Vorráðstefna
Jarðfræðafélags Íslands

Ágrip erinda

Haldin í Öskju,
Náttúrufræðahúsi Háskóla Íslands
9. mars 2018

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Umsjón:
Þorsteinn Sæmundsson, Sigurlaug María Hreinsdóttir, Lúðvík E. Gústafsson, Ásta Rut Hjartardóttir, Þóra Björg Andrésdóttir, Sylvía Rakel Guðjónsdóttir og Erla María Hauksdóttir

Dagskrá Vorráðstefnu JFÍ, 9. mars 2018

08:20 – 08:50	Skráning
Fundarstjóri	**Erla María Hauksdóttir**
08:50 – 09:00	Setning *Þorsteinn Sæmundsson*
09:00 – 09:15	Þróun sigkatla Mýrdalsjökuls frá 2010 til 2017 lesin úr hæðarkortum aflað með fjarkönnun, yfirborðshæðarsniðum og hreyfingu GPS-stöðva í kötlum *Eyjólfur Magnússon*
09:15 – 09:30	Magma storage conditions below Eyjafjöll, based on clinopyroxene macro- and megacrysts from Seljalandsheiði *Bryndís Ýr Gísladóttir*
09:30 – 09:45	Volcanic fingerprints in stable water isotopes of precipitation over the North Atlantic *Hera Guðlaugsdóttir*
09:45 – 10:00	Skýrir kristöllun apatíts úr Heklukviku myndun súru kvikunnar? *Ingibjörg Andrea Bergþórsdóttir*
10:00 – 10:15	Conceptual model of Krafla *Knútur Árnason*
10:15 – 10:30	Quartz formation processes in the Icelandic crust – A coupled $\delta^{18}O$ and $\delta^{30}Si$ study *Barbara Kleine*
10:30 – 11:00	**Kaffi – Veggspjaldasýning**
11:00 – 11:15	Hversu hratt þróast kvika í rótum Heklu? *Olgeir Sigmarsson*
11:15 – 11:30	Country-wide deformation field over Iceland inferred from interferometric analysis of Sentinel-1 SAR images *Vincent Drouin*
11:30 – 11:45	Physical modeling constraints on thickness and geometry of the melt body feeding the 2014-2015 diking and eruption, and the triggering of caldera collapse, in the Bárðarbunga volcanic system *Freysteinn Sigmundsson*
11:45 – 12:00	Breytingar á b-gildi jarðskjálfta í Bárðarbungu í tengslum við yfirstandandi umbrot í eldstöðinni *Páll Einarsson*
12:00 – 13:00	**Matur – Veggspjaldasýning**
Fundarstjóri	**Ásta Rut Hjartardóttir**
13:00 – 13:15	Surtseyjarborunin 2017: Fjölþjóðlega verkefnið SUSTAIN, fyrstu niðurstöður *Magnús Tumi Guðmundssom*
13:15 – 13:30	Hafísborið efni í Íslands-Noregshafi á síðasta jökulskeiði *Erna Ó. Arnardóttir*

13:30 – 13:45	Er eldvirkni á Íslandi sambærileg á nútíma og síðasta jökulskeiði? *Esther Ruth Guðmundsdóttir*
13:45 – 14:00	Hekla volcano, Iceland, in the 20th century: Lava volumes, production rates and effusion rates *G.B.M. Pedersen*
14:00 – 14:15	Causes and triggering factors for large scale displacements in the Almenningar landslide area, in central North Iceland *Þorsteinn Sæmundsson*
14:15 – 15:00	**Veggspjaldasýning**
15:00 – 15:30	**Kaffi**
15:30 – 15:45	Hrun íslenska meginjökulsins í lok síðasta jökulskeiðs og myndun efstu og elstu fjörumarka *Hreggviður Norðdahl*
15:45 – 16:00	Volume changes in lake Kleifarvatn 2014 – 2017 *Þóra Björg Andrésdóttir*
16:00 – 16:15	Eru merki um forna ísstrauma á Norðausturlandi? *Ívar Örn Benediktsson*
16:15 – 16:30	Extensive glacier advances during the Pleistocene-Holocene transition on Svalbard *Ólafur Ingólfsson*
16:30 – 16:45	Endurteknar framrásir jökuls í Melasveit í neðri hluta Borgarfjarðar á síðjökultíma *Þorbjörg Sigfúsdóttir*
16:45 – 17:00	Modeling Flow Dynamics and Constraining the Modeled Stress Balance of the Langjökull Glacier Using Mass Balance and Surface Velocity Measurements, 1997-2016 *Rebecca A. Robinson*
17:00 –	**Móttaka**

Veggspjöld

Er Kvikuframleiðni Kötlu jöfn síðustu 3500 ár?

Bergrún Arna Óladóttir, Olgeir Sigmarsson og Guðrún Larsen

Heklugos á mið-nútíma – rannsókn á gjóskulögunum Heklu DH (Blakki) og Heklu Ö

Daníel Freyr Jónsson, Esther Ruth Guðmundsdóttir, Guðrún Larsen, Bergrún Óladóttir og Olgeir Sigmarsson

Monte Carlo simulated annealing method for coupled earthquake locations and 1D velocity structure determination: 'Minimum' models with constant velocity gradient layers

Einar Kjartansson and Ingi Th. Bjarnason

Holocene tephra stratigraphy in the Vestfirðir peninsula, NW Iceland

Esther Ruth Guðmundsdóttir, Anders Schomacker, Skafti Brynjólfsson, Ólafur Ingólfsson and Nicolaj K. Larsen

Are Torfajökull magmas invading the Hekla/Vatnafjöll volcanic system? Some preliminary results.

Guðrún Sverrisdóttir and Sæmundur Ari Halldórsson

Flýtur eins og tappi: Samband flotjafnvægishreyfinga og framvindu hörfunar íslenska meginjökulsins af landgrunninu í lok síðasta jökulskeiðs

Hreggviður Norðdahl og Ólafur Ingólfsson

Putorana ice sheet advance over southern Taimyr, NW Siberia, during the Late Saalian (MIS 6)

Ívar Örn Benediktsson and Per Möller

Improving early Holocene tephrochronology of North, Northeast and East Iceland

M. Kalliokoski, E.R. Guðmundsdóttir, B.A. Óladóttir, H. Norðdahl and Í.Ö. Benediktsson

Networking European Volcano Observations and Community through the EPOS Research Infrastructure and the EUROVOLC Networking Project

Kristín S. Vogfjörð, EPOS team and EUROVOLC team

Bygging Múlajökuls eftir framhlaup og tengsl hennar við undirlag jökulsins

Magnús Freyr Sigurkarlsson, Ívar Örn Benediktsson and Emrys Phillips

Mapping of fractures within the Reykjanes fissure swarm, SW-Iceland

Páll Einarsson, Ásta Rut Hjartardóttir, and students of the courses Tectonics and Current Crustal Movements in the Faculty of Earth Sciences, University of Iceland 2017

Geochemical characteristics of an enriched Icelandic tholeiitic magma suite: the case of the Kverkfjöll volcanic system

E. Ranta, S.A. Halldórsson, G.H. Guðfinnsson, E. Bali, V. Nykänen, K. Grönvold and R. Kaikkonen

Assessing $\delta^{18}O$ heterogeneity in Icelandic olivine crystals

M. B. Rasmussen, S. A. Halldórsson, M. J. Whitehouse and S. A. Gibson

Efnisyfirlit

Ágrip

Er kvikuframleiðni Kötlu jöfn síðustu 3500 ár?

Bergrún Arna Óladóttir[1], Olgeir Sigmarsson[1,2] og Guðrún Larsen[1]

[1] Norræna eldfjallasetrið, Jarðvísindastofnun Háskóla Íslands, Öskju, 101 Reykjavík
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Kvikuframleiðni virkra eldstöðva, eða það magn kviku sem upp kemur á ákveðnum tíma, stjórnast sennilega að hluta eða öllu leyti af undirliggjandi kvikuaðfærslukerfi. Uppbygging kvikukerfis Kötlu hefur að öllum líkindum verið breytilegt á nútíma þar sem kerfið breyttist úr einföldu aðfærslukerfi yfir í net silla og ganga, sem þróaðist síðan yfir í afmarkað kvikuhólf. Þetta ferli hefur verið tvítekið á nútíma. Síðustu ~3500 árin eru dæmigerð fyrir breytingu úr kvikuhólfstímabili yfir í einfalt kerfi. Kvikuframleiðni beggja tímabila hefur verið metin út frá rúmmáli 25 gjóskulaga, sautján þeirra mynduð í virku kvikuhólfi (1700 f.Kr. - 920 e.Kr.) og átta í einföldu kerfi (virkt síðan ~940 e.Kr.). Meðalstærð gjóskulaga á báðum tímabilum var um 1 km^3 en þrátt fyrir það var gjóskuframleiðsla um þrisvar sinnum meiri þegar kvikuhólf var virkt (6.3 km^3/öld á móti 2.4 km^3/öld). Því virðist aðfærslukerfið stjórna gjóskuframleiðni og gosgerð með því að beina kviku lóðrett upp í megineldstöðina þegar kvikuhólf er virkt sem leiðir af sér aukna sprengivirkni vegna samspils kviku og vatns og þ.a.l. aukna gjóskumyndun. Þegar einfalt kvikuaðfærslukerfi (þ.e. gangur) er ráðandi virðist kvika jafnframt koma upp utan jökulhulinnar megineldstöðvarinnar sem leiðir til hraungosa og minni gjóskuframleiðslu. Jöfn aukning uppsafnaðs rúmmáls gosefna frá Kötlu síðustu 3500 ár (sjá mynd) bendir til þess að inn- og útflæði kviku í kerfið hafi verið í jafnvægi (steady-state volcano). Tímamunur milli þess að djúpstæð innskotavirkni treðst inn í kvikuaðfærslukerfið (rauðar örvar á mynd sem sýna aukningu á hallatölur eða aukinn framleiðsluhraða gosefna) og þess að lægri styrkur utangarðsefna mælist í gjósku kerfisins (gráar strikalínur á mynd) fer minnkandi með tíma. Fyrir um 2600 árum fylltist kvikukerfið með þeim afleiðingum að framleiðsluhraði gosefna jókst en merki (í kvikusamsetningu) þeirrar innspýtingar kemur ekki fram í gosefnum fyrr en 600 árum seinna. Önnur fylling kvikukerfisins verður fyrir u.þ.b. 1400 árum en þá tekur mun skemmri tíma fyrir frumstæðari samsetningu innskots basaltsins að koma fram, eða um 250 ár. Að endingu kemur samsetning innspýtingar fram einungis 50 árum seinna. Þetta ferli bendir til þess að hið virka kvikuhólf fari minnkandi og hverfi að lokum

Heimildir

Bergrún Arna Óladóttir, Olgeir Sigmarsson, Guðrún Larsen. 2015. Gjóskuframleiðni og kvikukerfi Kötlu. Haustráðstefna Jarðfræðafélags Íslands. Reykjavík 20. nóv 2015.

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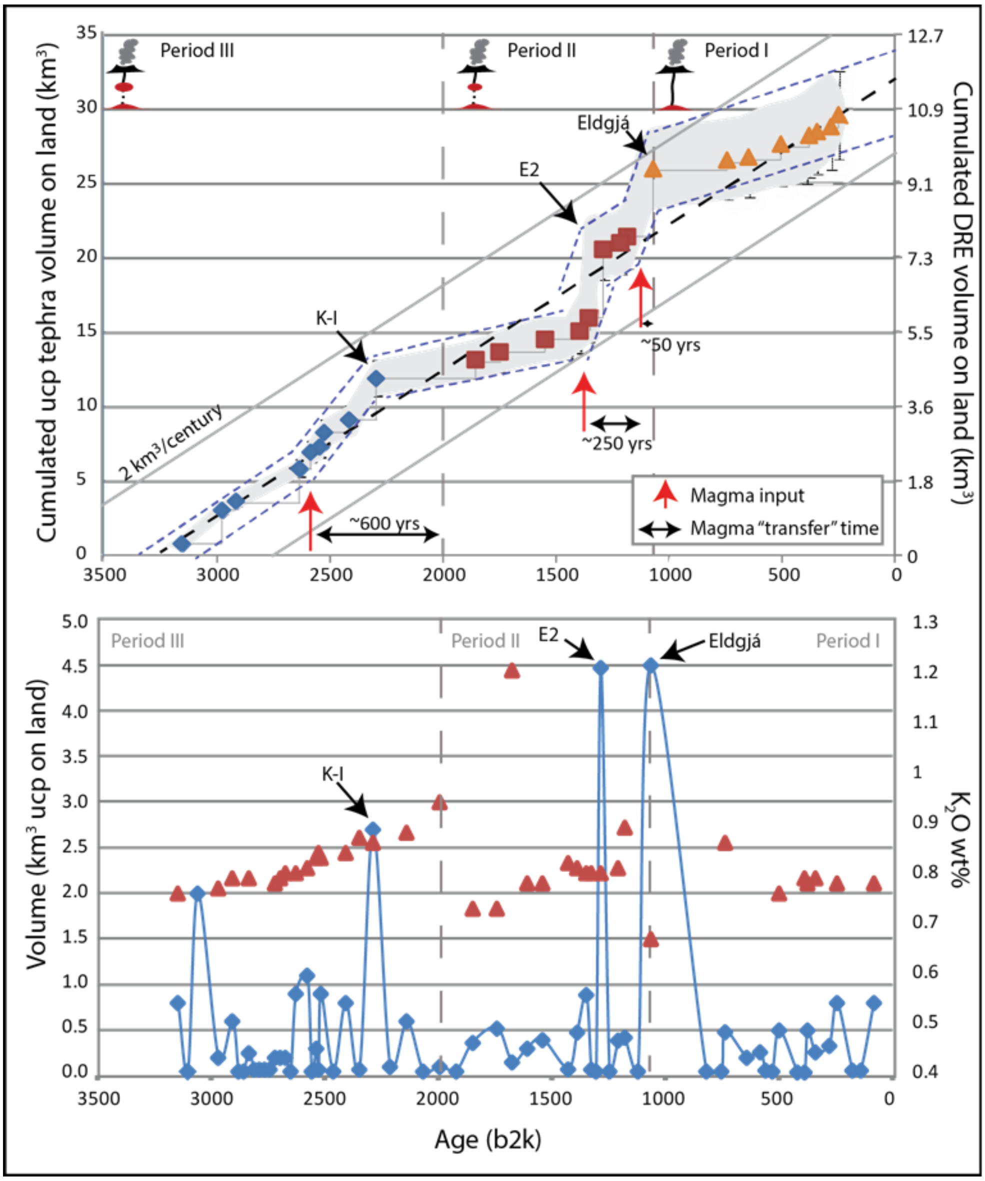
Period III
Period II
Period I
Eldgjá
E2
K-I
2 km³/century
~50 yrs
~250 yrs
~600 yrs
Magma input
Magma "transfer" time
Cumulated ucp tephra volume on land (km³)
Cumulated DRE volume on land (km³)
Volume (km³ ucp on land)
K2O wt%
Age (b2k)

Magma storage conditions below Eyjafjöll, based on clinopyroxene macro- and megacrysts from Seljalandsheiði

Bryndís Ýr Gísladóttir and Enikő Bali

Faculty and Institute of Earth Sciences, University of Iceland

Large clinopyroxene macro- and megacrysts were discovered in the Upper Pleistocene "ankaramite" outcrops of Seljalandsheiði in Eyjafjallajökull. The pyroxenes are mostly of augite composition and they display wide range in magnesium-values (Mg#: 57.9-83.3) and also in their minor oxides such as TiO2 (0.00-2.46 wt%), Al2O3 (0.94-6.28 wt%) and Cr2O3 (0.0-0.9 wt%). These pyroxenes are generally strongly zoned, where normal-, reverse-, oscillatory-, sector- and patchy zoning patterns as well as the combination of these were observed (Fig. 1). Magma mixing can possibly explain the presence of inverse zoning patterns.

