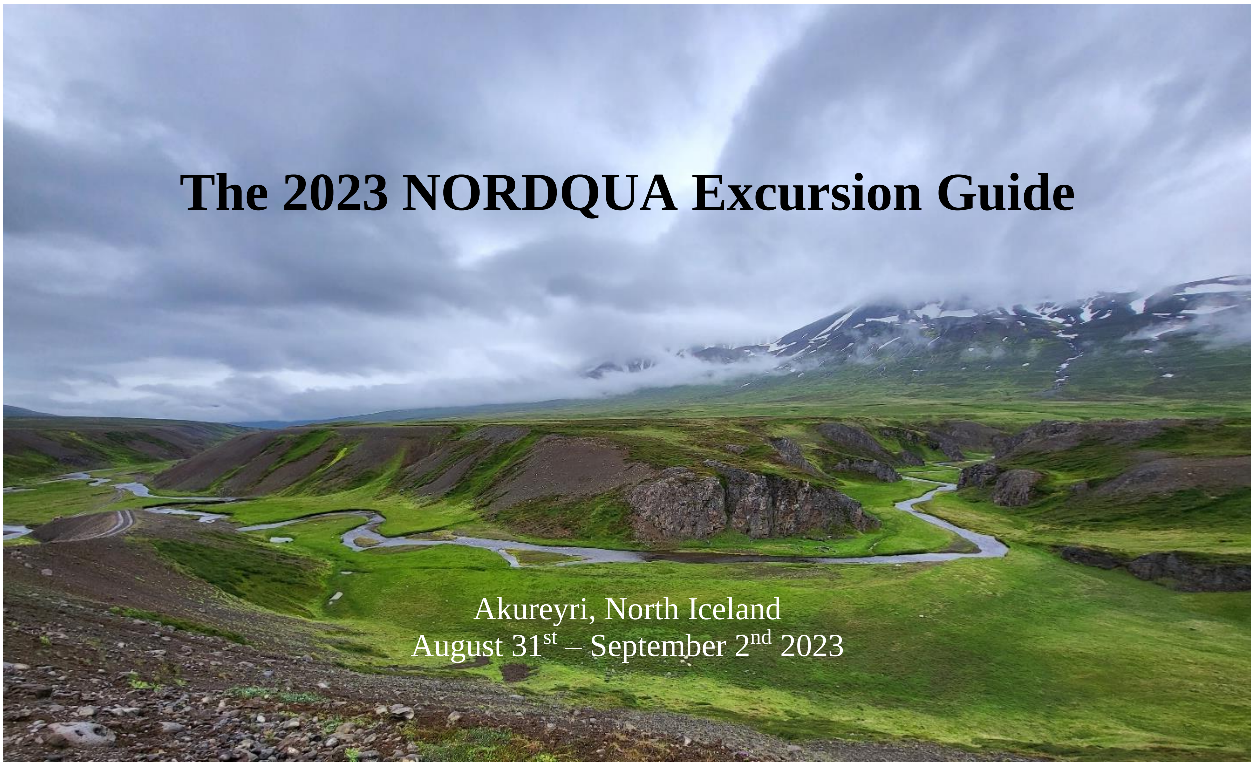

The 2023 NORDQUA Excursion Guide

Akureyri, North Iceland
August 31st – September 2nd 2023

UNIVERSITY OF ICELAND
INSTITUTE OF EARTH SCIENCES

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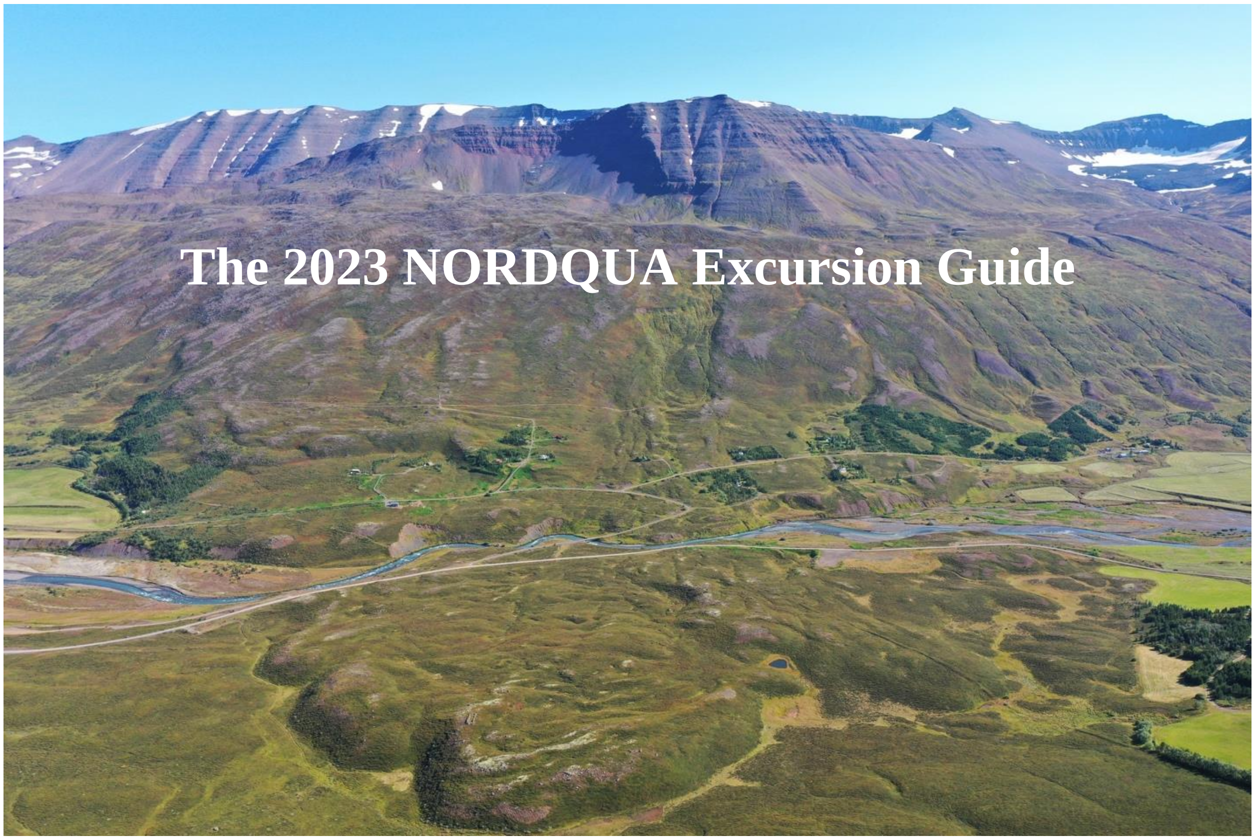
Above: The spillway canyon of the Late glacial ice-lake in Fnjóskadalur, North Iceland (ÍÖB 2023).

The 2023 NORDQUA Excursion Guide



Above: Oblique aerial image of Hvarf in Skíðadalur, North Iceland (SB 2023).

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Table of Contents

Welcome and Introduction

Excursion Overview ……………………3

NORDQUA Programme

Trip 1, August 31 ……………………..4
Trip 2, September 1 ……………………..8
Trip 3, September 2 ……………………11

List of participants ……………………18

The 2023 NORDQUA Excursion – North Iceland

Trip 1:

