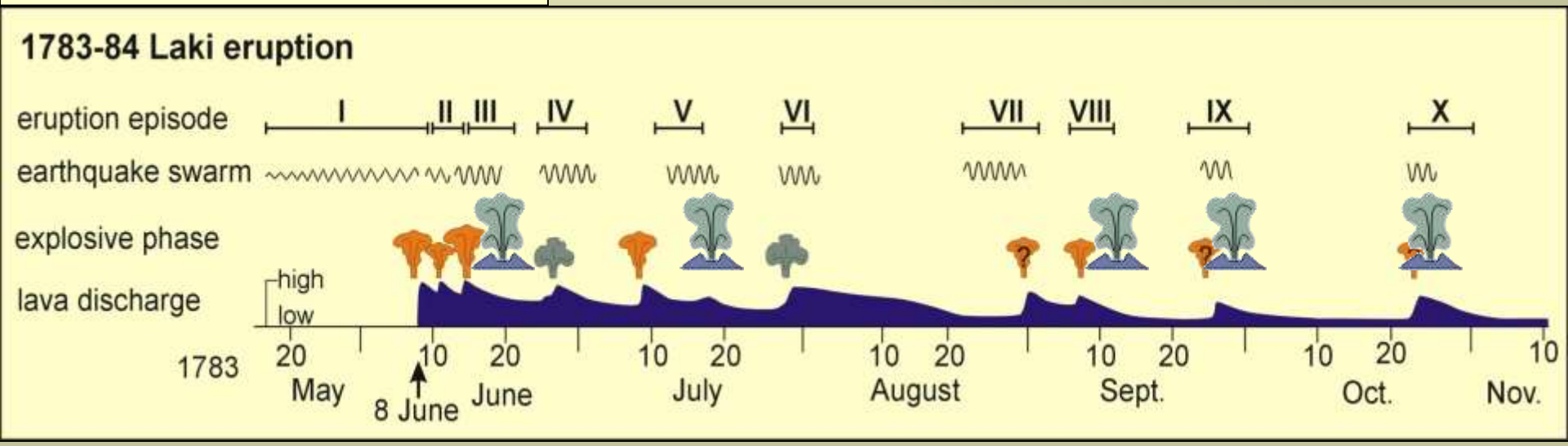
Skaftáreldar: gossagan

Skaftáreldar stóðu yfir í 8 mánuði, með svo gott sem samfeldu hraunflæði ásamt 10 sprengigosafösum, þar sem hver fasi var á við stærð við Heklugosið 1991. Sprengigosin mynduðu 10-13 km háa gosmekki sem þeyttu gjósku og gösum upp í neðri hluta heiðhvolfsins.



Gos í Grímsvötnum

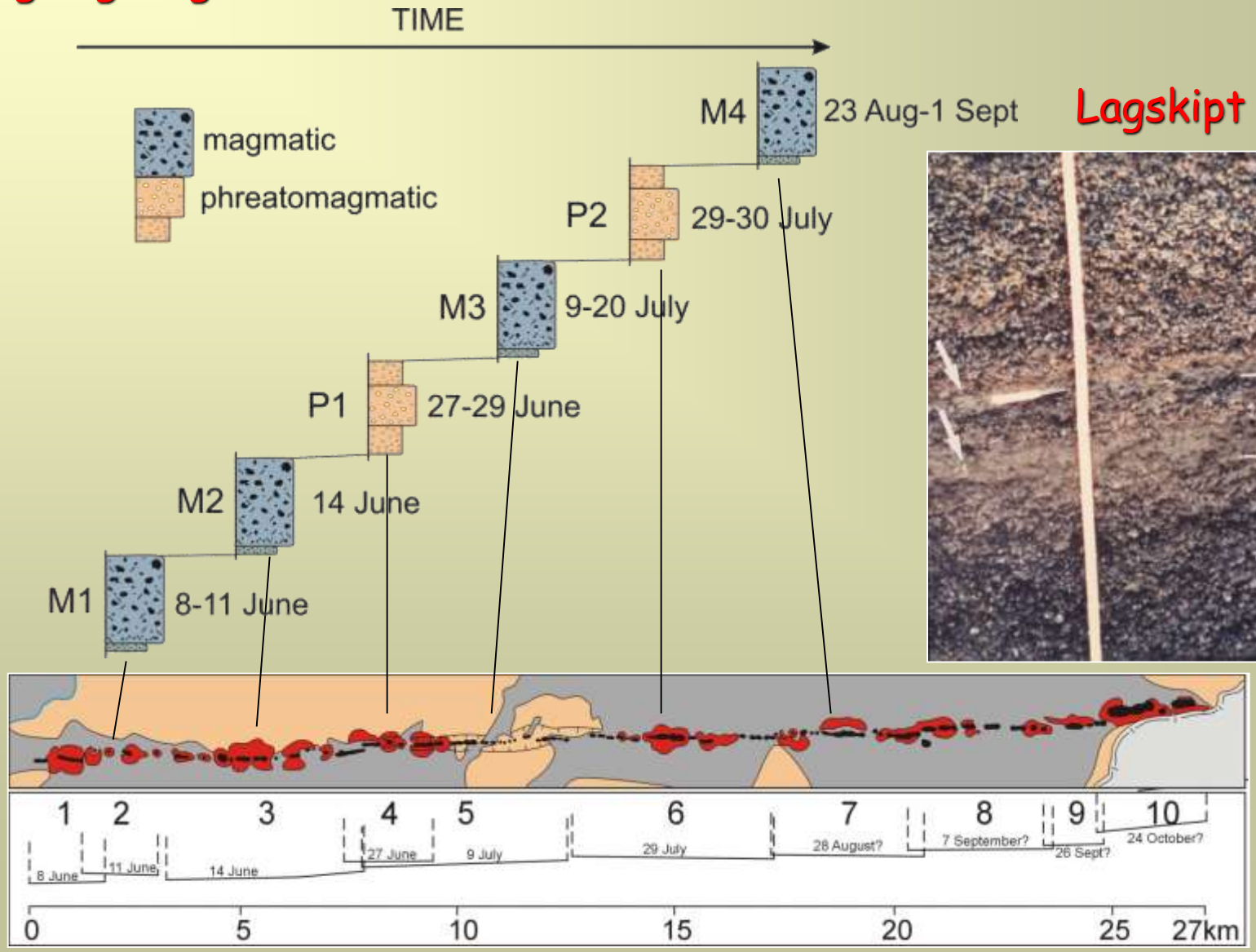
Fyrstu 6 mánuðir gossins



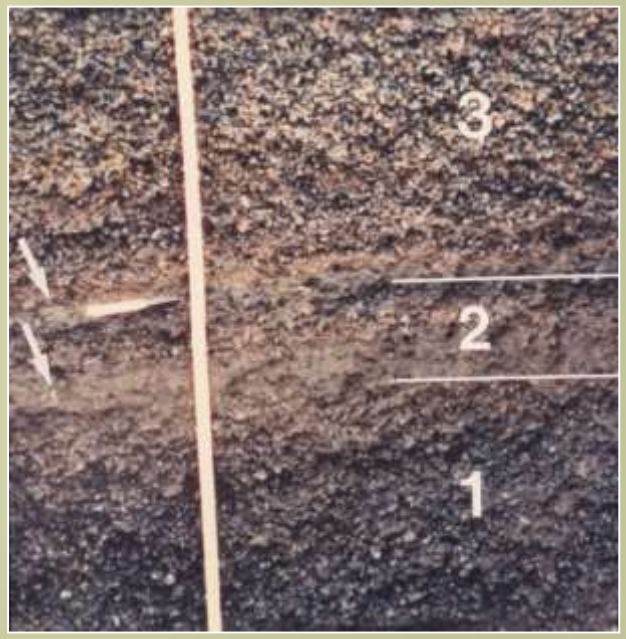
Thordarson og Self, 1993; Thordarson, o.fl., 2003

Lagskipting gjóskunnar

Lagskipting gjóskunnar gefur til kynna marfalda sprengigosafasa og reglulega færslu á virkninni til norð-austurs



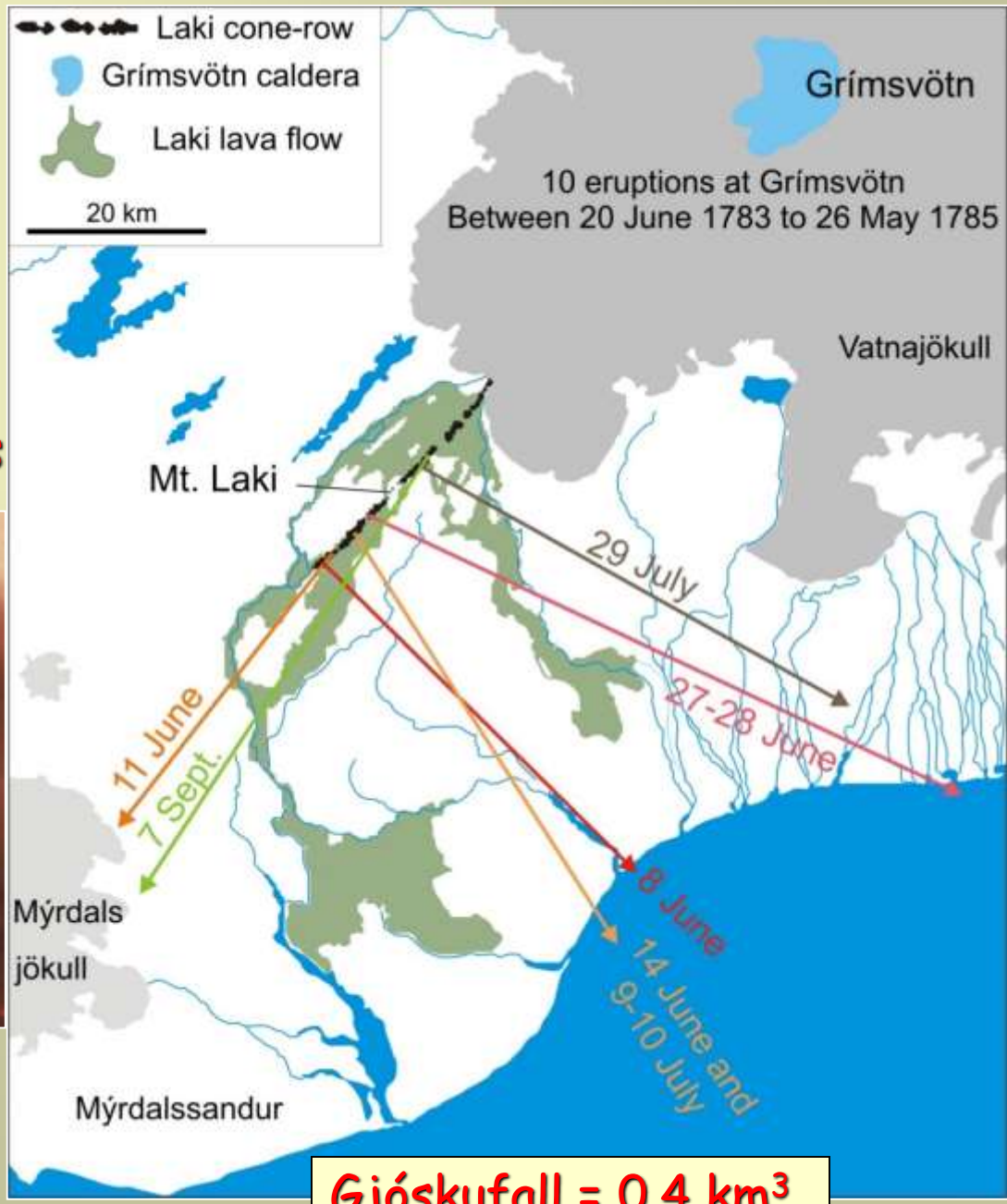
Lagskipt gjóska



Skaftáreldar

Framvinda I - Sprengigos

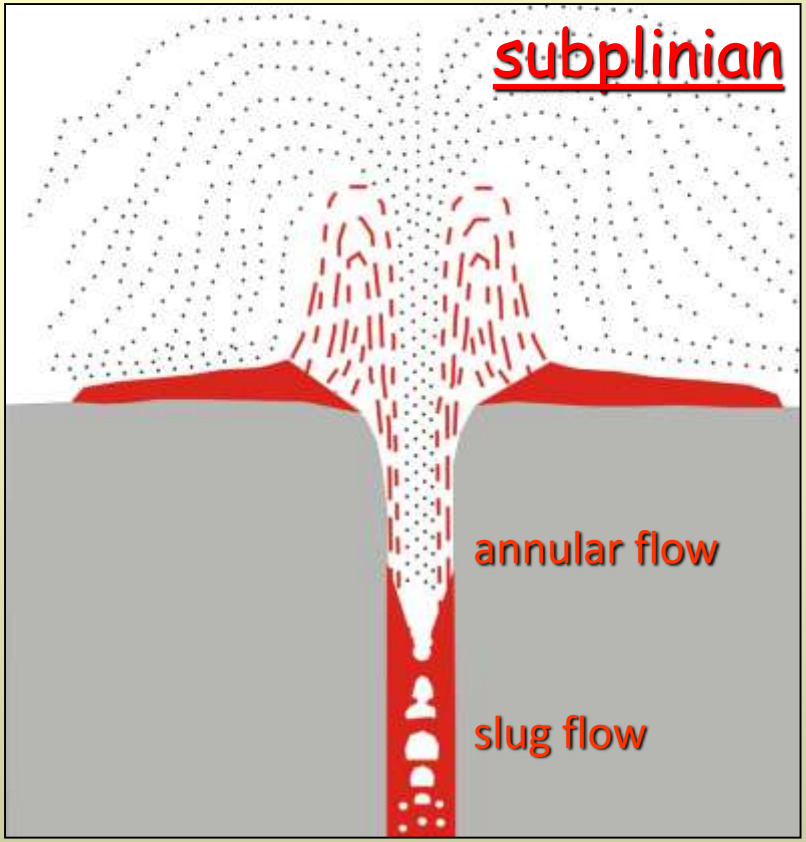
Tímasetning sprengivirkni, útbreiðslustefna gosmakkar og lagskipting gjóskunnar gefur til kynna marga sprengigosafasa og færslu á virkninni til norðausturs



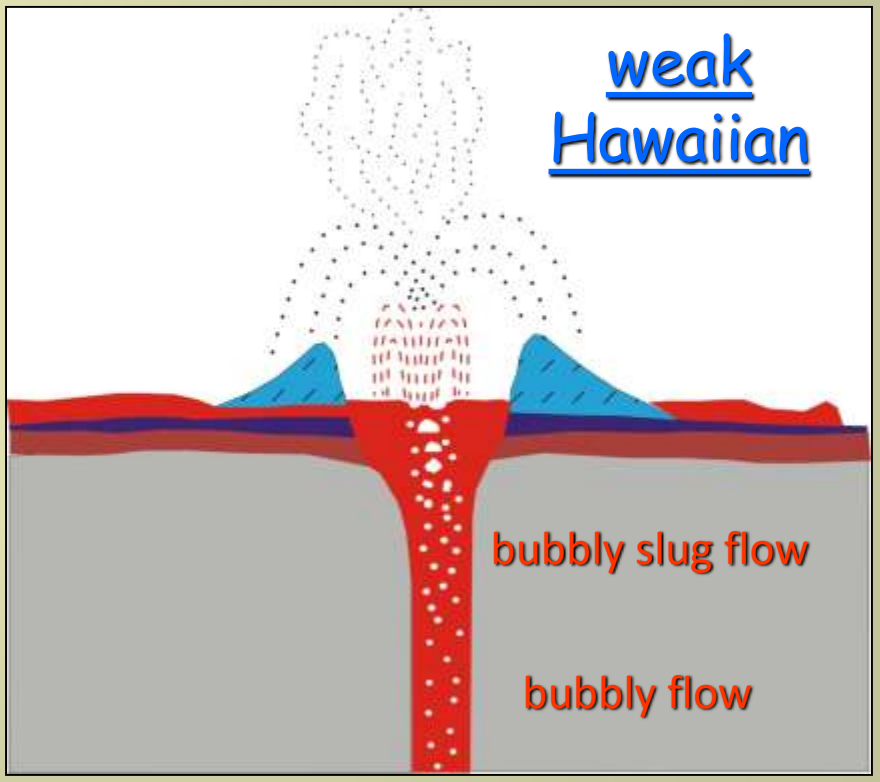
Gjóskufall = 0.4 km^3

Thordarson og Self, 1993;
Thordarson, o.fl., 2003

Sprengivirkni: Líkan



Famleiðni í hámarki í byrjun einstakra hrina
Öflug kvikustrókavirkni, kvikusrókahraun og subplínísk sprengigos



Famleiðni í lægri kantinum í seinnihluta einstakra hrina
Veik kvikustrókavirkni, hraunflæði úr gígum og upphleðsla á gjallkeilum

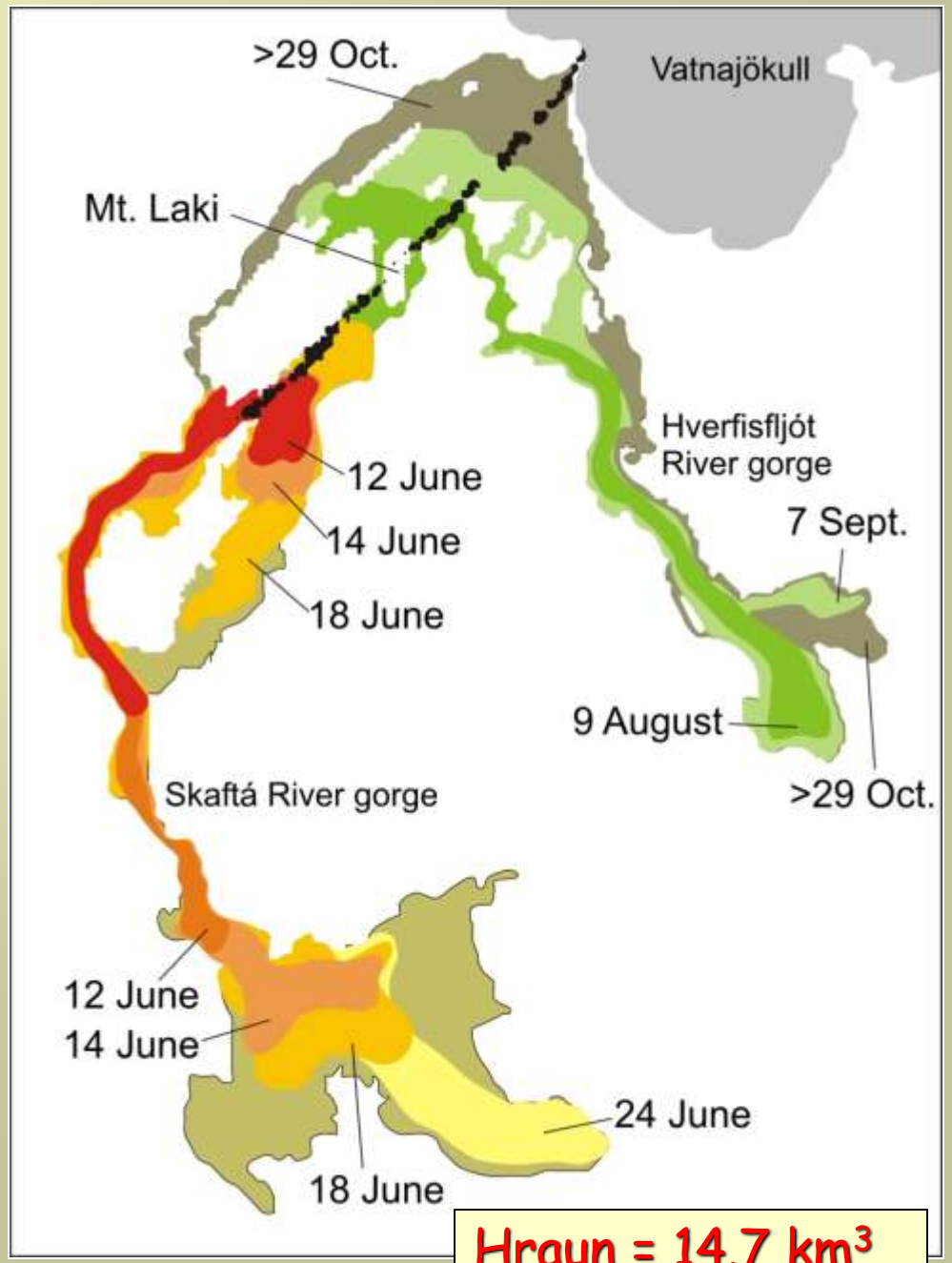
Thordarson, et al., 1996

Skaftáreldar

Framvinda II - Hraunflæði

Með aðstoð vettvangskannanna er hægt að nota lýsingar Jóns Steingrímssonar á hraunflæðinu til þess að kortleggja legu hraun-jaðarsins á tilteknum dögum.