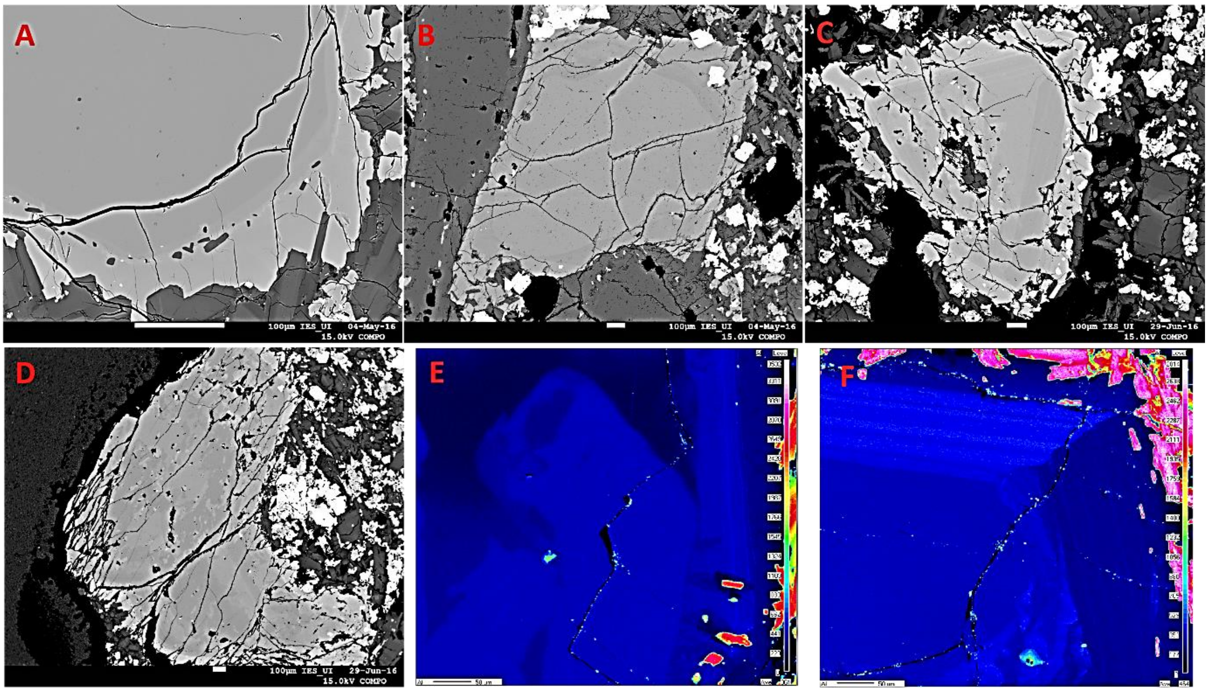

Figure1: A) Normal zoning, B) Reverse zoning, C) Oscillatory zoning, D) Patchy zoning, E) Complex zoning and F) Sector zoning. Figures A, B, C, D are back scattered electron images, Figures E and F are chemical maps of alumina, where brighter fields indicate higher concentrations.

A newly published clinopyroxene-melt thermobarometer from Neave and Putirka (2017) was used to obtain crystallization temperature and pressure. This thermobarometer needs both chemical composition of the clinopyroxene along with a chemical composition of a melt in equilibrium. As the samples contained no glass, previously published glass composition from the Eyjafjöll Volcanic System were matched to the pyroxene compositions following the equilibrium criteria of Neave and Putirka (2017). The glass compositions were obtained from Keiding and Sigmarsson (2012), Moune et al. (2012) and Loughlin (1995).

Macro and Megacrysts with Mg#>72 gave crystallization pressure range of 0.8-5.9 kbars and temperature range of 1140-1150°C, corresponding to the depth of 2.2-16.2 km. More evolved clinopyroxenes crystallized at 0.0-4.2 kbars pressure and temperature range of 1070-1180°C.

This would correspond to the depth of 0.0-11.7 km. Our pressure and temperature estimates were compared to those obtained from the 2010 Eyjafjallajökull eruption by Keiding and Sigmarsson (2012) (Figure 2). For better comparison their data were recalculated with the thermobarometer used here. The results on the two eruptions strongly overlap, indicating the crystallization conditions preceding and during these two different eruptions were similar and that the magma storage conditions has not changed significantly since Upper Pleistocene.

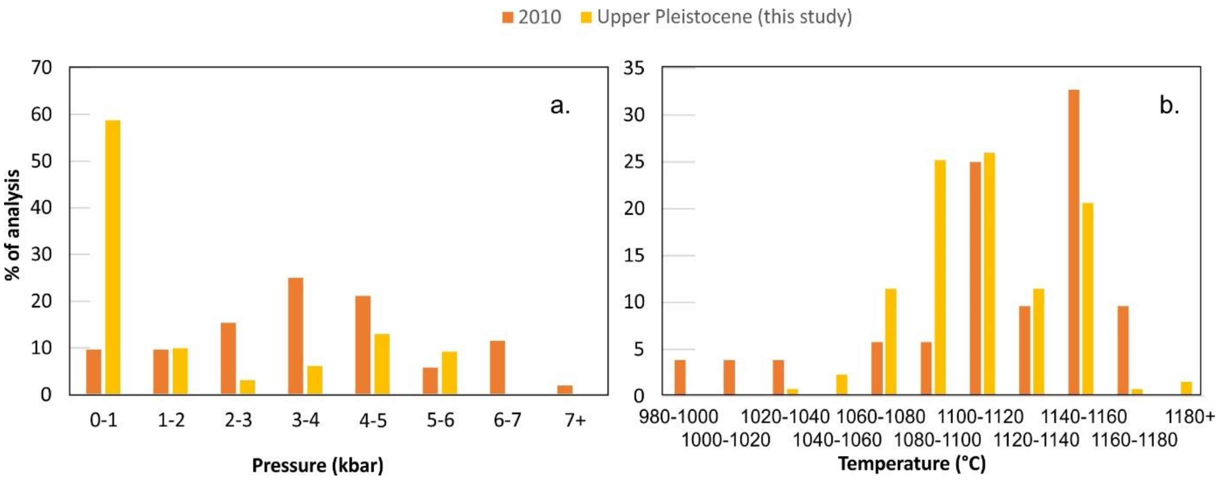

Figure 2: Pressure (a) and temperature (b) estimates from the 2010 eruption of Eyjafjallajökull and from the Upper Pleistocene outcrop in Seljalandsheiði. Data from the flank and summit eruption of 2010 from Keiding and Sigmarsson (2012) compared to data from this study. It is notable that both the pressure (P) and temperature (T) estimates during these two eruptions overlap within the uncertainty of P-T calibrations (±1.4 kbar and ±45 °C, respectively), indicating similar crystallization conditions.

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Heklugos á mið-nútíma – rannsókn á gjóskulögunum Heklu DH (Blakki) og Heklu Ö

Daníel Freyr Jónsson[1], Esther Ruth Guðmundsdóttir[1], Guðrún Larsen[2], Bergrún Óladóttir[2] og Olgeir Sigmarsson[2]

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Rannsóknir á forsögulegri gosvirkni Heklukerfisins á Hólósen hafa að mestu beinst að stóru plínísku eldgosunum Heklu 5 (7100 ára), Heklu 4 (4300 ára), Heklu 3 (3000 ára) ásamt fyrsta sögulega gosinu, Heklu 1 (1104 AD) (Larsen o.fl. 2013). Gosvirknin í kerfinu á milli þessara stóru gosa hefur hinsvegar fengið minni athygli. Í þessari rannsókn beinast sjónir að gjóskulögunum Heklu DH og Heklu Ö sem finnast í jarðvegi á milli Heklu 5 og Heklu 4. Aldur Heklu DH er um 6600 ár, áætlaður út frá jarðvegsþykknunarhraða og geislakolsgreiningar gefa 6060 ár fyrir Heklu Ö (Guðmundsdóttir o.fl. 2011). Markmið rannsóknarinnar er að kanna útbreiðslu þeirra og rekja uppruna, ásamt vangaveltum um samsetningu Heklukviku á fyrri hluta nútíma.

Útbreiðsla og rúmmál

Bæði Hekla DH og Hekla Ö voru rakin í fjölmörgum jarðvegssniðum innan við 30 km frá Heklu, auk þess sem gögn úr fyrri rannsóknum voru notuð til að meta útbreiðslu laganna.

Við Tagl (19 km norður af Heklu) finnast þessi tvö gjóskulög í sömu jarðvegsopnu, ásamt Heklu 5 og Heklu 4. Hekla DH mælist þar 153 cm þykkt, er dökkgrá og einkennist af samlímdum, fínkornóttum botni. Efstu 30 cm lagsins eru talsvert dekkri að lit, grófkornóttari og laus við alla samlímingu. Hekla Ö er tvílit, ljósgul neðst en dekkri ofar. Lagið mælist 50 cm þykkt í Taglasniðinu og liggur þar beint ofan á öðru mun minna, kolsvörtu gjóskulagi frá Heklu sem kallast Hekla Mói.

Hekla DH hefur afmarkaða útbreiðslu til norðurs. Það finnst í jarðvegi á Norðurlandi, auk þess sem gjóskan var greind í setkjarna af hafsbotni undan Norðurlandi ásamt Heklu Ö (Guðmundsdóttir o.fl. 2011). Niðurstöður þessarar rannsóknar benda til að Hekla DH gjóskan hafi komið upp í sprungugosi í nágrenni Valagjár, um 16 km NA af Heklu.

Hekla Ö hefur mikla útbreiðslu á landinu og finnst víðsvegar á Suðurlandi, Norðurlandi og Norðausturlandi (Óladóttir o.fl. 2011; Guðmundsdóttir o.fl. 2011). Hekla Ö hefur tvo þykktarása sem benda til uppruna í Heklu sjálfri. Aðalþykktarásinn stefnir til norðnorðausturs frá Heklu, en sá minni í austlægari átt.

Rúmmálsreikningar samkvæmt þykktarkorti af Heklu DH gefa um 0.8 km^3 af nýfallinni gjósku en Hekla Ö er um 1 km^3 (Guðmundsdóttir o.fl. 2011).

Efnafræði

Sýnum til efnagreiningar var safnað í Tagli. Átta sýni voru tekin upp í gegnum Heklu DH og fjögur úr Heklu Ö. Þrjátíu korn á stærðarbilinu 125-250 µm úr hverju sýni voru síðan greind í JEOL JXA-820 örgreini Jarðvísindastofnunar Háskóla Íslands. Straumur geislans var 10nA, hröðunarspennan 15 keV og þvermál geislans 10 µm.

Efnasamsetningu Heklu DH má greina í aðskilda hópa út frá aðalefnasamsetningu. Megin-efnasamsetning Heklu DH er basalt andesít (52-57% SiO_2) sem greinist í tvo aðskilda hópa en jafnframt finnst töluvert basalt (<52% SiO_2) í gjóskunni. Basalt-andesíthóparnir eru mjög ólíkir að samsetningu aðalefna og greinast vel í sundur með því að skoða styrk TiO_2 og Al_2O_3. Annar basalt-andesít hópurinn er afar líkur því basalt-andesíti sem upp hefur komið í sögulegum gosum í Heklu. Hinn hópurinn, sem er með hærri styrk TiO_2, er ólíkur efnagreindum hraunum eða gjósku úr Heklu. Þetta há-títan basalt-andesít myndar hinn dökka efri hluta gjóskulagsins í Tagli, auk þess sem hann greinist hér og þar í neðri hluta lagsins.

Stór hluti Heklu Ö einkennist af dasít/rhýólít (>62% SiO_2) en basaltkorn eru algeng. Hæst mælist kísilinnhaldið 75% neðst í gjóskulaginu, en aðeins 62-63% efst. Hvorki finnst basalt-andesít né andesít (57-62% SiO_2) í Heklu Ö.

Umræður

Bent hefur verið á að í Heklu 5 vanti allt basalt-andesít og andesít, sem bendir til þess að framleiðsla þess í Heklukerfinu hafi líklega hafist eftir Heklu 5 (Sverrisdóttir 2007). Hekla DH, sem myndaðist um 500 árum eftir Heklu 5, er að miklu leyti basalt-andesít og er það líklega fyrsta uppkoma þeirrar kvikugerðar í Heklukerfinu.

Heklu Ö má setja í flokk með stóru, kísilríku gjóskulögunum úr Heklu. Gjóskan er sambærileg Heklu 5 að því leyti að í henni finnst hvorki basalt-andesít né andesít. Þróaði hlutur Heklu Ö fellur í kísilinnihaldi úr 75% niður í 62%. Til samanburðar fellur Hekla 5 úr 72% niður í 66% (Sverrisdóttir 2007). Andesít er hinsvegar nokkuð stór hluti í tveimur rúmmálsmestu gjóskulögum Heklu, Hekla 4 og Hekla 3, sem bæði mynduðust seinna en Hekla Ö. Því er líklegt að framleiðsla andesíts hafi ekki hafist fyrr en eftir Heklu Ö. Framleiðsla basalt-andesíts í kerfinu var hinsvegar hafin þegar Hekla DH myndaðist, u.þ.b. 500 árum áður en Hekla Ö.

Rúmmál Heklu Ö er aðeins áætlað u.þ.b. 1 km^3 sem nýfallin gjóska, en þrátt fyrir það hefur Hekla Ö mikla útbreiðslu. Með efnagreiningu má tengja Heklu Ö við áður greinda Heklugjósku sem fannst í vatnaseti í grennd við Drangajökul (Schomacker o.fl. 2016), sem undirstrikar mikla útbreiðslu gjóskulagsins. Með þessum fundi þarf að kortleggja gjóskulagið betur til vesturs og endurmeta rúmmál þess. Útbreiðsla Heklu Ö er sambærileg við Heklu 3, þrátt fyrir miklu minna þekkt rúmmál. Tveir þykktarásar Heklu Ö benda til breytilegrar vindáttar á meðan gosinu stóð sem olli þessari miklu útbreiðslu gjóskunnar.

Heimildir

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Country-wide deformation field over Iceland inferred from interferometric analysis of Sentinel-1 SAR images

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Iceland is ideal for satellite radar interferometry (InSAR) as large areas of the country are desert covered with lavas and generally vegetation is limited and sparse. Coherence in interferograms can thus be retained over long periods (> 5 years) in many places. However, snow accumulation in winter makes only summer acquisitions (from mid-June to end-September) useful, in general, for interferometry.

The start of the Sentinel-1 mission in late 2014 has revolutionized the way InSAR monitoring and research can be carried out in Iceland. Prior, SAR acquisitions were limited and usually had to be ordered, without knowing if the images would be acquired. Therefore, having a time-series with good temporal resolution was hard to achieve and usually restricted to specific areas, leaving large parts of the country uncovered. Although the spatial resolution offered by the Sentinel-1 SAR instrument is not has good as for the TerraSAR-X or COSMO-SkyMed missions, the Sentinel-1 mission provides an extensive coverage of Iceland as each image covers an about 255 km wide area via three 85 km wide swaths. Moreover, Sentinel-1 images are acquired and delivered every 12-days (6-days since early 2017). Therefore, for each track, there are about 8 acquisition times for summer 2015 and summer 2016, and about 16 acquisitions time for summer 2017.

We have analyzed six Sentinel-1 tracks between summer 2015 and summer 2017 to achieve a full high-resolution coverage of the deformation over Iceland. Interferograms were generated with the ISCE software and multi-looked to have approximately a 100 m resolution. Time series analysis of the interferograms were carried out to reveal average line-of-sight (LOS) changes. Tracks were selected so that each part of the country is covered with at least one ascending track and one descending track. The different satellite views from descending and ascending tracks allows to decomposition of observed LOS changes into estimates of the near-East (approximate east) and near-Up (approximate vertical) velocities everywhere in Iceland, with exception of low coherence areas like glaciers and farmland. Glacial isostatic adjustment is the main country-wide source of deformation observable in the near-Up velocities, from a few mm/yr at the coasts and up to a few cm/yr near the ice-caps. On a local scale, geothermal utilization from power plants on the Reykjanes peninsula and north Iceland are also clearly visible. Plate spreading constitutes the main signal in the near-East velocities (~1.5 cm/yr), but post-rifting relaxation following the Bárðarbunga 2014 rifting episode is also observed. The observed deformation also include many additional local signals from magmatic and anthropogenic origin, e.g. subsidence in the Askja caldera of about 2 cm/yr. The results are important for improved understanding of the interplay between the many different deformation sources in Iceland, and how interaction of plate spreading, GIA, magmatic, geothermal and tectonic sources contribute to the combined deformation field in Iceland.

Monte Carlo simulated annealing method for coupled earthquake locations and 1D velocity structure determination: 'Minimum' models with constant velocity gradient layers

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Ray-tracing through a one dimensional earth model, consisting of layers of constant velocity gradients and continuous value across layers, is used to evaluate and improve a velocity model for processing micro earthquake data in Iceland.