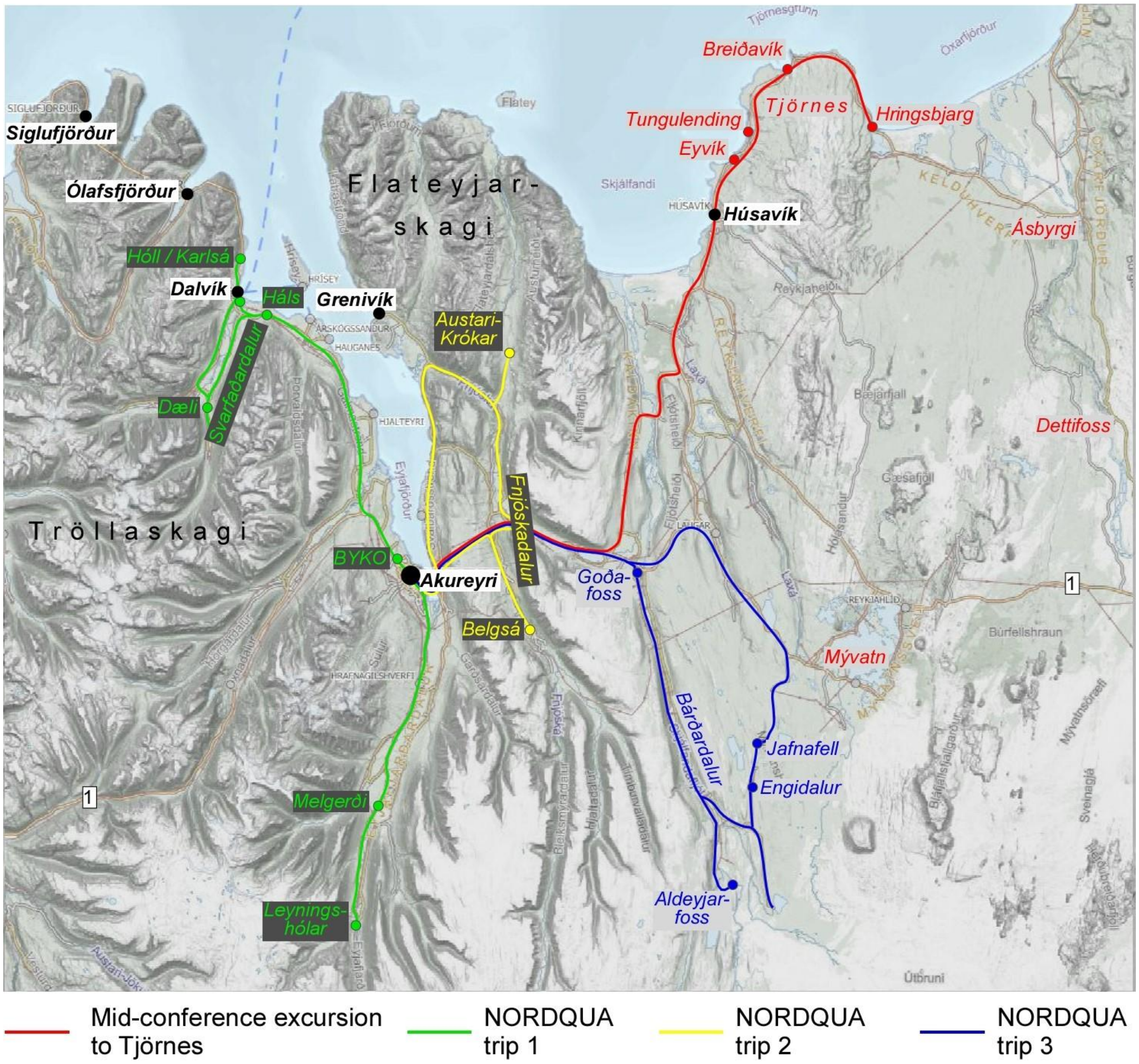
The alpine glacial landscapes and slope instabilities of the Tröllaskagi Peninsula.

Trip 2:

Signatures of deglaciation dynamics, ice-lakes and their tephrochronological age control in Fnjóskadalur.

Trip 3:

Geomorphological fingerprints of fast-flowing ice streams within the Iceland Ice Sheet in Bárðardalur.



Map of North Iceland with overview of the PalaeoArc Mid Conference Excursion to Tjörnes (Red) and the NORDQUA Excursion consisting of three-day trips (Green, Yellow and Blue).

Trip 1:
The alpine glacial landscapes and slope instabilities of the Eyjafjörður and the Tröllaskagi Peninsula.

Eyjafjörður general glacial history:

During the Last Glacial Maximum, Eyjafjörður hosted one of the major outlet glaciers of the Iceland Ice Sheet (IIS) which extended out onto the shelf, north of Iceland (Norðdahl, 1983, 1991; Norðdahl and Hafliðason, 1992; Andrews et al., 2000). Ice streamed from the central highlands through the catchment draining a portion of the IIS as well as confluent tributaries form the Tröllaskagi peninsula (Fig. 1). Consequently, the Eyjafjörður outlet glacier was a composite glacier, fed both by the central highland ice divide and local tributary glaciers from the bounding alpine peninsulas (https://www.map.is/base/@524625,609838,z5.85746897379557,0; Stop 1 & 2; Hóll and Hrísahöfði).

During the Late Glacial, the Eyjafjörður outlet, like other outlets and ice shelfs of the IIS, abruptly retreated to an unknown position. Subsequently the Eyjafjörður outlet glacier (and regional tributaries) re-advanced, with the Eyjafjörður ice margin extending out to just south of the island of Hrísey. This fluctuation has left distinct lateral moraines on the eastern side of the fjord (Fig. 2; Stop 1). An apparent marine limit beach ridge at roughly 30 m a.s.l., close to the lateral moraine marks the highest known position of relative sea level in the outer parts of Eyjafjörður At that time, the Eyjafjörður outlet glacier sealed off the Dalsmynni valley (Fig. 2) damming the extensive ice-lake in the Fnjóskadalur valley east of the fjord (Norðdahl, 1983). Considerable quantities of the Skógar-Vedde Tephra were trapped in the ice-lake, constraining its Younger Dryas age as well as the concurrent formation of the Hrísey terminal zone in Eyjafjörður (Norðdahl and Hafliðason, 1992). The occurrence of the Late Glacial Skógar-Vedde Tephra in clastic sediments in the area has greatly aided stratigraphic correlations within Eyjafjörður (Norðdahl, 1983; Norðdahl and Hafliðason, 1992).

A marginal position of the Eyjafjörður outlet glacier close to Espihóll (Stop 5), some 50 km south of the Younger Dryas terminal zone (Fig. 2, 3), represents a substantial retreat of the glacier and inundation of the sea (Pétursson and Norðdahl, 1999; Norðdahl and Pétursson, 2000). Raised shorelines correlated with this position of the glacier are found at decreasing altitudes from about 40 m a.s.l. at Espihóll to about 10 m a.s.l. at Dalvík and Svarfaðardalur. (Stop 2 and 5). By using arguments from shoreline gradients, glacio-isostatic uplift and dated tephra in the Eyjafjörður region it is possible to estimate the age of the Espihóll marginal position to be about 9,800 ^{14}C yr. BP or roughly 11.2 cal. ka BP (Norðdahl,

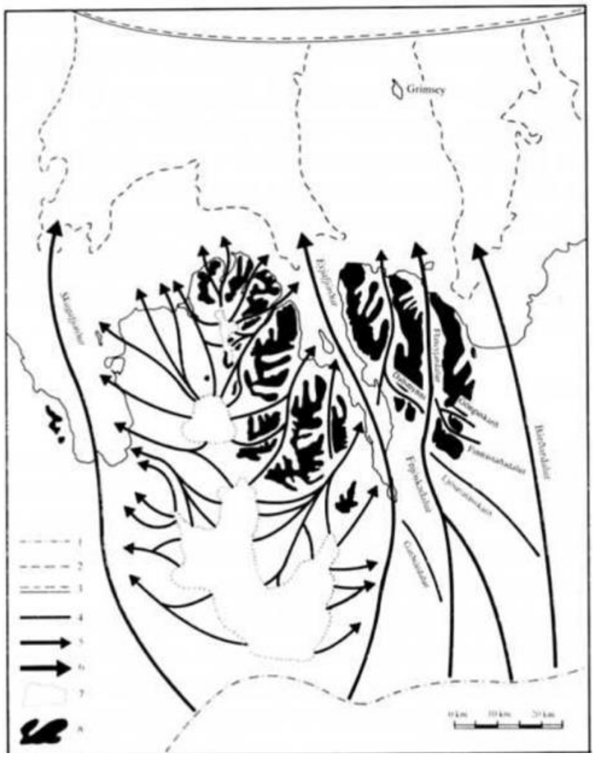


Fig. 1. Schematic map of ice flow and drainage divides in North Iceland during the LGM of the Iceland Ice Sheet, ice-free areas with valley and cirque glaciers in black (Norðdahl, 1991).