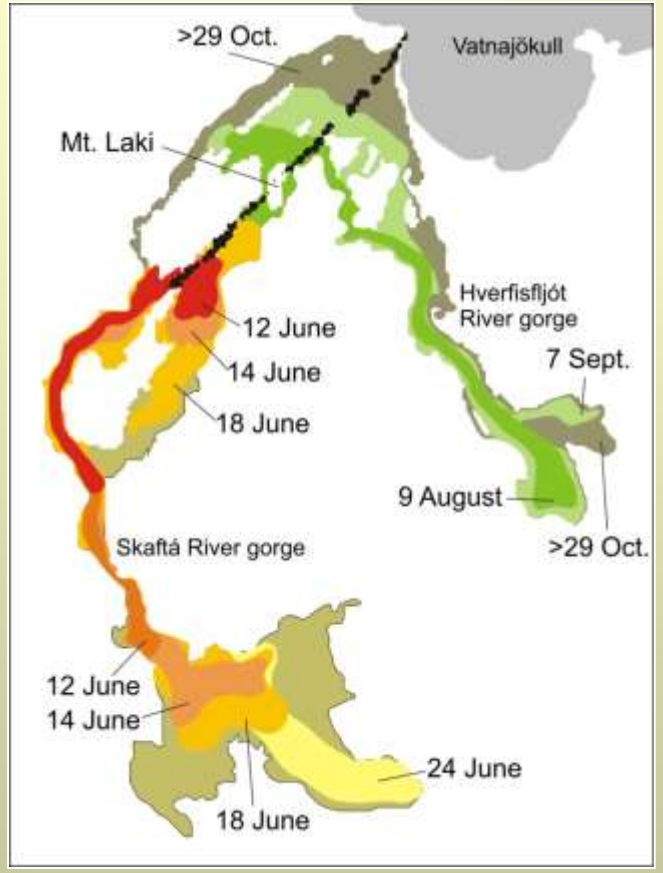
Þessar upplýsingar eru notaðar til þess að meta magn/rúmmál kviku sem hefur borist til yfirborðs á einstökum tímapunktum og þannig framleiðninna í gosinu á tímaeiningu

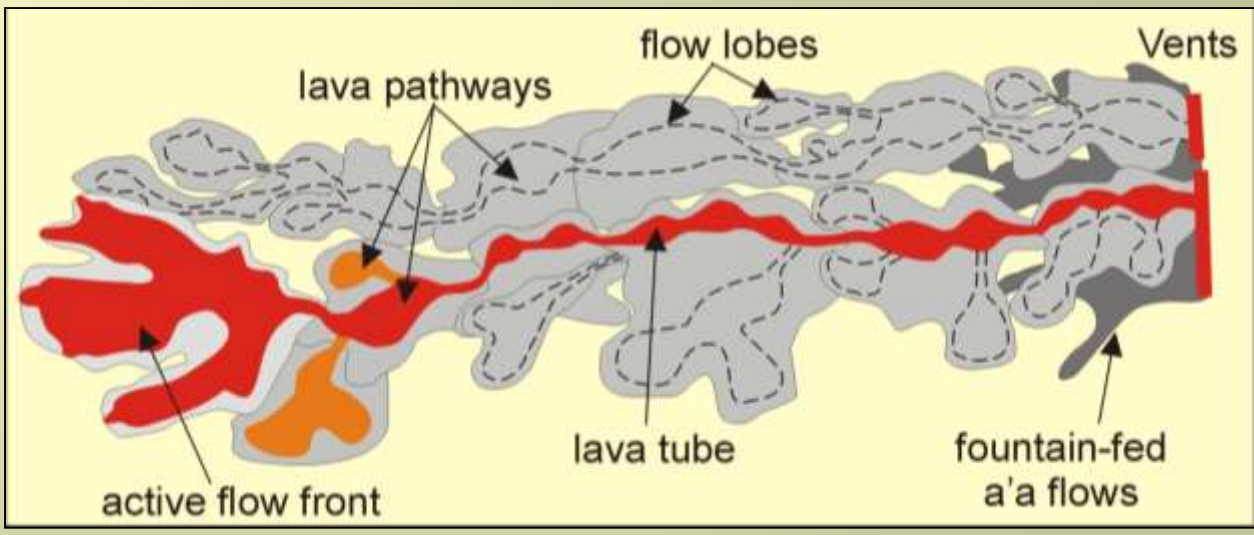


Hraun = 14.7 km^3

Thordarson og Self, 1993;
Thordarson, o.fl., 2003

Skaftáreldar: Hraunflæði I

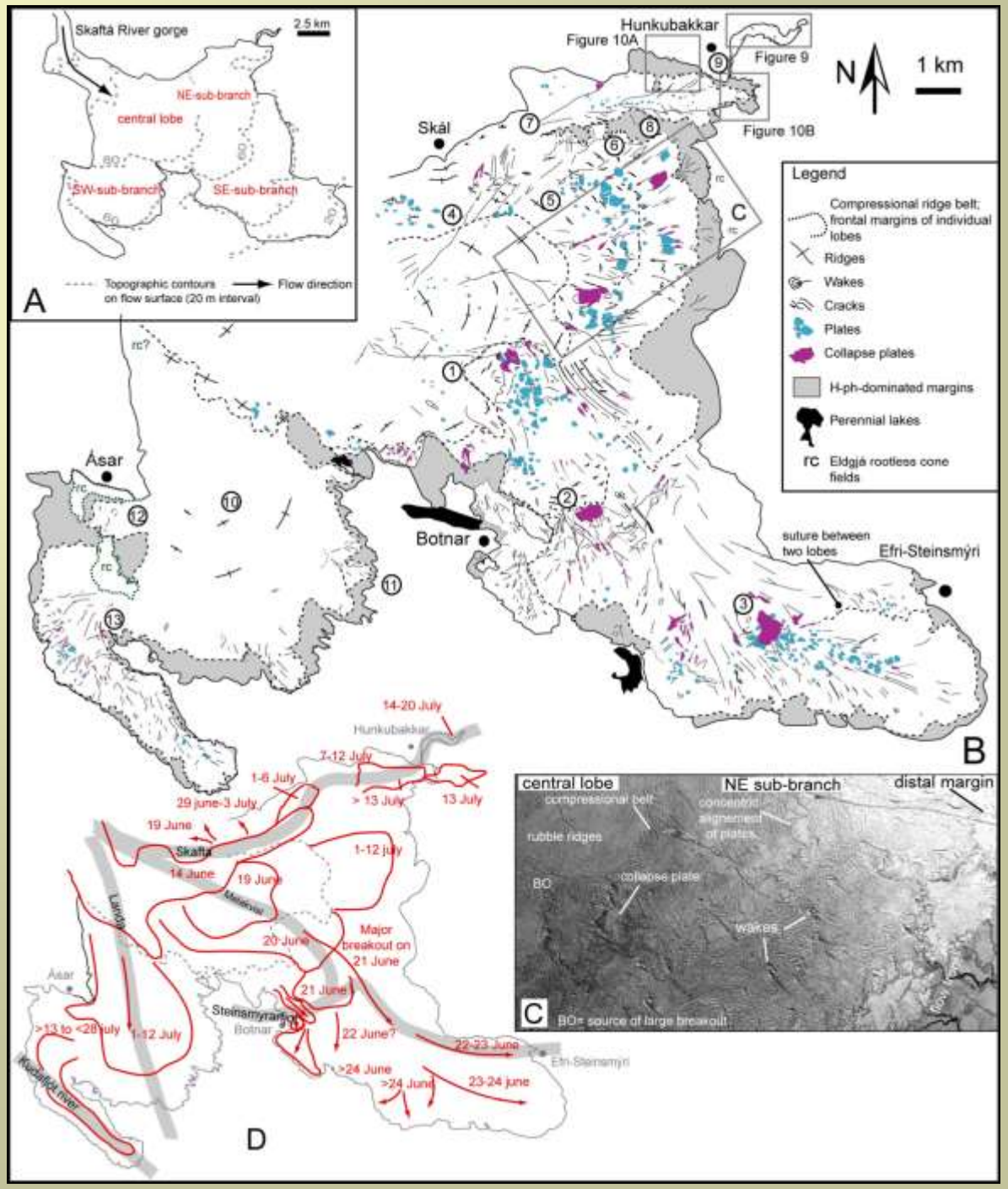




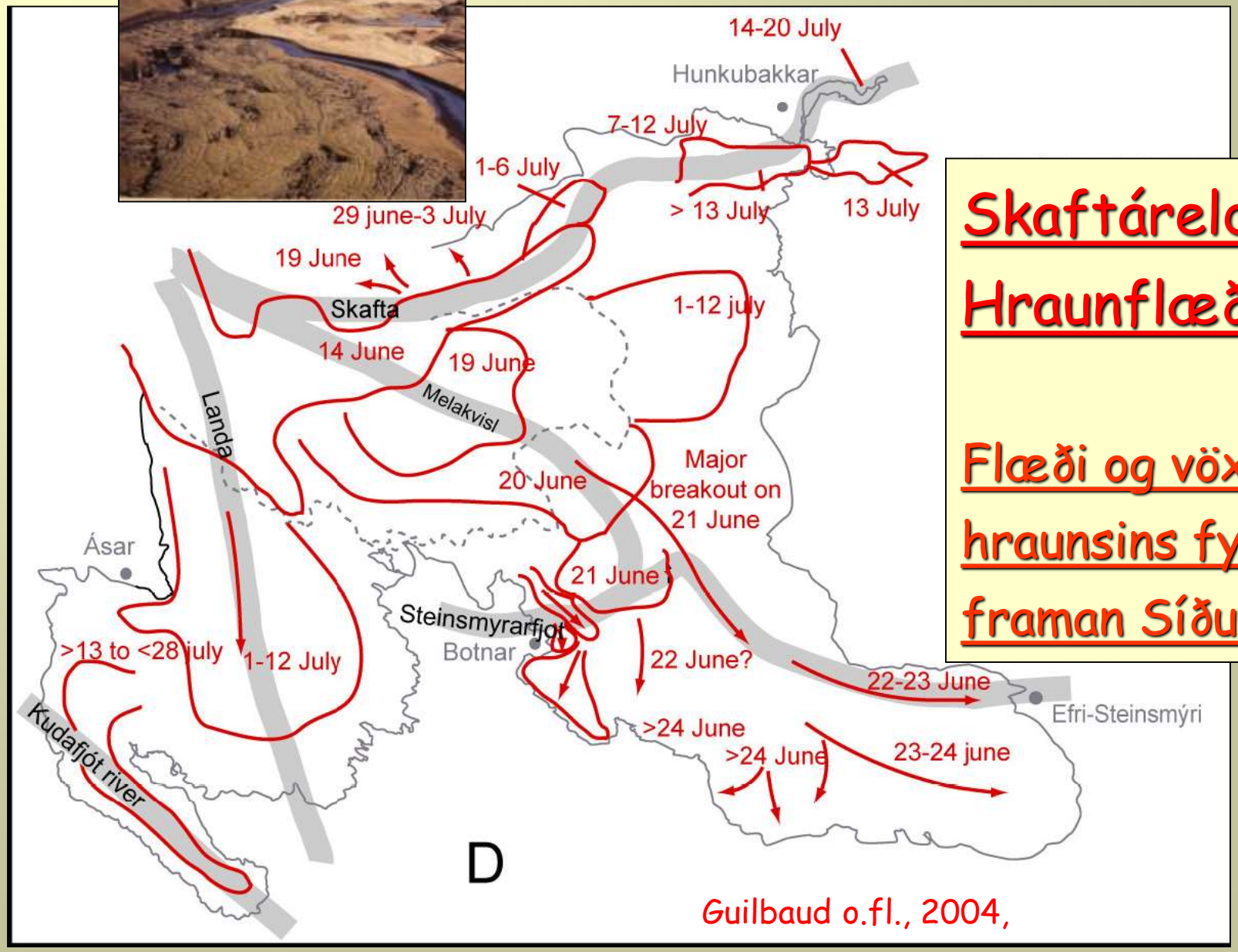
Hraunið flæddi í rásum undir kyrrstæðri og samfelldri skorpu.
Mjög hitavænt ferli – kólnun <0.1° C/km

Skaftáreldar:

Hraunflæði IIa



Guilbaud et al., 2004,



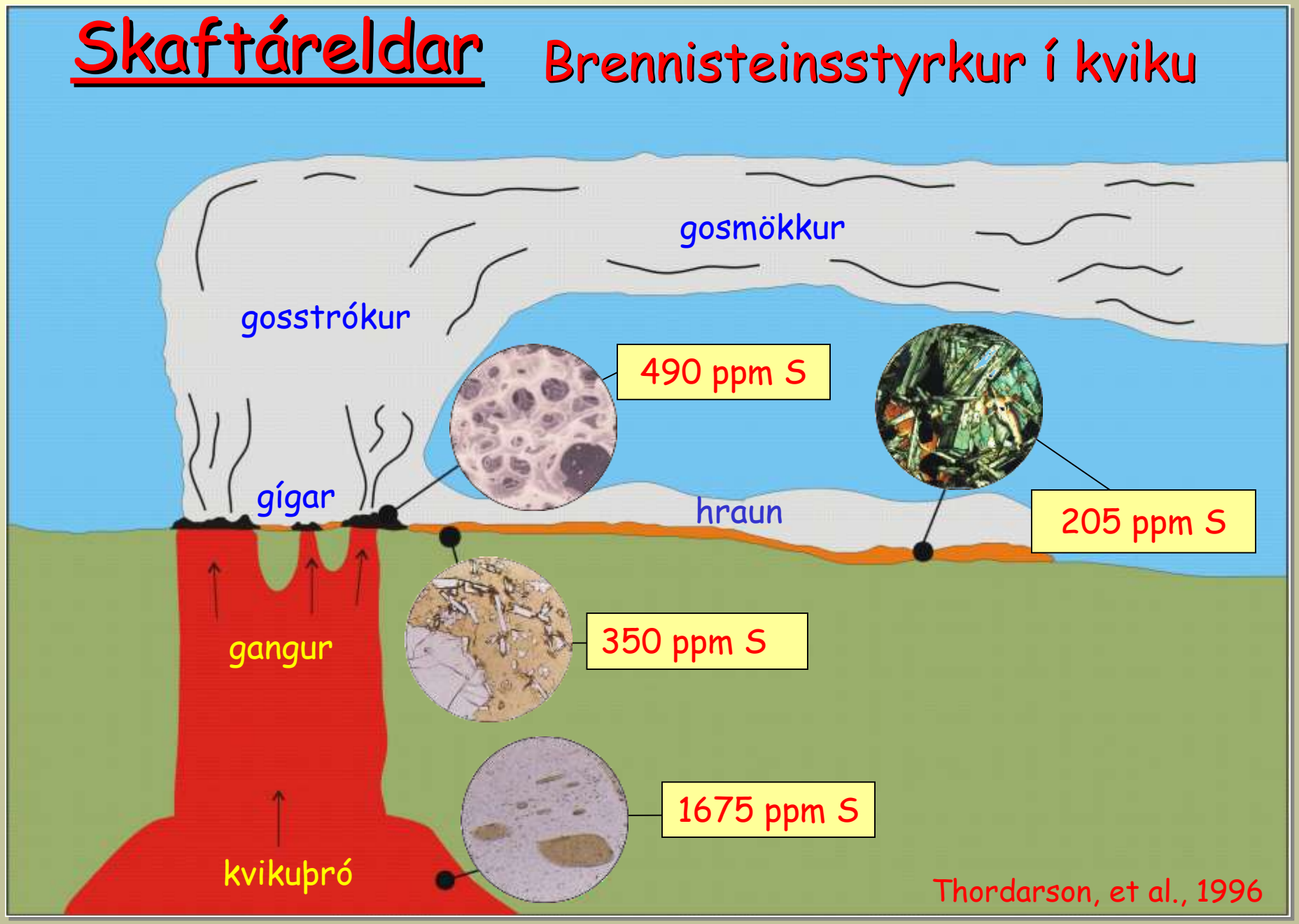
Skaftáreldar Hraunflæði

Flæði og vöxtur hraunsins fyrir framan Síðuna

Guilbaud o.fl., 2004,

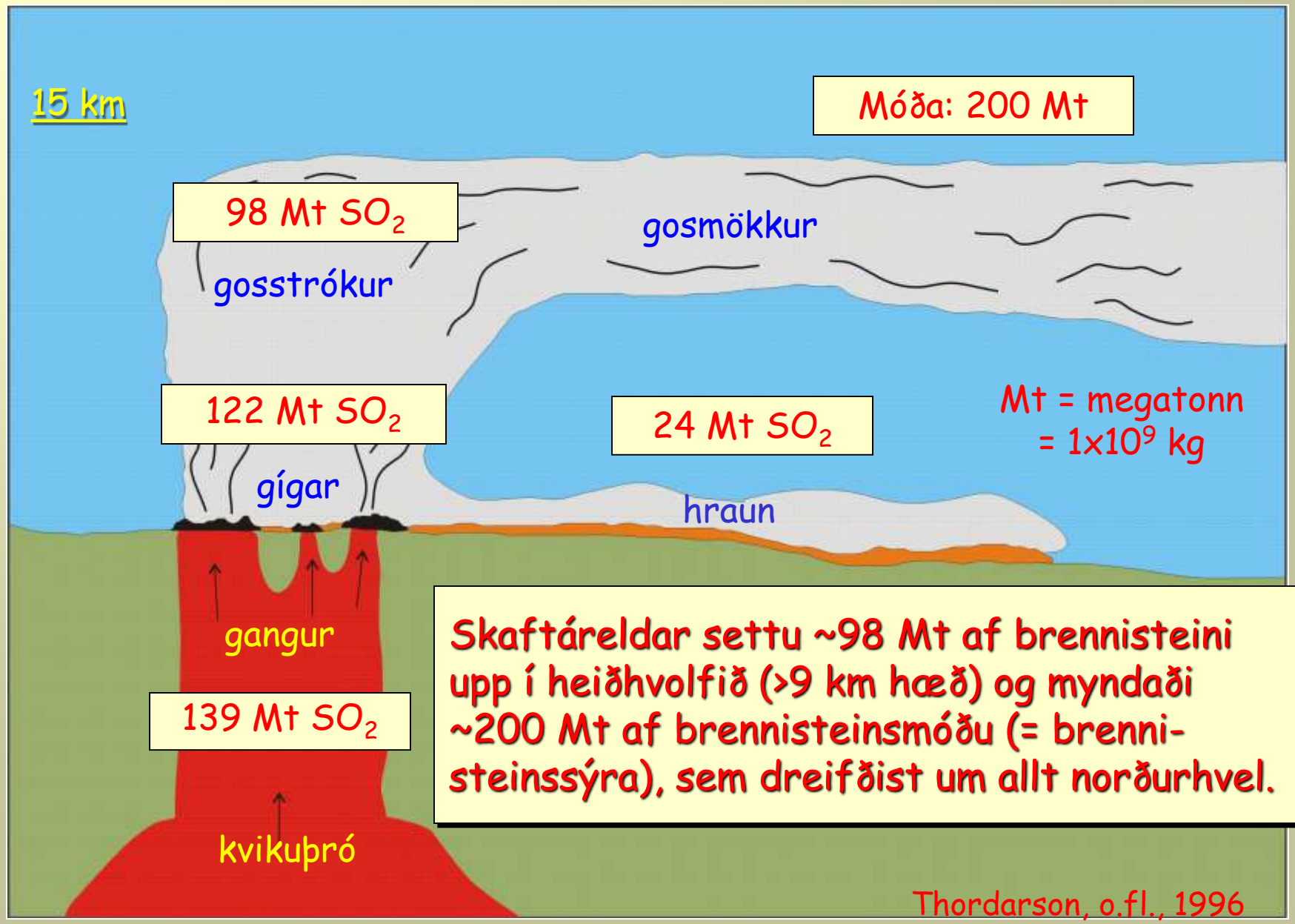
Skaftáreldar

Brennisteinsstyrkur í kviku



Thordarson, et al., 1996

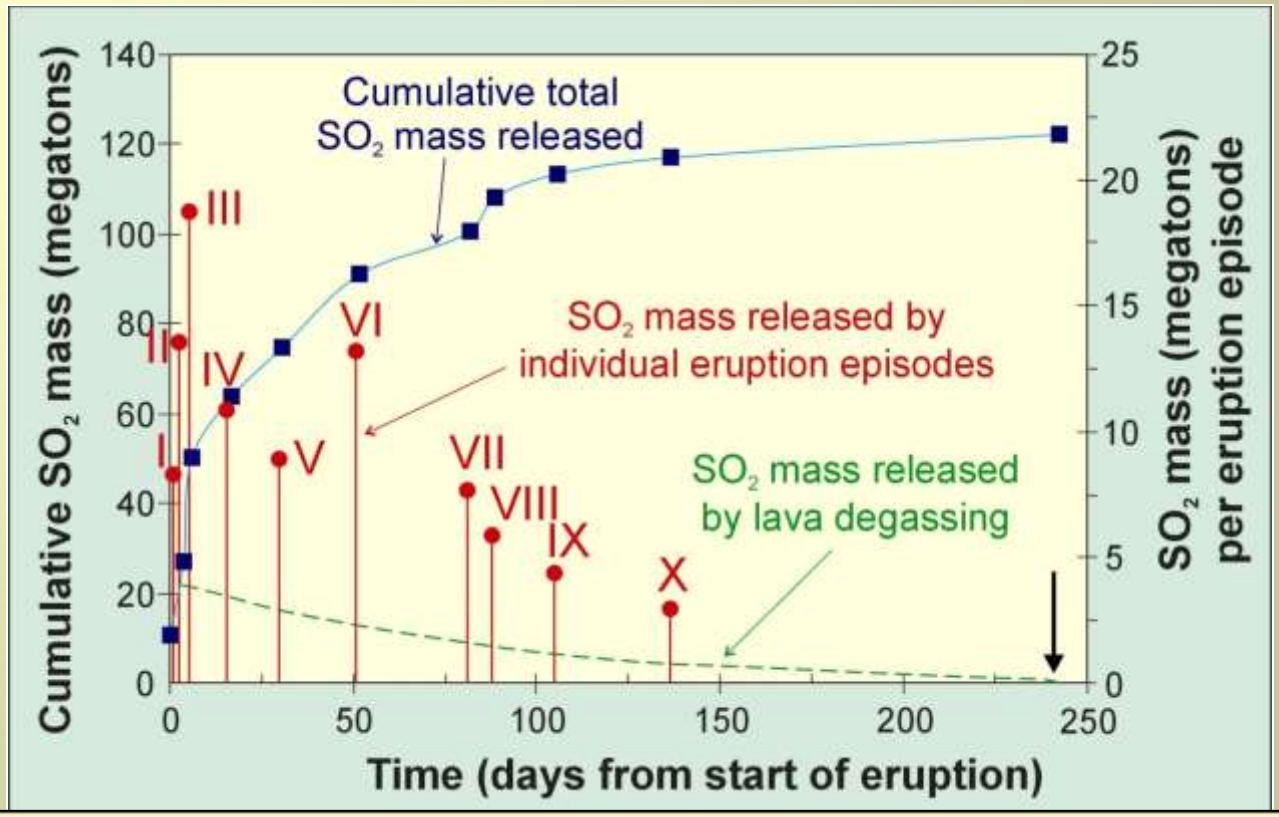
Skaftáreldar Brennisteinsútgösun

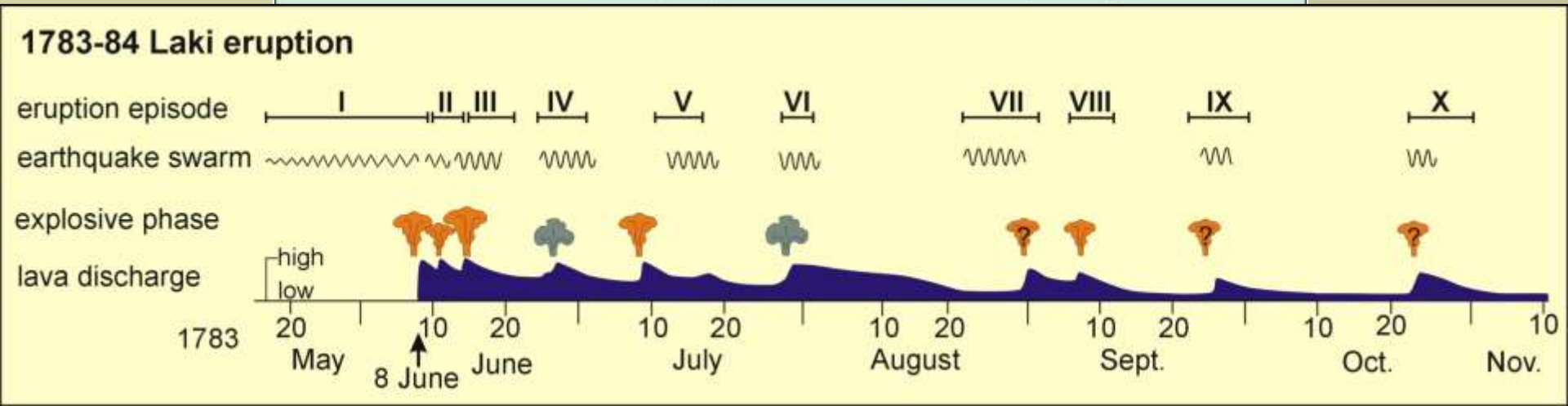


Skaftáreldar settu ~98 Mt af brennisteini upp í heiðhvolfið (>9 km hæð) og myndaði ~200 Mt af brennisteinsmóðu (= brennisteinssýra), sem dreifðist um allt norðurhvel.