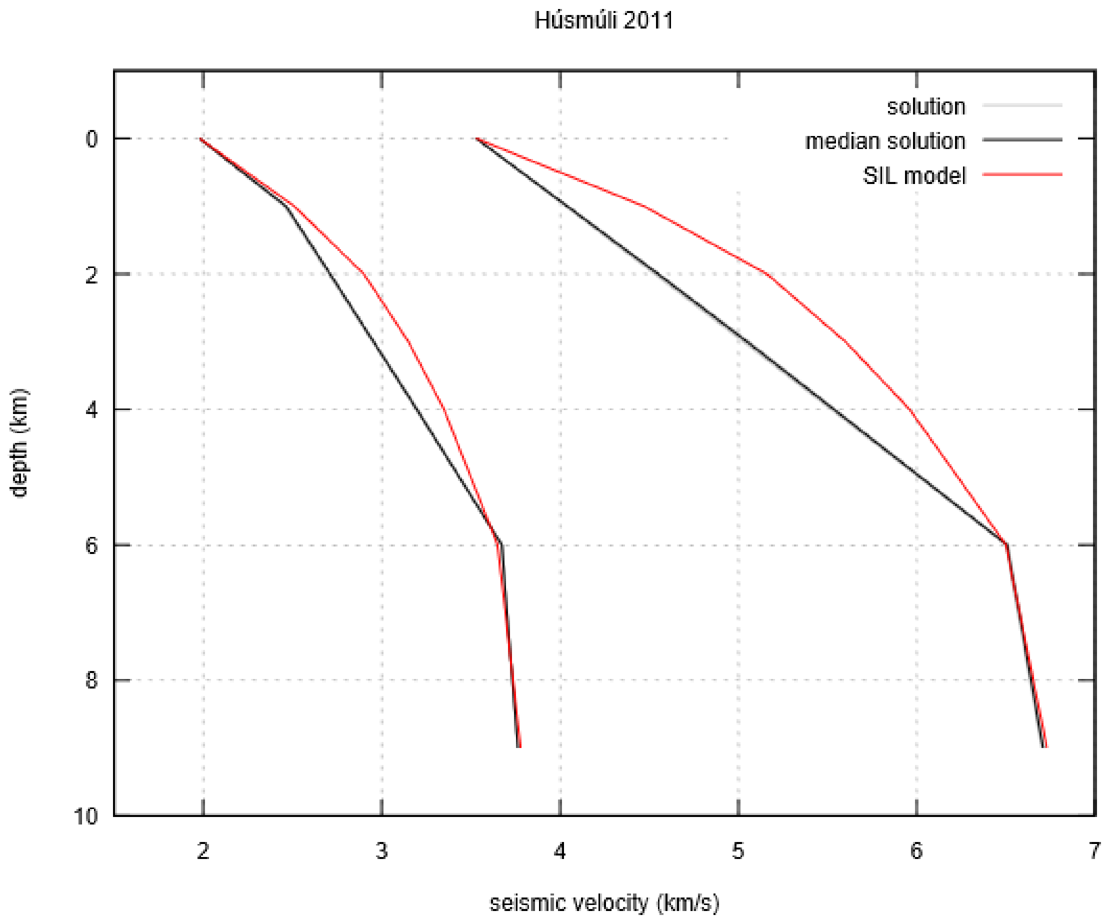
An iterative Monte Carlo (MC) method with simulated annealing is used to estimate velocity values at boundaries between layers, as described above, by searching for the velocity function that minimizes the residuals for observed arrival times for both P and S phases of micro earthquakes.

MC methods utilize a random search through model space to find an optimum solution. We use the "root mean square" of the time residuals for each observed phase as a measure of the quality of the trial solutions. Simulated annealing is a variation of the MC method where the trial solutions are sometimes accepted even when the quality (of the measure) declines.

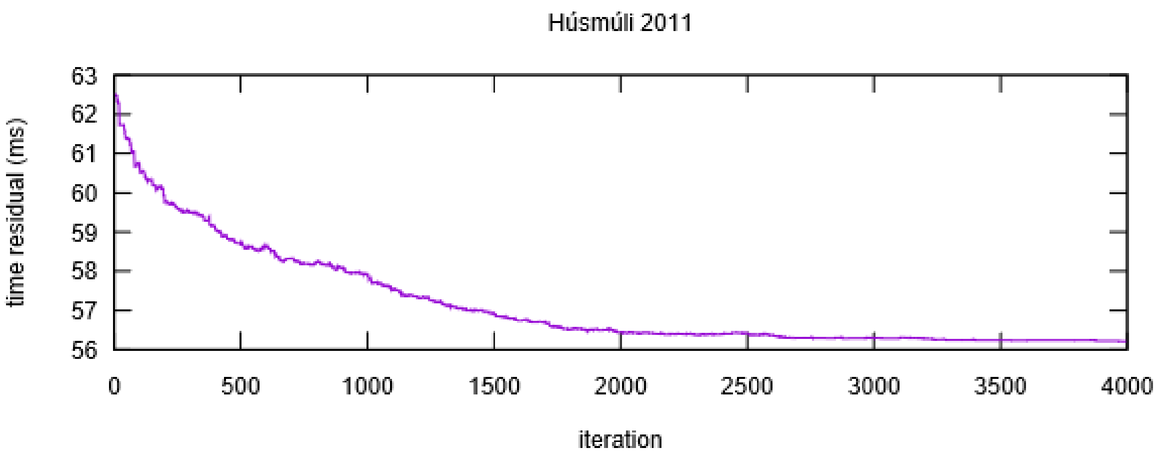
Most processing of the digitally recorded earthquake data on the national seismic network in Iceland makes use of the standard SIL velocity model, with layers of constant velocity gradients.

We start with the SIL model and determine P and S velocities simultaneously, i.e. the ratio between the velocities of P and S waves is not constrained in the inversion. Weights applied to the P-wave observations are 1.73 times the weight of the S-wave. In the figures below we show results where velocity values for depths of 1,2,3,4, 6 and 9 km were determined using the MC method. At other depths the values from the SIL model are used unchanged. The velocity functions are constrained with gradients that decrease with depth. This ensures that the travel-time curves are single valued and without any focusing of rays. The earthquakes are relocated in each iteration.

We applied the method to different locations in South and Southwest Iceland, with the number of earthquakes used typically ranging from a few hundred to a few thousand. Our results show that the standard SIL velocity model fits well for earthquake locations in the central part of the South Iceland Lowland region but there are some discrepancies elsewhere, especially in volcanic zones.



From 3186 recorded events in the Húsmúli geothermal area (western flank of the Hengil central volcano) in year 2011, 730 of the better quality events were used in a MC inversion. The figure shows MC velocity models (black), P-waves (right) and S-waves (left), using the SIL model (red) as the starting model. The black curves are the median of 10 different runs. All ten runs are plotted (gray), but due to their similarities they can hardly be distinguished from the median. Surface velocity is constrained to the SIL model.



The second figure shows residuals of P- and S-wave arrival times vs the number of iterations of a MC inversion. Notice how the simulated annealing chooses most often solutions with lower residuals and, less frequently, solutions with higher residuals. The new model gives approximately a 10% better fit to the data after 4000 iterations.

Hafísborið efni í Íslands-Noregshafi á síðasta jökulskeiði

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Hafísset, efni í sjávarseti sem á uppruna sinn í jökulís, lagnaðar ís eða hafís, hefur verið notað til þess að afla upplýsinga um fornloftslag og fornhafstrauma í jarðsögunni. Tilvist hafíssets í sjávarseti endurspeglar útbreiðslu og umfang hafíss, og flutningur hafísborins efnis ræðst af yfirborðs- og djúphafstraumum hverju sinni. Auk þessa getur berg- og kristaltegundagreining á hafísseti gefið upplýsingar um uppruna efnisins.

Hér er kynnt rannsókn sem miðar að því að nota breytingar í magni og uppruna hafísborins efnis sem og aðrar breytur til að rannsaka fornhafstrauma, loftslag og umhverfisbreytingar á síðasta jökulskeiði í Norðurhöfum. Rannsóknarsvæðið er norður og norðaustur af Íslandi, í Íslands-Noregshafi. Í þessari rannsókn verður sjónum sérstaklega beint að uppruna hafíssets þar sem bergbrot, kristallar og gjóska stærri en 125 míkrómetrar verða rannsökuð. Hafsvæðið norðan við Ísland spilar stórt hlutverk vegna þess hve viðkvæmt það er fyrir umhverfisbreytingum. Þar blandast sterkir hafstraumar bæði úr norðri og suðri og mynda haffræðilega flókið svæði. Uppruni og dreifing hafíssets er mælikvarði á útbreiðslu hafíss og gæti gefið mikilvægar vísbendingar um hafstrauma á síðasta jökulskeiði.

Í verkefninu eru tveir sjávarsetkjarnar, IS-4C og IS-1C, rannsakaðir. Kjarnarnir, sem eru 4,3 og 6,2 m langir, voru teknir árið 2012 norður og norðaustur af Íslandi á 1598 m dýpi og 821 m dýpi. Hér verða kynntar niðurstöður úr kjarna IS-4C. Kolefnisaldursgreiningar á þeim kjarna sýna að efstu 251 sm spanna síðustu ~42000 ár, en nákvæmara aldurslíkan er í vinnslu. Aldurslíkan fyrir kjarna IS-1C liggur enn ekki fyrir. Gjóskulög verða notuð til þess að styðja við kolefnisaldursgreiningar.

Hafísborið efni hefur verið greint og flokkað með tveggja sentimetra millibili í kjarna IS-4C. Efninu er skipt í þrjá meginflokka: bergbrot, kristalla og gjósku. Auk þess voru svifgötungar taldir og greindir til tegunda og mælingar gerðar á súrefnissamsætum í götungunum. Niðurstöður sýna áberandi sveiflur í magni hafísborins efnis og götunga, auk breytileika í gerð hafísborins efnis með tíma. Borin hafa verið kennsl á nærri 40 möguleg gjóskulög í kjarna IS-4C. Unnið er að efnagreiningum á þeim og tengingum við tímasett gjóskuleiðarlög í þeim tilgangi að bæta aldurslíkan kjarnanna.

Holocene tephra stratigraphy in the Vestfirðir peninsula, NW Iceland

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In recent years the terrestrial tephra stratigraphy in Iceland has been vastly improved through detailed investigations of soil and lake sediment archives revealing hundreds of tephra layers. These studies have focused on areas in south, north, east and central parts of Iceland. Fewer studies have been carried out in west Iceland. The aim of this study was to significantly improve the knowledge of tephra stratigraphy and tephrochronology in western Iceland by investigating the sedimentary records from eight lakes in the northernmost part of the Vestfirðir peninsula. In these eight lake sediment records spanning the Holocene, 39 tephra layers have been identified, thought to represent 34 eruptive events originating from five volcanic systems; Hekla, Katla, Snæfellsjökull, Grímsvötn and Veiðivötn-Bárðarbunga. Of these 39 tephra layers, 34 have not been reported before in the Vestfirðir peninsula. Six have recently been reported in the area; the Hekla 1693 tephra (Brynjólfsson et al., 2015) Snæfellsjökull Sn-1 tephra, Hekla 3 tephra, Hekla 4 tephra, Brattihjalli tephra (Schomacker et al., 2016) and Saksunarvatn tephra (Schomacker et al., 2016; Harning et al., 2016). Here we propose that the Brattihjalli tephra is in fact the 6060 year old Hekla Ö tephra marker layer, demonstrating that the Hekla Ö tephra extended much further to the west than previously reported, covering about 2/3 of the country. Thus, the Hekla Ö tephra covers an as large area in Iceland as the Hekla 5, Hekla 4, Hekla 3 and Hekla 1104 tephras, emphasizing the importance of Hekla Ö as a chronological marker.

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Er eldvirkni á Íslandi sambærileg á nútíma og síðasta jökulskeiði?

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Gjóskulagaskipan á Íslandi er nokkuð vel þekkt á nútíma, sérstaklega á miðhluta og síðari hluta nútíma. Fjöldi rannsókna hefur verið gerður á gjóskulögum í jarðvegssniðum víðsvegar um land, einkum á Norður-, Austur- og Suðurlandi auk miðhálendis. Minna er vitað um fjölda gjóskulaga og skipan þeirra á Vesturlandi og Vestfjörðum en hins vegar hafa nýlegar rannsóknir þaðan verið að líta að líta dagsins ljós. Mestur fjöldi gjóskulaga í jarðvegi er innan Eystra gosbeltisins, en þar hefur meira en 300 lögum verið lýst. Algengast er að jarðvegssnið nái í mesta lagi 5-8.000 ár aftur í tímann. Eldri jarðvegur er sjaldgæfur en þó má finna jarðvegssnið og stöðuvatnaset eldra en 10.000 ára.

Viðamikil þekking hefur hlotist á sögu sprengigosa á nútíma með rannsóknum á gjóskulagaskipan. Sprengigos hafa verið flest í Grímsvatnakerfi, þar á eftir fylgja eldstöðvakerfi Bárðabungu-, Heklu og Kötlu. Út frá fjölda gjóskulaga má sjá að eldvirkni á sér stað í lotum með 140, 500 og 4-5.000 ára millibili (Larsen et al., 1998; Óladóttir et al., 2011; Gudmundsdóttir et al., 2016 o.fl.).

Markmiðið með verkefninu sem hér er kynnt er að auka þekkingu og skilning á hegðun íslenskra eldstöðva með því að afla upplýsinga um sögu sprengigosa og eldvirkni enn lengra aftur í tímann, nánar tiltekið á síðasta jökulskeiði. Til þess þarf að leita út fyrir landsteinana, vegna skorts á jarðvegi og setlögum frá þessum tíma. Ætlunin er að bera saman eldvirkni á nútíma og síðasta jökulskeiði með því að skoða gjóskulagaskipan í jarðvegsniðum og í sjávarseti á norðanverðu landgrunni Íslands. Rannsóknaspurningar snúast um hvaða eldstöðvakerfi voru virk, hversu mikil var virkni þeirra og hvort eldvirkni á síðasta jökulskeiði hafi verið sambærileg virkninni á nútíma. Getur þessi samanburður á sprengivirkni á hlý- og jökulskeiði sagt eitthvað til um áhrif umhverfisaðstæðna, eins og stærð og útbreiðsla jökla, á eldvirkni á Íslandi?

Fyrstu niðurstöður sýna að gjóskulög frá Kverkfjallakerfi voru algengust síðustu 55.000 árin og gjóskugos á Kolbeinseyjahrygg voru áberandi á síðjökultíma. Að auki eru vísbendingar um að 4-5.000 ára lota í sprengivirkni/eldvirkni hafi varað frá síðasta jökulskeiði.

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Þróun sigkatla Mýrdalsjökuls frá 2010 til 2017 lesin úr hæðarkortum aflað með fjarkönnun, yfirborðshæðarsniðum og hreyfingu GPS-stöðva í kötlum

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Sagt er frá rannsókn á þróun sigkatlanna í Mýrdalsjökli síðan 2010 sem byggð er á 18 hæðarkortum sem flest eru gerð eftir fjarkönnunargögnum. Þrjú hæðarkortanna voru mæld árlega með leysi (lidar) úr flugvél frá 2010 til 2012, fimm eru unnin er út frá WorldView gervihnattaljósmyndum (úr ArcticDEM gagnasafninu) frá 2013 til 2015 og níu hæðarkort eru unnin eftir Pléiades gervihnattaljósmyndum á tímabilinu 2014-2017. Auk þess var eitt hæðarkort unnið úr þéttum GPS-sniðmælingum frá vori 2016. Að auki voru skoðuð hæðarsnið yfir katlanna sem mæld voru að vori og hausti með GPS á snjósleða eða radar úr flugvél. Tíðust eru hæðarkortin frá síðustu tveimur sumrum, þrjú frá 2016 og sex frá 2017 en þá var stysti tími milli mælinga 15 dagar. GPS-stöðvar sem mældu samfellt í tíma voru einnig starfræktar í kötlum sumurin 2016 (ein stöð) og 2017 (fimm stöðvar) sem mældu ketilsig í nokkrum smáhlaupum með hámarksrennsli upp á tugi rúmmetra á sekúndu eða minna.

Gagnasafnið sýnir nokkuð ólíka hegðun milli ketilsvæða (hópur tveggja eða fleiri nálægra sigkatla). Sum svæðin eru mjög stöðug á rannsóknartímanum, einungis sjást minniháttar breytingar dýpis og lögunar bæði frá ári til árs og einnig frá vori til hausts. Það gefur til kynna að vatn safnist ekki fyrir undir þeim heldur leki jarðhitabráð jafnóðum undan þeim og að jarðhitinn undir kötlunum sé í góðu jafnvægi við nettó ísflæði að þeim og yfirborðsafkomu þeirra. Önnur ketilsvæði sýna árstíðabundið mynstur vatnssöfnunar sem gjarnan lýkur með hlaupi nálægt miðju sumri og veldur dýpkun á katlanna sem oft er nálægt 10 m. Svæðið kringum ketil 16 (meginupptakasvæði hlaupsins í júlí 2011) sem tekur til a.m.k. 6 katla passar í hvorugan áðurnefndra flokka. Hlaup þaðan koma á öllum árstíðum, jarðhitavirkni virðist breytast frá ári til árs og flakka á milli katla. Þannig dýpkar einn ketill yfir eitt eða fleiri ár meðan nágrannaketill grynnkar. Í kjölfarið snýst mynstrið við, ketillinn sem dýpkaði fer að grynnka og öfugt fyrir nágrannann. Vísar að sambærilegri hegðun sést á fleiri ketilsvæðum.

Þessi rannsókn er hluti Kötlu Köldu Rannís-verkefnisins sem enn er í fullum gangi. Af þeim sökum verður haldið áfram öflun tíðra fjarkönnunargagna næsta sumar ásamt því að reka 5-6 GPS-stöðvar í kötlunum.