1981, 1983; Norðdahl and Hafliðason,1992; Ingólfsson et al., 1995; Norðdahl and Einarsson, 2001). A subsequent and lower set of raised shorelines in Eyjafjörður is found at altitudes between 5 m a.s.l. at the mouth of Svarfaðardalur to about 30 m asl at Melgerðismelar south of Espihóll in Eyjafjörður (Fig. 2).
https://www.map.is/base/@540286,555928,z5.419135640462215,0; Stop 4; Melgerði & Espihóll.

Raised shorelines and marginal features south of the proposed Younger Dryas terminal zone by the island Hrísey in Eyjafjörður are younger than the 12.1 cal. ka BP old Skógar-Vedde Tephra RSL. Thus, during a period of 900 years the main outlet glacier in Eyjafjörður retreated some 50 km. This extensive retreat was most likely caused by a considerable negative mass-balance of the ice sheet and the local glaciers leading to a rapid thinning of the Eyjafjörður outlet glaciers. The degradation of a rapidly thinning tidewater glacier was probably enhanced by transgression of RSL which broke up and floated the Eyjafjörður ice margin and (Norðdahl and Pétursson, 2000).

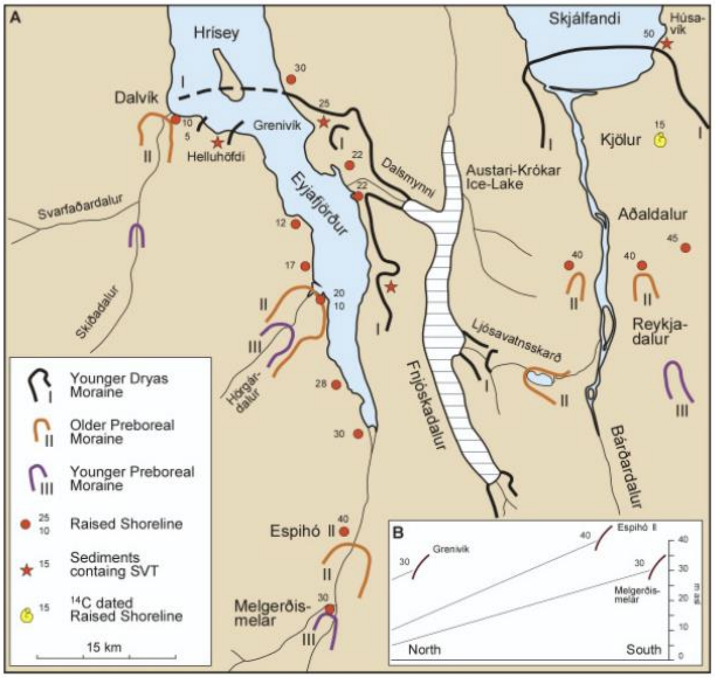


Fig. 2. A) Outline of the deglaciation of the Eyjafjörður – Skjálfandi area in North Iceland. Raised shorelines and elevations indicated. B) Extent and gradient of three successive raised shorelines with respective ice margins (Norðdahl and Pétursson 2005).

At the time of the Espihóll formation considerable valley glaciers extended out of the tributaries into the mouth of the main valleys, Svarfaðardalur (Hrísahöfði stop 2) and Hörgárdalur. Ice marginal positions from the tributary outlets are denoted by marginal deltas *c.* 10 m a.s.l. and 20-25 m a.s.l., respectively. As the main outlet glacier of the fjord retreated, those valley glaciers retreated as well but with occasional halts or readvances leading to the formation of marginal features further in the valleys, such as ice contact deltas, lateral terraces and marginal moraines. However, geomorphology and stratigraphical studies indicate in general a restricted glacier cover with alpine style glaciation on the Tröllaskagi peninsula, leaving mountains and at least some valleys ice free during the deglacial time (Sigbjarnarason, 1983; Norðdahl, 1991; Stötter, 1991; Bendiktsson et al 2022).

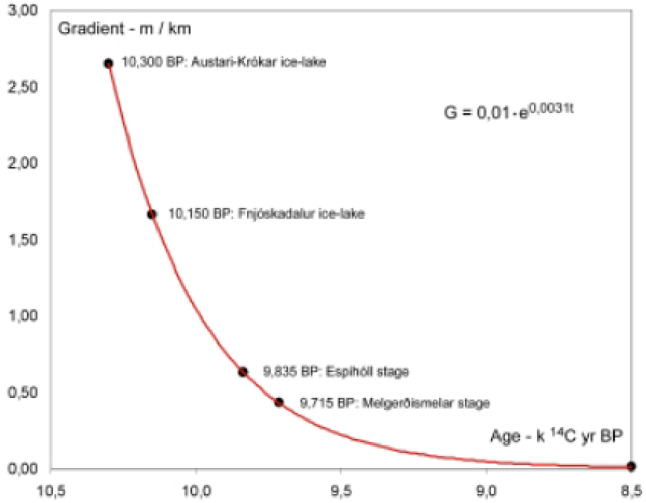


Fig. 3. Projection of decreasing shoreline gradient with time in the Eyjafjörður area (Norðdahl and Pétursson 2005; modified from Norðdahl, 1981).

Holocene history, alpine glaciers and landslides

(https://www.map.is/base/@517392,593864,z5.418333333333332,0; Stop 3; Svarfaðardalur)
Glaciers in Tröllaskagi are believed to have exhibited similar extent during the Early Holocene as they do at present. Thus, numerous corrie glaciers, perennial snow fields, rock glaciers and at least some valley glaciers existed about 700-1300 m a.s.l. in valley and corrie bottoms during the Early Holocene. (Stötter, 1991; Guðmundsson, 1997; Stötter et al., 1999; Wastl et al., 2001, 2005). During the Holocene Thermal Maximum (HTM), glaciers in Tröllaskagi were greatly reduced. Whether they disappeared completely or not remains unclear (Guðmundsson, 1995; Stötter et al., 1999; Wastl et al., 2001). However, various lines of evidence constraining rock glaciers and moraine stabilization suggest Tröllaskagi's debris-covered glaciers stagnated and persisted ice cored during the HTM (Tanarro et al., 2019; Campos et al., 2019; Fernández-Fernández et al., 2020; Palacios et al., 2021). This is in accordance with the persistence of modelled permafrost through the Middle Holocene in the alpine landscape (Etzelmüller et al. 2020). During the Middle Holocene about 5.5-4 ka ago Tröllaskagi glaciers transitioned from their minimum Holocene extent to the early expansion of the Neoglaciation.

The Neoglaciation was characterised by episodic glacier expansion with many ice margins reaching their Late Holocene maximum during the Little Ice Age while some had already reached that during an earlier phase of the Neoglacial. However, this remains unclear in many cases due to lack of dated landforms (Guðmundsson, 1997; Stötter et al, 1999; Kirkbride and Dugmore, 2006). Glacial landforms representing the Late Holocene glacial fluctuations are widespread in the present forelands of cirque and valley glaciers in Tröllaskagi. Common landforms are (hummocky) moraines, both ice free and ice cored, remnants of stagnant debris covered glacier tongues. Those landforms commonly relate to the LIA and Neoglacial fluctuations of the glaciers (Kugelman, 1991; Caseldine and Stötter, 1993; Stötter et al., 1999; Brynjólfsson et al., 2012; Fernández-Fernández et al., 2020; Palacios et al., 2021).

There are currently about 150 glaciers in the Tröllaskagi peninsula situated about 800-1300 m a.s.l. These glaciers are largely controlled by local conditions and microclimate. And thus, the glaciers are often located in north facing cirques and hanging valleys, characterized by reduced solar radiation. Furthermore, the glaciers are often sustained by avalanche derived snow accumulation and snow drifts to off-set their summer ablation (Björnsson, 1991; Brynjólfsson, 2012). Mass balance measurements during the last 15 years have revealed surprisingly many positive mass balance years. However, glaciers still exhibit net loss and discontinuous retreat during this period (Brynjólfsson, 2018, 2019, 2020). There are many partly or even completely debris-covered cirque glaciers which respond slowly to climate fluctuations (Campos et al., 2019) compared to the short respond time of the debris-free cirques and valley glaciers in this region (Björnsson, 1991; Caseldine and Stötter, 1993; Brynjólfsson et al, 2012; Fernández et al., 2017). Some of Tröllaskagi´s glaciers exhibit surge behavior, leaving distinct geomorphological fingerprints like crevasse-squeeze ridges, flutes, hummocky moraine, and small end moraines (opposed to prominent end moraines and often annual moraines in front of the non-surging glaciers; Brynjólfsson et al., 2012).

