Fláajökull (north lobe), Iceland: active temperate piedmont lobe glacial landsystem

Journal:	*Journal of Maps*
Manuscript ID:	TJOM-2015-0092.R1
Manuscript Type:	Original Article
Date Submitted by the Author:	13-Jul-2015
Complete List of Authors:	Evans, David,John,Alexander; University of Durham, Geography Ewertowski, Marek; Durham University, Geography; Adam Mickiewicz University, Faculty of Geographical and Geological Sciences Orton, Chris; Durham University, Department of Geography
Keywords:	glacial landsystem, active temperate glacier, Iceland

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David J A Evans, Marek Ewertowski and Chris Orton

Department of Geography, Durham University, South Road, Durham DH1 3LE, UK

Corresponding author: d.j.a.evans@durham.ac.uk

Abstract

A 1:6,250 map of the foreland of Fláajökull's north lobe as it appeared in 1989, together with a 1:350 scale map of a sample area of recently exposed glacial landforms from 2014, enables an assessment of the spatial and temporal evolution of glacial landform assemblages at the margin of an active temperate piedmont lobe terminating at ice-marginal thickening till wedges. The pattern of landform development captured in these maps indicates that the glacier margin developed strong longitudinal crevassing and well-developed ice-marginal pecten (three dimensional crenulations) during its historical recession. This is recorded by early recessional phase linear push moraines on well-drained distal slopes of the foreland and the later development of inter-related sawtooth moraines, crevasse squeeze ridges and till eskers, indicative of extending ice flow and poorly drained sub-marginal conditions. This landform record is a palaeoglaciological signature of a changing process-form regime inherent within the active temperate piedmont lobe landsystem model.

Key words: glacial landsystem; active temperate glacier; Iceland

1. Introduction

The aim of this study was to map, at the large scale of 1:6,250, the distribution of glacial sediment-landform associations on the Fláajökull north lobe foreland (Figure 1), an area that displays a conspicuous arcuate moraine assemblage, comprising fluted/overridden ridges, recessional push ridges and geometrical ridge networks. This landsystem signature displays many similarities to that of the neighbouring forelands of Heinabergsjökull and Skálafellsjökull (Evans & Orton 2014), indicative of all these glacier snouts being characterized by the dynamics of active temperate piedmont lobes. However, the density of overridden moraines and widespread occurrence of sawtooth moraines (cf. Price 1970; Matthews et al. 1979; Fredin & Burki 2008; Burki et al. 2009) with unusually long limbs, geometrical ridges (crevasse infills), and numerous till eskers (*sensu* Christoffersen et al. 2005; Larsen et al. 2006; Evans et al. 2010) are embellishments specific to this landsystem that reflect the intensive development of longitudinal crevassing in lobate snouts terminating at marginal-thickening till wedges (cf. Evans & Hiemstra 2005) rather than outwash heads, as exemplified at Heinabergsjökull. Given the importance of the juxtaposition and complex interactions of the various sub-marginal landforms evolving at the glacier snout at the present day, a further larger scale map (1:350) was produced for a small area of the foreland based upon an unmanned aerial vehicle (UAV) aerial survey in 2014. This large scale mapping provides some details representative of the complex set of landforms that have emerged on the foreland since 1989, during which time Fláajökull has receded by more than 500 m

2. Methods of map production

The map 1:6,250 map has been produced with no new topographical ground survey of the study area. Hence the landform and surficial geology mapping was undertaken on two, non-rectified, and manually stitched aerial photographs taken by Landmælingar Íslands in 1989, and contours are derived from the existing 1:50,000 topographic map, based on the ISN 93 datum. The relief of most landforms is less than the 20 m contour intervals and therefore the lack of newly surveyed contours does not impact significantly on the representation of the glacial geomorphology. The distortion inherent in non-rectified aerial photographs was minimized by using the central portions of the images for mapping. The glacier surface is represented by a mask compiled directly from the aerial photographs but does not contain any contours as these were not surveyed for this map.