Physical modeling constraints on thickness and geometry of the melt body feeding the 2014-2015 diking and eruption, and the triggering of caldera collapse, in the Bárðarbunga volcanic system

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The most probable depth for the melt body feeding the 2014-2015 Holuhraun eruption has been estimated from geochemistry, ground deformation patterns, and seismicity to be in the 7-10 km depth range. This places the melt body below the brittle-ductile boundary, where viscoelastic deformation processes prevail in the long term. The density of the melt while residing in the crust is inferred to have been about 2700 kg/m^3, significantly less dense than the surrounding crust. Seismic velocity structure of the Icelandic crust suggests a general model for density, with crustal density values around 2950 kg/m^3 at the 7-10 km depth range. Thus, the melt was buoyant, with an upward pressure (buoyancy pressure) on the roof of the magma source (density difference × thickness of magma body × g). Approximate physical modelling arguments suggest that this pressure, scaled by a factor dependent on the geometry of the magma source (close to a value of 1; assumed here), can not exceed the tensile strength of the crust. Tensile strength of the crust itself is not well constrained, but if in the range of 2 MPa, then the thickness of the melt body could not have exceeded about 800 m based on the density difference. The melt body could have been thinner if some overpressure within the source was due to inflow of magma into the source in the months prior to the onset of activity as seismic activity and GPS-measurements suggest. The geometry of the magma source resulting in the largest pressure reduction under the collapsing area within the Bárðarbunga caldera is a body with lateral dimensions comparable to the width of the caldera. Removal of about 0.3 km^3 of magma, inferred to have marked the onset of caldera collapse evidenced by a series of M>5 earthquakes, can cause a large pressure drop under the collapsing piston. Indeed, if the melt body is modelled as a penny shaped crack with a radius of 4.5 km and the shear modulus of the crust is 15 GPa, then the pressure acting on the roof of the melt body in comparison to lithostatic pressure could change from about +2 MPa to -23 MPa during removal of 0.3 km^3 of magma into the dike. Such large underpressure is likely to facilitate the onset of a caldera collapse.

Are Torfajökull magmas invading the Hekla/Vatnafjöll volcanic system? Some preliminary results

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Volcanic systems in Iceland have been defined in different ways and boundaries between them are often rather ambiguous and questionable. An archetype volcanic system in Iceland, is generally believed to consist of a central volcano and a corresponding fissure swarm that erupt magmas from the same source. In reality, Icelandic volcanic systems are likely much more diverse and complicated. For example, interactions between two plumbing systems are well documented for some Icelandic volcanic systems (e.g., Mørk, 1984) as well as for the Kilauea-Mauna Loa systems on Hawaii (Rhodes et al., 1989).

The Hekla/Vatnafjöll system is a good example of this confusing nomenclature. Hekla has been regarded as a typical Icelandic volcanic system where the central volcano erupts evolved magmas through ca. 4 km long fissures, repeatedly opening on the volcano summit. In contrast, the approximately 60 km long fissure system erupts magmas of basaltic compositions, forming hyaloclastic ridges during glacial times, and lava flows following deglaciation. Most of these formations are near-parallel to the NE-SW heading of the Hekla summit crater. Vatnafjöll is a parallel and prominent mountain complex just east of Hekla, consisting of closely spaced, three to four hyaloclastite ridges. No volcanic center is evident, but the fissure system has erupted during glacial times and in early Holocene. The erupted material is dominated by basalts whose composition is strikingly similar to basalts associated with the Hekla system (Jakobsson, 1979). However, a narrow and steep, ca. 1 km long hyaloclastite ridge, visible in the NE corner of Vatnafjöll reveals outcrop of rhyolitic intrusive rocks. The rhyolite is a porphyritic obsidian, and hand specimens resemble those from the Rauðfossafjöll silicic tuya formations which lie 5 km NE of Vatnafjöll and have been regarded as being part of the Torfajökull volcanic system (e.g., McGarvie et al. 2006). It´s characteristics differ thus notably from Hekla rhyolites which generally contain a small proportion of phenocrysts. In light of these findings, it is interesting to note that Chekol et al. (2011) also reported the occurrence of silicic pumice among the Hekla 2000 eruptive products, which did not resemble Hekla rhyolites chemically and isotopically. Notably, these rhyolites are mildly peralkaline rhyolites of similar chemical composition as Torfajökull rhyolites.

In this study, the relationship of Hekla and its neighbor in the east, Torfajökull, is explored by means of chemical and isotopic data. In addition, and as a part of this study, new Pb isotope data have been obtained to put constraints on possible mantle source(s) supplying melts to the Hekla system in different time and space. Major and trace elements, have been measured in all samples. Samples were chosen to show no mechanical mixing, and the main emphasis was on collecting time series from fresh basaltic rock covering the spatial extend of the volcanic system (i.e., both along and across it). Material representative for the more evolved part of Hekla products was also included. The Hekla rocks are dominated by Fe-Ti rich transitional basalt and andesites to sub-alkaline rhyolites. Preliminary data reveal somewhat homogenous isotopic compositions for the Hekla rock suite. When compared to available data from the Torfajökull systems (Thirlwall et al., 2004; Baker et al., 2004), it becomes evident that the Pb isotopic characteristics of the Hekla/Vatnafjöll are notably different from magmas representative for the Torfajökull system. Moreover, the silicic samples reported by Chekol et al. (2011) resemble Torfajökull better than Hekla. Chekol et al., (2011) point this out and also mention the similarities of these silicic samples with a dacite xenolith found in the 1970 basaltic andesite tephra (Sigmarsson et al., 1992). Although volumetrically minor amongst Hekla eruptive products, their occurrence raises questions on their origin. However, we suggest that these xenoliths originate as fragments of older intrusion into the plumbing system, as opposed to representing recent magma production beneath Hekla and Vatnafjöll. We note that the Pb isotopic composition of these xenoliths is not as radiogenic as available Torfajökull analyses, but clearly more radiogenic than the Hekla rhyolites. However, they do not lie on a straight mixing line between Torfajökull and Hekla product, implying yet another source that contributes melts to these apparently homogenous volcanic systems.

Although no isotopic data are yet available for the Vatnafjöll intrusion and Rauðfossafjöll, their chemical characteristics suggest a close relationship to the Torfajökull plumbing system. Torfajökull is the largest, presumable the oldest central volcano and therefore the most mature central volcano in the region (McGarvie et al., 2006). Although Torfajökull is always referred to as a peralkaline silicic center, the chemical compositions vary significantly between units, where peralkalinity seems to follow decreasing trend with time (McGarvie et al., 2006). The youngest glacial rhyolithic formations are defined as ring structures surrounding the old, large Torfajökull caldera discontinuously. Rauðfossafjöll are one of these formations, a cluster of subglacially erupted peralkaline silicic formations about 70k years old (McGarvie, 2006). How rare these peralkaline rock findings are, is probably because the Hekla system has been much more productive in Holocene than the Torfajökull system. Ongoing research aims at further elucidating these complex interactions between plumbing systems of the South Iceland Volcanic Zone.

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Volcanic fingerprints in stable water isotopes of precipitation over the North Atlantic.

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North Atlantic climate variability is dominated by four main modes of the atmospheric circulation (Cassou et al., 2004). These modes are: The Atlantic Ridge, The Scandinavian Blocking and the negative and positive phase of the North Atlantic Oscillation. Each of these modes, or weather regimes, has a distinct climate pattern that can be identified in various pressure and temperature fields from the surface and up to the stratosphere. As an example, the positive phase of the North Atlantic Oscillation (NAO+) results in a warmer and wetter climate over N-Europe and the Eastern part of N-America while the Scandinavian Blocking causes a stagnant climate in the area of its geographic location (Hurrel, 1995; Cassou et al., 2004). The importance of these weather regimes in North Atlantic climate variability was underlined when their fingerprint was identified in the stable water isotope ($\delta^{18}O$) records of Greenland ice cores, although the known NAO is still considered to be the most dominating one (Ortega et al., 2014). To estimate how the weather regimes influence $\delta^{18}O$ over larger area, the whole North Atlantic, we investigated $\delta^{18}O$ in selected stations from the Global Network of Isotopes in Precipitation (GNIP). Here we present results where we have identified a distinct pattern in the GNIP $\delta^{18}O$, not observed before, associated with each of these weather regimes. This can offer a more quantitative approach when studying how volcanic eruptions influence atmospheric circulation. Volcanic sulphate aerosols reaching the stratosphere after major eruptions are well known for their impact on global climate. Due to their chemical properties the aerosols scatter short-wave radiation cooling the earth's surface in the first 1-2 years after an eruption, while absorbing terrestrial long-wave radiation warming the stratosphere. These temperature changes can alter the atmospheric circulation resulting in some weather regimes being more frequent than others. Therefore we also investigated if volcanic eruptions leave a fingerprint in the $\delta^{18}O$ of GNIP that can be associated with any of the four weather regimes identified. Both large equatorial and high latitude (northern hemisphere) eruptions were investigated and results will be presented.

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Hrun íslenska meginjökulsins í lok síðasta jökulskeiðs og myndun efstu og elstu fjörumarka

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Lýst er sambandi á milli stærðar íslenska meginjökulsins (IIS), flotjafnvægishreyfinga jarðskorpunnar (ens. *isostasy*) og hnattrænna sjávarborðsbreytinga (ens. *eustasy*). Í kjölfar hruns íslenska meginjökulsins varð tímabundið jafnvægi á milli þessara þátta þegar brún jökulsins staðnæmdist skammt innan við núverandi strönd landsins á Vesturlandi. Þá mynduðust efstu og jafnframt elstu fjörumörk í um 150 m h.y.s. í Stóra-Sandhóli í mynni Skorradals. Þessi fjörumörk eru um 14.700 ára gömul en lægri og yngri fjörumörk eru um 12.000 og 11.200 ára gömul. Þessi yngri fjörumörk mynduðust samfara stækkun íslenska meginjökulsins og áflæði sjávar á yngri Dryas og Preboreal.

Við innanverðan Breiðafjörð eru efstu fjörumörk meira en 14.100 ára gömul á meðan yngri og lægri fjörumörk eru af yngri Dryas og Preboreal aldri. Á vestanverðri Melrakkasléttu er skipan fjörumarka mjög á sama veg nema að þau efstu eru þar um 14.800 ára gömul. Annars staðar á landinu þar sem skipan fjörumarka er með þessum hætti, þau efstu hlutfallslega hátt yfir sjó og önnur yngri lægra yfir sjó, má ætla að þau hafi myndast við svipaðar kringumstæður, þ.e.a.s. þegar tímabundið jafnvægi á milli jökulfargs, flotjafnvægis og sjávarborðs komst á.

Þessar niðurstöður eru notaðar til að áætla stærð íslenska meginjökulsins í kjölfar þess að hann hrundi á um 300 ára tímabili á milli 15.000 og 14.700 ára BP. Brún hans var þá víðast hvar skammt innan við núverandi strendur landsins – í mynni dala og fjarða. Á þeirri stundu, skömmu áður en hröð hlýnun Bøllingtímans hófst, var stærð jökulsins um 45 % af mestu stærð hans við hámark síðasta jökulskeiðs (LGM). Í lok Bøllingtímans, fyrir tæpum 14.000 árum síðan, og áður en jökullinn fór aftur að stækka vegna kólnandi veðurfars, var stærð hans aðeins um 20 % af mestri stærð hans við hámark síðasta jökulskeiðs. Þessi mikla minnkun jökulsins varð til þess að strandsvæði landsins náðu sem næst fullu flotjafnvægi og ekki er útilokað að afstætt sjávarborð þess tíma hafi staðið einum 80 m neðar en það gerir í dag.

Flýtur eins og tappi: Samband flotjafnvægishreyfinga og framvindu hörfunar íslenska meginjökulsins af landgrunninu í lok síðasta jökulskeiðs

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Jarðskorpan undir Íslandi einkennist einkum af því að vera ofan á heitum reit, að 30-35 km þykkt steinhvelið er að hluta til bráðið og því að seigja deighvelsins er hlutfallslega lítil. Hraðar breytingar á afkomu Vatnajökuls hafa leitt til nær tafarlauss landriss eða landsigs þannig að telja verður að á hverjum stað og tíma ríki sem næst flotjafnvægi.

Til þess að strandlínur geti myndast verður að ríkja tímabundið jafnvægi á milli flotjafvægis-hreyfinga jarðskorpunnar og sjávarborðsbreytinga. Áberandi strandlínur, sem sjást víða um land, mynduðust í tvígang þegar jöklar stækkuðu (landsig) og afstætt sjávarborð hækkaði og tímabundið jafnvægi var á milli þessara þátta. Þetta gerðist bæði á yngra Dryas og Preboreal fyrir um 12.000 og 11.300 árum síðan. Efstu fjörumörk á Vesturlandi mynduðust fyrir um 14.700 árum í kjölfar hruns íslenska meginjökulsins og skömmu áður en mikil og skyndileg hlýnun Bøllingtímans hófst, þ.e.a.s. við aðstæður þegar hefði mátt gera ráð fyrir því að land væri að rísa mun hraðar en sem nam hækkun sjávarborðs. Myndun fjörumarkanna verður best skýrð á þann veg, að fyrir um 14.700 árum hafi orðið hlé á minnkun jökulsins og að tímabundið jafnvægi varð á milli flotjafnvægis jarðskorpunnar og sjávarborðsbreytinga.

Myndun greinilegra fjörumarka er mælikvarði á framvindu afkomu jökla vegna þess að strandlínur myndast við hjöðnun bæði jákvæðrar og neikvæðrar af komu jöklanna. Myndun efstu og elstu fjörumarka á Vesturlandi, rétt fyrir upphaf Bølling-Allerød hlýnunarinnar, undirstrikar því mikilvægi þess að þekja bæði eiginleika stein- og deighvelsins undir Íslandi og framvindu afkomu jöklanna.

Skýrir kristöllun apatíts úr Heklukviku myndun súru kvikunnar?

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Fosfatsteindin apatít er þekkt fyrir háan styrk af svokölluðum utangarðsefnum, þ.e. efnum sem illa ganga inn í steindir. Hún spilar því stórt hlutverk í þróun snefilefna í þeim kvikum sem hún kristallast út úr. Tilgátu um að apatít aðskilnaður úr ísúrri kviku Hekla við hlutkristöllun skýri efnasamsetningu dasíts og rýólíts hefur ekki verið hægt að sannreyna vegna skorts á gögnum um dreifistuðla (D) snefilefna á milli apatíts og bráðar. Lægra U/Th í kísilríkri kviku Heklu er talið benda til íblöndunar við skorpubráð sem hefði lágt U/Th, en apatít kristöllun gæti allt eins skýrt lækkun hlutfallsins ef steindin hefði $D_U/D_{Th} > 1$, þ.e. ef steindin tæki meira U en Th úr ísúru bráðinni við myndun dasíts. Lægra Th samsætuhlutfall í andesíti og dasíti miðað við Heklubasalt mætti í því tilfelli skýra með kvikuþróun sem tæki nokkra tugi árþúsunda (Chekol et al. (2011) fremur en eldri kenning um skorpubráðnun og kvikublöndun (Sigmarsson et al., 1992).

Mælingar hafa verið gerðar á styrk snefilefna í apatíti og gjóskugleri og dreifistuðlar reiknaðir fyrir sýni úr Heklu. Gjóskusýnin eru frá basalt-andesíti til rýólíts að samsetningu, mynduð í eldgosum árið 1970, 1158 og í gosinu sem lagði H3 gjóskuna yfir landið. Snefilefnagreiningar voru líka gerðar á gleri úr 1913 basalti frá Lambafitjum. Dreifistuðlar eru kynntir fyrir þó nokkur snefilefni (Rb, Sr, Y, Zr, Nb, Ba, La, Ce, Pr, Nd, Sm, Gd, Yb, Lu, Th og U). Sjaldgæfu jarðmálmarnir, eða lantaníð (e. rare earth elements, REE: La, Ce, Pr, Nd, Sm, Gd, Yb og Lu) ganga auðveldlega inn í byggingu apatíts sem og Sr og Y. Aukin seigja bráðar, vegna fjölliðunar kísils og súrefnis, hefur sterk áhrif á dreifistuðla lantaníða í apatíti.

Chekol et al. (2011) taldi kristöllun á apatíti orsök lækkunar U/Th í bráðinni frá basalti yfir í dasít. En þá þyrfti $D_U^{apatite} > D_{Th}^{apatite}$ til þess að skýra lækkunina. Hins vegar sýna hinar nýju *in-situ* snefilefnamælingar svipaða dreifingu U og Th á milli apatíts og þriggja glergerða, þ.e. basaltískt andesít (H1970), dasít (H1158) og rýólít (H3). D_U/D_{Th} gildin eru 1.22 (±0.85), 1.05 (±1.00) og 1.07 (±0.70) fyrir þessar breytilegu berggerðir og eru því öll innan skekkjumarka við gildið einn. Hlutkristöllun apatíts dugar því ekki til að skýra lækkun U/Th frá basalti yfir í þróaða kviku. Með öðrum orðum, hlutkristöllun kvikunnar myndaði ekki súru kvikuna undir Heklu, sem að öllum líkindum varð til á árþúsunda fresti fremur en tugum árþúsunda.