A total of 178 rock glaciers have been mapped in the peninsula and their present state of activity classified to intact or relict (Lilleøren et al., 2013). They are considered to originate from either paraglacial processes or from debris-covered glacier snouts, both aspect and rate of debris accumulations is considered important for the evolution of these rock glaciers (Jónsson, 1957, 1976; Whalley et al., 1983; 2021; Tanarro et al., 2019; Fernandes et al., 2020; Palacios et al., 2021). The occurrence of rock glaciers and creeping talus slopes at high elevations in Tröllaskagi is consistent with widespread mountain permafrost above 800-900 m a.s.l. (Etzelmüller et al., 2007, 2020; Farbrot et al. 2007; Czekirda et al., 2019

Large landslides (rock slides / rock avalanches) are common in Iceland (with many hundred large rock slope failures), particularly in Central North Iceland, the East Fjords and the West Fjords. The deposits are often clustered around old extinct central volcanos that were buried in the Tertiary basalt rock formations, but subsequently exposed again by Quaternary glacial erosion. In those areas the bedrock stratigraphy is heavily disturbed by the volcanic and tectonic activity, characterized with great dip of bedrock layers, extensive dyke formations, fracture zones, faults and geothermal altered clayish acidic tuff and tephra layers. Consequently these regions are characterized by relatively weak bedrock layers, consistent with the widespread occurrence of landslides around the extinct central volcanos in the basaltic zone of Iceland (Sæmundsson et al., 2005; Pétursson and Jónsson, 2006; Brynjólfsson et al., 2016). Generally, the landslides are largely

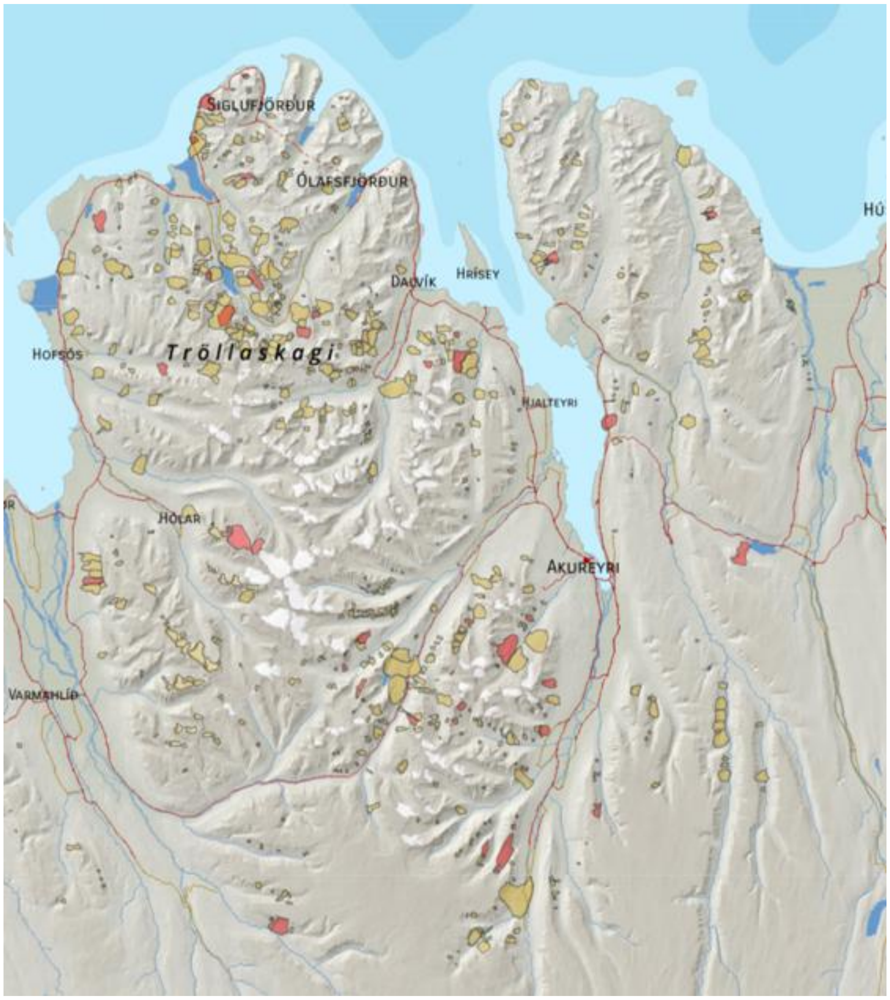


Fig. 4 Above: Overview of mapped landslides in the Central North Iceland region (unpublished, VÍ & NÍ) Red polygons indicated features exhibit active creeping. Below: Photo of Hausafönn an about 0.5 km^2 cirque glacier and there in front an extensive glacier derived ice cored debris, which at present part of is actively creeping and part of is inactive.

believed to have failed shortly after deglaciation. Despite this assumption, landslide morphology and vegetation cover vary greatly from feature to feature (Jónsson, 1976; Whalley et al., 1983; Pétursson and Jónsson, 2006). While very few of these features have been dated directly, rough studies of soil formations and tephrochronology suggest most of failures are Early Holocene in age. However, numerous are believed to be from the Middle Holocene *c.* 3-6 ka BP, as well as some from the Late Holocene include a few historic events (Jónsson, 1976; Guðmundsson, 1997; Pétursson og Jónsson, 2006; Sveinsson et al., 2008). Consequently, there are several theories associated with their failure. (https://www.map.is/base/@535301,538369,z6.332468973795545,0; Stop 5; Leyningshólar)

Common to many previously glaciated regions, the combination of post-glacial debutressing as well as erosional undercutting closely links these failures with deglaciation (during the Late Glacial and onset of the Holocene. Furthermore, it is hypothesized that crustal deformation related to glacio-isostatic adjustment (particularly in Iceland) may also play a key role in the triggering of these large rock slope failures (Jónsson, 1976; Whalley et al., 1983; Cosssart et al. 2014). Ground thermal conditions and changes of ground water conditions are also believed to be a key aspect of rock slope stability in alpine setting. Thus, the degradation of permafrost (deepening of the actively layer and thawing of porewater) during the Holocene thermal optimum may also have resulted in a phase of widespread landslides in Iceland. Additionally, the seismically active landscape of Iceland could also lead to large rock slope failure. This suggests the potential for a series of landslides associated with tectonic instability or a phases of seismic unrest. While some combination of all these aspects likely played a role in the triggering of the several hundred landslides in Iceland, the lack of geochronological constraints does not allow us to effectively allocate a dominant control in failure mechanism (Pétursson, 2006; Sveinsson et al., 2008; Brynjólfsson et al., 2016).

Trip 2:
Signatures of deglaciation dynamics, ice-lakes and their tephrochronological age control in Fnjóskadalur.

The subject of to-day's excursion is to introduce you to the deglaciation history of the northernmost Fnjóskadalur valley and of an ice-dammed lake reaching some 35 km south of the overflow on the Flateyjardalsheiði threshold. The excursion with go to the northernmost part of Fnjóskadalur to the ice-lake overflow and en-route we will experience a successively changing morphology demonstrating deglaciation across the Flateyjardalsheiði threshold and down into a lake basin. Northern Fnjóskadalur Lateral channels are found between 400 m and 500 m a.s.l. on the west side of northernmost Fnjóskadalur. These channels were formed along the margin of a glacier which at that time filled the valley up to about 500 m a.s.l. (Fig. 1).