Since 1989 Fláajökull has receded by more than 500 m along most of its margin, exposing a complex network of glacial landforms. Continued observations on the spatial and temporal development of these landforms provide invaluable insights into the evolution of the glacial geomorphology of the whole foreland and hence a large scale (1: 350) map of the most recent features exposed at the north side of the snout was compiled based on a UAV survey in September 2014 (Figure 2). Low altitude images were taken using a small, lightweight UAV quadcopter equipped with a 12-megapixel, wide-angle lens camera. Images were acquired at an elevation of 40 m above the launching point. The ground image pixel size was ~0.016 m. In total four flights were performed and 175 images were taken covering 0.1 km^2. The craft was equipped with a 3D gimbal system and because images were acquired while the craft was hovering, photographs were all well focussed. The images were handled with Agisoft Photoscan software. A point-cloud containing 98.90 million points was generated and subsequently georeferenced to the UTM 28N coordinate system using 23 ground control points (GCPs). GCPs were surveyed with Topcon Hiper II dGPS system and post-processed. GCPs were used to optimize and provide survey control on the point-cloud. An average density of points was 963.7 points/m^2. Finally, meshed 3D models were generated from the point-cloud and subsequently transformed into a raster, grid DEM with 0.03 m cell size. The total DEM error measured against GCPs was 0.063 m (x = 0.037, y = 0.038, z = 0.035). A low-density point-cloud was used to produce an orthophoto mosaic with the 0.016 m cell size to enable high resolution landform mapping.

3. Historical evolution of the Fláajökull snout and foreland

The earliest map of Fláajökull is the Danish Geodetic Survey map of 1904, which depicts the glacier margin some 300 m inside the maximum historical limit (Figure 1). Evans et al. (1999) lichenometrically dated the outermost moraine of Fláajökull's south lobe, in the valley (Heinar) that joins the foreland of Heinabergsjökull. From this they proposed an age of 1884/85 based upon the age-size approach and an acceptance of historical documentation that indicates an 1887 AD maximum age for the outermost Little Ice Age moraines in the area, for both Heinabergsjökull and Fláajökull (Thorarinsson 1939); the period 1882-1892 was identified by Ahlmann and Thorarinsson (1937) as a time frame for the maximum of the most recent Little Ice Age advance of Fláajökull. A longer chronology has been proposed by McKinzey et al. (2004, 2005) for the Heinabergsjökull moraines lying immediately inside the proposed 1887 AD moraines of Evans et al. (1999). This is based upon the employment of the size-frequency lichenometric method and the discovery of tephras in the moraine stratigraphy, suggesting a date of sometime between 1850 and 1887 AD, using Bradwell's (2004) age-gradient curve, or 1818–1886 AD, using Bradwell's (2001) age-size curve. These calculations infer an older age for Evans et als' (1999) outer moraine, a moraine that Dabski (2002, 2007) suggests dates to 1870-1894 AD using a variety of dating methods and archives.

In the early to mid-1990s, a number of south Vatnajökull outlet glaciers, including Fláajökull, readvanced and maintained a quasi-stationary ice front for around 5 years (cf. Bradwell et al. 2006; Evans et al. 2009; Bennett & Evans 2012). This was significant in terms of the Fláajökull foreland geomorphology in that it resulted in the construction of a composite push moraine (Evans 2003, 2005; Evans & Hiemstra 2005) typical of stationary temperate glacier snouts (Krüger 1993; Evans 2013). This moraine was being initiated at the time of aerial photograph capture in 1989 and was observed during its construction and abandonment over the period 1993-2002, allowing a full understanding of the process-form relationships and process sedimentology associated with sub-marginal till accretion and moraine genesis (Evans & Hiemstra 2005).

The large lakes that are portrayed on the map near the snout have been deepened and extended by the artificial damming of the westerly flowing meltwater rivers as part of a long term strategy to divert the proglacial drainage over the sandur (see "made ground" surficial geology classification). More recently, further dams have been constructed to divert the majority of the drainage again towards the west, resulting in the more extensive flooding of the landforms portrayed on this map around the large lakes and in the linear sandur corridors that are aligned ice margin parallel.