Líklegast er því að súra Heklukvikan myndist við hlutbræðslu á vatnaðri og ummyndaðri basaltskorpu. Bræðslutilraunir á amfíbólíti við 3 kbör sýna að dasít myndast við rúmmlega 900 °C og 10-20% hlutbráðnun (Sigmarsson et al., 1992). Hversu mikið skorpan er vötnuð er hins vegar óljóst. Aðalefnagreiningar voru gerðar á gleri, ólivín og plagíóklas kristöllum í dasítgjóskunni (H1158). Glerið hefur samsetningu að meðaltali 67.4 % SiO_2 (± 0.73) og þykir því vera einsleitt, en það sama á við um ólivín kristallana sem eru Fo_{24} (± $Fo_{0.48}$). Plagíóklas hefur breytilegri samsetningu eða frá $An_{37}Ab_{61}$ til $An_{55}Ab_{43}$. Þær efnagreiningar sem gerðar voru á beinum kristalflötum og á nærliggjandi gler sýna að plagíóklas og ólivín eru í efnavarmafræðilegu jafnvægi við glerið (K_D(Ab-An) á milli 0.05-0.15 og K_D(Fe-Mg) á milli 0.27-0.33). Þegar kristallar reynast í jafnvægi við umlykjandi kviku má beita á þá hita- og þrýstingsmælum sem kvarðaðir hafa verið með tilraunum (Neave and Putirka, 2017; Putirka, 2008). Samkvæmt útreiknuðum hitastigum hefur ólivín og plagíóklas kristallast úr H1158 dasít kvikunni við 900°C ef vatnsstyrkur kvikunnar var 5 þunga %. Þetta er í fullu samræmi við nýlegar mælingar á H_2O styrk í glerinnlyksum af dasít samsetningu í járnríkum ólivíni Heklugjósku (Lucic et al., 2016; Portnyagin et al., 2012). Því má álykta að gjóskan frá 1158 gosinu endurspegli hlutbræðslu skorpu við 900°C sem gefi af sér dasítbráð með 5% H_2O. En þá hefur þessi ummyndaða og vatnaða basaltskorpa ekki innihaldið nema 0.5-1% H_2O.

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Eru merki um forna ísstrauma á Norðausturlandi?

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Jarðvísindastofnun Háskólans

Þótt talsverðrar þekkingar á útbreiðslu íslenska meginjökulsins hafi verið aflað á undanförnum áratugum er enn margt á huldu um hegðun hans og þróun í tíma og rúmi. Til dæmis hafa komið fram tilgátur um hraðfara ísstrauma sem fluttu ís og set um dali, firði og flóa að jöðrum jökulsins. Þessar tilgátur hafa einungis verið sannreyndar að litlu leyti og lítið er því vitað um legu, lögun og virkni slíkra ísstrauma eða jarðfræðileg ummerki þeirra.

Nýtt verkefni, sem ýtt var úr vör sumarið 2017, miðar að því að sannreyna hugmyndir um ísstrauma á Norðausturlandi með því að rannsaka jökulræn landform og setlög við Þistilfjörð, Bakkaflóa, Vopnafjörð og í uppsveitum þeirra, sem og á Jökuldalsheiði. Hefðbundnum aðferðum landmótunar- og jöklajarðfræða verður beitt ásamt jarðeðlisfræðilegum og jarðtæknilegum aðferðum. Auk þess verður sýnum til aldursgreininga safnað. Markmið þessa alls er að skýra skriðvirkni og –hraða ísstrauma í tíma og rúmi, hjöðnun þeirra, og hvernig straumlínulöguð landform eins og jökulöldur eða risakembur myndast. Verkefnið getur gefið vísbendingar um stöðugleika meginjökla sem ganga í sjó fram og hve viðkvæmir ísstraumar eru fyrir hækkun sjávarborðs, og þar með aukið skilning okkar á afkomu meginjökla. Niðurstöður verkefnisins má nota til að skorða líkanreikninga á myndun landforma undir jöklum og framvindu íslenska meginjökulsins í lok síðasta jökulskeiðs.

Frumkortlagning landforma bendir til þess að nokkrir ísstraumar hafi mótað fyrrgreind svæði og að þeir hafi ekki verið virkir á sama tíma. Líklegt er að landmótun á umræddum svæðum endurspegli mestmegnis upptakasvæði ísstrauma, sem aftur á móti bendir til þess að meginhluti þeirra hafi legið utan við núverandi strönd landsins. Landform, sem áður höfðu verið kortlögð, voru sannreynd við útivinnu sumarið 2017 og innviðir jökulalda á Bustarfelli ofan Vopnafjarðar kannaðir. Í ljós kom að öldurnar eru aðallega úr aflagaðri jökulurð og aðgreindu seti. Þverstæðir hryggir ofan Bakkaflóa og hryggir með breytilega legu ofan Þistilfjarðar voru einnig skoðaðir og virðast að mestu vera úr botnurð. Frekari útivinna, þar sem jarðsjármælingar verða m.a. notaðar við könnun hryggjanna, mun miða að því að rannsaka enn frekar setgerð og byggingu landformanna.

Putorana ice sheet advance over southern Taimyr, NW Siberia, during the Late Saalian (MIS 6)

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Previous studies in NW Arctic Siberia suggest that local ice caps around the Kara Sea shelf merged there repeatedly to form a Kara Sea Ice Sheet (KSIS). When assembled to a large ice sheet, initial northward flow from the Byrranga Mountains on the Taimyr Peninsula reversed as the ice sheet further expanded southwards. The most extensive glaciation over Taimyr occurred during the Taz/Late Saalian (MIS 6), during which the KSIS advanced from NW onto the Putorana Plateau south of Taimyr. However, stratigraphic sites along the Bol'shaya Balaknya River (situated on southern Taimyr) suggest that the Taz/Late Saalian expansion of the KSIS from NW was preceded by ice coming from the Putorana Plateau to the south, a conclusion based on our site BBR 16. This site reveals a fining upwards sequence from fluvial sands to shallow glaciomarine mud with shell fragments, dated with ESR to 171 ka BP. This sequence is glaciotectonically deformed and unconformably overlain by subglacial traction till. The glaciotectonic deformation as well as clast fabrics in the overlying till, indicate stress application from southerly directions. Our preliminary model suggests a marine transgression due to a growing Putorana ice sheet, before it overrode southern Taimyr during the Late Saalian (MIS 6). This occurred at the same time as a KSIS advanced from the north beyond the Byrranga Mountains. The KSIS subsequently merged with the Putorana ice sheet and eventually pushed the maximum extent of Late Saalian ice well south of the Putorana Plateau.

Improving early Holocene tephrochronology of North, Northeast and East Iceland

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The Icelandic tephrochronology is an important tool for dating and correlating sedimentary archives, landforms and archaeological sites both in Iceland and overseas. A robust tephrochronology is also essential for deriving information on volcanic history and eruption frequency patterns. The Icelandic tephrochronology is the result of a long line of research and the chronology consists of geochemically well characterized and well dated tephra horizons. However, the early Holocene part of the Icelandic tephrochronology lacks securely dated tephra marker horizons. Ages of tephra layers in soil profiles and peatlands located between the Hekla 5 and the so-called Saksunarvatn tephra have previously been dated only indirectly by interpolating soil or sediment accumulation rates between tephra layers of known age. As this period represents about one third of the Holocene and is marked by several short climate fluctuations and rapid environmental change in Northern Europe, it is critically important to establish new tephra markers within this part of the tephrochronology.

The aim of our research is to establish new tephra marker layers for the early Holocene by geochemically characterising tephra using electron probe microanalysis, careful comparison and correlation of tephra stratigraphy between sites and ^{14}C dating of selected tephra layers. The detailed tephra stratigraphy from Lake Lögurinn, East Iceland (Guðmundsdóttir *et al.* 2016) is used as an aid in selecting research sites and targeting potential tephra markers in soil sections, lake sediments and peatlands in East, Northeast and North Iceland.

Thus far, tephra stratigraphy has been constructed for all the sites which has enabled correlations of tephra layers between sites. The tephra stratigraphy shows that most of our study sites lack visible horizons of silicic tephra which traditionally form the core of the Icelandic tephrochronology. Majority of our sites contain one basaltic layer which seems to have sufficiently unique physical and chemical characteristics to distinguish it from other tephra layers close in age and could form at least a local marker layer. To further improve reliability of the between-site correlations and ^{14}C - age determinations of the chronology the cryptotephra method was tested for the first time in Iceland on one of our soil section sites. As a result a silicic cryptotephra layer, likely consisting of the Fosen/Reitsvík tephra (Lind et al. 2013; Guðmundsdóttir et al. 2016), was found. The next step towards an improved Icelandic early Holocene tephrochronology is further work with cryptotephra layers and ^{14}C sampling and dating of selected tephra layers.

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Quartz formation processes in the Icelandic crust – A coupled $\delta^{18}O$ and $\delta^{30}Si$ study

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Quartz and SiO_2 polymorphs are major constituents of a variety of plutonic, sedimentary and metamorphic rocks and important secondary products in many hydrothermal systems. As quartz is often associated with hydrothermal and ore deposits, its origin and paragenesis remains subject of considerable discussion. This study focusses on coupled Si ($\delta^{30}Si$) and O ($\delta^{18}O$) isotope systematics in quartz and SiO_2 polymorphs to assess quartz formation processes within the Icelandic crust.

The studied sample set contains (1) igneous quartz from crustal xenoliths and micro-granites (>550 °C), (2) high-temperature hydrothermal quartz (~200-400 °C) and (3) low-temperature hydrothermal quartz and amorphous silica (<150 °C). Oxygen and silicon isotopes in quartz and SiO_2 polymorphs were analysed *in-situ* using SIMS to investigate the sources of O and Si to the crust but also to unravel crustal processes (e.g., fluid-rock interaction, boiling and cooling) that affect major reactions and isotope fractionation during secondary mineral formation in hydrothermal settings.

The measured isotopic values are strongly correlated with quartz formation conditions and the source of O and Si to the system. Magmatic quartz reveals $\delta^{18}O$ (-5.6 to +6.6 ‰) and $\delta^{30}Si$ (-0.4 ±0.2 ‰) values representative for mantle- and crustally-derived melts in Iceland. Hydrothermal quartz and SiO_2 polymorphs display a larger range of $\delta^{18}O$ (-9.3 to +30.1 ‰) and $\delta^{30}Si$ (-4.6 to +0.7 ‰) values.

By using quantitative isotope modelling, crustal processes including fluid-rock interaction, boiling and cooling were simulated to investigate their effects on the formation of secondary quartz and its isotopic composition. At hydrothermal high temperature (~200-400 °C), variations in $\delta^{18}O$ and $\delta^{30}Si$ of quartz can be explained by equilibrium isotope fractionation accompanying progressive fluid-rock interaction. At hydrothermal low temperature (<150 °C), boiling followed by cooling may result in ^{30}Si-depleted quartz and amorphous silica. $\delta^{18}O$ values of the same grains were found to be dependent on the source of the water (e.g., seawater or meteoric water) and fractionation between liquid, vapor and secondary minerals.

In the context of our own data set and published $\delta^{18}O$ and $\delta^{30}Si$ data on hydrothermal silica deposits, we demonstrate that large ranges in $\delta^{30}Si$ values coupled to insignificant $\delta^{18}O$ variations may result from silica precipitation in a hydrothermal fluid conduit associated with near-surface cooling. While equilibrium isotope fractionation between fluids and quartz seems to prevail at high temperatures, kinetic fractionation likely influences isotope systematics at low temperatures. These results demonstrate that $\delta^{30}Si$ and $\delta^{18}O$ values of quartz can be utilized to constrain and quantify various hydrothermal processes occurring in the Earth's crust.

Conceptual model of Krafla

Knútur Árnason

Íslenskar orkurannsóknir

Krafla, NE Iceland, and its geothermal system(s) have complex structures and have been extensively studied for decades. Recent reinterpretation of gravity data indicates a buried inner caldera within the 110-ka caldera. This inner caldera was probably formed during eruption(s) 80 ka ago. The gravity data also show WNW-ESE trending low density structure cutting through both calderas. Both the inner caldera and transverse structures influence the geothermal system(s). Heat sources seem to be mainly confined within the inner caldera, north of the transverse structure. This is suggested to be due to slight change in the direction of spreading in the volcano. The very different thermal conditions in different parts of the geothermal system(s) is suggested to be due to bimodal (shifting with time) of crustal spreading. Finally it is suggested that re-melt of geothermally altered basaltic rocks and migration of buoyant silicic magma to shallow levels, like the one encountered in IDDP-1, can be an important, but overlooked, heat transport mechanism to volcanic geothermal systems.

Networking European Volcano Observations and Community through the EPOS Research Infrastructure and the EUROVOLC Networking Project

Kristín S. Vogfjörð, EPOS team and EUROVOLC team

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The *European Plate Observing System* (**EPOS**, www.epos-ip.org) is an infrastructure project on the European Roadmap for Research Infrastructure and funded by the EU ESFRI/Infrastructure program. Having completed its Preparation Phase, the project is presently half way through the Implementation Phase, heading for the Operational Phase at the end of 2019. Over 20 European countries participate in the EPOS project and most of them are expected to become members of the **EPOS-ERIC** research infrastructure organization to be established in summer 2017. The project is led by INGV in Rome and the future head quarters of **EPOS-ERIC** will be located there. The consortium of the member countries will govern the operation of **EPOS** over the coming decades. The Icelandic Meteorological Office leads Iceland's participation in **EPOS**. Other participating institutions are the University of Iceland, The National Land Survey of Iceland and the Earthquake Engineering Research Center. The Icelandic Ministry for the Environment has agreed to fund the yearly cost of membership to EPOS. The Icelandic EPOS consortium will formalize the collaboration in 2018.

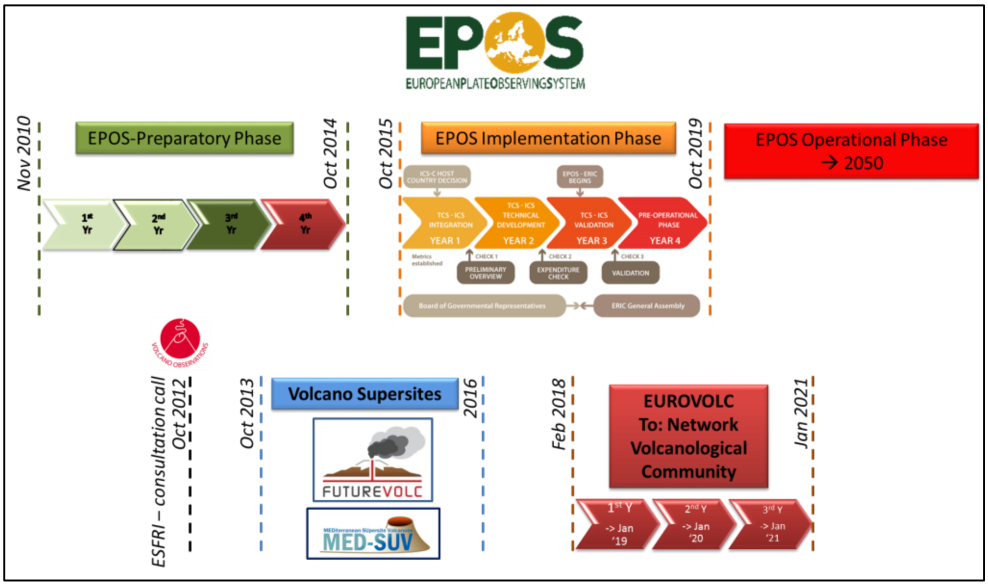

Figure 1. Timeline for the construction of the EPOS Research Infrastructure and its relation to the time frame of the two volcano GEO supersite projects, FUTUREVOLC and MED-SUV, and to the Networking project EUROVOLC. EUROVOLC will make data available through the EPOS VO-TCS (Volcano Observations Thematic Core Service).

EPOS builds upon the investments of European countries in their national Research Infrastructures (**RI**) in Earth sciences and will construct *e*-Infrastructures to enable access to the data, products and services from the RIs. The different thematic communities within **EPOS** (seismology, geodesy, volcanology, geomagnetism, satellite, etc.) will each construct Thematic Core Services (**TCS**) to facilitate access to their data. The *Volcanological Observations TCS* (**VO-TCS**) will focus on access and services to users from the volcanological community.

In coordination with **EPOS**, the EU funded two projects to establish GEO volcano supersites. These projects, which were completed in 2016 were the Icelandic led **FUTUREVOLC** project, focused on Icelandic volcanoes and the Italian led **MED-SUV** project, focused on Volcanoes in southern Europe. The two projects constructed limited services to data from their volcanoes. The **EPOS VO-TCS** will to some degree build upon these and other existing services of the volcanological community, but also develop new and more versatile services.