The very prominent north-south orientated ridge Ásar is an esker (NF-1) which reaches about 260 m a.s.l. just north of Garðsfell. To the north, the Ásar-esker is successively lowered and grades into an esker-network, pitted sandur and an ordinary sandur (NF-2). These features were formed by a glacier that moved north along Fnjóskadalur and terminated on Flateyjardalsheiði. After a retreat of this glacier, a gap was eroded through the Ásar-esker, about 2.5 km north of Garðsfell. This gap is 800 m wide with bottom at about 150 m a.s.l., thus being 50 m lower that the water divide on Flateyjardalsheiði. Northern Fnjóskadalur was at that time drained towards and through Dalsmynni. https://www.map.is/base/@551966,599213,z6.476666666666659,0; Stop 1; Austarikrókar)

The strandline that can be traced along both sides of northern Fnjóskadalur and into Dalsmynni were formed by an ice-lake. Two deltas are found in this part of Fnjóskadalur, one (NF-3) at about 220 m a.s.l. (1 km northeast of Ytri-Hóll) and the other one (NF-4), the Austari-Krókar delta at about 200 m a.s.l. (800 m south of Austari-Krókar. The last-mentioned delta which contains the Skógar/Vedde-tephra, was deposited in the gap in the Ásar-esker. The altitude of the strandlines here is between 200 m and 220 m a.s.l. and shows that an ice-lake had its outlet north across Flateyjardalsheiði, where a 200 m broad channel was cut through the esker-network. Dalsmynni and Ljósavatnsskarð were blocked at that time (Fig. 1 and 3).

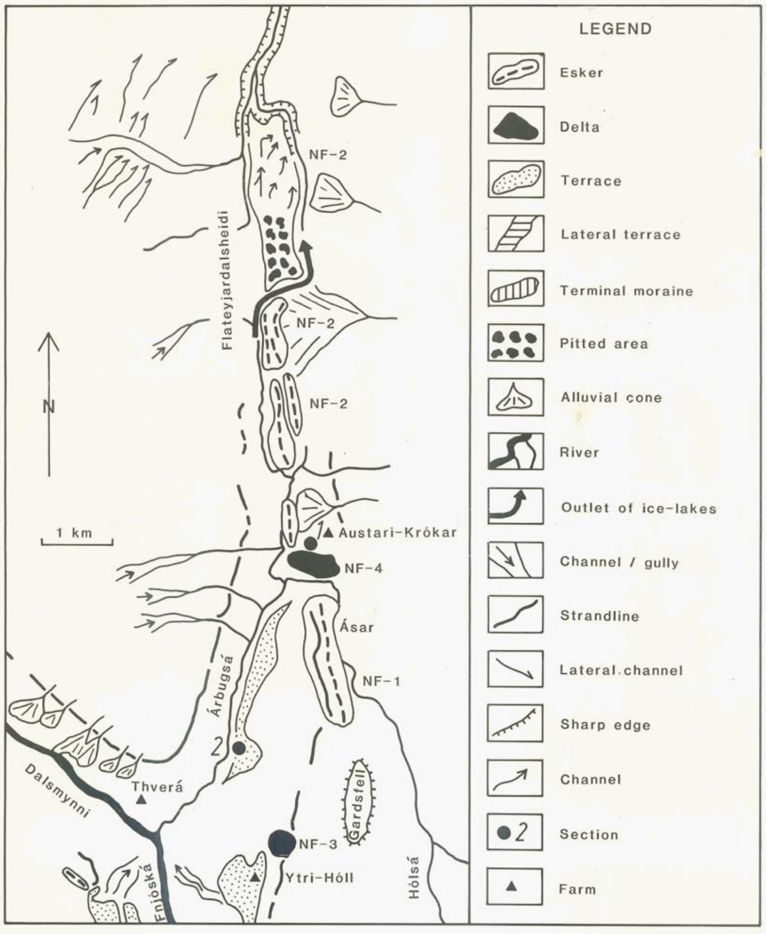


Fig. 1. Map of landforms and features in north Fnjóskadalur (Norðdahl, 1983).

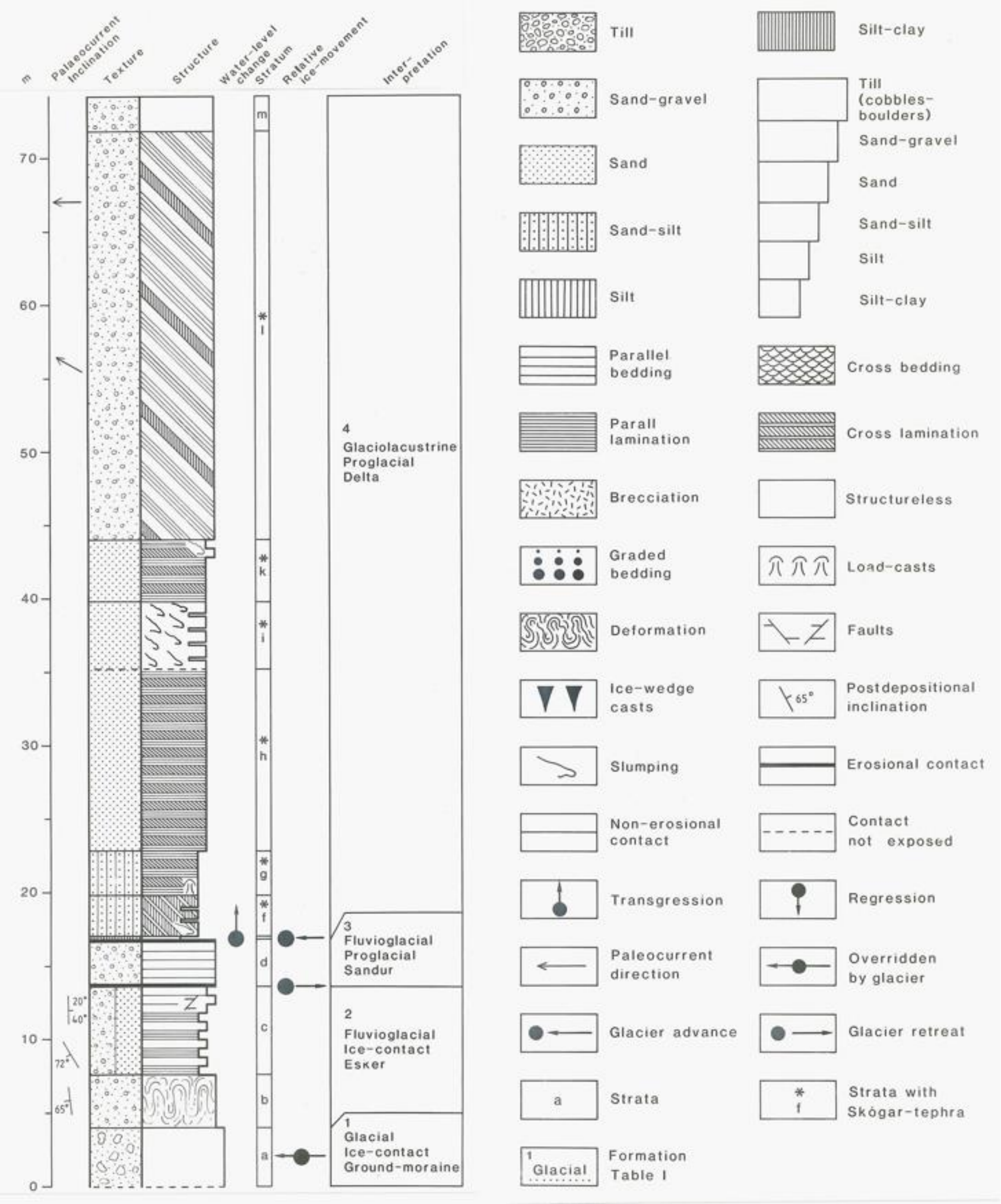
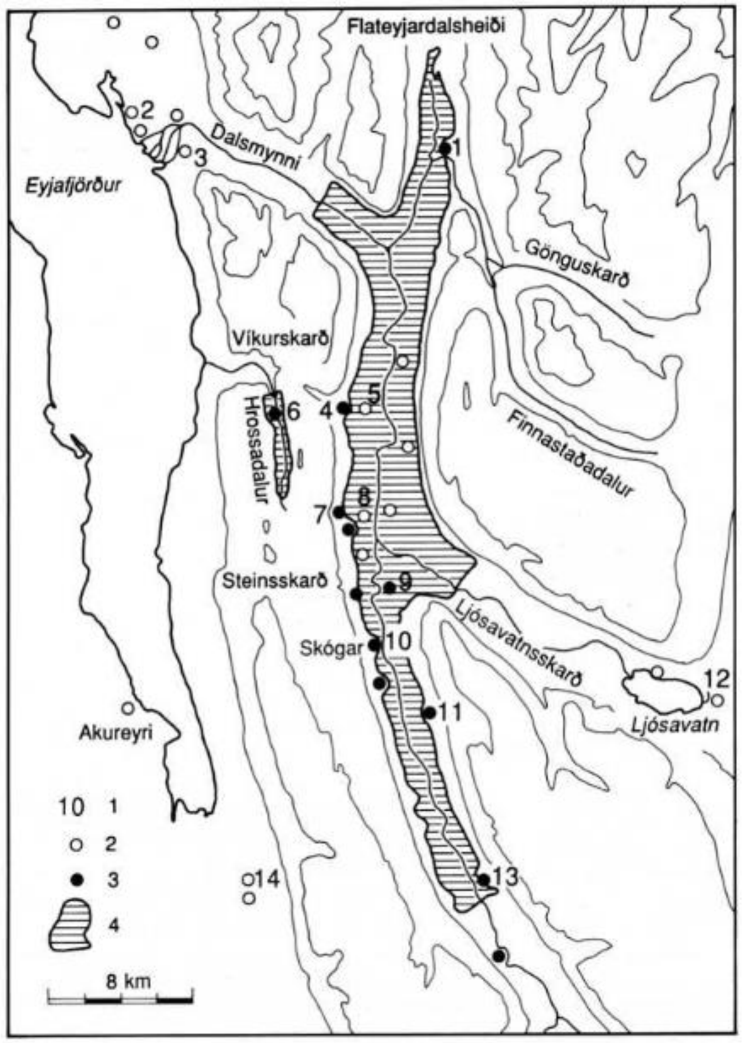
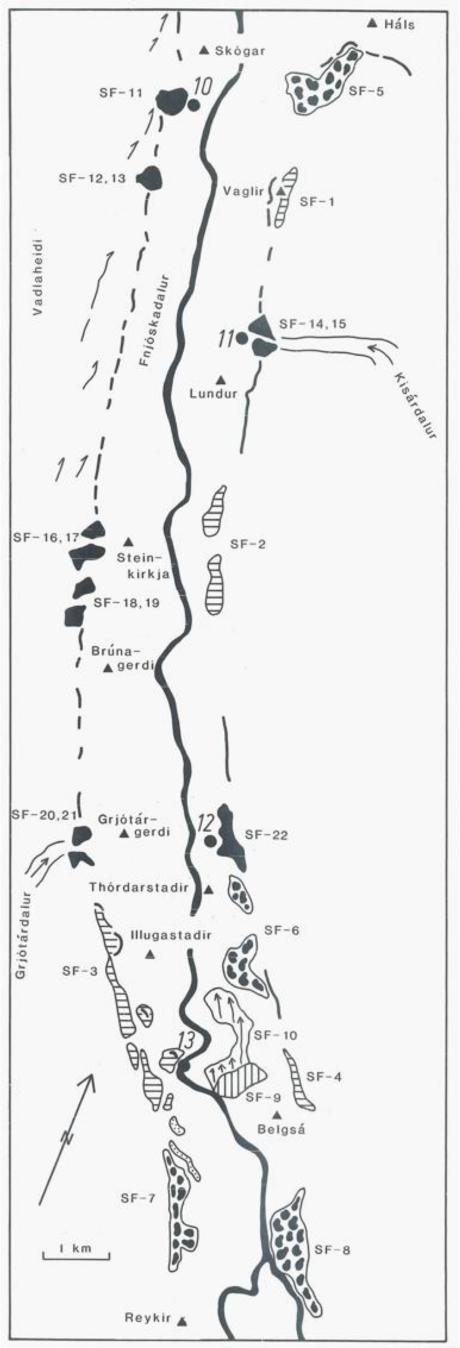