Thordarson, o.fl., 1996

Brennisteinsútgösun í einstökum goshrinum





Laki Eruption - venue for Big Science

RELEGATED

Benjamin Franklin
(1784)

During several of the summer months of the year 1783, when the effect of the sun's rays to heat the earth in these northern regions should have been greatest, there existed a constant fog over all Europe, and great part of North America. This fog was of a permanent nature; it was dry, and the rays of the sun seemed to have little effect towards dissipating it, as they easily do a moist fog, arising from water. They were indeed rendered so faint in passing through it, that when collected in the focus of a burning glass, they would scarce kindle brown paper. Of course, their summer effect in heating the earth was exceedingly diminished.

Hence the earth was early frozen,

Hence the first snows remained on it unmelted, and received continual additions.

Hence the air was more chilled, and the winds more severely cold.

Hence perhaps the winter of 1783-4, was more severe, than any that had happened for many years.

The cause of this universal fog is not yet ascertained. Whether it was adventitious to this earth, and merely a smoke, proceeding from the consumption by fire of some of those great burning balls or globes which we happen to meet within our rapid course round the sun, and which are sometimes seen to kindle and be destroyed in passing our atmosphere, and whose smoke might be attracted and retained by our earth; or whether it was the vast quantity of smoke, long continuing to issue during the summer from Hecla in Iceland, and that other volcano which arose out of the sea near that island, which smoke might be spread by various winds, over the northern part of the world, is yet uncertain.

PROMOTED

The French naturalist M. Mourgue de Montredon was the first to tie the dry fog of 1783 to an eruption in Iceland;

He did so in a lecture at the Royal Academy of Montpellier, on 7 August 1783.

OTHERS

J. L. Christ, German naturalist [1783]

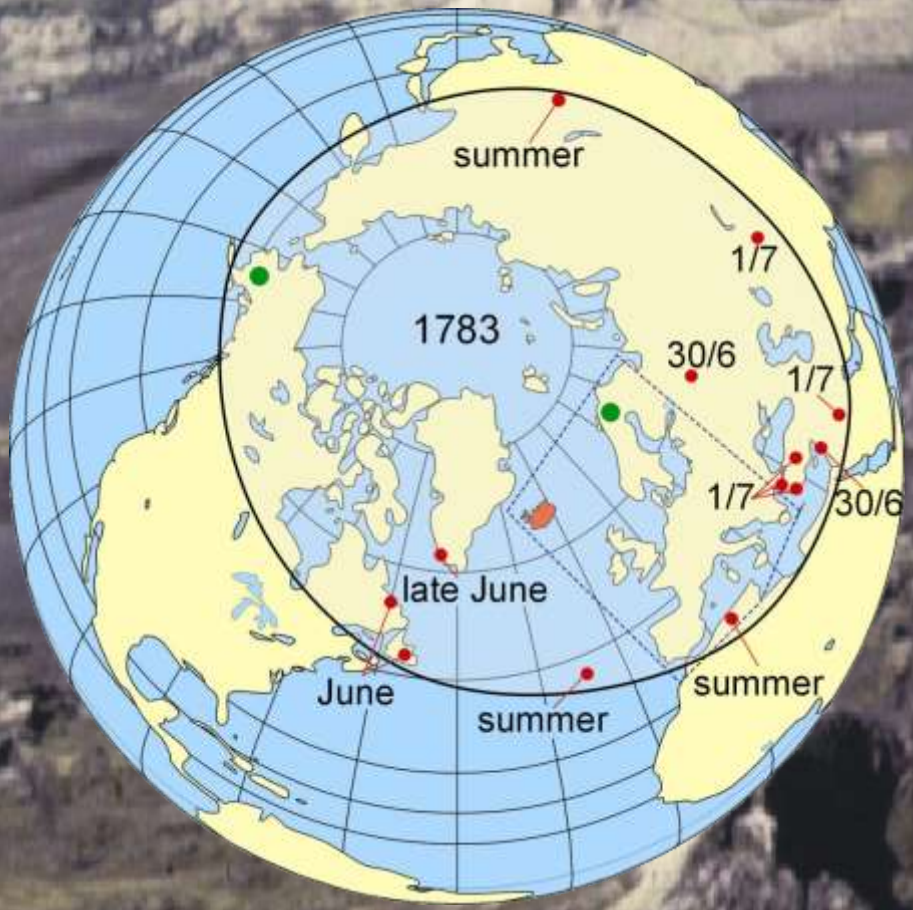
Prof. C. G. Kratzenstein, Univ. Copenhagen [1784,

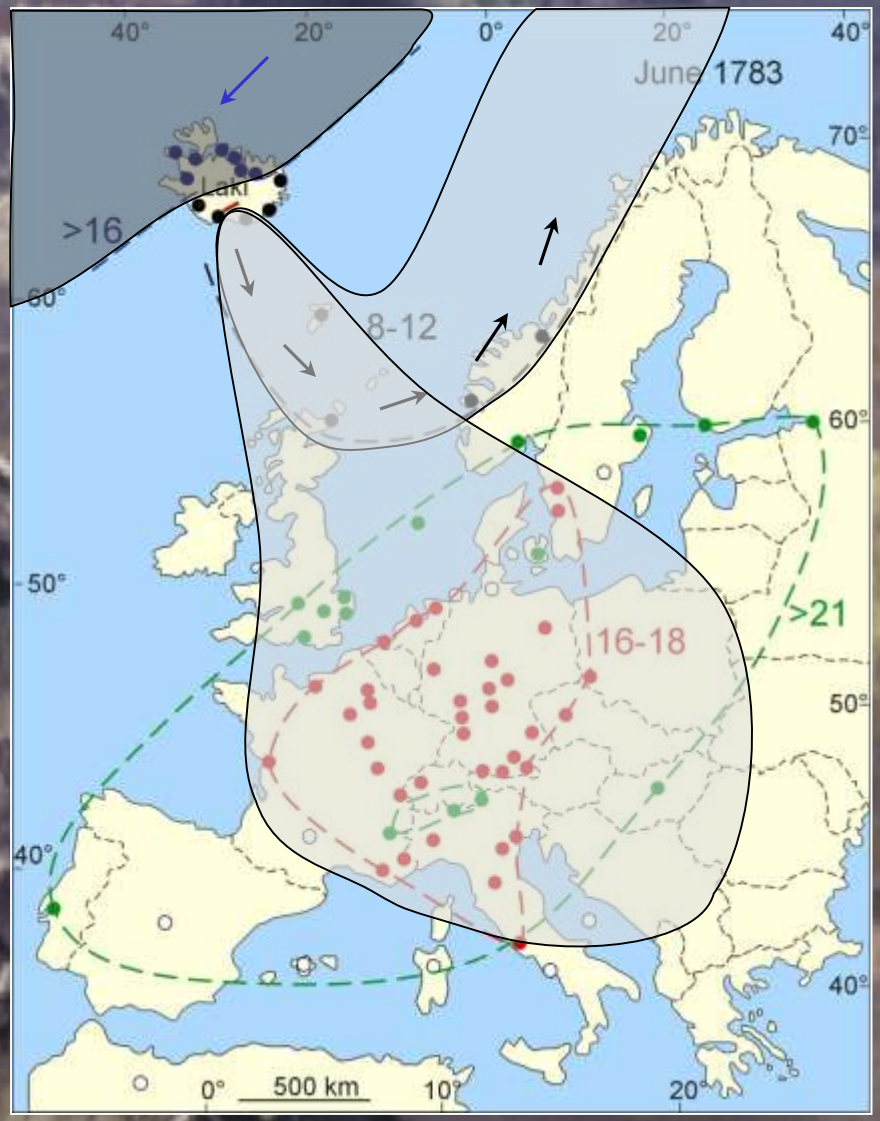
B. Franklin. US ambassador in Paris [1784]