The volcanological group in **EPOS** responded to an **ESFRI** (*European Strategic Forum for Research Infrastructure*) call for consultation in 2012 on important Networking activities to build research communities. A subsequent proposal from the group to an Integrating Action call resulted in the funding of a 3-year Networking project, **EUROVOLC**, (*EUROpean Network of Observatories and Research Infrastructures for VOLCanology*). The aim of **EUROVOLC** is to:

- Network the distributed and fragmented volcanological community
- Provide access to volcanological data and products in coordination with the **EPOS VO-TCS** (*Volcano Observations Thematic Core Service*)
- Provide Trans-national Access to observational and research infrastructures on European volcanoes
- Provide Virtual Access to computing and modeling facilities
- Carry out Joint Research Activities to support decision making by VOs, civil protection and authorities before, during and after volcanic unrest and eruptions, and contribute to mitigating volcanic risk.

The **EUROVOLC** consortium is made up of 18 partners from 9 European countries, but the project is led by the Icelandic Met Office in collaboration with INGV in Catania, Sicily and the University of Iceland. The Icelandic Civil Protection (Almannavarnir) and Landsvirkjun power company also participate in the project.

Figure 2. Countries (blue) participating in the Horizon2020 EUROVOLC project. The countries' relative share of the € 5 million funding from the EU is shown by the size of the dot.

Breytingar á b-gildi jarðskjálfta í Bárðarbungu í tengslum við yfirstandandi umbrot í eldstöðinni.

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Stærðardreifingu jarðskjálfta í dæmigerðum skjálftarunum er stundum lýst með formúlu Gutenbergs og Richters: log**N** =**a** – **bM.** Hér táknar **N** fjölda skjálfta af stærðinni **M** og stærri, **a** og **b** eru fastar sem lýsa skjálftavirkni svæðis eða tímabils. Gildið á **b** lýsir því hversu margir litlir skjálftar fylgja hverjum stærri skjálfta, en **a** er logrinn af fjölda skjálfta af stærðinni 0 og stærri. Færð hafa verið góð rök fyrir því að b-gildi geti endurspeglað spennuástand svæðis. Hátt b-gildi gefi vísbendingu um lága bergspennu, lágt b-gildi háa spennu.

Bárðarbunga er ein af eldstöðvum Íslands sem hefur sýnt viðvarandi, þráláta skjálftavirkni í meira en fjóra áratugi. Við könnuðum b-gildi skjálftanna á tímabilinu 2011-2017 og breytingar á því með það í huga að þær gætu tengst ástandi eldstöðvarinnar, til dæmis spennubreytingum í þaki kvikuhólfs í nýlegum eldsumbrotum og aðdraganda þeirra. Mælitímabilinu má skipta upp í 1) tímabil vaxandi skjálftavirkni (2011-2014), 2) tímabil öskjuhruns (2014-2015), og 3) tímabil vaxandi skjálftavirkni í kjölfar öskjuhrunsins (2015-2017). Vísbendingar eru um landris innan öskjunnar á síðasta tímabilinu.

Ákvörðuð voru b-gildi fyrir hlaupandi 600 skjálfta tímabil ásamt öryggismörkum. Gildin sýna kerfisbundna breytingu sem hugsanlega tengist atburðarás í eldstöðinni. Í upphafi tímabils 1 er b-gildið ~ 1, sem er algengt gildi á skjálftasvæðum. Það tekur að falla 2013 - 2014 og er um 0,5 þegar öskjusigið, gangainnskot og eldgos í Holuhrauni hefst. Stærðardreifing skjálftanna á tímabili 2 er mjög óregluleg og fylgir ekki Gutenberg-Richter dreifingunni. Vísbendingar eru um að skjálftar séu af tveimur gerðum með ólíka stærðardreifingu. Á tímabili 3 er b-gildið hátt í fyrstu en lækkar síðan eftir því sem skjálftavirknin vex. Breytingarnar á b-gildi við öskju Bárðarbungu eru í samræmi við það að spenna hafi aukist í aðdraganda umbrotanna sem byrjuðu í ágúst 2014. Þær eru einnig í samræmi við að spenna hafi verið lág í kjölfar sigsins mikla sem lauk í febrúar 2015, en hafi síðan hækkað. Lágt b-gildi og mikil skjálftavirkni um þessar mundir bendir til þess að þrýstingur undir eldstöðinni fari vaxandi.

Bygging Múlajökuls eftir framhlaup og tengsl hennar við undirlag jökulsins

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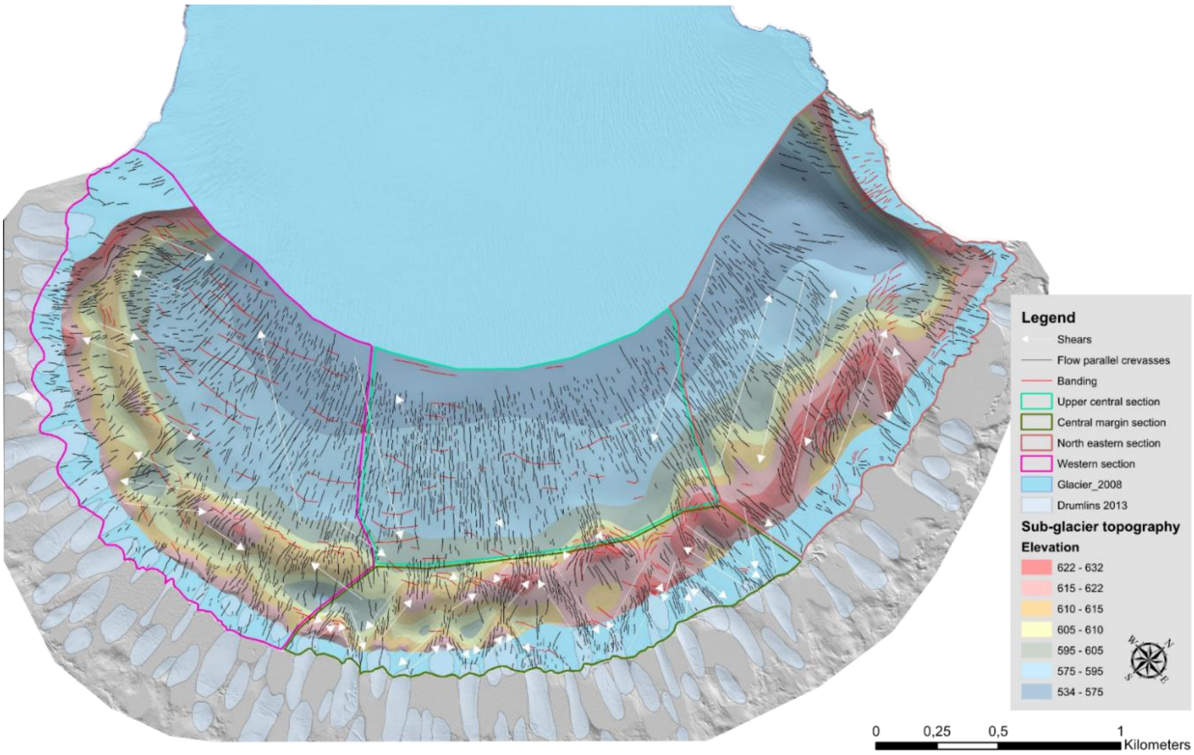
Bygging skriðjökla og ísstrauma er margbrotin. Hún tekur mið af flæði þeirra og má skipta í mismunandi svæði eftir byggingareinkennum. Byggingareinkenni jöklanna geta endurspeglast í landslaginu undir þeim, s.s. í formi ílangra hryggja (jökulalda), rifjagarða, hliðrunargarða og sprunguhryggja. Ítarleg greining á álagi og byggingu jökuls getur hjálpað til við túlkun landslags undir jöklum og aukið skilning okkar á hegðun og þróun þeirra.

Rannsókn okkar snýr að byggingu og þróun Múlajökuls eftir framhlaupið 2008 og tengslum þessa við landslag sem jökullinn huldi að framhlaupi loknu en hefur komið í ljós á síðustu árum vegna hops. Byggingareinkenni á yfirborði jökulsins og hryggir framan við sporðinn voru kortlögð ítarlega með hjálp loftmynda, mynda úr flýgildi, auk nákvæmra hæðarlíkana. Hefðbundnum aðferðum í jöklajarðfræði og landmótun var beitt við að kanna setgerð, byggingu og dreifingu hryggjanna framan við jökulinn. Nákvæm kortlagning sprungumynstursins í framanverðum (~1 km) Múlajökli gerir okkur kleift að skipta honum upp í 22 byggingarsvæði. Þetta flókna sprungumynstur má tengja við landslag undir jöklinum sem einkennist af djúpu bæli innan við bogadreginn hrygg og raðir ílangra jökulalda sem finnast undir núverandi jökulsporði (Lamsters o.fl. 2016; Benediktsson o.fl. 2017; Finlayson o.fl. innsent). Niðurstöður rannsóknarinnar benda til þess að rennsli og skriðhraði Múlajökuls sé mestur fyrir miðju en minni til beggja hliða. Mörkin á milli þessara svæða einkennast af misþróuðum hliðrunarbeltum með sveigðum og skástígum togsprungum sem sýna vel innbyrðis hreyfingar í jöklinum. Hliðrunarbeltin leiða í ljós flókið mynstur ísflæðis í sporði Múlajökuls og margbrotið samspil á milli jökuls og undirlags (mynd 1). Langflestir hryggjanna framan við jökulinn liggja nokkurn veginn samsíða flæðistefnu hans og langsprungum í sporðinum, og samanstanda mestmegnis af jökulruðningi með kubbalaga hnullungum og einangruðum vösum af aðgreindu seti. Þetta bendir til þess að hryggirnir hafi líklega myndast er botnurð þrýstist upp í sprungur sem náðu niður í botn jökulsporðsins. Einstaka þverstæða hryggi má einnig finna þétt við jökulsporðinn en þeir eru taldir vera ýtigarðar og ekki beintengdir sprungumynstri jökulsins.

Sambandið á milli byggingar jökla og landforma í undirlagi þeirra er enn torskilið en gæti eflt þekkingu okkar og skilning á hreyfingum núverandi jafnt sem fornra jökla og jökulbreiða.



Mynd 1. Í bakgrunni er hæðalíkan frá 2008 með 0.5m upplausn (Jóhannesson ofl., 2013). Jöklinum hefur verið skipt upp í fjögur megin svæði út frá einkennandi sprungustefnu og hliðrun á brotabeltum. Undirlag jökuls er sýnt í mismunandi litum eftir hæð yfir sjó (sjá skýringar hægra megin á mynd). Hvítar örvar tákna hliðrun á brotabeltum og svartar línur sýna langsprungur. Einkennandi fyrir Múlajökul er hið sérstaka tígullaga sprungumynstur í framanverðum jöklinum.

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Surtseyjarborunin 2017: Fjölþjóðlega verkefnið SUSTAIN, fyrstu niðurstöður

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Allt frá því Surtsey myndaðist á árunum 1963-67 hefur hún skipað ákveðin sess innan eldfjallafræði og við hana er síðan kennd surtseysk gosvirkni. Vísindamenn lögðu mikla vinnu í að fylgjast með gosinu meðan á því stóð og liggja fyrir nákvæmar lýsingar á gangi þess frá upphafi til enda. Eftir að gosinu lauk hefur þróun Surtseyjar verið skipulega rannsökuð og niðurstöðum lýst með nokkuð reglubundnum hætti. Þetta á við um jarðfræði almennt, jarðhita, ummyndun, landmótunarfræði, landnám lífs og uppbyggingu vistkerfis. Þakka má þeirri framsýni sem fólst í verndun eyjunnar allt frá upphafi og vinnu sem farið hefur fram í tengslum við Surtseyjarfélagið hve vel hefur tekist til að þessu leyti. Sumarið 1979 var unnið stórt borverkefni í Surtsey þar sem 180 m kjarni náðist niður í gegnum austurbarm Surts I, aðalgígsins frá fyrstu mánuðum gossins. Á þeim áratugum sem liðnir eru frá borun hefur jarðhitavirkni haldist veruleg í eyjunni þó kerfið hafi heldur kólnað frá því fyrst var mælt í borholunni sumarið 1980.

Haustið 2014 var haldinn fundur í Vestmannaeyjum þar sem saman kom fjölþjóðlegur 20 manna hópur vísindafólks á sviði eldfjallafræði, jarðefnafræði og líffræði. Niðurstaða fundarins var sú að full ástæða væri til að bora tvær nýjar kjarnaholur í Surtsey. Í því skyni var skipulagt rannsóknaverkefnið SUSTAIN og hafist handa við að afla fjár til rannsóknanna. Lagt var upp með að rannsaka einkum eftirfarandi þætti: (1) Innri byggingu eyjunnar, (2) þróun jarðhitans, enda er hann einstakt dæmi um skammlíft jarðhitakerfi í rekbelti úthafsskorpu og (3) fjölbreytileika örvera, virkni þeirra á mismunandi dýpi og við mismunandi hitastig í innviðum eyjarinnar. Þá var lagt upp með að önnur holan sem boruð myndi nýtast næstu áratugi sem neðanjarðar rannsóknarstöð til vöktunar, sýnatöku og tilrauna á samspili örvera, jarðsjávar og bergs.

Borunin fór fram í ágúst og september 2017 en viðvera í eynni var frá 23. júlí til 12. september. Leyfi fyrir verkefninu var veitt frá Umhverfisstofnun en tímaglugginn fyrir borunina var milli loka varptímans og burðartíma sela á norðurtanganum. Fylgt var ströngum skilyrðum um umgengni, meðferð efna og úrgangs auk þess sem öll ummerki önnur en holutopparnir sjálfir voru afmáð að lokinni borun. Svo til allir flutningar fóru fram með þyrlum, en bor, eldsneyti og annar búnaður var yfir 60 tonn. Landhelgisgæslan sá um stórflutninga í upphafi og lok verkefnis og komu að því varðskipið Þór og þyrlan TF-Líf. Norðurflug sá um flutninga á fólki, vistum og kjarna meðan á boruninni stóð og Björgunarfélag Vestmannaeyja hjálpaði einnig til þegar þörf var á aðstoð báts. Lengst af voru 13 manns í Surtsey meðan á borunum stóð og unnið á 12 tíma vöktum. Bandaríska borfyrirtækið DOSECC sá um borunina og fimm bormenn þess voru í eyjunni frá lokum júlí til 10. september.

Fyrri holan var boruð við hlið holunnar frá 1979. Hún varð um 190 m djúp og náðist samfelldur kjarni nema í neðstu nokkrum metrunum þar sem gjóskan var enn ósamlímd. Kjarninn er að mestu ummyndað móberg með einstöku basaltinnskotum. Seinni holan var skáhola, boruð undir 35°horni frá lóðréttu og stefndi inn að miðju gosrásarinnar. Í megindráttum var kjarninn svipaður og í lóðréttu holunni, mismikið ummyndað móberg með stöku basaltinnskotum. Holan varð 354 m löng og náði í gegnum ganginn sem var aðfærsluæð flæðigosins í Surti I 1964-1967. Botn skáholunnar liggur um 230 metrum undir sjávarmáli sem þýðir að hún nær 100 metra niður fyrir hafsbotninn eins og hann var fyrir gosið. Holan liggur allstaðar í móbergi og eru neðstu 100 metrarnir því í gígrás sem sprengigosið í nóvember – desember 1963 hefur rofið í sjávarsetið, en það er a.m.k. 100 metra þykkt á þessu svæði. Bráðabirgðamælingar voru gerðar á hita í holunum 10. september. Forvitnilegasta niðurstaða þeirra mælinga er sú að gosrásin undir eynni virðist enn vera nokkrum tugum gráða heitari en bergið umhverfis, 50 árum eftir goslok.

Extensive glacier advances during the Pleistocene-Holocene transition on Svalbard

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A variety of data suggest extensive glacier advances on Svalbard in connection with the Pleistocene-Holocene transition, during period of regional warming. We present a study of a well-constrained end moraine formed during the Lateglacial-early Holocene transition in De Geerbukta, NE Svalbard. The landform was deposited by an outlet glacier re-advancing into a fjord suggesting a far more extended position than the late Holocene maximum. We compare the synchronicity of this glacier advance to climate and 15 other proposed Lateglacial-Early Holocene glacier advances in Svalbard. The evidence suggests that the Lateglacial-Early Holocene glaciers were much more dynamic than hitherto recognized, exhibited re-advances and extended well beyond the extensively studied late Holocene glacial expansion. We suggest that the culmination of the Neoglacial advances during the Little Ice Age does not mark the Holocene maximum extent of most Svalbard glaciers; it is just the most studied and most visible in the geological record. Furthermore, the evidence suggests that the final phase of Svalbard deglaciation, after the last major glaciation, was characterized by widespread advances of Svalbard outlet glaciers. The presentation will discuss the implications of this.