Fig. 2. Top Right: Lithostratigraphic log depicting the Fnjóskadalur sediment sequence (Norðdahl, 1983).





The sediments in the Austari-Krókar delta were deposited towards northwest-west by a stream flowing north along the eastern side of the Ásar-esker. That stream was most likely formed by melt water from the glacier in Bárðardalur being conducted into and through Finnastaðadalur and Gönguskarð when glacier-tongues from the glacier in Bárðardalur reached into the easternmost valleys. The sediments of the Austari-Krókar have, based on their lithological features, been divided into twelve different stratigraphic units that in turn are composed of several beds and laminae. These stratigraphic unit have, based on sedimentological criteria, been interpreted and grouped into four different formations (Fig. 2).

Fig. 3. Left: overview map of the Fnjóskadalur ice lake (Norðdahl, 1983).
Fig. 4. Right: Map of landforms and features in southern Fnjóskadalur (Norðdahl, 1983).

Fm 1, glacial –ice-contact–ground-moraine (diamicton)
Fm 2, fluvioglacial – ice-contact – esker
Fm 3, fluvioglacial – proglacial – sandur
Fm 4, glaciolacustrine – proglacial – delta

Due to the occurrence of the Skógar-Vedde-tephra in the sediments in Fnjóskadalur, it is possible to correlate several deltas with the Austari-Krókar ice-lake. The northwest limit of the Austari-Krókar ice-lake in Dalsmynni is unknown, but towards the south it was limited by the Fnjóskadalur-glacier which terminated at a marginal delta deposited by a stream which flowed towards the north along the margin of the Fnjóskadalur-glacier. Deltas in central Fnjóskadalur (Grímsgerði and Hrísgerði) were formed by streams flowing across the Vaðlaheiði plateau, the mountain ridge between Fnjóskadalur and Eyjafjörður, and into the Austari-Krókar ice-lake (Fig. 3). The composition of the Skógar/Vedde-tephra and its distribution within Fnjóskadalur has been described by Norðdahl & Hafliðason (1992).

In the southern portion of Fnjóskadalur, an east-west orientated till ridge reaching to about 230 m a.s.l. and halfway across the valley floor about 500 m northwest of Belgsá (https://www.map.is/base/@556171,568509,z6.5883333333333323,0) is considered to be a terminal-moraine (Fig. 4). The ridge was deposited on top of a sandur which apparently is undisturbed and which extends for about 1.5 km north beyond the terminal-moraine. The strandlines, which can be traced along both sides of southern Fnjóskadalur and end abruptly opposite the terminal-moraine at Belgsá, were formed in an ice-lake. Above Illugastaðir, a strandline was eroded both into the edge of a terrace and also around the more easterly remnants. This clearly indicates that the glacier had retreated from this part of the valley prior to the formation of the strandline. Seven different deltas can be correlated with the strandlines in southern Fnjóskadalur. A single delta about 1 km south of the Skógar farm at about 255 m asl. It contains the Skógar/Vedde-tephra.

Trip 3

Geomorphological fingerprints of fast-flowing ice streams within the Iceland Ice Sheet in Bárðardalur.

Location on map.is: https://www.map.is/base/@577120,557000,z5,0

Bárðardalur is a 45-km long and 2-3-km wide valley in the North Iceland, extending from Sprengisandur and Ódáðahraun on the edge of the highland plateau and the Northern Volcanic Zone to about 25 km within the coast of the Skjálfandi Bay (Fig. 1). The valley floor is flat between steep but low hills on each side and is covered by the Bárðardalshraun lavas and the glacial river Skjálfandafljót.