4. Glacial geomorphology and surficial geology

Seven surficial geology map units are identified on the glacier foreland on the 1:6,250 scale map, each one being associated with specific landforms and geomorphic process-form regimes. These are colour-coded on the map and relevant landforms are depicted using symbology, following the protocol established for previous Icelandic glacier foreland maps (Bennett et al. 2010; Evans & Twigg 2002; Evans et al. 2006a, 2007, 2009; Evans & Orton 2014; Howarth & Welch 1969a, 1969b). The foreland is dominated by glacifluvial deposits and till, with other surficial units forming only minor coverage.

4.1 *Till and moraine*

The till and moraines surficial map unit is characterized by the surface flutings and recessional push moraines typical of the active temperate landsystems of southern Iceland but also contains conspicuous crevasse fill ridges and minor till eskers, that are not widely displayed in active temperate forelands elsewhere. Individual till stratigraphic units are typically less than 1 m thick and display all the characteristics of subglacial traction till (Evans 2000; Evans et al. 2006b). Thicker till coverage occurs where composite moraines have been constructed by marginal till wedge stacking, resulting in repeating vertical sequences of multiple A and B horizons (*sensu* Boulton & Hindmarsh 1987; Figure 3). Such a process was observed during the early 1990s, when a negative North Atlantic Oscillation signal triggered glacier snout readvance and stabilization for at least 5 years (Bradwell et al. 2006; Evans & Hiemstra 2005; Figure 4a, b). The resulting composite moraine (Figure 4c) was under construction on the 1989 aerial photographs and hence is depicted in this map at the glacier margin. Thicker tills also occur where the most recent (historical Little Ice Age) till sheet overlies overridden moraines. More common are thin tills (<1 m thick) and individual recessional push moraines, which are produced every year and typically have a saw-tooth or crenulated plan form (Figure 5). This morphology has been clearly related in Iceland to construction along glacier snouts strongly indented by closely spaced, longitudinal crevasses or pecten (Price 1970; Sharp 1984; Evans & Twigg 2002; Evans & Orton 2014). The localized close spacing of these moraines, together with annual shifts in the positioning of pecten, gives rise to areas of extremely complex superimposition (Figure 5). Although the fine-grained diamictic till blanket and sawtooth push moraines dominate the till and moraine map unit, more bouldery tills and moraines have been constructed at the former southwest margin of the glacier (Figure 6). Here a sequence of marginally stacked boulder-rich tills have been constructed at the historical Little Ice Age maximum limit, documenting the delivery of coarser debris loads to the former ice margin from the steep bedrock bluffs that separate the north and south lobes of Fláajökull.

The locally well-developed crevasse fill ridges and minor till eskers are morphologically distinct from push moraines because they are orientated oblique to push moraine crests but not parallel to former ice flow, the latter indicated by adjacent fluting patterns. The crevasse fill ridges are similar to the geometric ridge networks described from many other glacier forelands (cf. Sharp 1985; Evans & Rea 1999, 2003; Jónsson et al. 2014) in that they comprise numerous straight limbs attached end on end, and in places cross each other to form elongate rectilinear nets. However, they nowhere resemble the dense, polygonal net shapes that have been reported as evidence of surge-induced crevasse squeeze ridge construction in Iceland (Sharp 1985; Evans & Rea 1999; Kjær et al. 2008; Rea & Evans 2011; Schomacker et al. 2014). In a number of cases these ridges merge into, or are aligned with, the limbs of sawtooth moraines, indicating that they originated by a similar depositional mechanism. Many such examples are now visible on the recently (post 1990s) deglaciated foreland (Figure 7), some of which are difficult to distinguish from flutings because they have been squeezed up into very long longitudinal crevasses. Hence the Fláajökull crevasse fill ridges are a product of glacier sub-marginal till squeezing into the dense longitudinal crevasse networks that give rise to remarkably indented radial pecten at the snout. Therefore the sawtooth push moraines and crevasse fill ridges are a landform assemblage diagnostic of strong radial ice flow in piedmont lobes overlying deforming till in saturated (poorly drained) locations (cf. Jónsson et al. 2014). Their predominance on the tops of overridden moraine arcs on only the inner half of the foreland attests to the former extensional crevassing created in the ice margin by the localized, arcuate topographic high points in the glacier bed.