Mapping of fractures within the Reykjanes fissure swarm, SW-Iceland

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Field exercises are conducted every year in the courses Tectonics and Current Crustal Movements at the University of Iceland. The purpose is to train students in field work, expand their experience with fault structures and evidence of crustal movements under field conditions. The field exercises in 2017 were conducted within the Reykjanes fissure swarm, one of the active swarms of the Reykjanes Peninsula Oblique Rift, a part of the boundary between the North America Plate and the Eurasia Plate.

The objectives are twofold: 1) To gather information for a surface fracture map and give an overview of the different styles of faulting within the fissure swarm, and 2) to gather data on fault throw on as many faults as possible in this area. Numerous transects across faults were measured by carrying a GPS-receiver across the faults.

The Reykjanes Peninsula Oblique Rift has an over-all trend of 70°. The plate boundary, as defined by a zone of seismicity, is highly oblique with respect to the spreading direction, which is 104° in this region. The fissure swarms of individual volcanic systems have a NE-trend, oblique to the plate boundary. Overprinting this pattern of fissure swarms is a system of many parallel strike-slip or oblique-slip faults with a N-S strike, so called bookshelf faults. Bookshelf faulting appears to be a characteristic of immature and oblique segments of the plate boundary in Iceland and is one of the main sources of large earthquakes in the country.

The field studies in 2017 were focused on the following issues:

1. Determine fault throw of the normal faults. Throws in the range 0-20 m were measured. Many fractures were primarily fissures, i.e. with very little vertical offset.

2. Document the decreasing intensity of fracturing within the NE-end of the fissure swarm where it dies out within the N-American Plate.

3. Map the fracture pattern associated with several strike-slip faults identified within the fissure swarm at Reykjanes. Two prominent strikes-slip faults show fracture pattern typical for such fault, en-echelon fractures and push-up hills. Five others are suggested.

Hversu hratt þróast kvika í rótum Heklu?

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Ísúra kvikan sem kemur upp í lok sögulegra Heklugosa er af nánast sömu samsetningu í gegnum tíðina, eða basaltískt andesít. Hún myndast að öllum líkindum við aðskilnað steinda og bráðar eftir 40-60% hlutkristöllun á basaltkviku af líkri samsetningu og basalthraunin umhverfis Heklu. Steindafylkið sem skilst frá ísúru bráðinni er samsett af 8-13% ólivín, 34-40% klínópýroxen, 32-41% plagíóklas (An_{55-65}) og 15-17% járn-títan oxíð (Sigmarsson et al., 1992; Chekol et al., 2011). Einsleit samsætuhlutföll Th sem og Sr, Nd, Pb og Nd og hlutfalla utangarðsefna eru í samræmi við hlutkristöllunarlíkanið.

Ekki er vitað á hvaða dýpi hlutkristöllunin á sér stað en hægt er að meta hversu hratt ísúra bráðin myndast. Geislavirkt ójafnvægi radíums og þóríums (^{226}Ra-^{230}Th) lækkar úr 1.16-1.04 í Heklubasalti niður í 1.07-1.00 (± 1-2%) í ísúru hraununum. Þessi lækkun kann að endurspegla geislavirkt niðurbrot ^{226}Ra ($T_{1/2}$: 1600 ár) ef hlutkristöllunin tæki lengri tíma en 200 ár, sem er sá lágmarkstími sem þarf til að mæla breytingu í geislavirkni radíums. Ef hinsvegar Ra gengur inn í þær steindir sem skiljast frá basaltbráðinni er kristöllunartíminn mun styttri.

Radium er stór jón og gengur illa inn í kristalbyggingu algengra steinda í basalti. Það hagar sér sem utangarðsefni og eykst því styrkur þess með þróun bráðar. Dreifistuðul þess (D_{Ra}) á milli steindafylkisins sem skilst frá og basaltbráðarinnar undir Heklu, má reikna út frá breytileika þess sem fall af styrk Th í bráðinni og reynist hann vera 0.08 ± 0.01. Þar sem radíum gengur aðeins lítillega inn í plagíóklas, af þeim steindum sem kristallast út úr bráðinni, má reikna dreifistuðul plagíóklas, D_{Ra} (plag-bráð) einfaldlega sem 0.08/0.36 = 0.22. Bræðslutilraunir sýna að dreifistuðull Ra milli plagíóklas og bráðar er nálægt 0.2 fyrir plagíóklas af samsetningunni An_{60} (Fabbrizio et al., 2009), sem er í fullu samræmi við Ra og Th dreifingu í Hekluhraunum. Því skýrist lækkun Ra einfaldlega með plagíóklas hlutkristöllun á tímaskala sem er mun styttri en 200 ár. Hversu mikið styttri verða frekar rannsóknir að leiða í ljós ef Rannís leyfir.

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Hekla volcano, Iceland, in the 20th century: Lava volumes, production rates and effusion rates

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Lava flow thicknesses, volumes and effusion rates provide essential information for understanding behavior of eruptions and their associated deformation signals. Hekla mountain erupted five times (1947-1948, 1970, 1980-1981, 1991, 2000) in the 20th century producing tephra and basaltic-andesite lava flows. These five eruptions were monitored and have detailed descriptions of the course of events [1-5]. However, the lava volume estimates are uncertain because they are based on the planimetric method [6], where the area of the flow field is multiplied by an estimated average lava thickness. Due to coarse sampling of lava thickness profiles, previous studies suggest that the planimetric volume estimates yields up to 50% uncertainties [6-7]. Here we address this problem by generating pre- and post-eruption digital elevation models (DEMs) for the last five eruptions from historical stereo photographs to produce the first lava flow thickness maps at Hekla volcano, Iceland.

The thickness maps (Figure 1) cover each of the last five lava-producing eruptions, and allow precise estimation of the lava flow volumes. Along with the eruption parameters for the 1980-81 eruption episode, details for the two individual eruptions in 1980 and 1981 are also provided. The average lava flow field thicknesses range from 5.5 m in the shortest eruption to 19.1 m in the longest eruption, while the bulk lava volume varies from $V_{1947\text{-}1948}$=0.742±0.138 km^3, V_{1970}=0.205±0.012 km^3, $V_{1980\text{-}1981}$=0.169±0.016 km^3, V_{1991}=0.241±0.019 km^3, V_{2000}=0.095±0.005 km^3 (Table 1).

Table 1. Eruption parameters for the five eruptions at Hekla Mountain in the 20th century. Mean output rate, MOR is based on the bulk lava volume and the eruption duration. The mean lava flow field thickness is denoted th and E is explosivity.

Lava flow field	Duration [d]	Repose time [yr]	th [m]	Area [km^2]	Lava [km^3]	MOR [m^3 s^{-1}]	Lava DRE [km^3]	Tephra DRE [km^3]	Total DRE [km^3]	E	Production rate (10^6 m^3 yr^{-1})
1947-1948	389	101	19	38.914	0.742 ±0.086	22	0.631±0.082	0.08±0.04	0.711±0.122	11.2	7
1970	61	23	12	17.128	0.211 ±0.012	40	0.179±0.012	0.03±0.015	0.209±0.027	14.7	9
1980	3	10	5	22.610	0.124 ± NA	479	0.105±NA	0.026±0.013	0.131±NA	19.8	13
1981	7	1	11	4.365	0.047 ±NA	78	0.040±NA	NA	0.040±NA	0.0	40
1980-1981	10	10	7	24.549	0.170 ±0.015	197	0.144±0.014	0.026±0.013	0.170±0.027	15.3	17
1991	53	10	10	24.672	0.241 ±0.019	53	0.205±0.018	0.01±0.005	0.215±0.023	4.7	21
2000	12	9	7	14.587	0.095 ±0.005	92	0.081±0.004	0.004±0.002	0.085±0.006	4.7	9

These new volumes improve the correlation between the measured E-W co-eruptive tilt change at the NAEF station (Figure 1) and erupted volume [8-9], indicating that tilt measurements at this station can be used as a proxy to estimate the eruption volume.

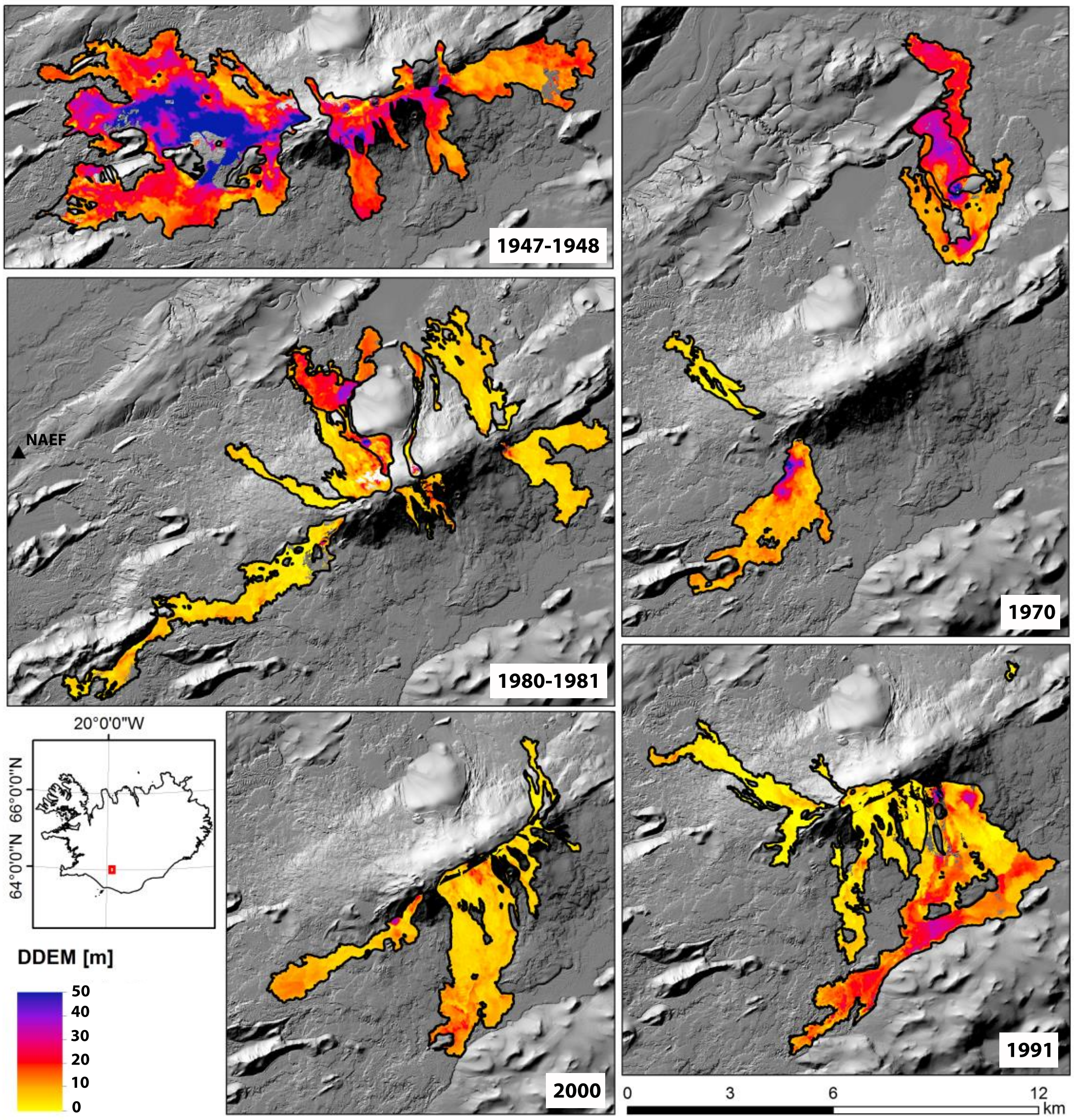

Figure 1. Lava flow thickness maps for Hekla Mountain in the 20th century. Background: hillshade from lidar DEM, with gaps filled with TDX DEM. The NAEF tilt station is marked on the 1980-1981 map.

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Geochemical characteristics of an enriched Icelandic tholeiitic magma suite: the case of the Kverkfjöll volcanic system

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The Kverkfjöll volcanic system is situated at the northern margin of the Vatnajökull ice cap, Iceland, 30 km east of the main axis of the Northern Rift Zone (NRZ). It hosts a central volcano with two ice-filled calderas, sitting on top of c. 35 km thick crust. The 60 km long fissure swarm is characterized by NNE striking subglacial pillow basalt ridges and post-glacial lava flows with associated scoria cones and crater rows. Perhaps because of its remote location and the lack of documented eruptions during the last 1300 years, published geochemical data of Kverkfjöll is limited. However, the volcanic system is very much active, as demonstrated for example by a lively high temperature geothermal system and a well-documented dike injection event below Mt. Upptyppingar in 2007 [1].

We present a preliminary geochemical dataset of the Kverkfjöll magma suite, collected from a large sample set (n = 71) of subglacially erupted pillow rim glasses. The data comprises major and trace elements and volatile abundances (EPMA, LA-ICP-MS, FTIR), as well as Hf-Pb and oxygen isotopes (MC-ICP-MS, IRMS). The Kverkfjöll magmas are almost exclusively basaltic tholeiites (MgO = 4-8 wt.%), with high concentrations of FeO (15 wt.%) and TiO_2 (3.5 wt.%). The most primitive samples are found on Mt. Upptyppingar at the northern end of the fissure swarm, while the most evolved samples (basaltic andesites) were collected from the slopes of the central volcano. Majority of the sample compositions cluster close to the onset of magnetite crystallization at MgO $\approx$ 4.8 wt.%.

The magmas are marked by a relative enrichment in K_2O (up to 1 wt.%) and incompatible trace elements. This, in conjunction with steep, negatively sloping REE_{CN} patterns with $(Sm/Yb)_{CN} > 2$, indicate that the magmas originate as deep (> 60 km) low degree partial melts of a mantle, which may closely resemble the mantle giving birth to the transitional magma suites of the off-rift Öræfajökull Volcanic Belt (ÖVB). Interestingly, this feature is also reflected in the Pb-Pb isotopic signature of Kverkfjöll, which departs from the NRZ trend toward the unique enriched mantle (EM) signature of the Öræfajökull volcano [2].

Furthermore, the Kverkfjöll basalts are distinctly enriched in H_2O (up to 1 wt.%) and Cl (up to 350 ppm). This volatile enrichment is offset from the fractional crystallization trends of other Icelandic tholeiites and is therefore likely to be an inherited feature of a presumably volatile-enriched mantle source. An emerging conclusion from our preliminary dataset is that the Kverkfjöll basalts tap a distinct, volatile-enriched EM-like component of the Iceland mantle, which seems to be accessed only by deep melting at the eastern periphery of the NRZ.

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Assessing δ^{18}O heterogeneity in Icelandic olivine crystals

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Oxygen isotope ratios (δ^{18}O) of Icelandic basalts are notably distinct from MORB-sourced basalts. Two prevailing hypotheses have been put forward to account for this: interaction with low-δ^{18}O crust or mantle heterogeneity (Muehlenbachs *et al.*, 1974). High-forsteritic (high Mg/Fe ratio) olivine crystals are widely used as a proxy for primary melt composition prior to crustal modification (Sobolev *et al.*, 2007). Therefore, their geochemical characteristics can be useful to determine the source of low-δ^{18}O in Icelandic basalts. Studies addressing this issue have mostly involved batch mineral laser-fluorination analysis which cannot resolve any intra-mineral δ^{18}O variability possibly present due to shallow-level processes, e.g. crustal contamination (Bindeman *et al.*, 2008). We couple *in-situ* δ^{18}O measurements of high-Fo# (>80) olivine crystals from the neovolcanic rift- and flank zones as well as older Tertiary units with major and trace elements. This is done by the use of SIMS, EMPA and LA ICPMS as tools to identify primary vs. secondary controls on some notable geochemical characteristics of Icelandic basalts.

Our analysed olivine grains, range in Fo# between 80 to 91.8 with limited intra-grain variability. Independent of Fo#, we observe a variation in δ^{18}O$_{(ol)}$ of >3 ‰ across Iceland, with most crystals plotting below the expected depleted mantle-value (~5.1 ± 0.2 ‰, Eiler, 2001). The lowest δ^{18}O$_{(ol)}$ (+2.77 ‰), is measured in crystals with Fo# 86 from central Iceland, close to the inferred plume head (Harðardóttir *et al.*, 2018). Trace element ratios of these olivine crystals (e.g., Mn/Fe and Mn/Zn) suggest a peridotitic mantle source. In contrast, crystals from the South Iceland Volcanic Zone display trace element ratios indicative of greater amount of pyroxenite in their source region while their δ^{18}O$_{(ol)}$ cluster around +4 ‰. These results, together with previously published ^{3}He/^{4}He values for these same samples (Harðardóttir *et al.*, 2018) imply a regional shift in the dominating mantle lithology and plumbing conditions beneath Iceland.