S. Palsson, Icelandic naturalist [1784]

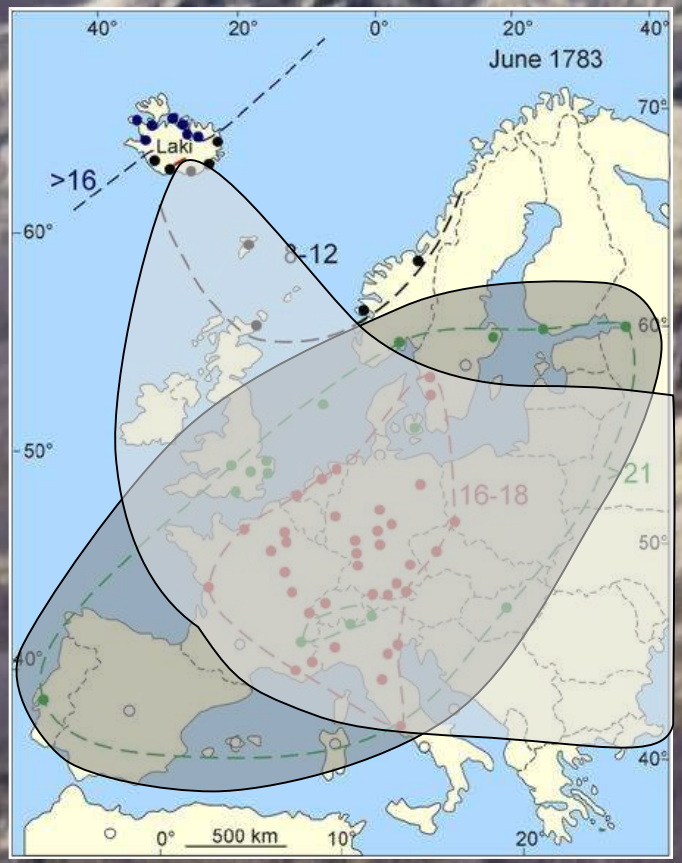
Skaftáreldamóðan - útbreiðsla

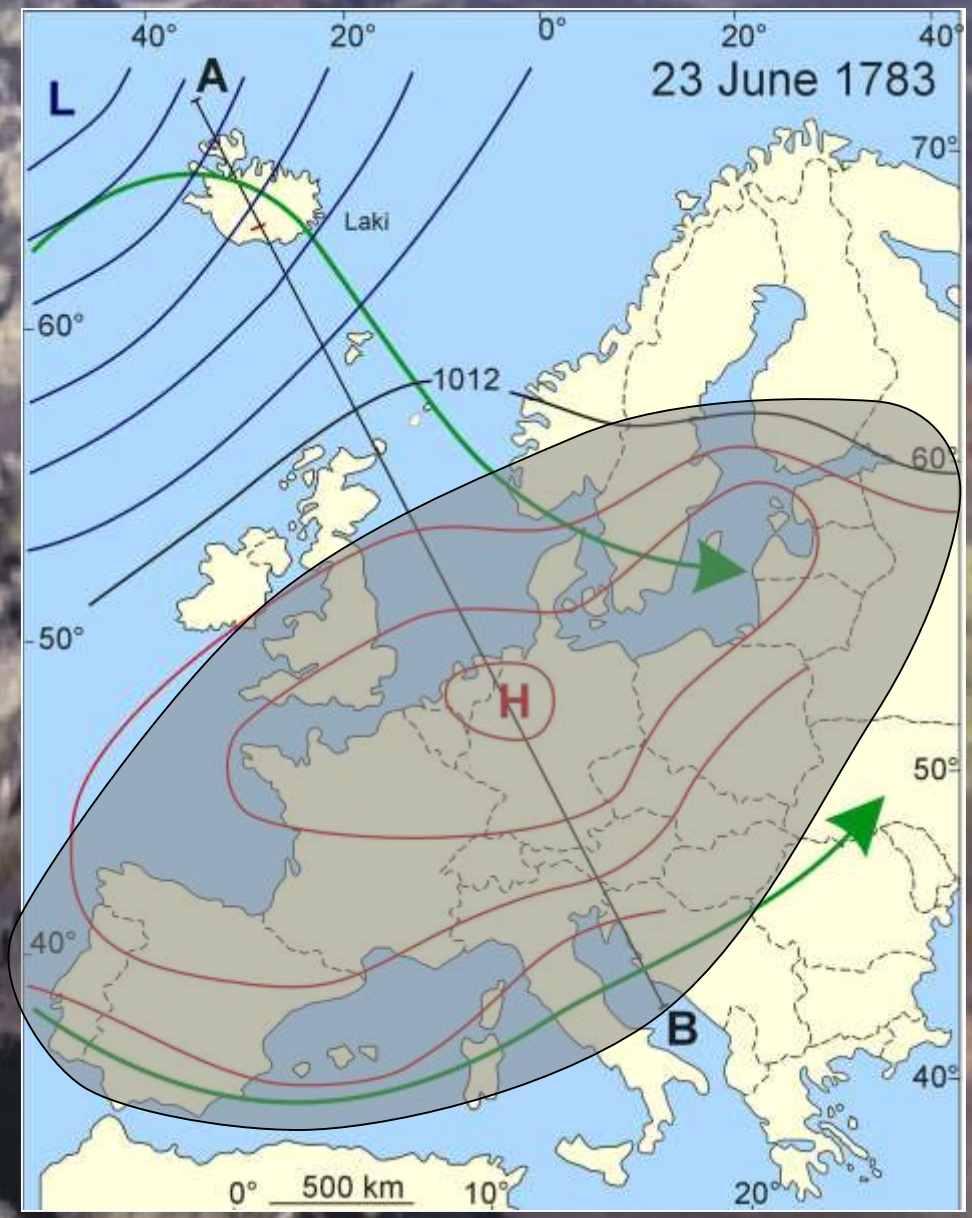
Þakkti efsta fjórðung jarðar



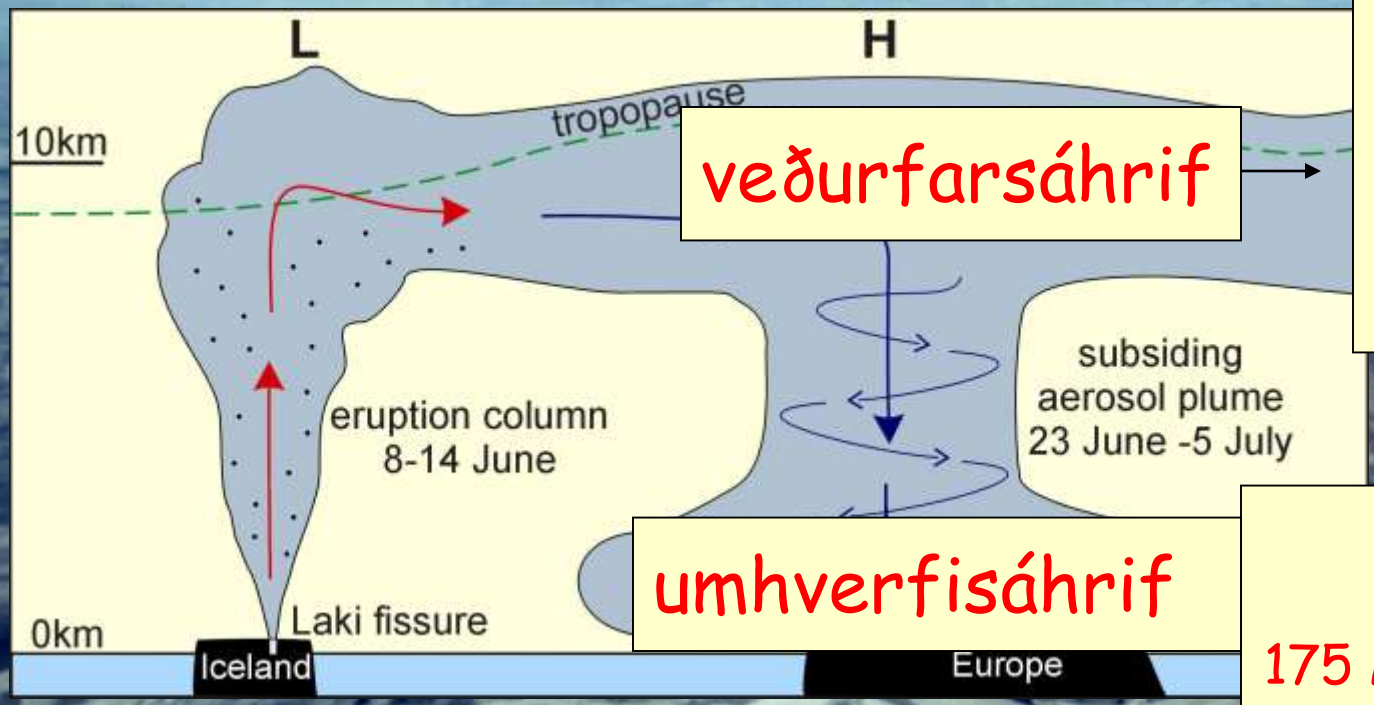


Skaftáreldamóðan - útbreiðsla





Dreifing brennisteinsmóðunnar



veðurfarsáhrif

umhverfisáhrif

Háloftamóða

25 Mt sátu eftir í háloftunum í >1 ár

= kólnun

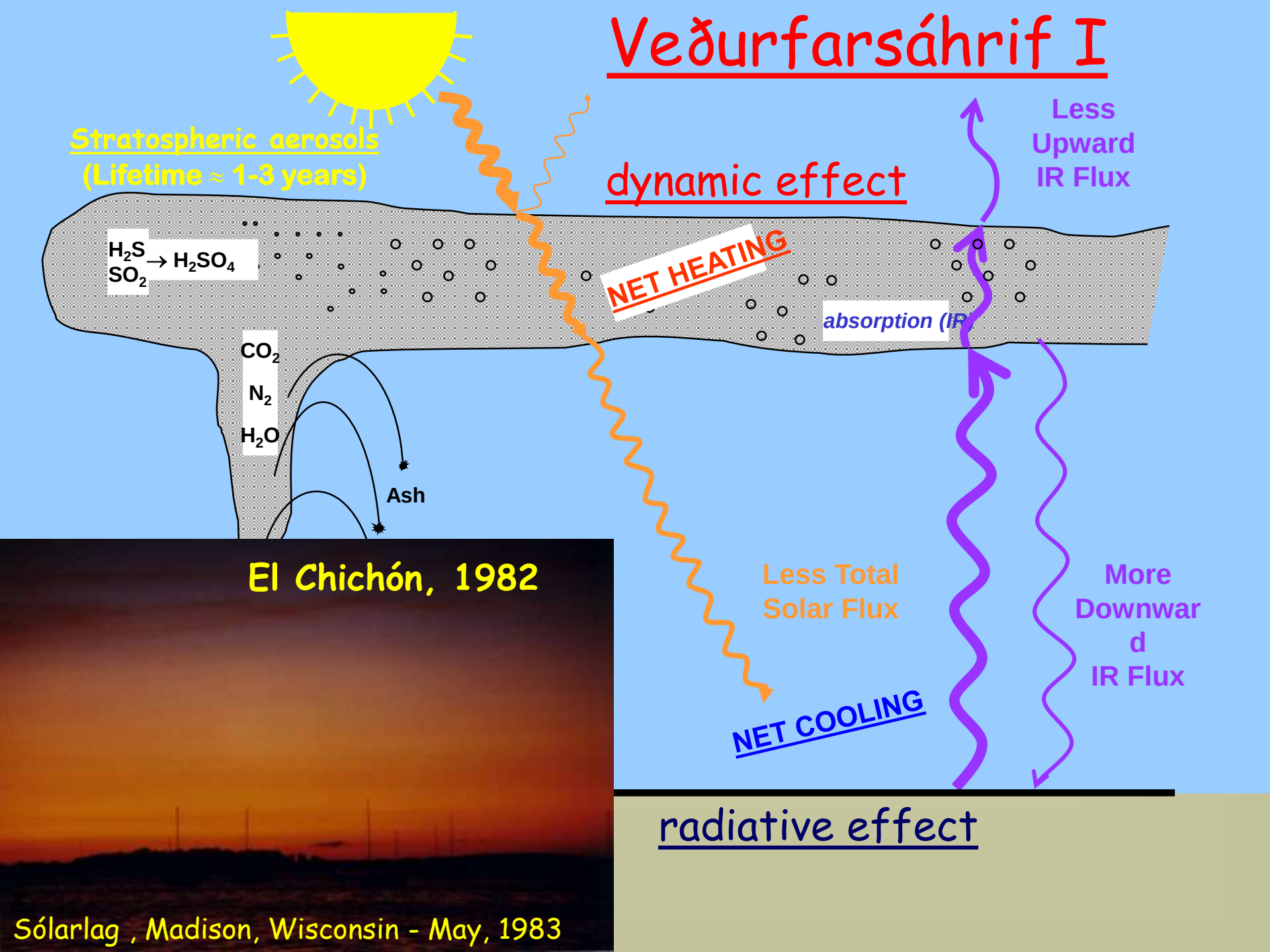
Þurraþoka

175 Mt féllu til yfirborðs

= mengun

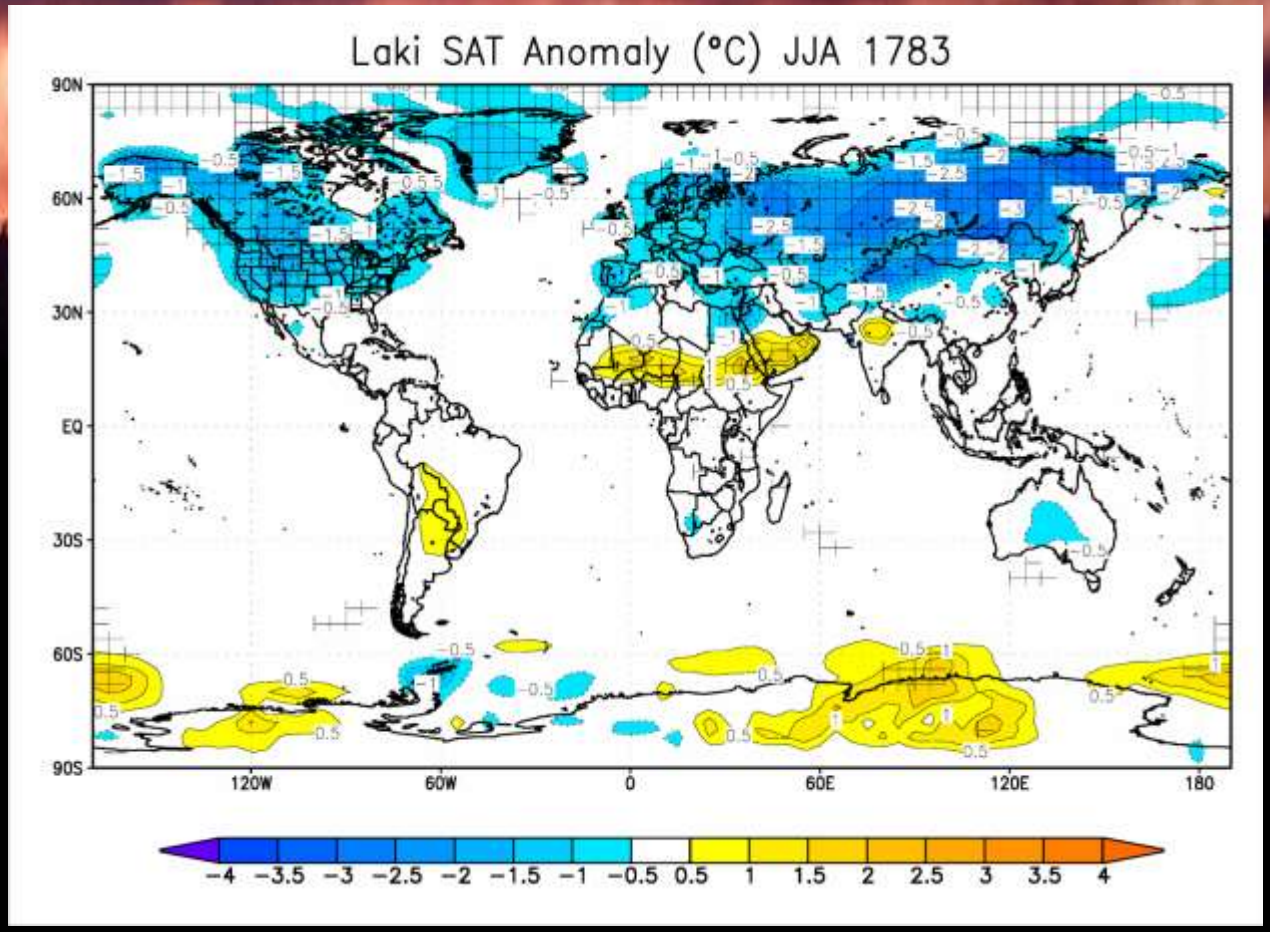
Gosmekkir og móða Skaftárelda bárust með vestlægum háloftavindum inn yfir Evrasíu og þaðan yfir N-Ameríku. Þessi háloftamóða dreifðist til yfirborðs jarðar í niður-streymisbeltum háþrýstikerfa.

Veðurfarsáhrif I



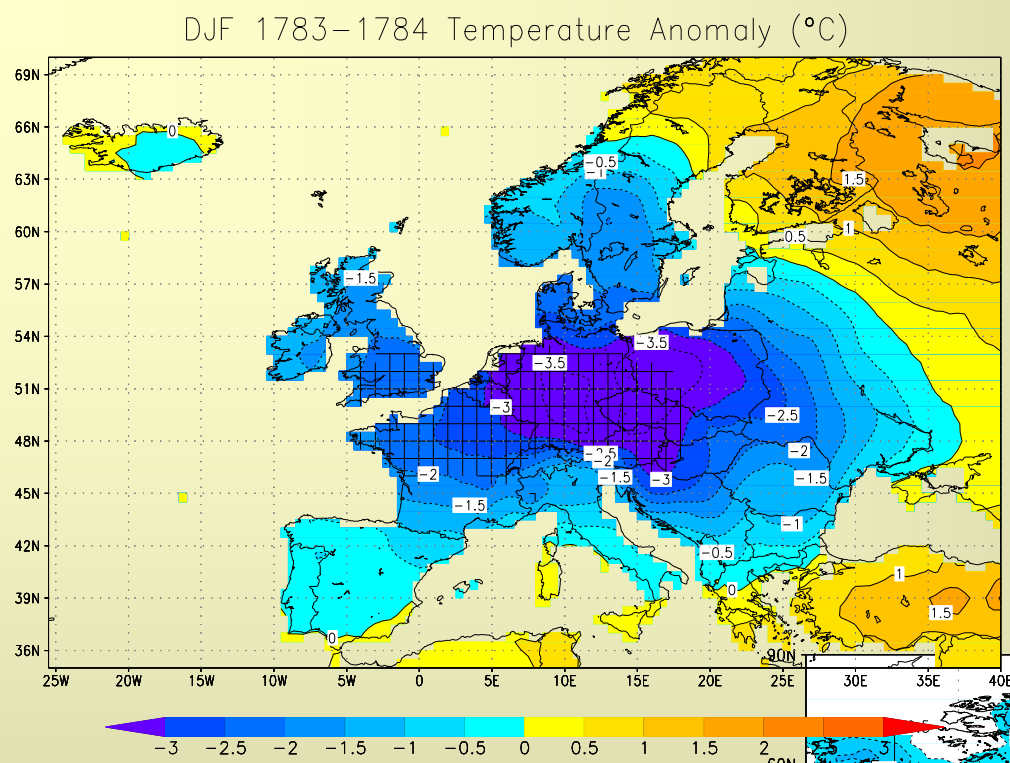
Kólnun vegna háloftamóðunnar sumarið 1783

Unusually Hot July in 1783
(Thordarson and Self 2003)



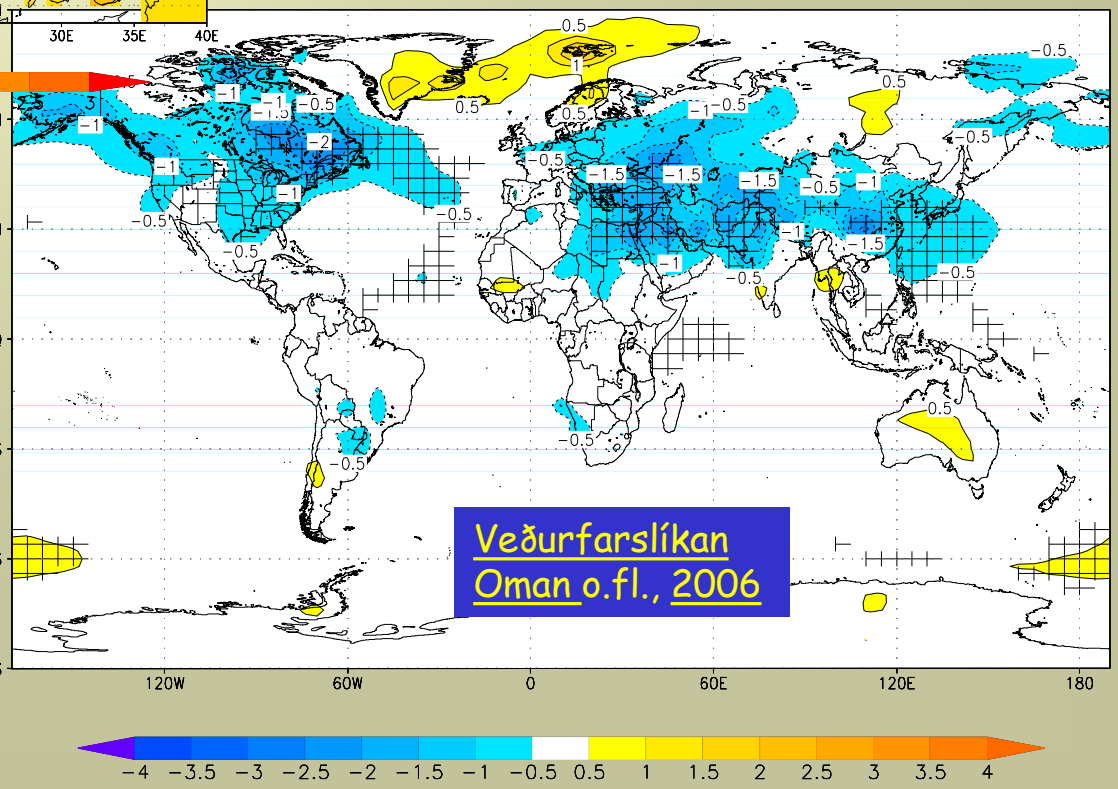
Global Circulation Modelling (Oman et al 2006)

Kólnun vegna háloftamóðunnar veturinn 1783-84



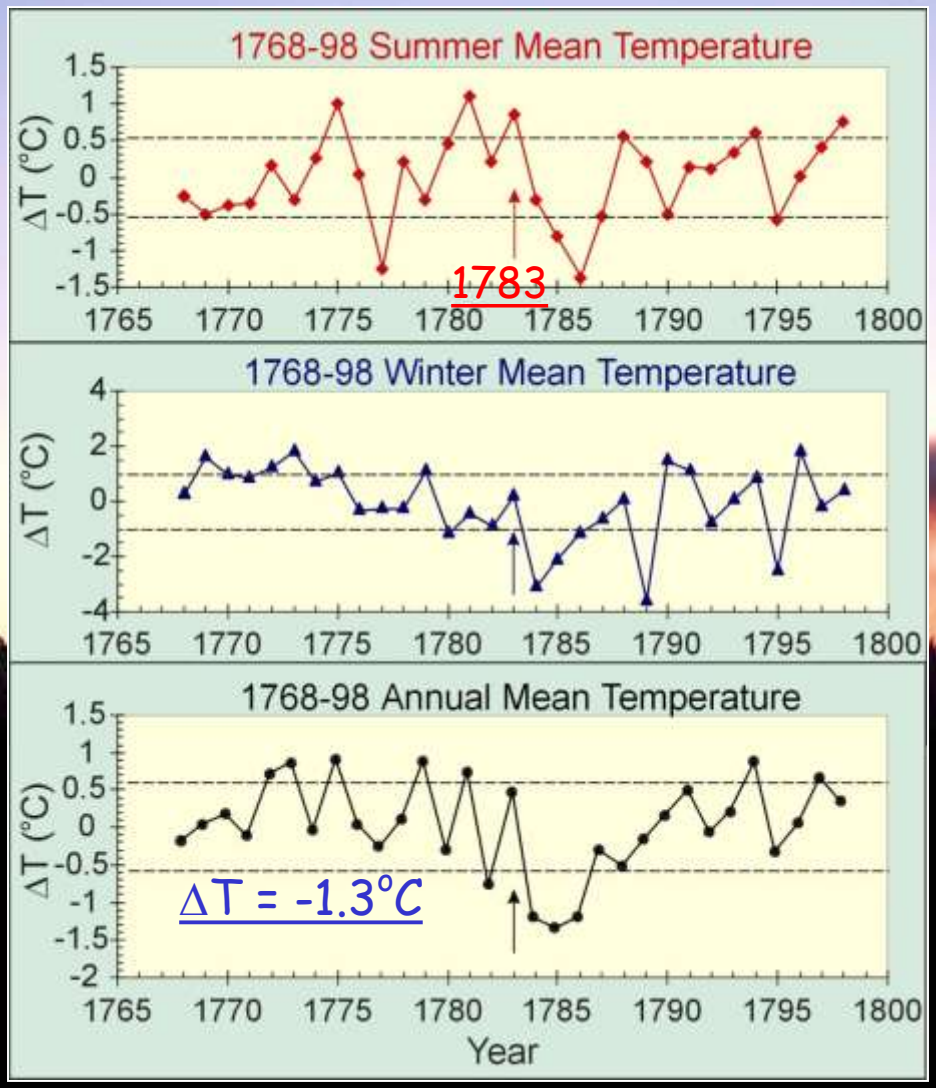
Luterbacher et al. (2004)

Frávik miðuð við 31 yr eðaltal, 1770-1800



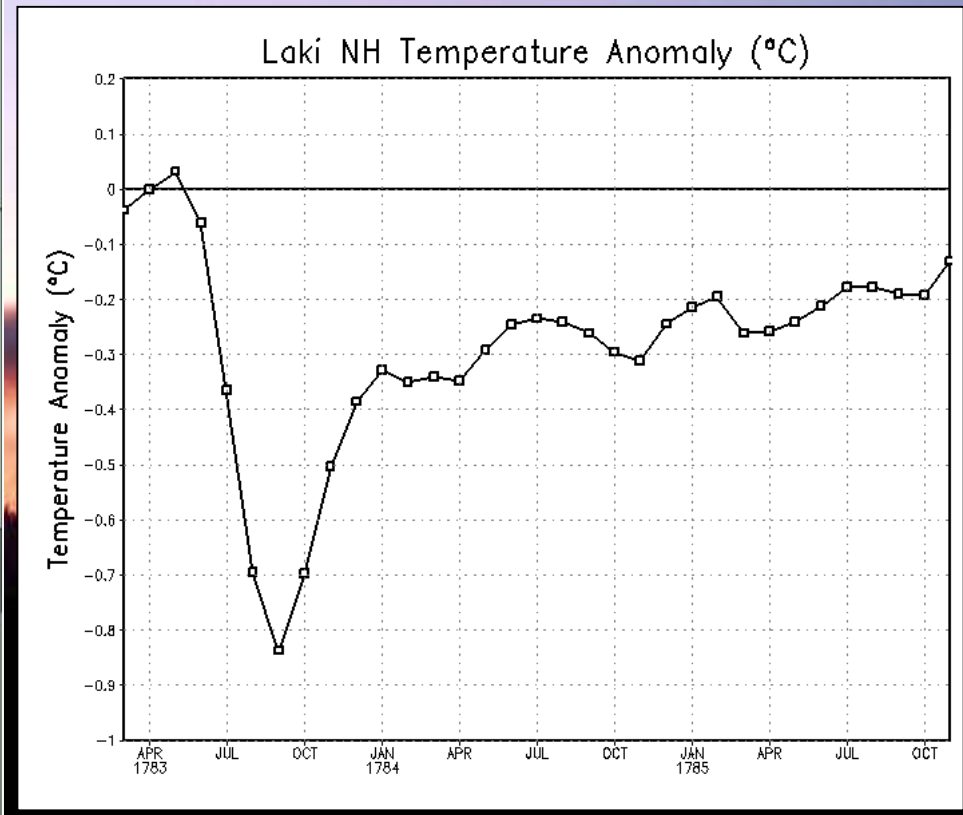
Veðurfarsáhrif I

Hitafar:
Evrópa og N-Ameríka 1768-98



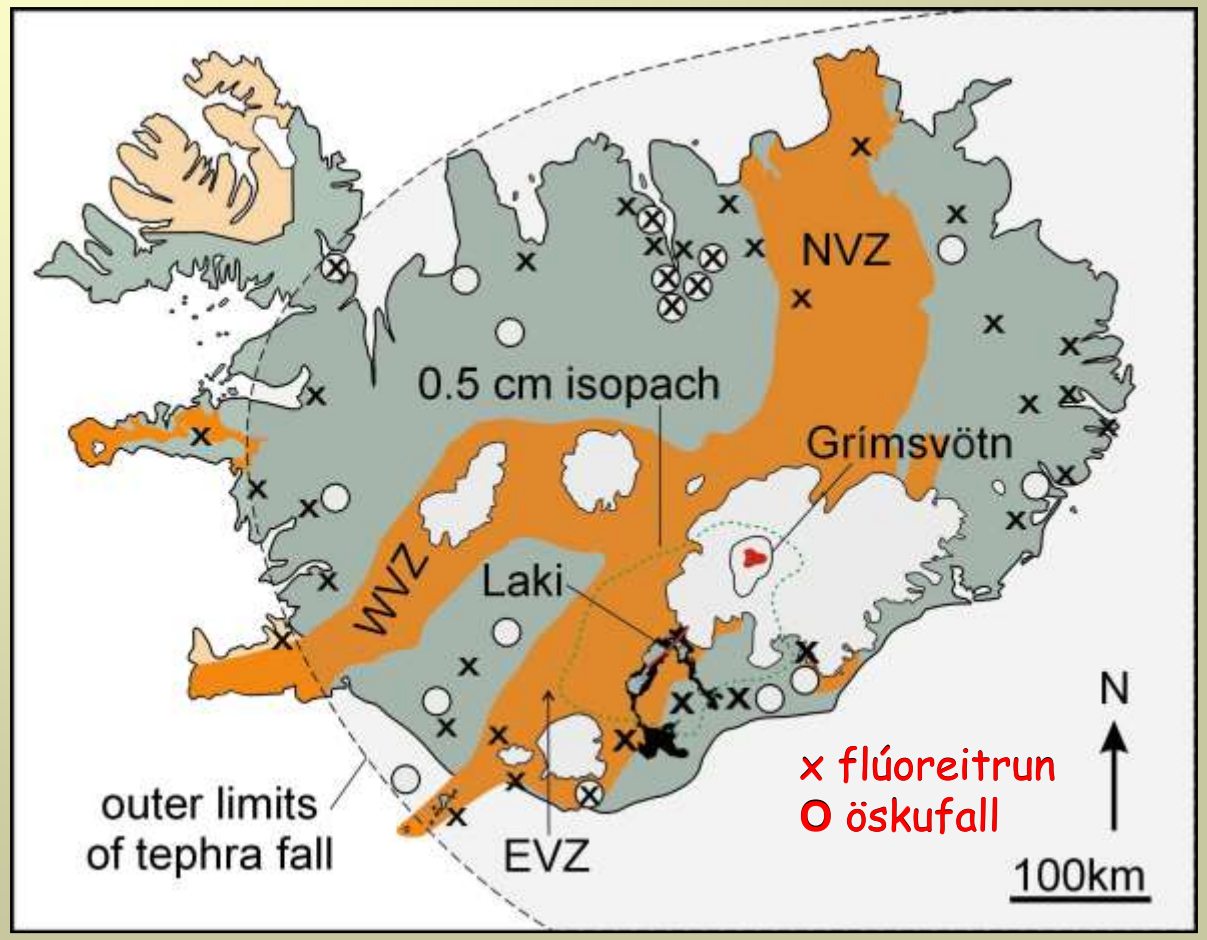
Thordarson and Self. 2003

Líkan: útreikningar



Luke Oman (PhD, 2006)

Skaftáreldar – Mengun á Íslandi náttúruhamfarir og umhverfisslys



Brennisteins og flúor mengað öskufall var megin orsök móðuharðindanna, útrýmdi >75% af kvikfénaði sem beint og óbeint drap ~22% landsmanna