Sinuous diamicton ridges or till eskers (Figure 8) have been identified previously on only a few glacier snouts globally (cf. Christoffersen et al. 2005; Larsen et al. 2006; Evans et al. 2010). Their origin in Icelandic settings is hypothesized to relate to the squeezing of dilatant till into an elongated cavity or R-channel immediately after meltwater evacuation, during a short period when the pressure gradient between the cavity and the till bed was steep and hence saturated till was subject to localized creep towards the elongate low pressure zone (Evans et al. 2010). In order to be preserved on a deglaciated foreland, till eskers must have been produced during the final stages of subglacial sedimentation, otherwise shear deformation would have remoulded them. As crevasse squeeze ridge preservation requires the same conditions, it is unsurprising to find them juxtaposed with till eskers (Figure 9).

Previous maps of the forelands of Icelandic active temperate glaciers have depicted areas of discrete overridden moraines but the extensive nature of the overridden moraine arcs at Fláajökull necessitate their inclusion in the till and moraine mapping unit. They constitute the underlying topography of the till and moraine area but are most prominent in the middle and inner foreland where they give rise to enclosed contours at 40 m and 60 m above sea level (Figure 10). They are inset, low amplitude arcs of fluted till (cf. Evans et al. 1999, 2009; Evans & Orton 2014; Evans & Twigg 2002; Krúger 1994) deposited prior to or during glacier advance to the historical Little Ice Age limit and then superimposed by sharper relief recessional push moraines during snout recession. The crests of the more recent push moraines are predominantly orientated parallel with the summit crests of the overridden moraines, making them easy to distinguish from other adornments including crevasse fill ridges and till eskers. Areas dominated by overridden moraines are evident also on the map where elongate ponds are absent or rare; such ponds are common between the localized high points formed by the recessional push moraines, especially on the outer foreland where overridden moraine arcs are less prominent.

4.2 *Glacifluvial deposits*

Glacifluvial deposits (including sand and gravel-cored eskers) are predominantly located in proglacial outwash sandur fans and glacier-margin parallel linear sandar. The major terraces and eroded cliffs on the sandar are mapped by the identification of terrace and cliff edges. The sandur fans, occupying the southwest, south and east parts of the map, were constructed largely during the historical Little Ice Age maximum when proglacial streams drained the outermost moraine arc. These have been incised and are now only partially occupied by the modern drainage after it passes through corridors between the overridden moraine arcs. Recent attempts by farmers to modify the drainage have given rise to localized ponding of these drainage corridors. The corridors are occupied by linear sandar which are orientated parallel to the ice-margin because they have been and are directed by the underlying topography of the overridden moraine arcs (Figure 10). Sand and gravel cored eskers are rare on the foreland, being located only in a large melt-out depression on the north side of the snout. This depression and its associated landforms, including the eskers, has evolved and gradually drained over the last two decades. The evolution of the area from a largely flat but locally pitted outwash surface to a large depression containing gravel and sand mounds and esker ridges displays all the process-form relationships of areas of melting glacier snouts buried by glacifluvial outwash and containing englacial drainage tunnels. Similar landform assemblages have evolved at the margins of Breiðamerkurjökull (Evans & Twigg 2002), Kvíárjökull (Bennett et al. 2010; Bennett &

Evans 2012) and Virkisjökull/Falljökull (Livingstone et al. 2010; Bradwell et al. 2013), where meltwater drainage appears to have bypassed overdeepenings in the subglacial environment.

4.3 *Glacilacustrine deposits*

A minor pocket of glacilacustrine deposits occurs on the northern part of the foreland, where it records the gradual emptying of the large melt-out depression produced by burying of part of the glacier snout by glacifluvial outwash. This forms a thin blanket to a veneer generally less than 3 m thick of sands, silts and clays.