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Modeling Flow Dynamics and Constraining the Modeled Stress Balance of the Langjökull Glacier Using Mass Balance and Surface Velocity Measurements, 1997-2016

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Háskóli Íslands

The flow of the Langjökull ice cap has been explored and constrained using the Parallel Ice Sheet Model (PISM) which was developed as a joint project between the University of Alaska at Fairbanks, the Potsdam Institute for Climate Impact Research, and several other institutions. Although PISM was developed mainly for the purpose of exploring the flow dynamics of large ice sheets, it can be forced with data sets from smaller ice caps and used as a numerical tool towards understanding ice flow over comparatively smaller spatial scales.

The data used to force PISM were collected between the years of 1997-2016. Measurements of the surface mass balance of the Langjökull glacier were taken at 22 stakes using the stratigraphic method (Pálsson et al., 2012), and temperature data was gathered from the Hveravellir weather station (vedur.is). Interpolated temperature and mass balance maps were then created for the Langjökull ice cap and used as forcing for the PISM initialization.

A series of modeling experiments are performed, each initialized with constant mass balance and temperature annual means. Measured bedrock and surface topography (Pálsson et al., 2012) are used as boundary conditions for the model. The constant climate simulations are used to provide a control against which the model sensitivity to other parameters is tested. By forcing the model forward 500 years in time with individual annual means between 1997 and 2016 as well as the overall mean for the period, a wide range of steady state geometries for Langjökull are found.

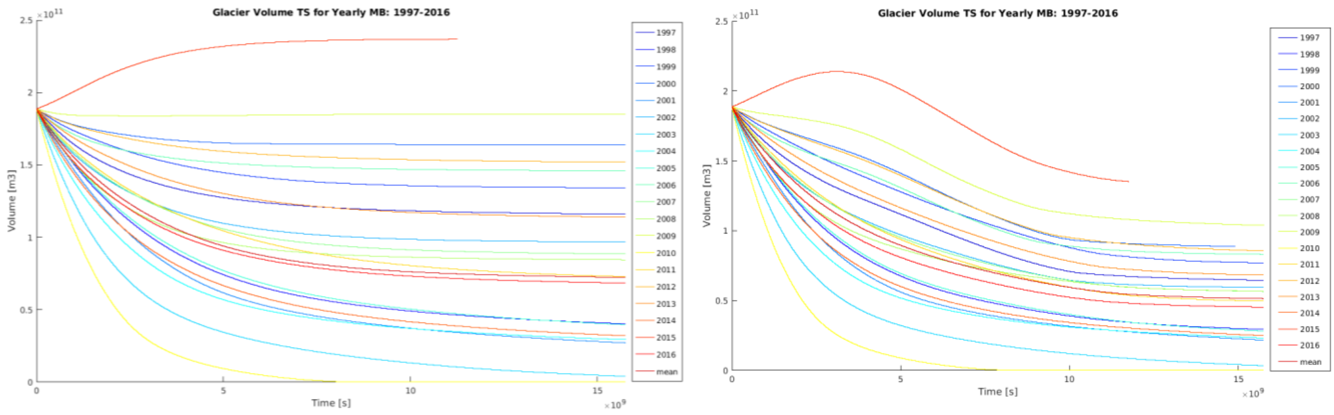

Figure 1: Time series of the modeled ice volume for each climate initialization for SIA only (left) and combination of SIA and SSA (right)

Additionally, a constraint on the stress balance of the ice cap was explored. The default stress balance applied by PISM is the Shallow Ice Approximation (SIA) which takes into account ice deformation under its own weight for ice that is significantly thinner than it is wide. However, when modeled surface velocities are compared to measurements taken on Langjökull, it is clear that there is likely a sliding component in the ice flow that should be taken into account, for example by including additional terms in the stress balance. However, when the Shallow Shelf

Approximation (SSA) was added to the SIA, modeled velocities are too high, in particular along the outlet Vestri-Hagafellsjökull.

Eystri- and Vestri-Hagafellsjökull have a history of surging with surge periods on the order of decades (Björnsson et. al, 2003). The additional sliding in the model results in a considerable velocity gradient that develops on Vestri-Hagafellsjökull around model year 185. This model behavior may give insight as to what types of situations can lead to a surge on this outlet. Although the model does not represent the surge periodicity, it can potentially be used as a proxy for surge precursors. Additionally, the measured velocity field on this outlet presents an non-surging upper-bound for the modeled velocities. Because of this, the flow line beginning at the summit of Langjökull and stretching all the way to the snout of Vestri-Hagafellsjökull was used as a profile along which thickness and surface velocity could be compared between modeled results and data.

Model-data comparison reveals that some climate initializations (i.e. some mass balance means) result in modeled ice that stands within the range of measurements, but some initializations result in velocity fields that are far too high. In order to constrain the sliding law, it was necessary to run more model experiments.

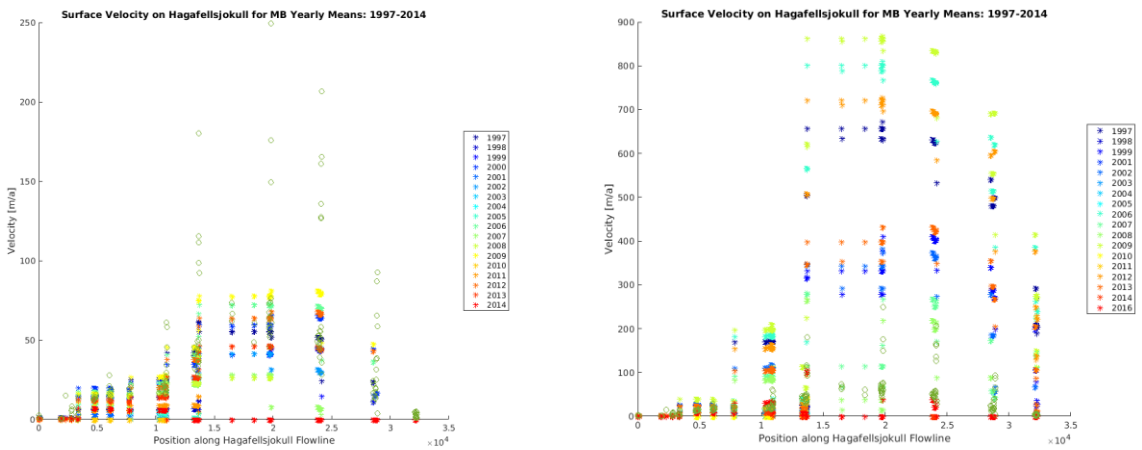

Figure 2. Modeled Surface Velocity (*) for each initialization (different colors) and Measured Surface Velocity (o) along V-HFJ flowline with combination of SIA and SSA (right) and SIA only (left)

There is an option within PISM that allows the user to assign elevation dependence to the sliding law. This way, ice in the ablation zone can be set up to slide far more easily than ice in the accumulation zone. Next steps for this project include choosing an optimal sliding law with an appropriate elevation dependence, as well as running the model with a time-dependent climate rather than a constant climate.

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Resolving water sources in Icelandic basalts: insights from hydrogen isotopes

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A recent melt inclusion study, largely focused on material associated with the proto Iceland plume at Baffin Island, revealed exceptionally negative δD values (down to –218‰), suggesting tapping of primordial water sources via the Iceland plume [1]. Limited hydrogen isotope data of basalts are available from Iceland and current datasets are restricted to highly degassed subaerial lava flows, providing limited insights into the importance of the inferred water reservoir in the Icelandic mantle today.

We report new water elemental abundance and hydrogen isotope data (n=73) for a suite of geochemically well-characterized subglacial and subaerial basaltic glasses from Iceland (see [2] and [3]) using SIMS and TC/EA-IRMS, respectively. The majority of samples are fresh subglacial glasses and cover all the currently active volcanic zones of Iceland. Most samples come from glassy pillow rims that were instantly quenched during eruption and, in some cases, under significant pressure from overlying glaciers.

Water contents in the basaltic glasses vary from 0.07 to 1.0 wt.% and we note that in general, high MgO samples tend to have low H_2O contents whereas samples with elevated H_2O contents display lower MgO. Water and sulfur nicely correlate and we note that out of the 73 analysed, only eight samples have S contents <500 ppm, confirming the generally undegassed nature of the sample suite. The undegassed nature of most samples is confirmed considering H_2O-Ce relationships: most samples fall within expected range in H_2O/Ce for undegassed MORB glasses (150-280) [4]. By comparison of water extracted during thermal combustion vs. water dissolved (SIMS) in glass samples we note that few samples appear to have released some extra water during thermal combustion - likely derived from clays or other alteration minerals. Hydrogen isotope data extracted from these samples have thus been omitted. δD values of the remaining glasses span a wide range from -118 to -65‰. There is no simple relationship observed between H_2O and δD although we note that the most positive δD values (> -80‰) are only evident in sample with H_2O contents > ~ 0.6%. Irrespective of H_2O contends, most samples display δD values below estimates for the depleted MORB mantle [5 and 6] and reach values as low as -118‰.

No simple relationship is observed between MgO contents of samples and their δD values. Critically, there is not an obvious trend of lowering δD values accompanying lower MgO contents. However, we note that the most primitive (MgO ~10%) and thus least degassed samples, have δD values as low as -110‰. To test whether observed H-isotope variations of the Iceland glasses result from degassing-induced modification of a common mantle source δD value, we setup a simple open system degassing model. Although this model can satisfactory explain the spread of our data, δD-MgO relationships demonstrate that it remains highly unlike that samples can be traced back to a single end-member composition via degassing. Also, such high water contents are much too high relative to current estimates for water contents of primary Icelandic melts. Consideration of δD-H_2O/Ce relationships, allows us to identify samples with modified δD values, for example due to degassing. For example, samples with H_2O/Ce ratios < or > than DMM (150-280; e.g., [4]) are likely related to secondary processes. Therefore, samples with low δD values as well as low H_2O/Ce are likely modified and have been filtered out.

δD-$^3He/^4He$ relationships facilitate identification of possible primordial water sources whereas δD-$\delta^{37}Cl$-Pb relationships allow us to assess the role of recycled water. Interestingly, high-$^3He/^4He$ samples generally display much lower δD values than expected for the depleted MORB mantle, confirming the presence of more primitive hydrogen signature present in the lower mantle. As low δD values (as low as -118‰) appear coupled to high $^3He/^4He$ values, a straight forward interpretation of δD-$\delta^{37}Cl$-Pb isotope relationships, that disaply positive correlations, involves incorporations of sea-water altered lithosphere (with δD of ~0‰), including the uppermost sedimentary package, into the Iceland mantle plume source.

Recycling of such seawater-influenced material into the Iceland plume source, has been argued to explain the halogen and heavy noble gas systematics of Icelandic basalts [3, 7, 8]. In conclusion, recycled material can satisfactory explain elevated H_2O contents of the Icelandic basalts relative to adjacent mid-ocean ridges and confirms the notion of a wet Iceland plume [9].

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Endurteknar framrásir jökuls í Melasveit í neðri hluta Borgarfjarðar á síðjökultíma

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Lítið er vitað um virkni jökla sem ganga í sjó fram í samanburði við jökla á landi og þau set- og landmyndunarferli sem eiga sér stað undir og framan við þá. Stafar það meðal annars af því hve erfitt er að komast að jaðri jökla sem ganga í sjó fram en einnig af skorti á opnum sem sýna setgerð og byggingu jarðmyndanna sem til hafa orðið af völdum þessara jökla.

Slíkar myndarnir má þó vel sjá í Melabökkum og Ásbökkum ásamt öðrum minni sjávarbökkum í Melasveit í neðanverðum Borgarfirði á Vesturlandi. Svæðið var hulið jökli á síðjökultíma en varð íslaust fyrir u.þ.b. 14 600 árum. Eftir hörfun ísaldarjökulsins var afstætt sjávarmál mun hærra en í dag og hlóðust þá upp þá þykk sjávarsetlög á svæðinu. Á síðjökultíma gengu jöklar fram og aflöguðu þessi setlög. Ekki er vitað nákæmlega hver aldur þessara jökulframrása er en geislakolsgreiningar á steingervingum sem finna má í jökulhnikuðum setlögum í bökkunum benda til að þær séu ekki eldri en u.þ.b. 13 000 ára.

Ítarleg rannsókn á setgerð og jökulhniki í Melabökkum og Ásbökkum leiddi í ljós röð af jökulgörðum mynduðum af jökli sem gekk niður Borgarfjörð. Byggingareinkenni garðanna benda til þess að hver garður hafi verið byggður upp nálægt jaðri jökulsins. Urðu þeir aðallega til er setlög ýttust upp við jökulsporðinn en einnig við framburð á sandi og möl með bræðsluvatni undan ísnum. Syðsti og jafnframt stærsti jökulgarðurinn er meira en 1,5 km breiður og 30 m hár og markar hann líklega hámarksútbreiðslu jökulsins. Jökulgarðarnir verða almennt yngri til norðurs, sem sýnir að þeir hafi orðið til við sveiflur í jöklinum er hann hörfaði til norðurs. Jökulgarðarnir marka þannig tímabil þar sem jökulsporðurinn gekk fram eða stóð í stað. Þessum atburðum fylgdi mikil framburður sets sem nýttist til myndunar nýrra jökulgarða. Eftir að jökulinn hopaði frá hverjum garði fyrir sig fylltust dældirnar á milli garðanna fljótlega af seti. Hylur það jökulgarðanna að mestu leyti og mótar því lítið sem ekkert fyrir þeim í landslagi ofan bakkanna. Þessi rannsókn varpar ljósi á virkni jökla sem ganga í sjó fram og getur aukið skilning á hegðun þeirra og virkni í tíma og rúmi.

Causes and triggering factors for large scale displacements in the Almenningar landslide area, in central North Iceland

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For over 40 years the Icelandic road authority has monitored displacements on and along the "whole year road" between the Skagafjörður fjord and the town of Siglufjörður, in the outermost part of the Tröllaskagi peninsula, in central North Iceland. The road crosses a 6 km wide landslide area, named the Almenningar area, and since the road was constructed, almost 50 years ago, landslide movements have repeatedly caused extensive damages to the road, often caused hazardous conditions. The road authority started to monitor the movements in 1977 and today measurements are performed in late autumn every year. These measurements have created a 40 years of data which in combination with other reports gives us unique opportunity to correlate the displacements to meteorological data, and thus determent the causes and triggering factors for the movements.

The road crosses three large landslides, the Hraun landslide in the south, the Þúfnavellir landslide in the middle part of the area and the Tjarnardalir landslide in the north. The front of all these landslides reaches the present coast forming up to 60 m high coastal cliffs, which show clear indications of extensive coastal erosion. Geomorphological indications and the measurements show that the landslide masses have westward movement towards the sea, with a maximum mean rate up to 70 cm/year in the Tjarnardalir landslide. The landslide debris and the underlying sediments were studied in several sections along the present shoreline. The stratigraphical record confirms that glaciomarine fine grained sediments, which rest on a till, underlie the landslide debris, at least in the coastal areas. The fine grained sediments have much lower permeability and thus the groundwater, which penetrates through the coarse grained landslide material, stops on the fine grained material. It is assumed that the main part of the sliding movement takes place on this boundary. There is a clear correlation between the landslide movements and weather conditions. The main sliding movement occurs during the snowmelt period and during the autumn rain period. It is suspected that extensive costal erosion also plays a role in the sliding movement. Electrical resistivity measurements performed on the debris mass indicate that the moisture content in the debris is very high, which indicates extensive ground water flow within the debris mass.

The prospect for the whole year road to the Siglufjörður fjord, crossing the landslide area is not bright. The constant damages occurring on the road can lead to severe situation and cause hazardous conditions for the traffic. The situation on the northern side of the Tjarnardalir landslide is thought to be more hazardous than in other areas. There, the undercutting of the sediments, due to costal erosion and sliding activity in the debris mass have destabilized the sediments underneath the road. New crevasses are opening and it seems that the crevasse zone is slowly merging further upwards into the debris mass above the road. If this continues, large parts of the road will fall or slide down, possibly tenths of meters.

Volume changes in lake Kleifarvatn 2014 – 2017

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Lake Kleifarvatn is known to have periods of higher and lower lake levels, and the area of the lake varies from 7.5 to 10 km^2. Combining high quality bathymetry data, surface DEM and areal lake coverage from satellite images, it is possible to construct a continuous elevation model in order to investigate the lake volume change during these periods. The outline of the lake was obtained using Landsat 8 satellite images obtained from USGS and NASA over a four year time period (2014 to 2017). Multi beam bathymetry data was then combined with the Arctic DEM from NASA to calculate the volume changes. The Kleifarvatn lake level was also compared to the total precipitation measurements from Keflavik to determine if the images corresponded to a period of low or high lake level. From 2014 to 2017, the volume of the lake changed from 0.37 km^3 to 0.48 km^3, corresponding to a 30% increase.