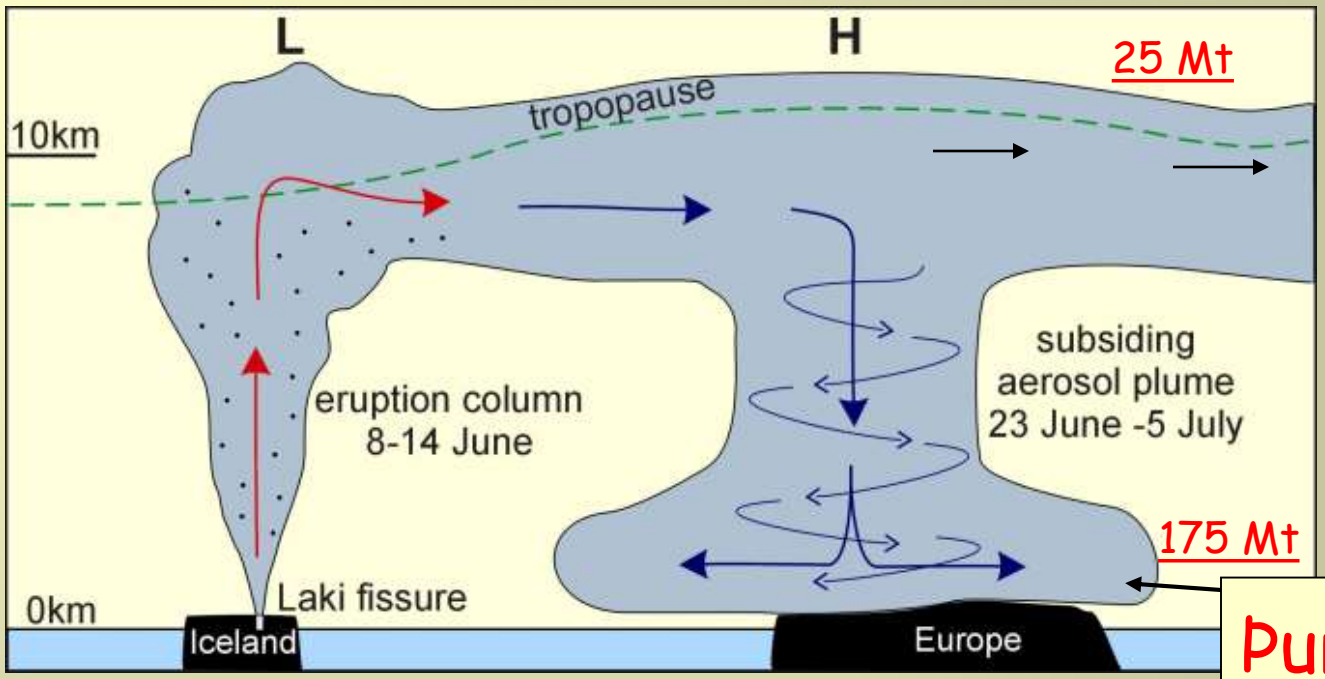
Thordarson og Self. 2003

Brennisteinsmóðan – fjarræn áhrif

van Swinden 1783

"Now some days before the 24 June (at Franeker thence from the 19th) a **certain continuous haze was seen**, but this excited no attention, since this phenomenon is not unusual here,….. But on the 24th day of the month the haze, which was **stronger** than on the preceding day, brought with it a very **distinct sulfurous odor.** …….many experienced very **troublesome headaches and respiratory difficulties**, similar to that which they experienced while the atmosphere around us was filled with the vapor of burned sulfur. ….. In the morning of the 25th the fields showed a very sad appearance. **The green color of the trees and plants had disappeared and the earth was covered with drooping leaves**. One would easily have believed that it was **October or November**. …… Moreover the injury, and falling of leaves, lasted for some time."

Brennisteinsmóðan – fjarræn áhrif II

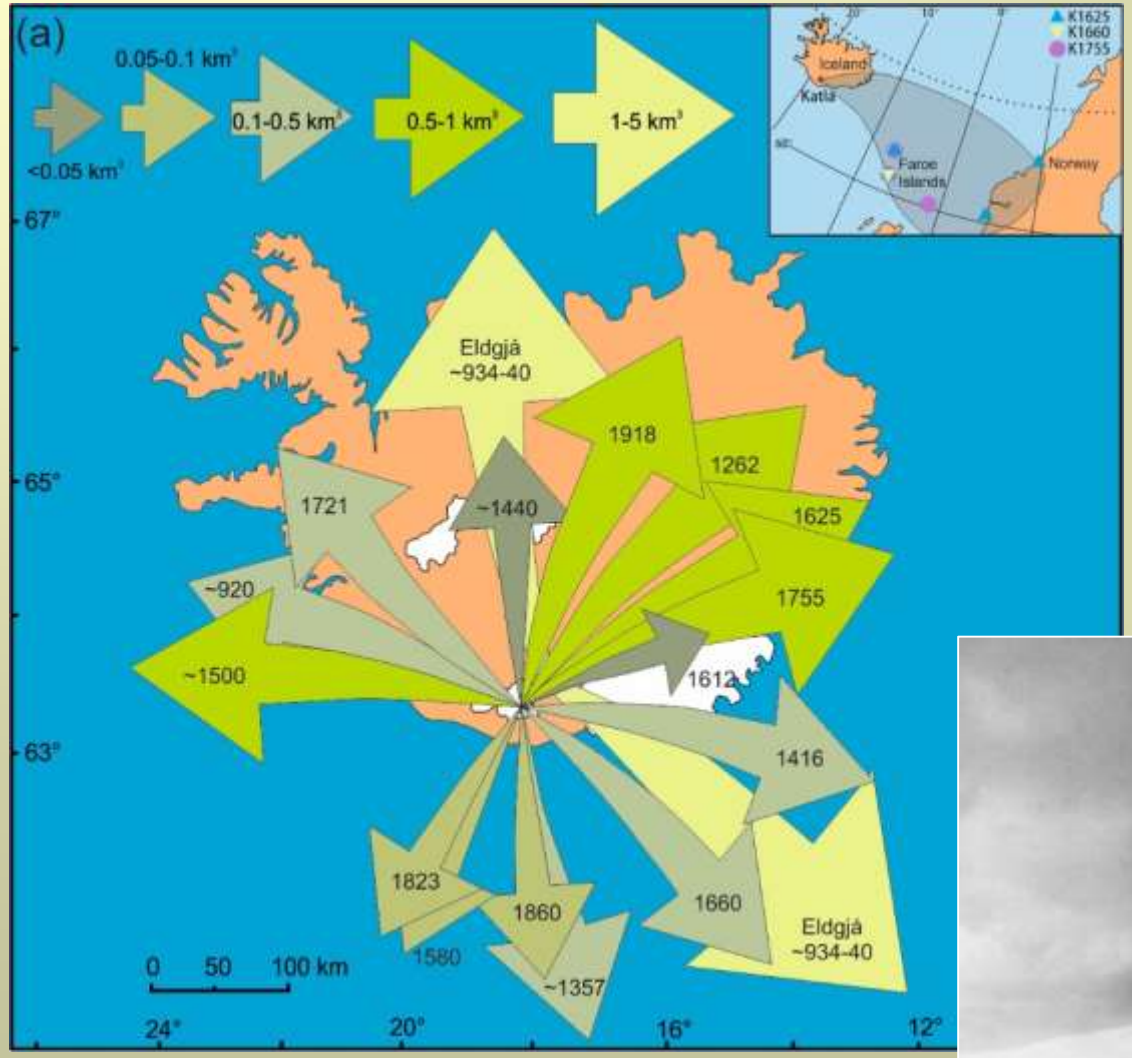


Þurraþoka

- Breinnisteinssýru úrfellið sumarið og haustið 1783 var í heild 175 Mt. (Thordarson og Self, 2003)
- Þetta jafngildir áfelli upp á 1000 kg af brennisteinssýru á km^2
- Brennisteinsmenguninn leiddi til víðtæks uppskerubrests og gróðurskemmda
- Veruleg aukning varð í dauðsföllum á Englandi og Frakklandi, allt að 25% (t.d. Grattan o.fl., 2005)

Katla eruptions

Katla, 21 (23) eruptions in 1100 years



Main dispersal direction of historic tephra layers

Katla
Year (AD)
(1999)
(1955)
1918
1860
1823
1755
1721
1660
1625
1612
1580
~1500
15. c.
~1440
1416
~1357
1262
1245
~1179
12. c.
934/398
~920
9. c.

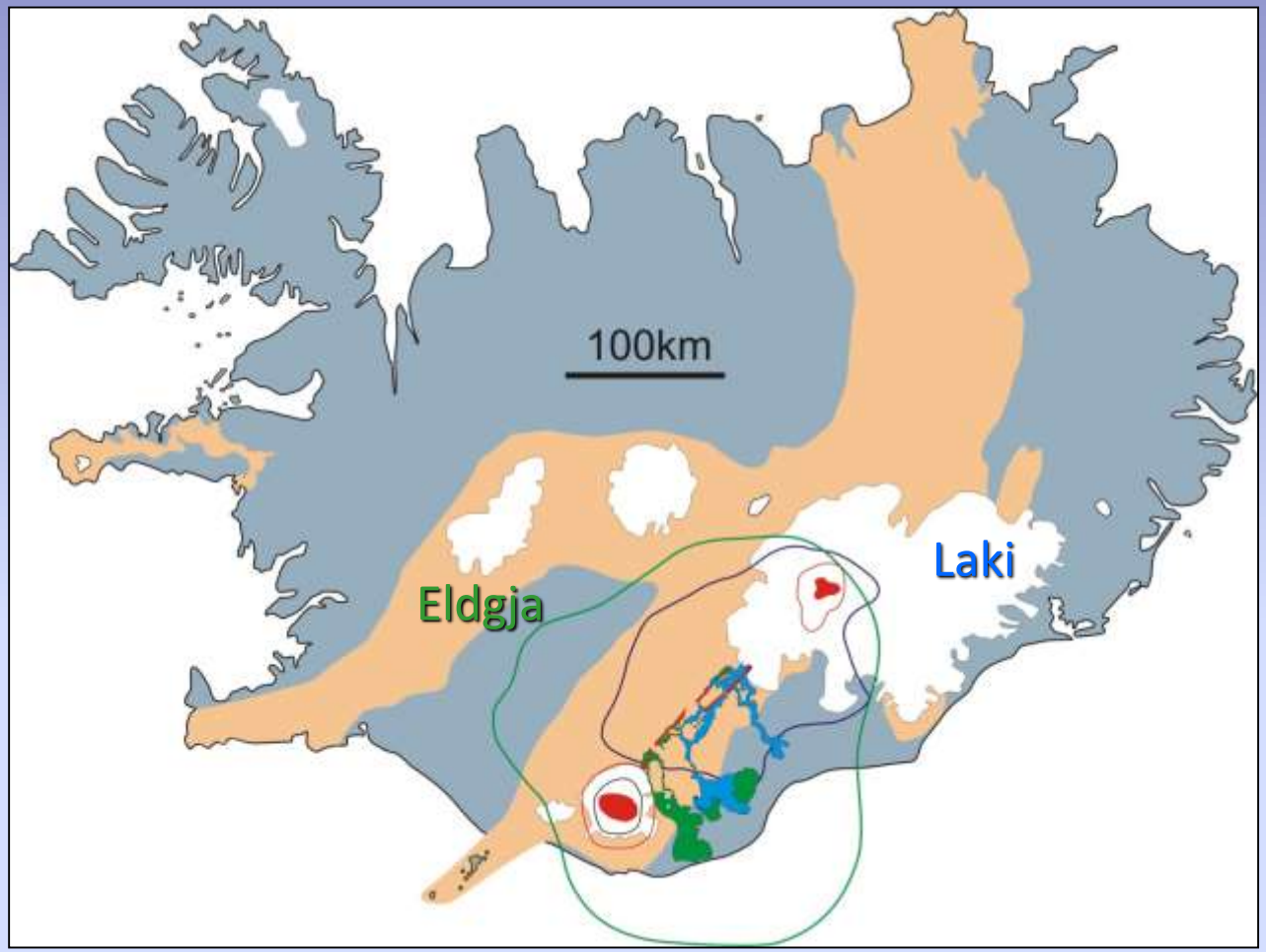
Thordarson and Larsen , 2007

Eldgjá 934-40

area of tephra fall within 0.5 cm isopach

Eldgjá >20,000 km^2

Laki >8,000 km^2



Eldgjá 934-40

>6 km^3 (>1.5 km^3 DRE)

>35 eruption episodes

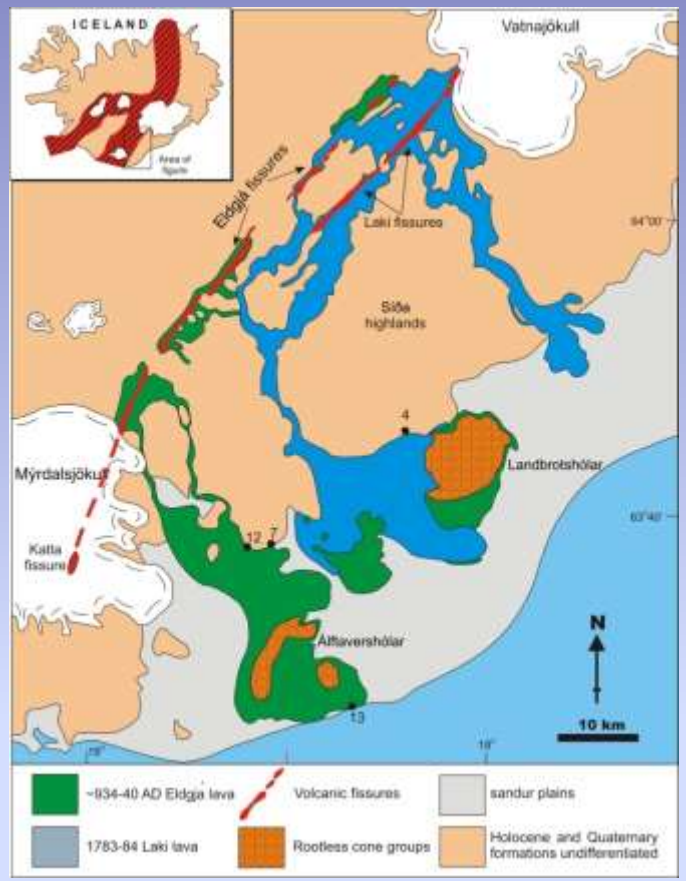
Laki 1783-84

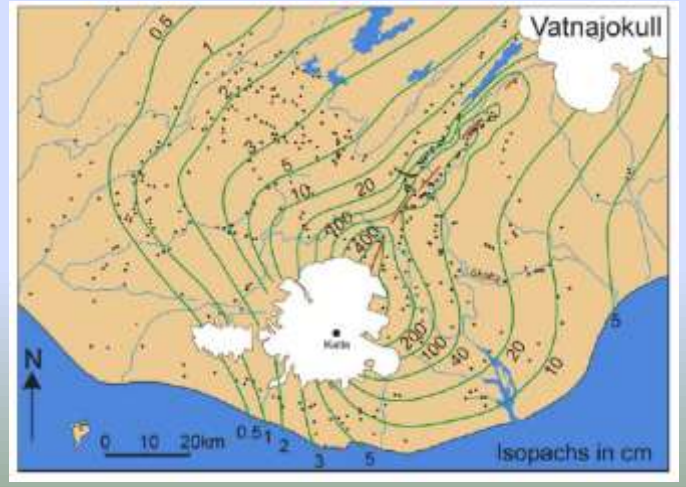
0.9 km^3 (0.4 km^3 DRE)

10 eruption episodes

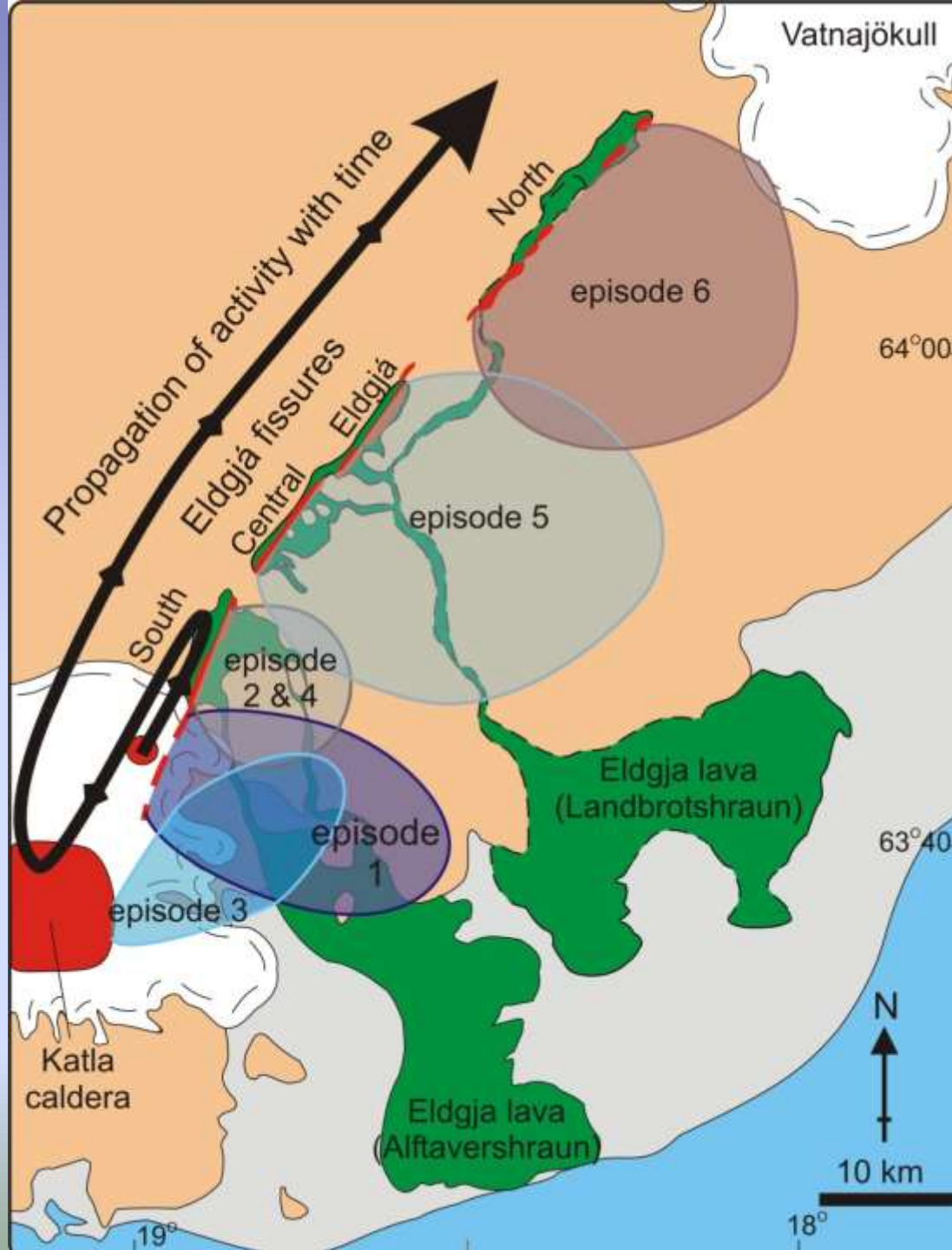
934-40 AD Eldgjá flood lava eruption

High Discharge, large volume of lava and tephra (34 explosive phases grouped into 6 episodes).