4.4 *Bedrock, residuum and paraglacial deposits*

Minor surficial units of bedrock, residuum and paraglacial deposits are depicted at the western and northern extremities of the map where they occur in association with the steep mountain slopes of Jökulfell and Fláfjall respectively. The *in situ* weathering products of the bedrock, which occur on the more shallow slopes and knolls, are classified as residuum. These areas of weathered bedrock also contain small patches of deeply weathered or wind deflated pre-Little Ice Age till too small to depict at this scale. Also present in such areas are localized drapes of aeolian (tephra) deposits and peat, especially in topographic hollows, again too small for representation at this scale. The paraglacial deposits include colluvial and debris flow fed fans reworked since historical glacier recession from glacial deposits on steeper slopes. Also included as paraglacial materials are scree slopes and debris flow fans derived from mechanically weathered bedrock outcrops. Numerous small bedrock outcrops, too small to map at this scale, also occur within the areas mapped as paraglacial deposits.

4.5 *Made ground*

Due to the localized historical modification of the foreland by farmers attempting to divert glacial meltwater, there are small areas of made ground. These constitute dams which have also been used as tracks and occur only in the western part of the foreland.

Spatial and temporal changes in the Fláajökull foreland: implications for the active temperate glacial landsystem model

Glacial landsystem maps allow the identification of landform patterns which can be instructive in relating process to form in both a spatial and temporal framework (cf. Bennett et al. 2010; Evans & Twigg 2002;). At Fláajökull, the north lobe has produced a distinct set of landform patterns that can be related to changing glaciological conditions through time and hence allow us to refine the active temperate piedmont lobe landsystem model (Figure 11). Firstly, we interpret the multiple arcs of overridden moraines as products of composite push ridge construction during phases of glacier stillstand (cf. Evans & Hiemstra 2005), either during a previous period of snout recession or during its advance to the Little Ice Age maximum. The marked snout-parallel linearity of the sandar deposited since recession from the Little Ice Age maximum limit has been developed as a result of the topographic control exerted by the overridden moraine arcs. Secondly, the recessional push moraines display two clear patterns; closely spaced and more linear forms occur on the outer foreland, whereas more sawtooth and partially superimposed forms occur on the inner foreland. The moraines of the inner foreland are also arranged in a series of clusters, the spacing between each cluster getting progressively smaller towards the present glacier margin. These two zones are separated by a fluted till surface with very few, fragmented push moraines, recording a period of glacier retreat over a distance of 250 m when moraine construction was subdued, likely due to rapid snout recession. Prior to and after this, more substantial push moraines were constructed every 2-50 m, with some superimposed moraines indicating several or more years of ice marginal stillstand. Finally, the distribution of crevasse squeeze ridges and till eskers on the inner foreland indicates that sub-marginal conditions were conducive to the squeezing of till into full depth crevasses and tunnels in the snout during the more recent period of glacier recession. This coincides with the change in push moraine pattern identified above and therefore represents a geomorphic signature of a change from a non-crevassed to a longitudinally crevassed snout with well-developed pecten as well as a change from a well-drained to poorly-drained foreland.

The underlying control on both of these inter-related changes is the topography of the substrate that was inherited by the glacier snout as it advanced and retreated from its historical Little Ice Age maximum. Specifically this topography was the surface of the overridden moraine arcs, as defined by the enclosed 40 m and 60 m contours; these contours define two overridden moraine arcs, the outermost of which possesses a long, shallow distal slope on which the outer zone of linear recessional push moraines and flutings are developed. The inner zone of superimposed sawtooth moraines, crevasse squeeze ridges and till eskers are developed inside the steeper, proximal slope of the outer overridden moraine arc; the increased spacing density of the sawtooth moraines begins inside the innermost overridden moraine arc where more extensive areas of low lying, poorly drained surfaces occur. Since 1989, when the aerial photographs used for mapping were taken, another overridden moraine arc has emerged, as represented by the enclosed 60 m contours on the northeast side of snout; this topographic high point has been adourned with the composite push moraine constructed during the mid-1990s readvance (Figure 5). Hence the glacial geomorphology records the development of strong longitudinal crevassing and concomitant well-developed ice-marginal pecten in the north lobe during its historical recession (Figure 9); during early recession from the shallow distal slope of the outermost overridden moraine, ice flow was most likely compressive and hence the ice margin was not heavily crevassed. Drainage was also unimpeded towards the south and onto the proglacial sandur fan. In contrast, since recession from the steeper proximal slope of the outermost overridden moraine arc, ice flow has been extensional as well as strongly lobate and the glacier snout has progressively thinned. Therefore full depth crevassing and pecten production has been the dominant control on glacier sub-marginal and marginal landform construction. Combined with the relatively poor proglacial drainage imparted by the emerging subglacial topography, this has given rise to a clear change in the nature and distribution of glacial landforms on the foreland and hence a palaeoglaciological signature of a changing process-form regime in an active temperate glacier lobe fed by marginal-thickening till wedges.