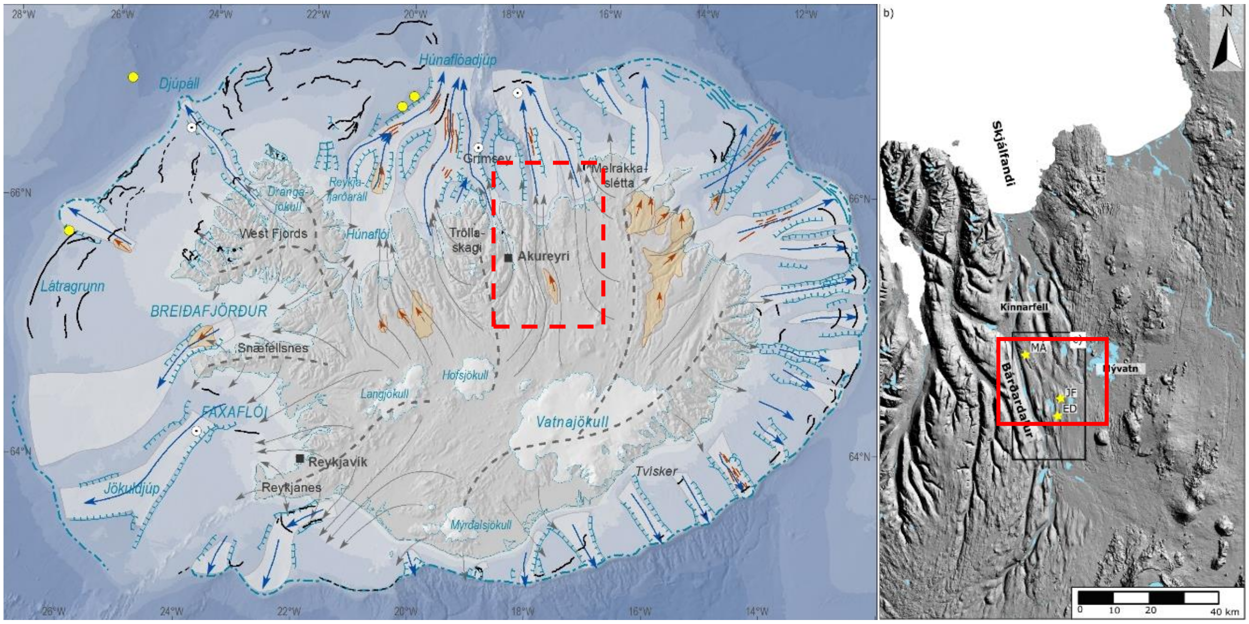


Fig 1. Left: Geomorphological features of the Iceland Ice Sheet. Beige-shaded areas include mapped streamlined subglacial bedforms (from Benediktsson et al., 2022). Red square indicates location of map to the right. Right: Location of Bárðardalur, North Iceland. The red square indicates location of Fig 3.

There are three Bárðardalshraun lavas in the valley (Hjartarson, 2004). The oldest and youngest lavas are coarse-grained while the one in the middle is fine-grained. They have flowed into the valley near the farm Svartárkot at the head of the valley. The middle lava formed Lake Svartárvatn and is most likely older than 10.300 ka BP because the Saksunarvatn tephra is found on top of it. The youngest lava is most visible and covers the valley floor almost towards the coast. The Aldeyjarfoss waterfall cascades off the youngest lava (Fig. 2; Hjartarson, 2004). Geochemical analysis of the Bárðardalshraun lavas suggests origin in the Bárðarbunga system (northern part of Vatnajökull) (Svavarsdóttir et al. 2017).

Figure 2. The Aldeyjarfoss waterfall in the Skjálfandafljót glacial river drops 20 m off the youngest Bárðardalshraun lava.

The glacial river Skjálfandafljót runs through the valley to the Skjálfandi Bay. The plateaus to the east, Fljótsheiði and Mývatnsheiði, have a relatively smooth surface, with no cliffs or sharp peaks. The surface is dominated by streamlined subglacial bedforms that extend all the way from the highland plateau in the south, to the northern end of the plateaus (Fig. 3; Arnardóttir, 2022). During the LGM, the Bárðardalur valley was occupied by the Iceland Ice Sheet, extending onto the northern shelf and probably all the way to the shelf brake (Norðdahl and Pétursson 2005; Patton et al. 2017; Benediktsson et al., 2022). Following a retreat during the deglaciation in the Bølling-Allerød interstadial, the glacier readvanced during the Younger Dryas, reaching the Skjálfandi Bay (Norðdahl and Pétursson 2005). During overall retreat following the Younger Dryas advance, a smaller Preboreal advance has been observed in the palaeo record (Norðdahl and Pétursson 2005).

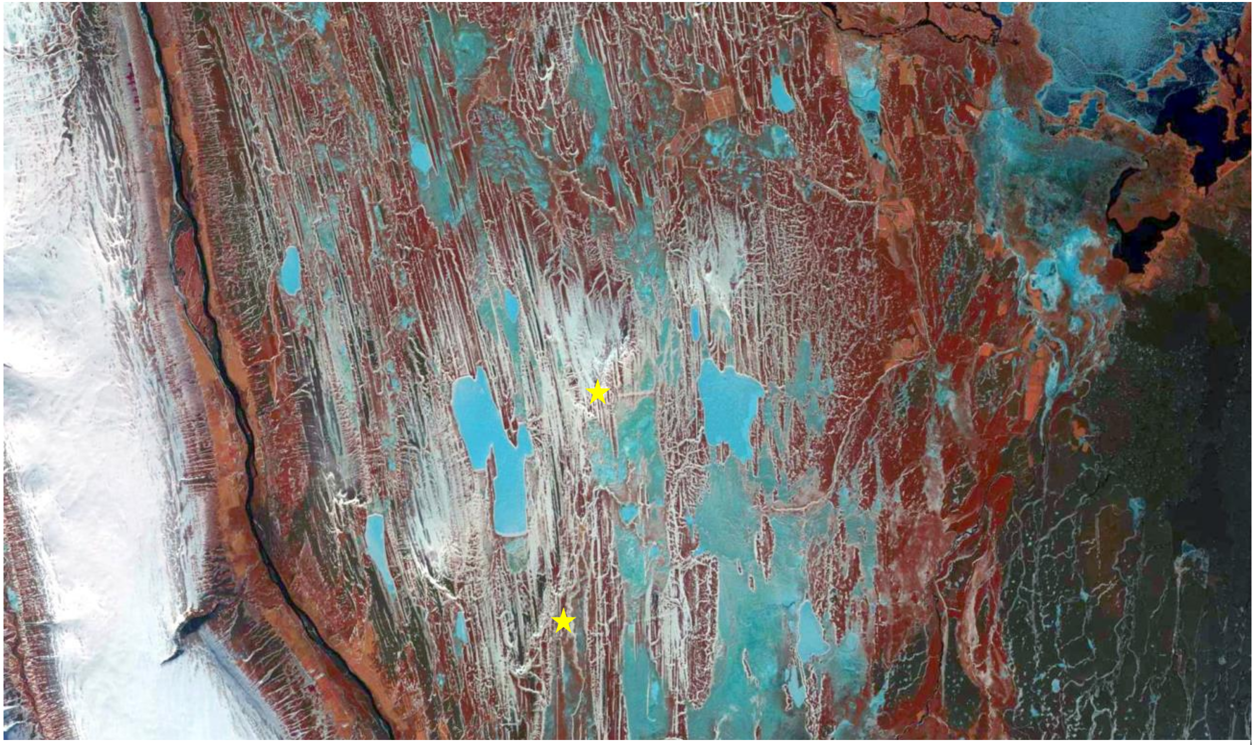


Figure 3. Sentinel-2, near-IR image from 30-03-2022 showing the Bárðardalur valley on the left, with the Skjálfandafljót river (dark streak) running through it to the north, and the streamlined terrain comprising drumlins and mega-scale glacial lineations to the east of the valley. The yellow stars show the approximate location of the Engidalur and Jafnafell sections in drumlins/MSGL.

Engidalur section, location on map.is: https://www.map.is/base/@579087,552780,z11,0
The Engidalur section is located in a N-S oriented landform which is 1095 m long and 80 m wide (elongation ratio 1:14). The section is 4 m tall and 7 m wide covering the center of the landform, slighly oblique to the landform long axis (Fig. 4). Three lithostratigraphic units are identified: 1) very firm, massive diamict; 2) deformed, laminated sand and silt including outsized clasts; 3) massive diamict with strong fissility. Clast morphological analysis reveals blocky and sub-angular to sub-rounded clasts. Clast fabrics are weak to moderately strong.

The diamicts are interpreted to be of subglacial origin (tills) and the sand and silt as glaciolacustrine sediments. Thus, the Engidalur sections represents three phases: 1) an early ice-sheet cover/advance; 2) proglacial lake during glacier retreat; 3) ice margin readvance with active ice streaming eroding, transporting, and deforming pre-existing sediments. Deposition and deformation seem to be dominant factors in the landform construction.