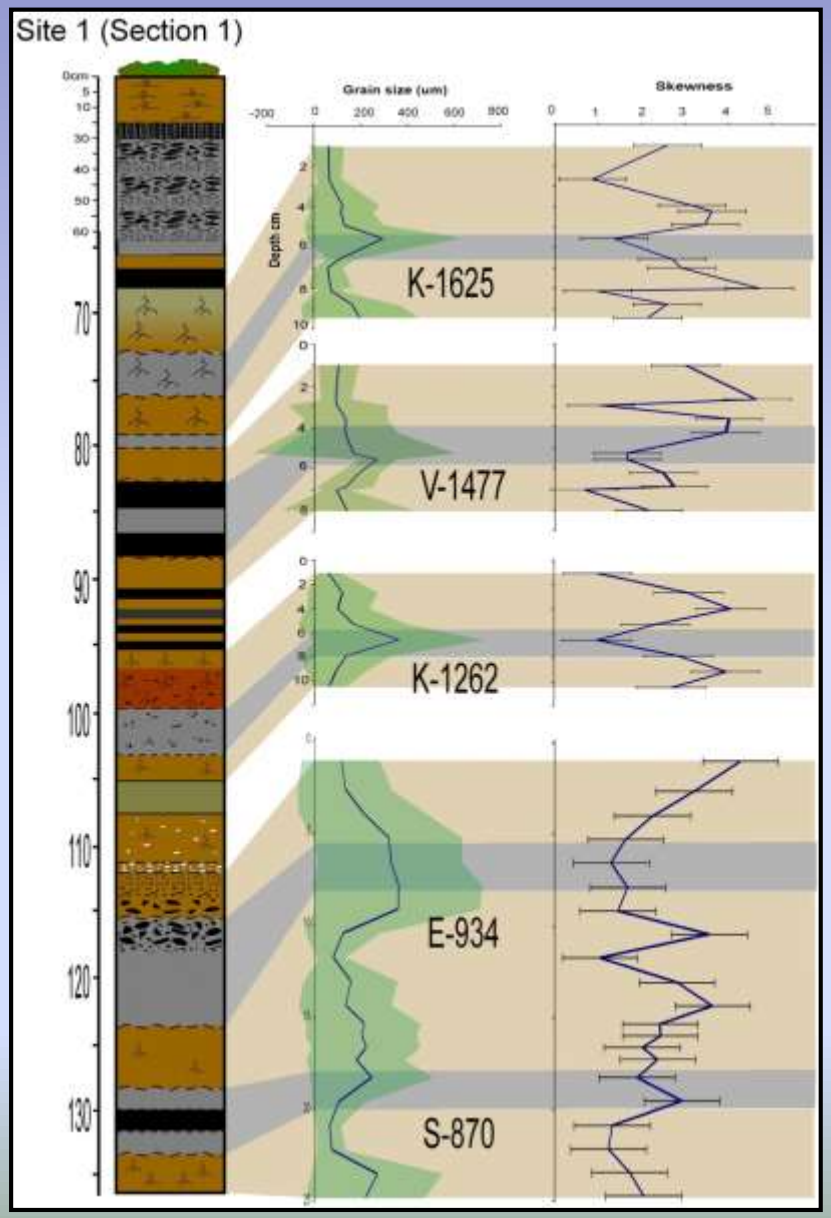
934-40 AD Eldgja eruption history

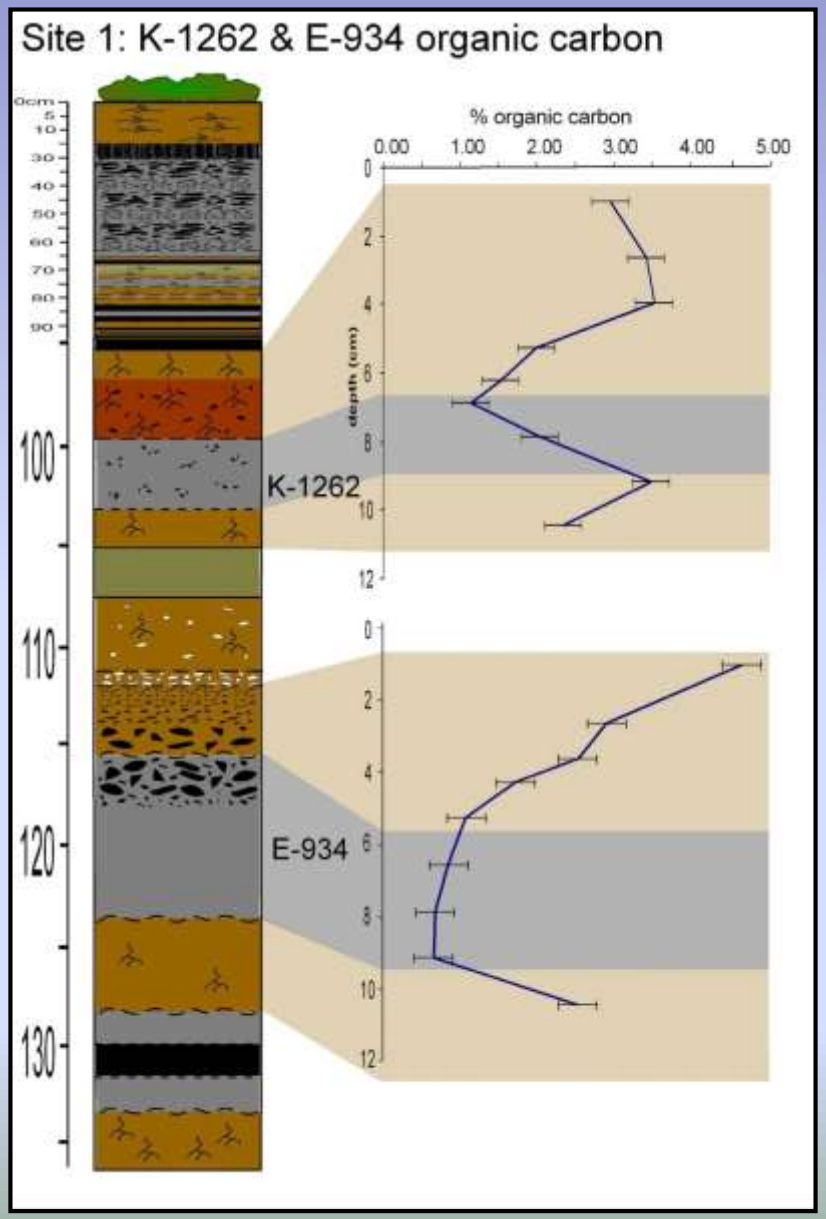


Thordarson unpubl. 2010

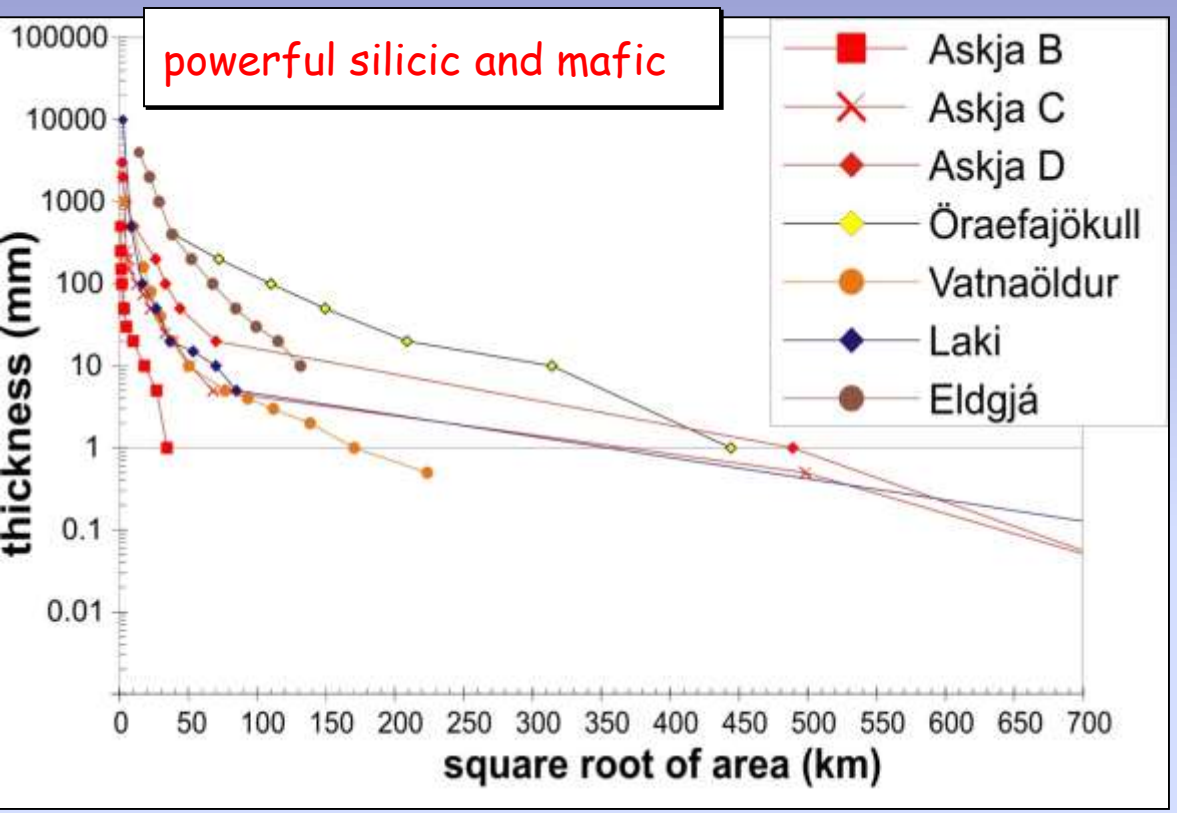
Eldgjá tephra in Álftaversafréttur (Álftavers highlands)

Effect of tephra fall on soil properties in the Eldgjá region





Súr sprengigos



Thordarson and Hoskuldsson, 2008
Larsen and Eiriksson, 2008

≥ 60 súr (> 64% SiO_2) gos á nútíma

with volumes up to 10 km^3

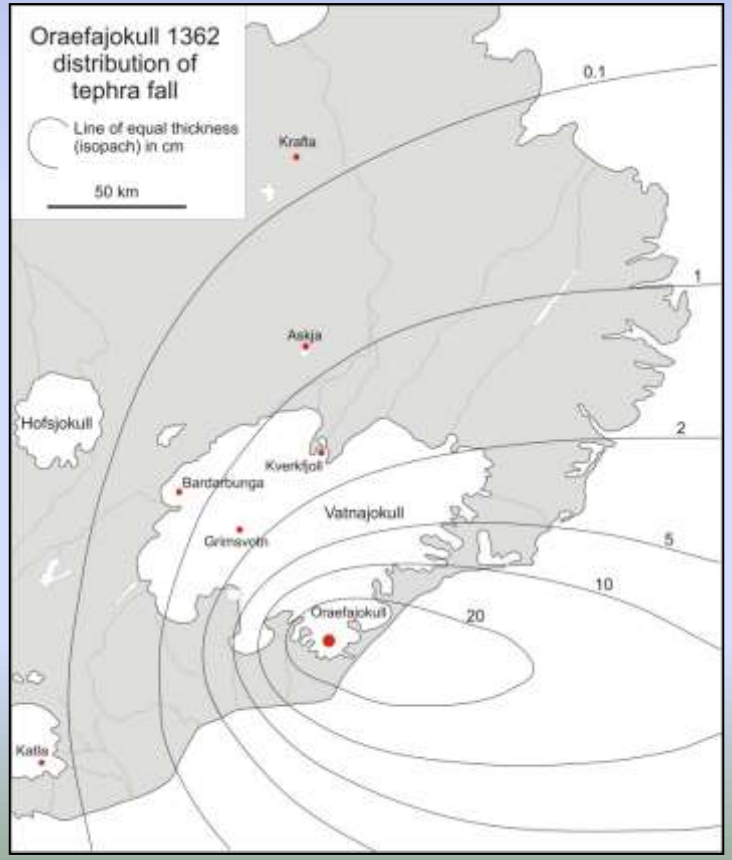
~40 Plínísk and subplínísk gos

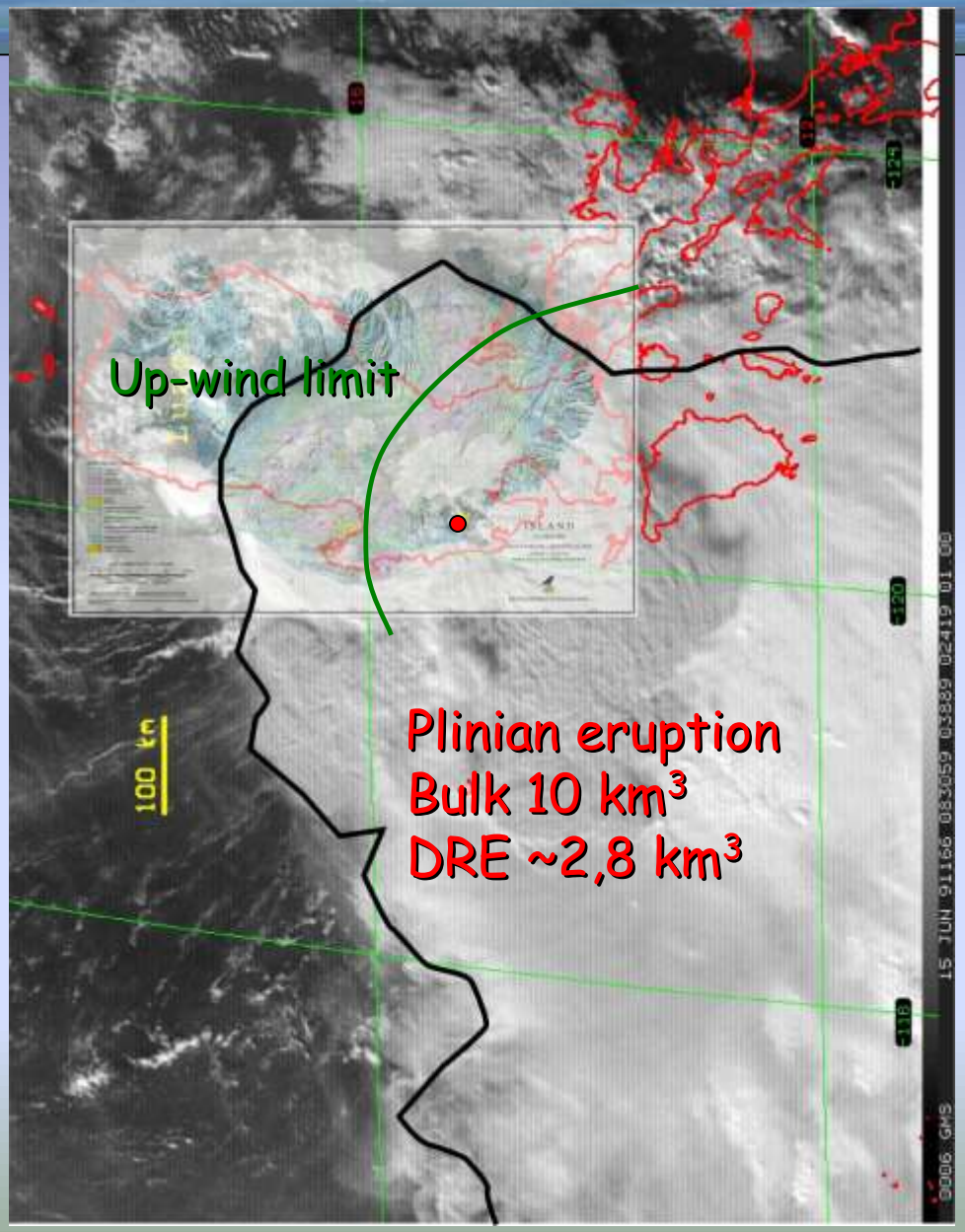
~19 phreatoplínísk

Explosive Silicic Eruptions

Öræfajökull AD 1362

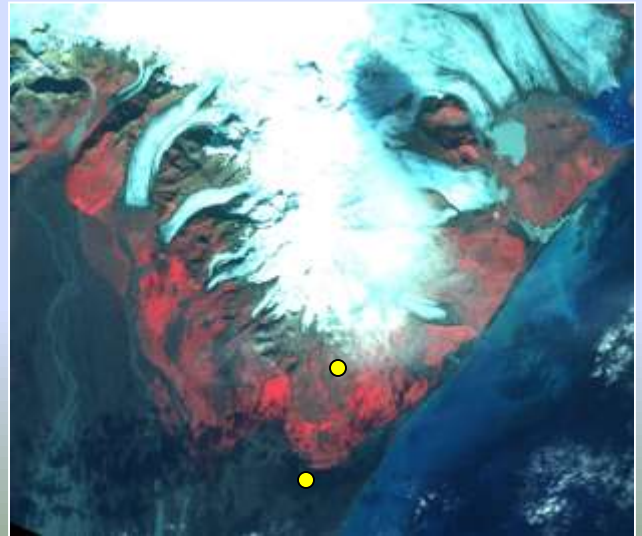
"Ash was carried over the north of the country to such extent that foot prints were visible".





Öræfajökull AD 1362

Hoskuldsson and Thordarson, unpublished 2012



Öræfajökull AD 1362 - Impact

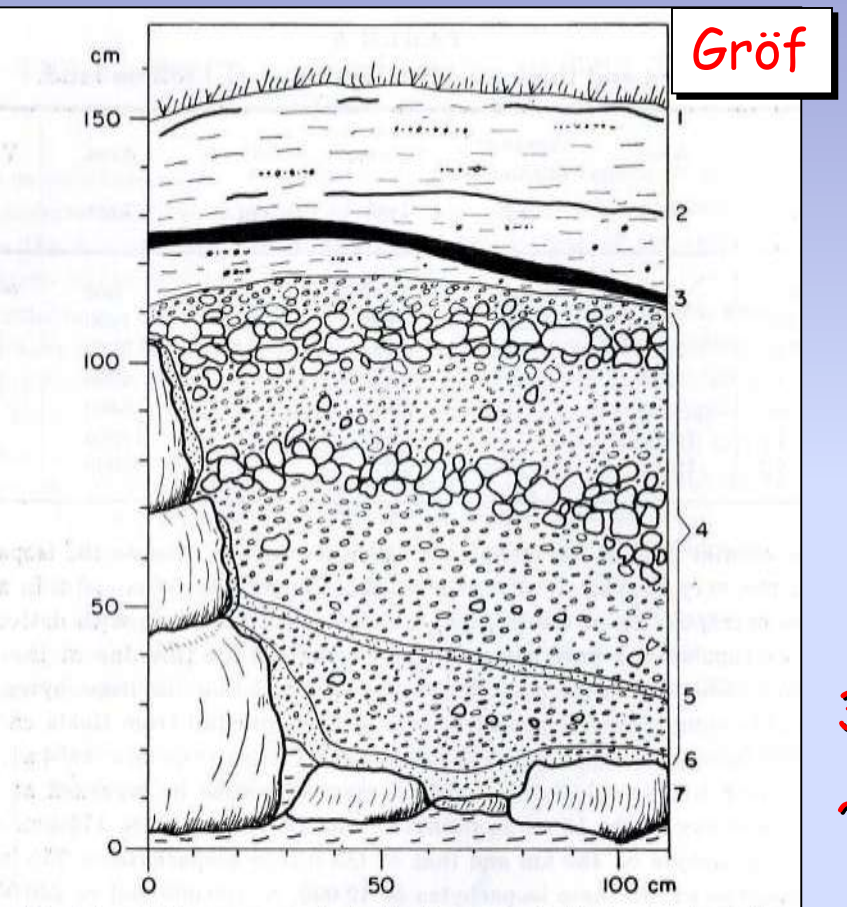
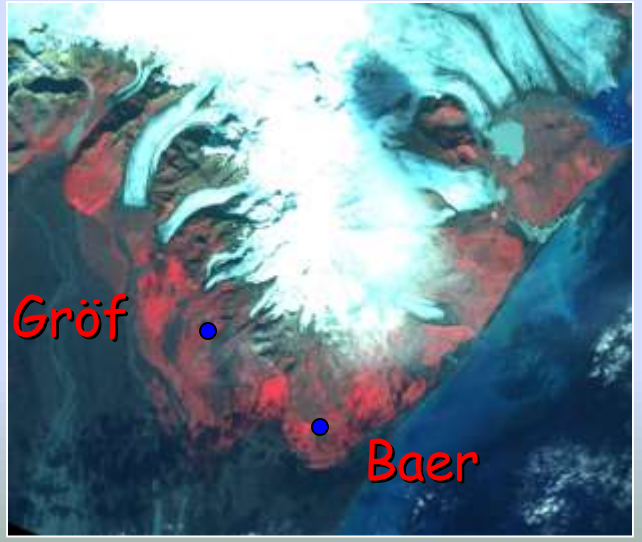


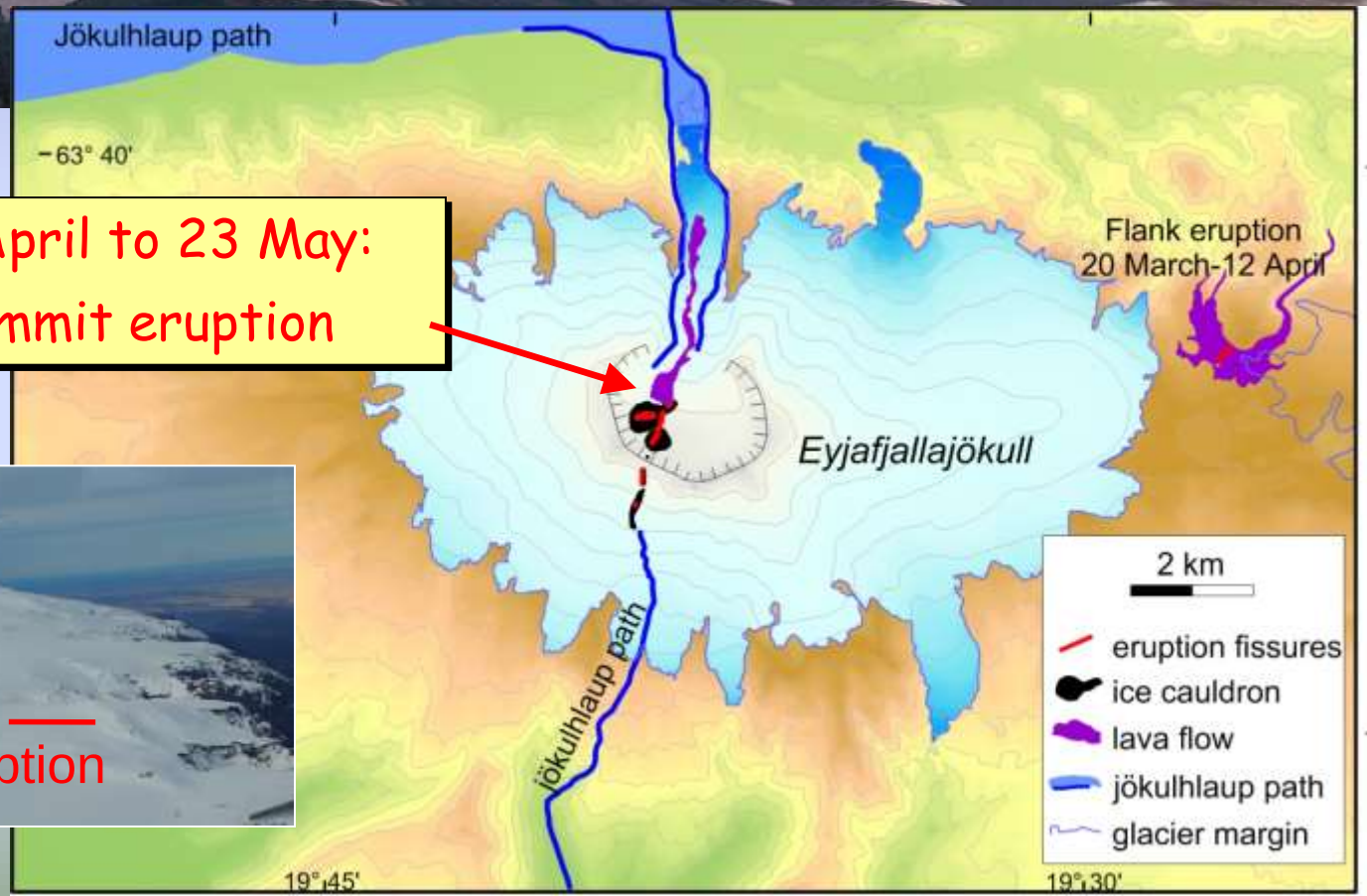
Fig. 28. Section measured at the farmruin Gröf, in front of the "Skáli", 4 m to the right of the main entrance. Drawn by the author, somewhat schematized, in Sept. 1955. 1: K 1918. 2 and 3: Black tephra layers. 4: Ö 1362 (5: A fine sandy layer, 6: The silty bottom crust of Ö 1362). 7: Stone pavement. Above Ö 1362 and beneath the stone pavement is loessial soil.