Conclusion

The 1:6,250 scale map of the glacial geomorphology and surficial geology of the Fláajökull north lobe foreland depicts an arcuate moraine assemblage, composed of fluted and overridden moraines superimposed by smaller recessional push moraines, geometrical ridge networks (crevasse squeeze ridges) and till eskers. The overridden moraines contain cores of multiple tills and associated glacifluvial sediments and mark the locations of former composite push moraine construction by glacier-marginal till thickening during periods of glacier stillstand, similar to that observed during the mid-1990s. They were overridden and fluted by the glacier during its advance to the Little Ice Age maximum and, despite being superimposed by smaller scale recessional landforms, their morphology has exerted a topographic control on the routing of proglacial outwash in snout-parallel linear sandar tracts. This subglacial topography, comprising three inset overridden moraine arcs lying inside a shallow distal sloping foreland, has been influential also in changing the glaciological and sub-marginal drainage conditions through time, as documented by the nature and pattern of the superimposed landforms that document the historical recession of the snout. The landforms indicate that the piedmont glacier lobe developed strong longitudinal crevassing and well-developed ice-marginal pecten during its historical recession. This is recorded by early recessional phase linear push moraines on the shallow, well-drained distal slope of the outermost overridden moraine, indicative of compressive ice flow, followed by later development of inter-related sawtooth moraines, crevasse squeeze ridges and till eskers, indicative of extending ice flow and poorly drained sub-marginal conditions. Hence the glacial geomorphology of the Fláajokull north lobe foreland documents a clear palaeoglaciological signature of a changing process-form regime and allows us to refine the active temperate piedmont lobe landsystem model, specific to forelands characterized by marginal-thickening till wedges and the topographic influence these wedges impose on smaller scale landform production in relation to glacier snout crevasse networks and sub-marginal drainage conditions. It also clearly demonstrates that the holistic nature of the landsystems mapping approach is a powerful tool in deciphering the palaeoglaciological record.

Software

The dGPS ground control points were processed using the Canadian Spatial Reference System (CSRS) Precise Point Positioning (PPP) tool. The orthophotomap and digital elevation model from UAV-based images were produced in Agisoft Photoscan Professional Edition. The geomorphology for the 1:350 map was prepared in ESRI ArcGIS and edited in Adobe Illustrator. The 1:6,250 scale map was drawn in Adobe Illustrator and the glacier image manipulation was undertaken in Adobe Photoshop.

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Figure captions

Figure 1: Annotated Google Earth image of Fláajökull and its foreland, showing the positions of the glacier snout through time based on various records.

Figure 2: Workflow diagram showing the construction of the 1:350 scale map of a portion of the recently deglaciated foreland based on UAV captured imagery.

Figure 3: Stratigraphic exposure through the innermost overridden moraine arc on the north side of the foreland, with boundaries between major sedimentary units marked by dashed lines. The lowest unit in the cliff is glacifluvial outwash and this is overlain by multiple tills with minor and discontinuous lenses of sand and gravel. Note that minor push moraines lie on the surface of the overridden ridge and these are related to the uppermost till.

Figure 4: The early to mid-1990s composite push moraine: a) during formation on the central foreland in 1993; b) cross section through the moraine on the north foreland after its abandonment in 2002, with multiple till units identified (after Evans & Hiemstra 2005); c) view across the moraine on the west foreland in 2014. Note the very steep distal and proximal slopes at this location.

Figure 5: View across the north foreland in 2008, showing the early to mid-1990s composite moraine in the centre foreground and the cross-cutting nature of this and the earlier sawtooth moraines as well as the most recent deglaciated foreland with its complex of overprinted push moraines, crevasse squeeze ridges and till eskers.