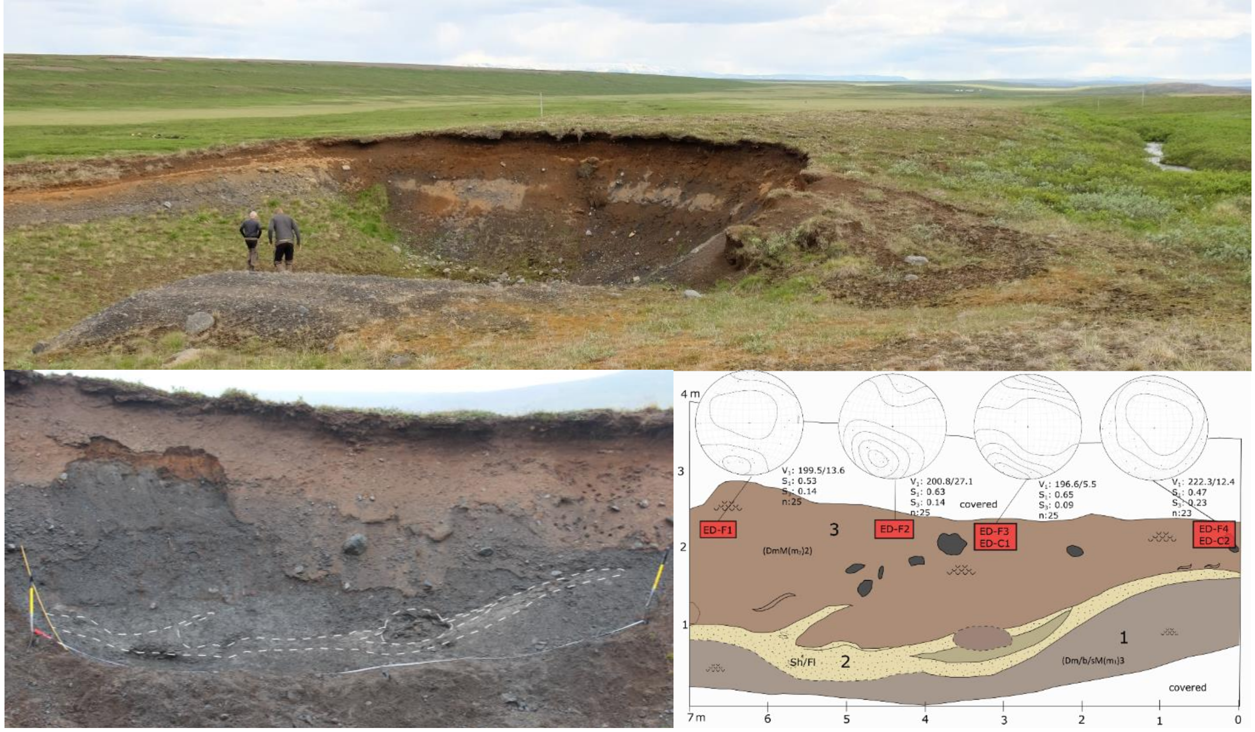


Fig 4. Upper: The Engidalur section, view is up-ice along the landform. Lower left: Annotated photograph of the cleaned section. Lower right: Section drawing showing the three lithofacies units and the deformation. Clast fabrics are shown above drawing.

Jafnafell section: location on map.is: https://www.map.is/base/@579878,557770,z11,0

This section is located in a N-S orientated landform on the southern slope of a small hill named Jafnafell. The landform is 575 m long and 78 m wide (elongation ratio 1:7). The section is 3 m high and 13 m wide and located in the middle of the landform. Four lithostratigraphic units are identified: 1) very firm, massive to stratified diamict; 2) deformed diamict with some ductile deformation; 3) laminated sand and silt; 4) fissile diamict. Contacts between units are generally sharp, unconformable, or interfingering. Clast morphological analysis reveals blocky and sub-angular to sub-rounded clasts. Clast fabric analyses show divergent trend from the long axis of the landform. The Jafnafell section represents multiple events, with the diamicts interpreted to be of subglacial origin (tills) and the sand and silt as glaciolacustrine sediments. The lowermost till represents an early ice-sheet cover/advance and overlying glaciolacustrine sediments indicate a glacial lake during ice sheet thinning and retreat. The glacial lake sediments were subsequently reworked, transported and deformed during an ice-sheet readvance. The divergent clast fabric indicates higher stress and deformation on the flanks of the landform, lenses of sorted sediments between units indication water at the ice-bed interface, and ductile deformation structures suggest high porewater pressure within the sediment. The formation of the landform appears to be dominated by deposition and deformation.

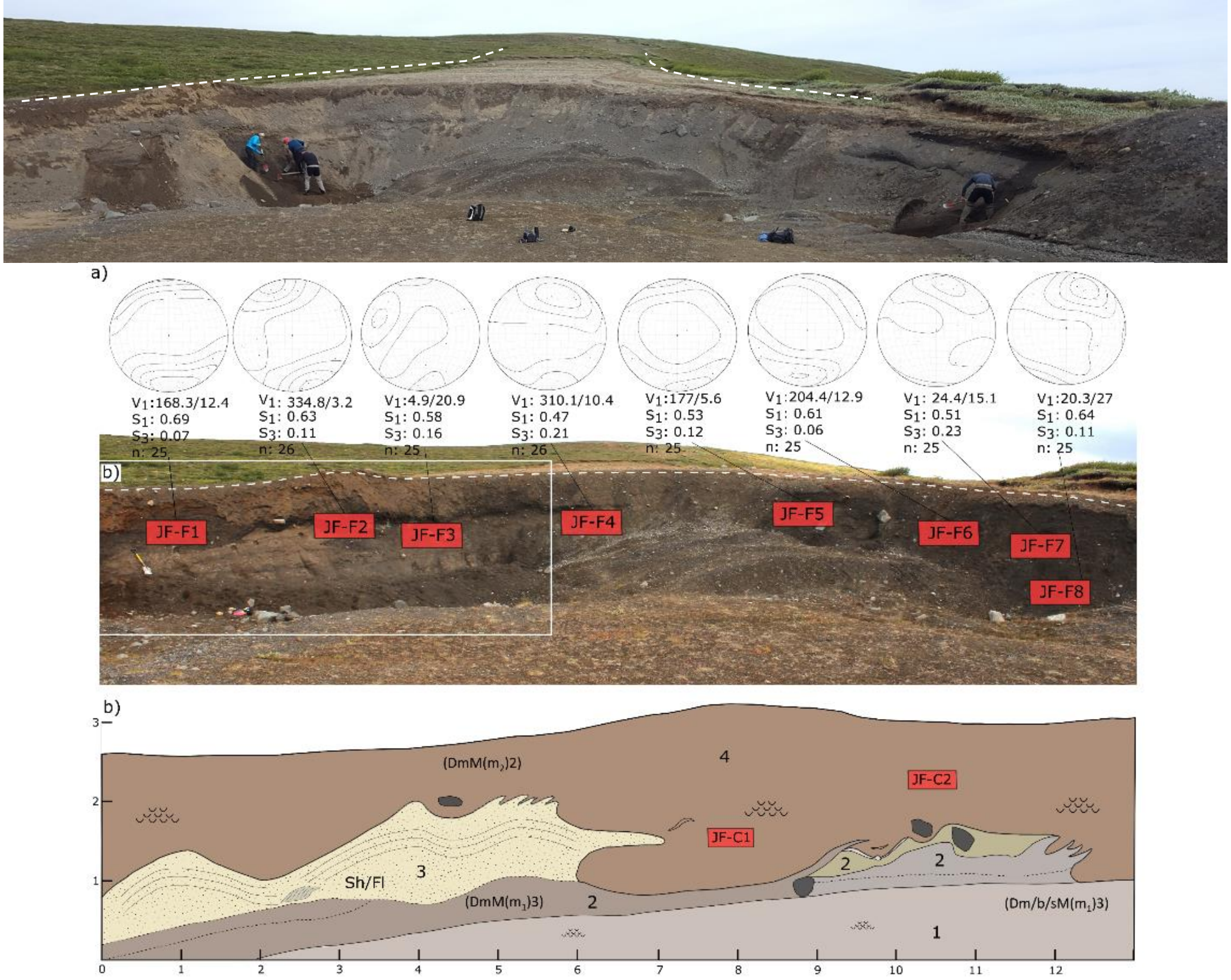


Fig 5. Upper: The Jafnafell section, view is down-ice along the landform. Lower: Annotated photograph and section drawing showing the main lithostratigraphic units and architecture. Clast fabrics are shown above.

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