35-40 farms

~400 people



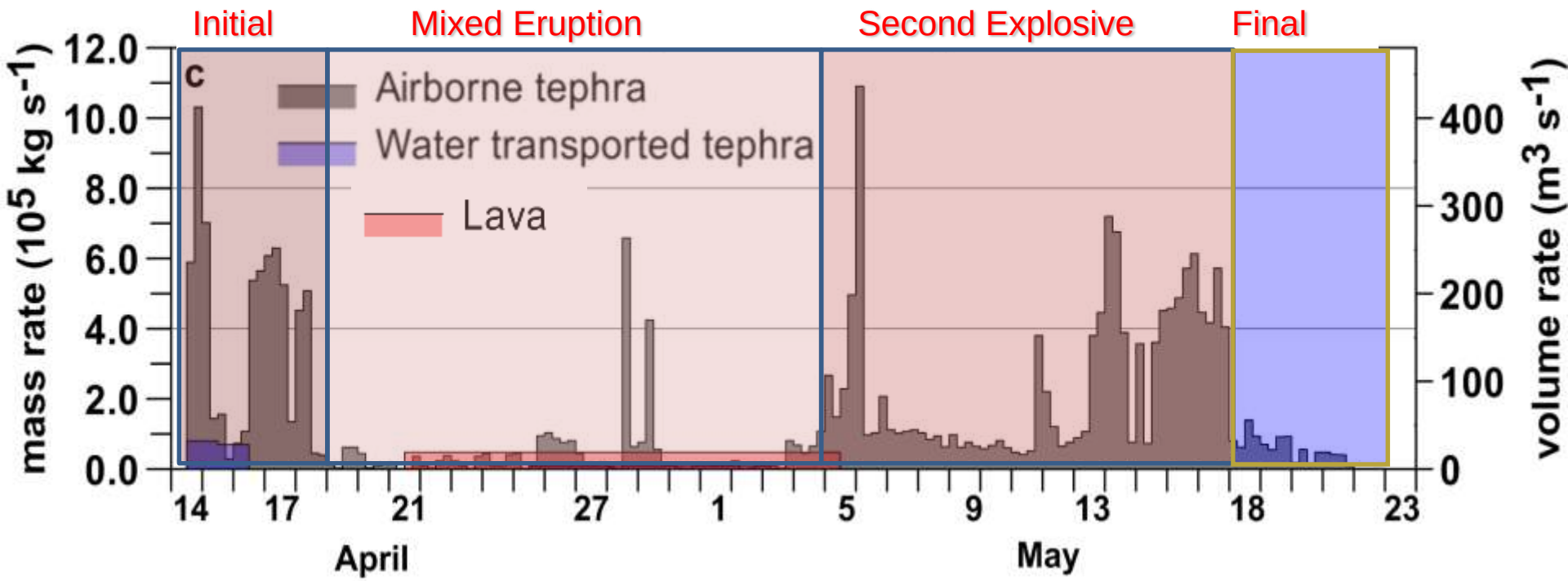
2010 Eyjafjallajökull summit eruption



14 April to 23 May:
summit eruption

Phases of the Summit Eruption

1. INITIAL INTRAGLACIAL EXPLOSIVE PHASE (14-18 April), featuring a series of jökulhlaups and Vulcanian-like explosions discharging magma at rates of 200 to 400 m^3/s and supporting 5-9 km high eruption columns.
2. MIXED ERUPTION PHASE (19 April to ~4 May), that designates a 15 day-long period of low magma discharge (typically <30 m3/s), with concurrent lava emission and weak explosions supporting 2-3 km high columns. During this period lava effusion dominated and weak explosions and lava emission; minor tephra production.
3. SECOND EXPLOSIVE PHASE (4-17 May) lasted for 14 days and was typified by moderate Vulcanian-like explosions and magma discharge of 50-250 m^3/s that supported 4-6 km high eruption plumes.
4. PHASE OF DECLINING ACTIVITY (18-23 May), the intensity of the eruption, plume height and tephra dispersal declined steadily over this period and on May 23 this 39 day-long eruption came to halt.



Views of the jokulhlaup on 14 April

Tephra transport and deposition

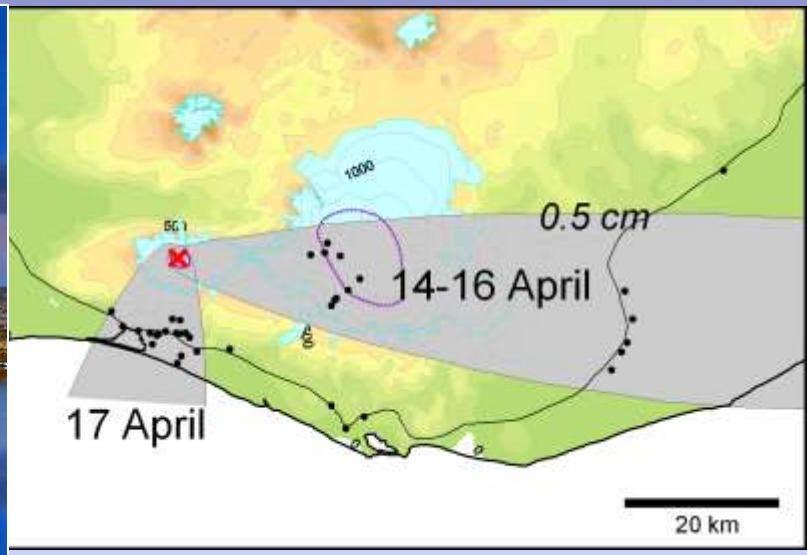
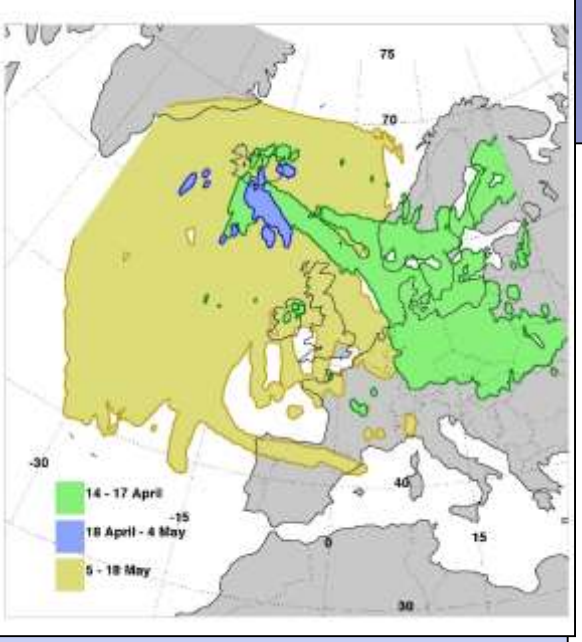
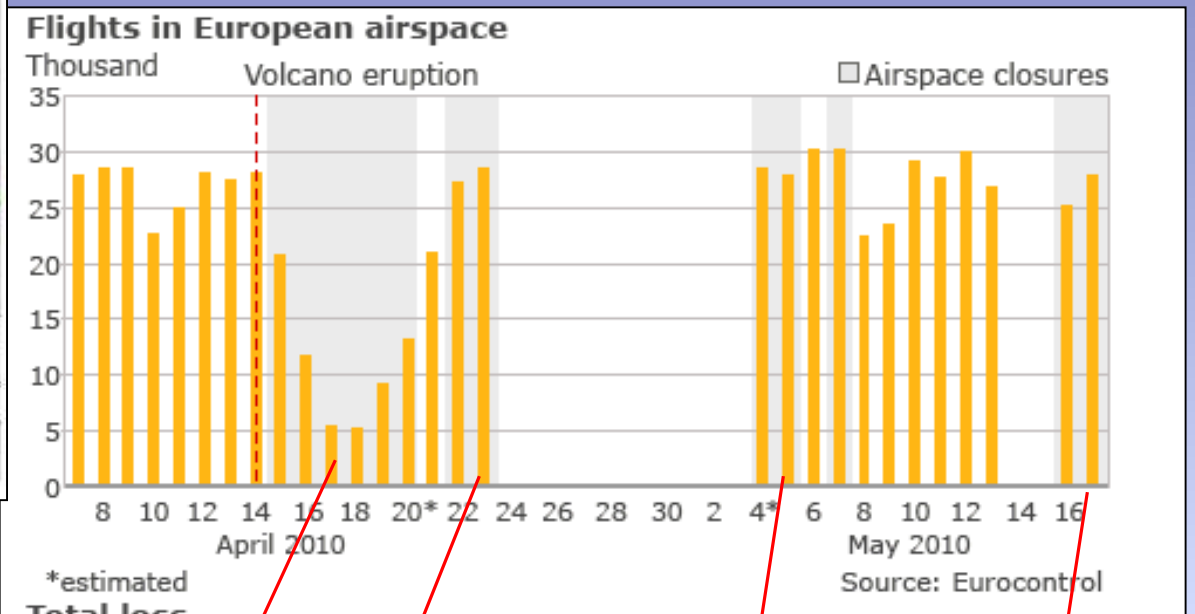
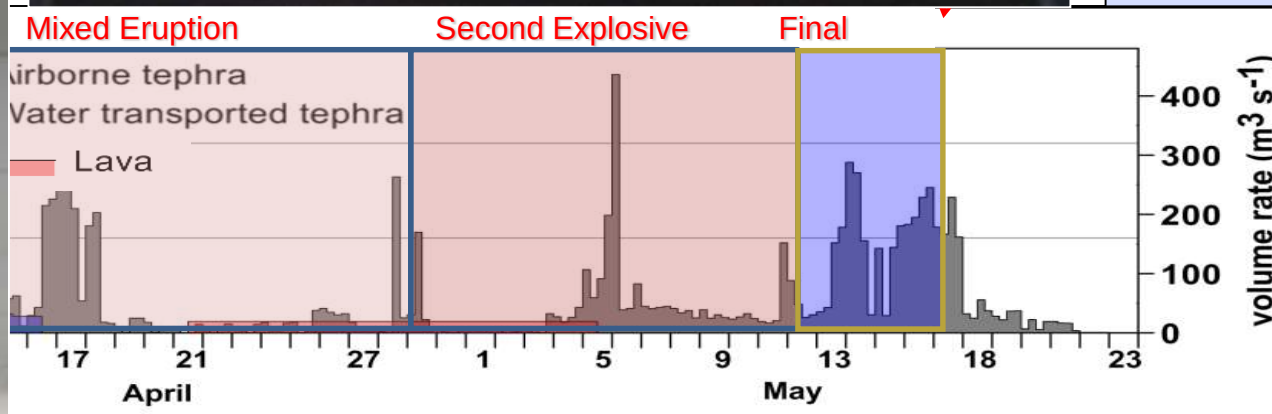


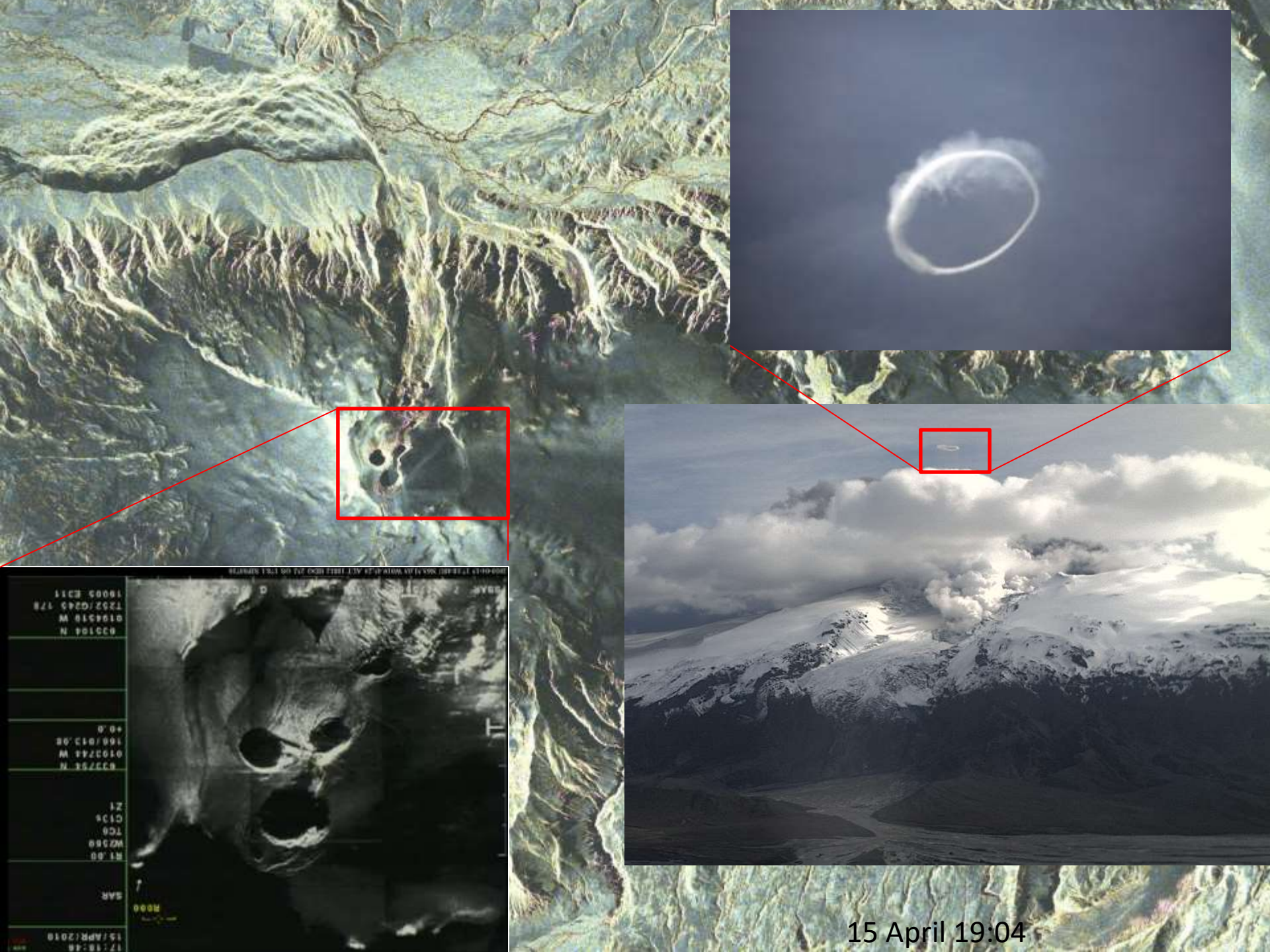
Photo: Halldor Kolbeinsson

Flight Interruptions

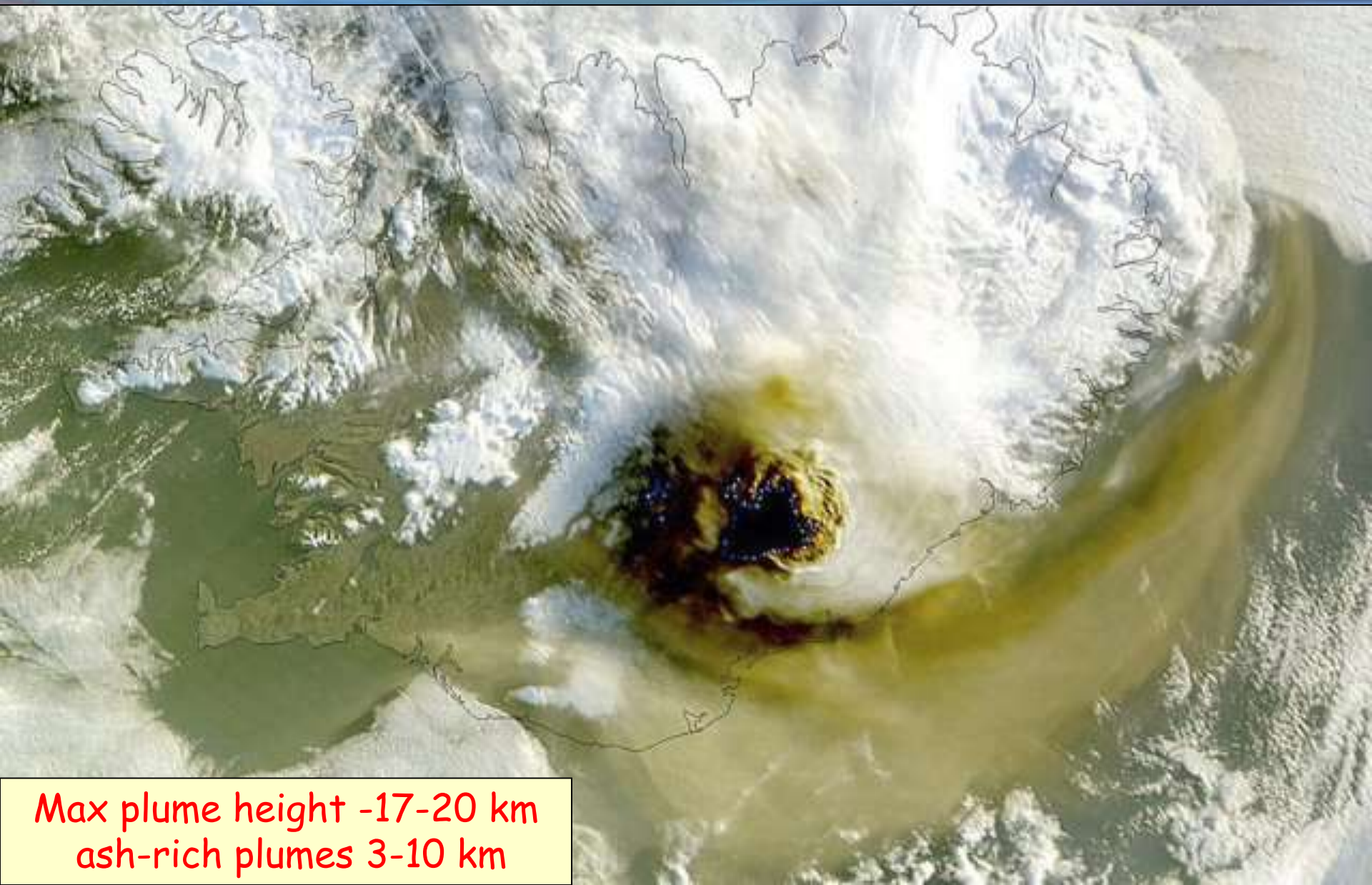







15 April 19:04

Grímsvötn 2011

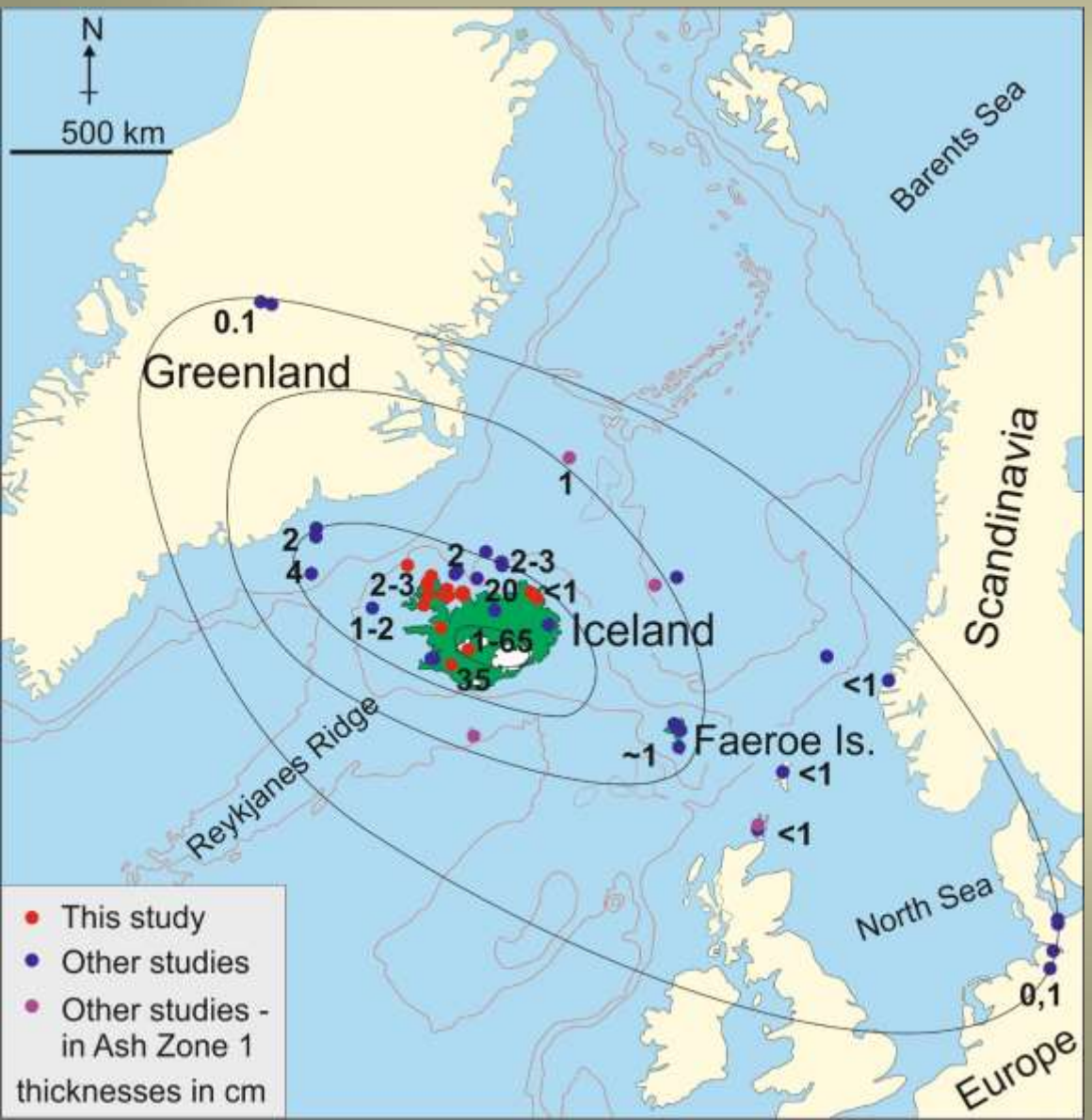


Max plume height -17-20 km
ash-rich plumes 3-10 km

Grímsvötn 2011

Grímsvötn 2011 og Eyjafjallajökull 2010 at distance of 7 km from vent

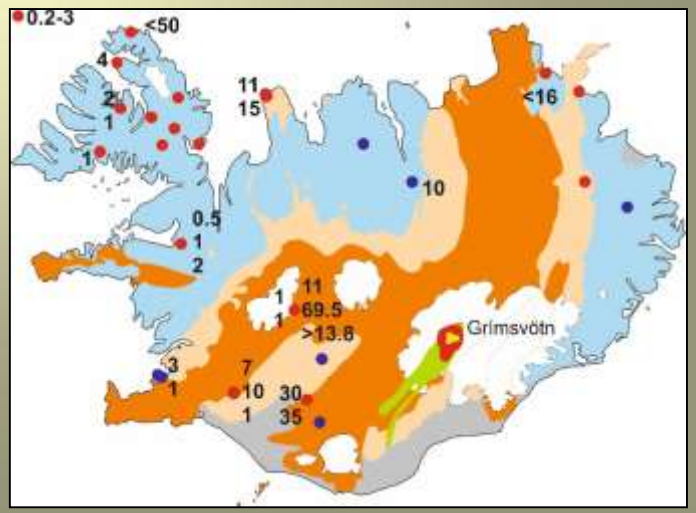
~10Ka Saksunarvatn tephra



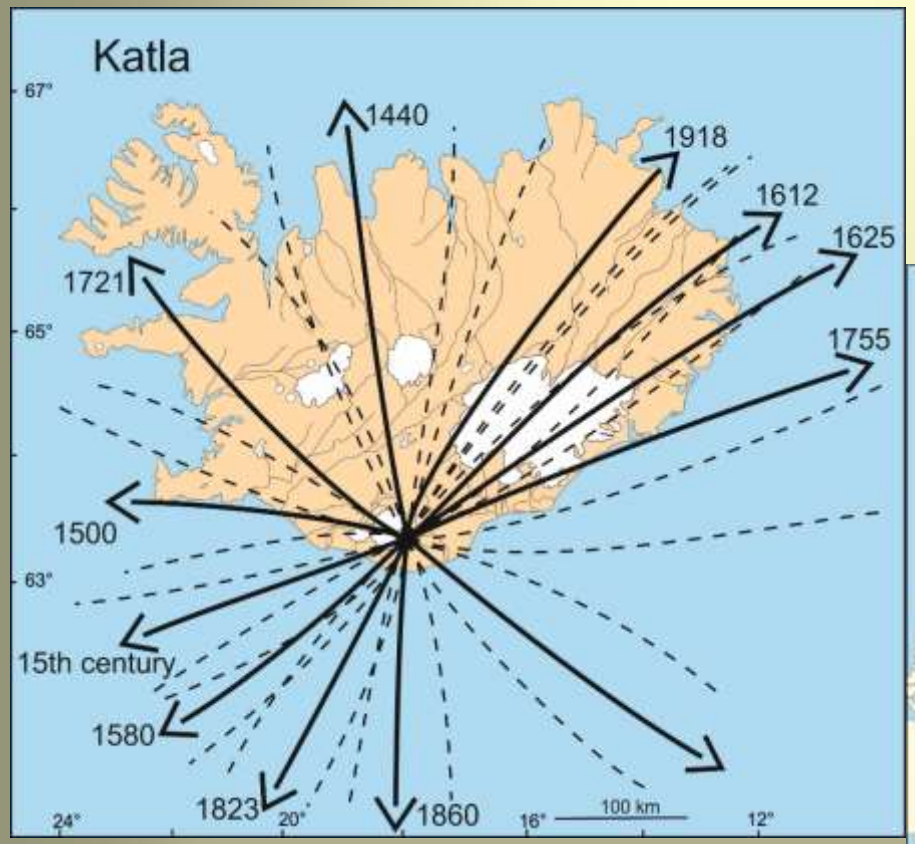
one layer = one eruption

- Area >1.5 million km^2
- Volume 80 to >400 km^3

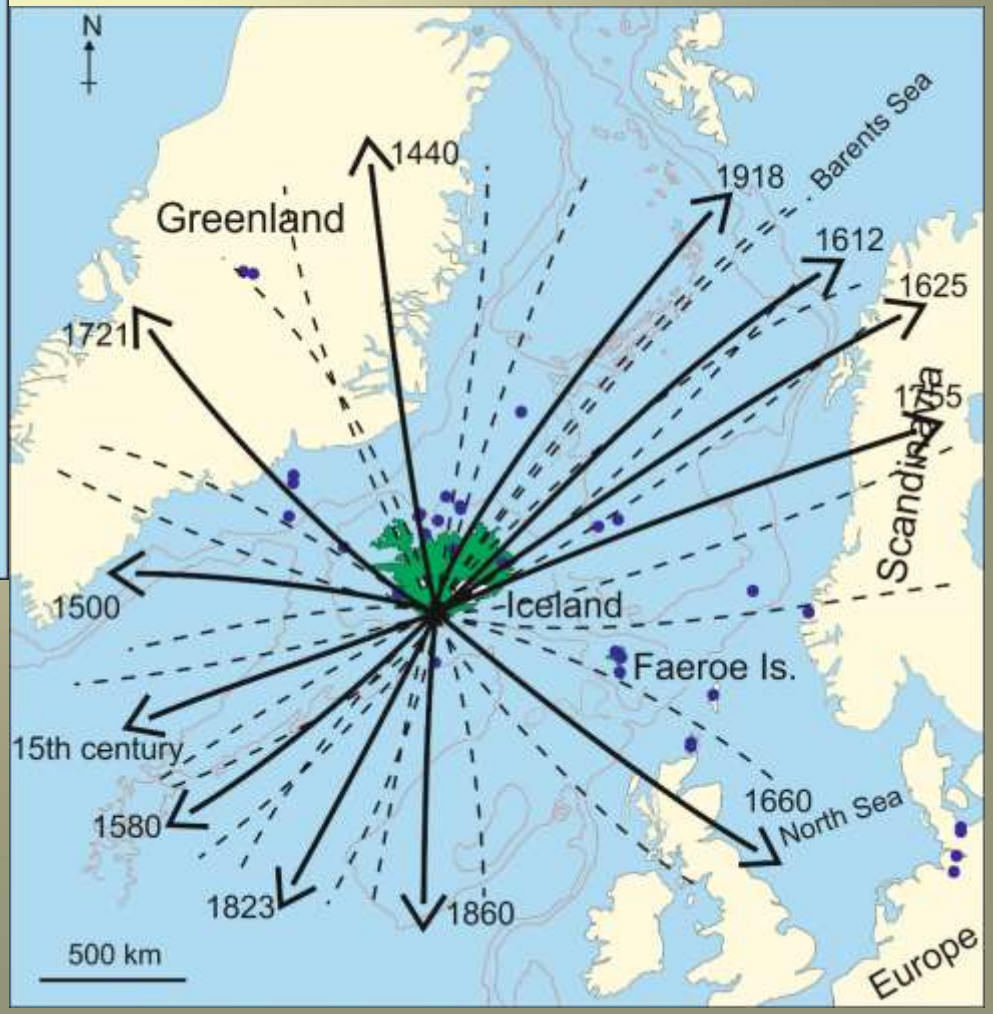
super-eruption!



500 years of Katla tephra fall



More or less cover all sectors around the source volcano.



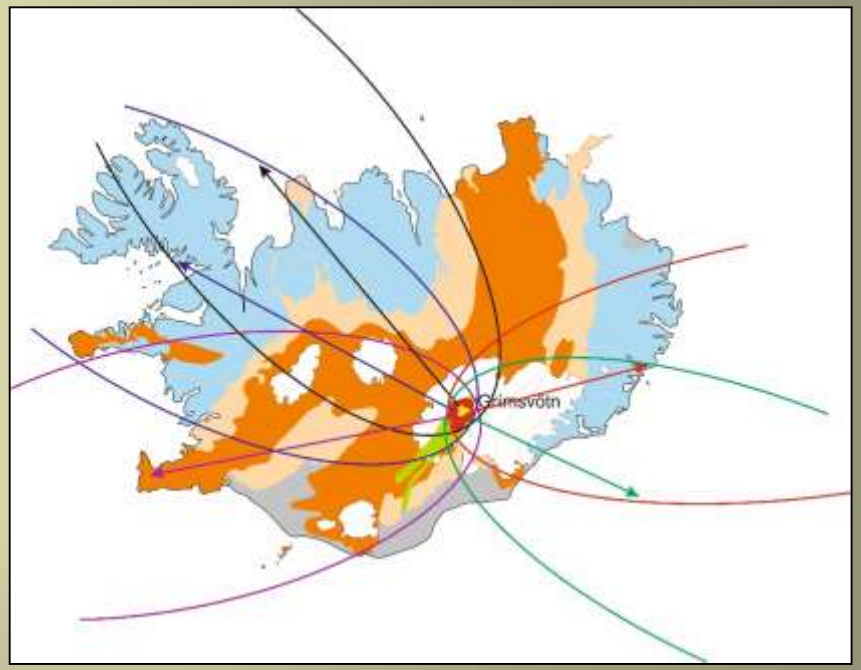
1-2 orders of magnitude bigger events would do the same across the Atlantic.

~10.5-9.9 ka Grímsvötn tephra layers

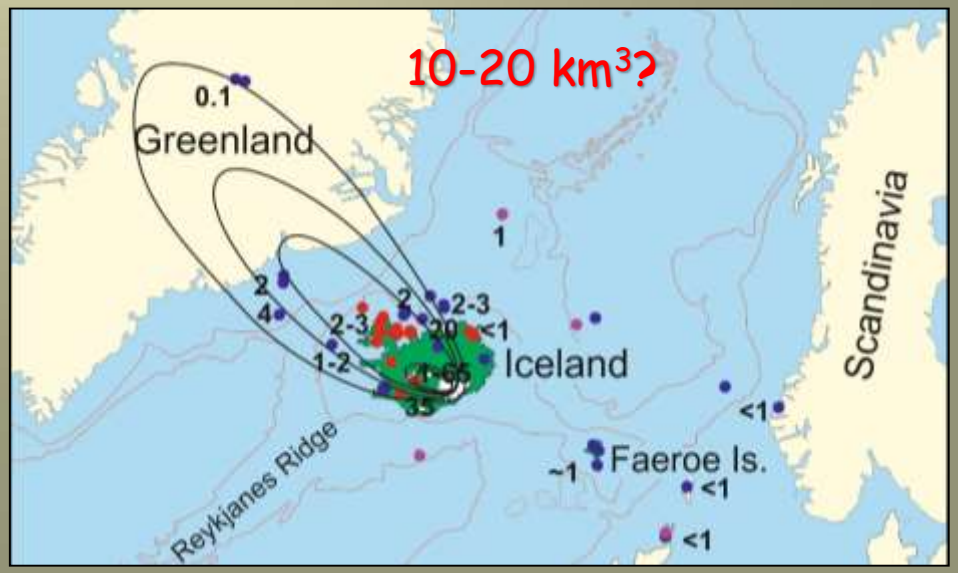
At least seven Grímsvötn tephra layers with volumes of1-20 km^3?

Multiple eruptions over ~500 yrs!

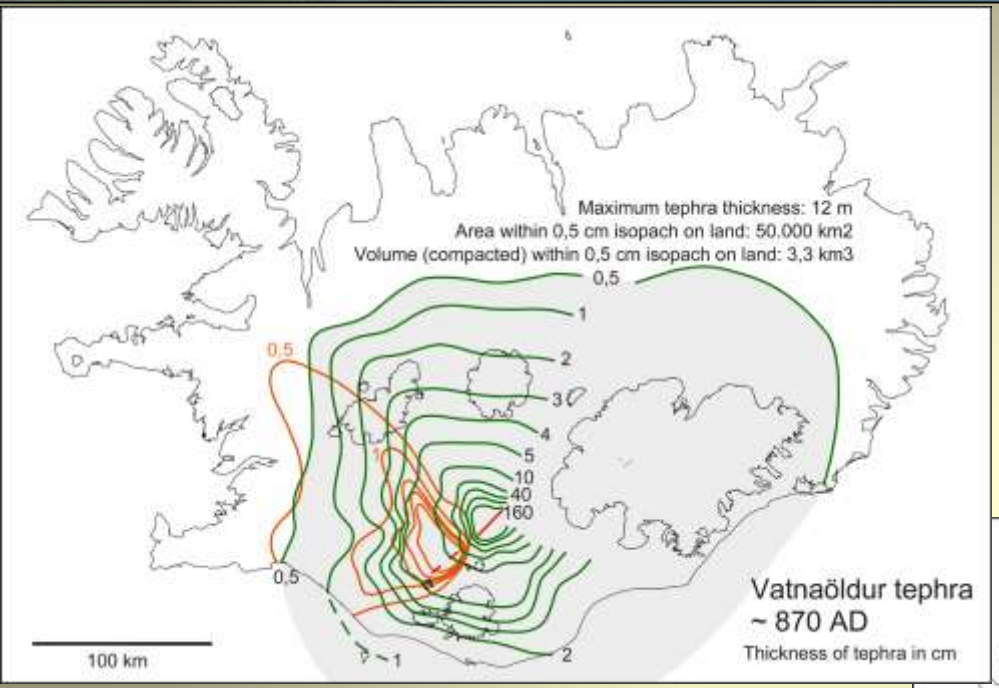
The 10.5-9.9ka sequence was a major eruption episode at Grímsvötn volcanic system!




10ka period tephra below Grímsvötn hut?



Stór basísk sprengigos á Nútíma

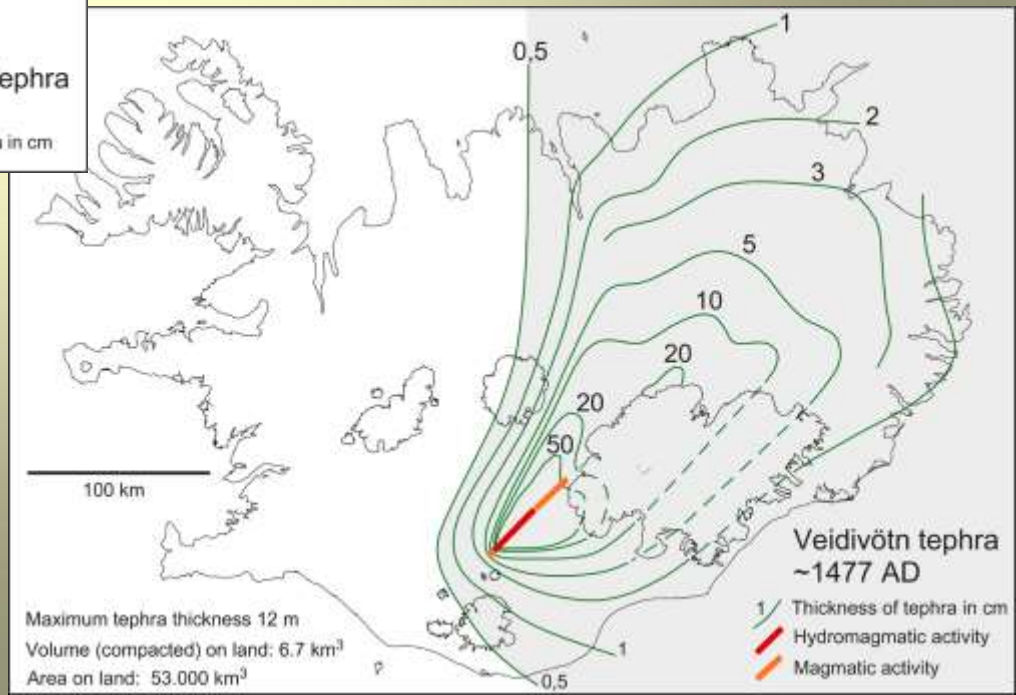


AD ~870 Vatnaöldur

Larsen, 1984

Myndir: O. Sigurdsson

AD 1477 Veiðivötn



Eldosið á Dyngjusandi 2014-15

Eldosið í tölum

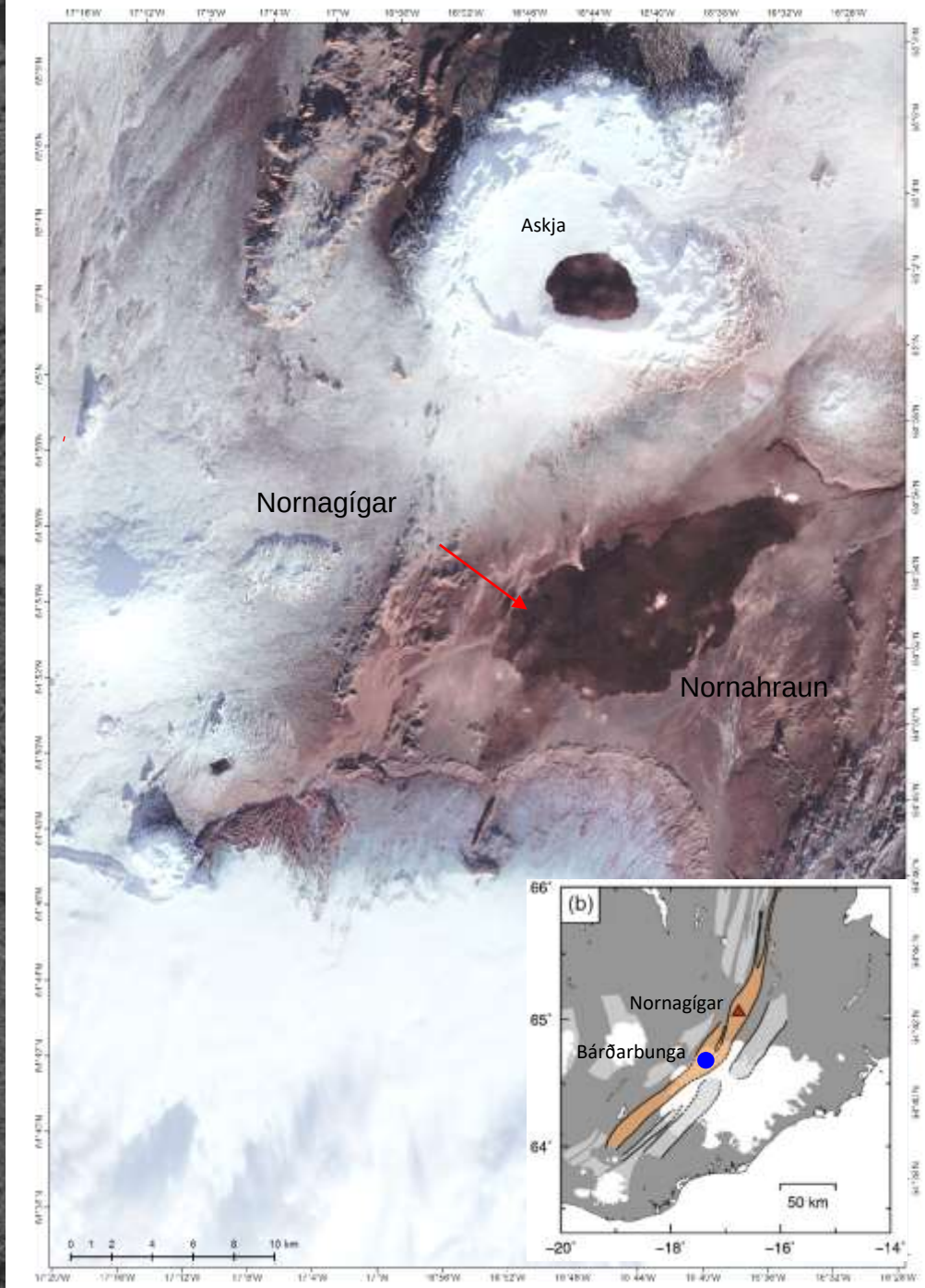
Bárðarbunga-Veiðivötn system

Dæmigert gosbeltabasalt
(MgO~6.85wt%; TiO_2~1.85wt%; K_2O~0.20wt%)

Upprunadýpi kviku: 6-12 km
Hitastig kviku: 1170-1190ºC

Lengd goss: 181 dagar
(31 áug 2014 til 27 feb 2015)

Lengd: 17.8 km
Flatarmál: 83.7 km^2
Rúmmál (bulk): 1.44 km^3
Rúmmá (DRE): 1.1-1.2 km^3
Meðalþykkt 17 m
Mesta þykkt 62 m
SO_2 massi: ~10 megaton (Tgr)



Christa og Martin
Takk fyrir okkur


Takk fyrir