Figure 6: The historical Little Ice Age maximum moraines on the southwest margin of the north lobe: a) view across the moraine ridges, showing their bouldery nature; b) stratigraphic exposure through the moraines, showing glacier marginally stacked boulder-rich tills outlined by dashed lines.

Figure 7: View across the recently deglaciated foreland in 2014, showing the details of cross-cutting and merging of crevasse squeeze ridges, sawtooth moraine limbs and frontal lobes, and minor flutings. The dense longitudinal crevasse networks and pecten responsible for these landforms are visible in the glacier snout.

Figure 8: Sinuous diamicton ridge, interpreted as a till esker, on the central foreland.

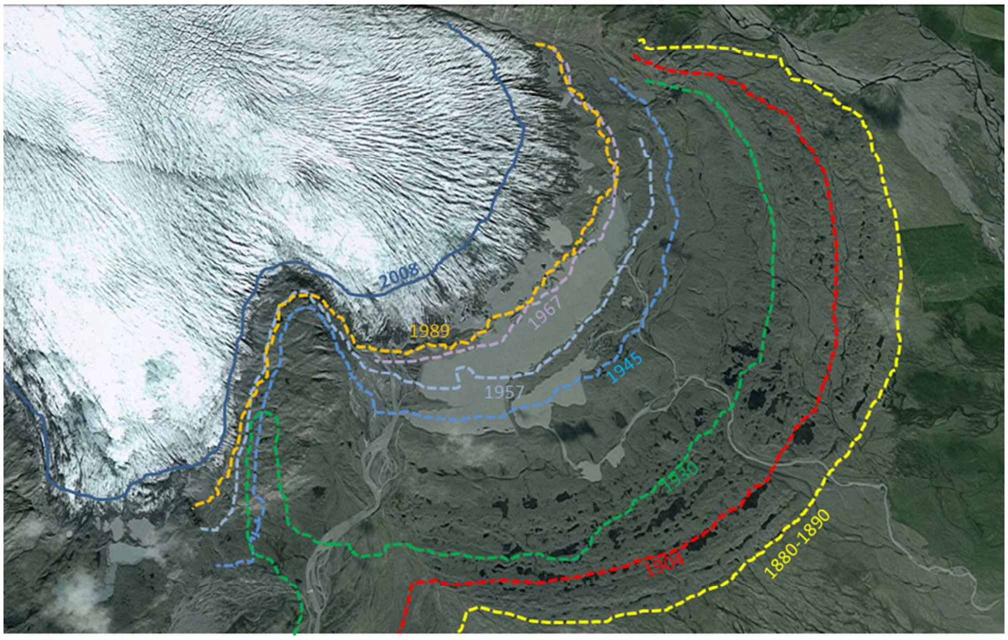
Figure 9: Views across the recently deglaciated foreland showing the juxtaposition of crevasse squeeze ridges/sawtooth moraines and sparse till eskers, including the area surveyed for the 1:350 scale map: a) ground view with main landforms identified; b) UAV oblique aerial photograph looking south; c) UAV oblique aerial photograph looking north, towards the glacier snout and showing the relationship between landform orientations and pecten.

Figure 10: View across an overridden moraine arc and linear, ice margin-parallel sandur towards the historical Little Ice Age maximum limit. The overridden moraine is outlined by the dashed line and is covered by crevasse squeeze ridges and minor flutings as well as some small recessional push moraines.

Figure 11: Conceptual model for the spatial and temporal development of the landform assemblages on the Fláajökull north lobe foreland, along a simplified topographical cross profile from the historical Little Ice Age limit to the present glacier margin.

Acknowledgements

Fieldwork at Fláajökull has been conducted during a number of field seasons under the auspices of the University of Glasgow Iceland Expeditions 1993 and 2002, and the Durham University Iceland Expeditions 2009 and 2014, funded by the Royal Scottish Geographical Society, Carnegie Trust and Royal Geographical Society. ME was supported by a Marie Curie Intra European Fellowship, 7th 471 Framework Programme (REA agreement number 299130). Comments by reviewers Simon Carr, Richard Waller, Alan Kehew and Anders Schomacker helped us to clarify the contents of this paper.



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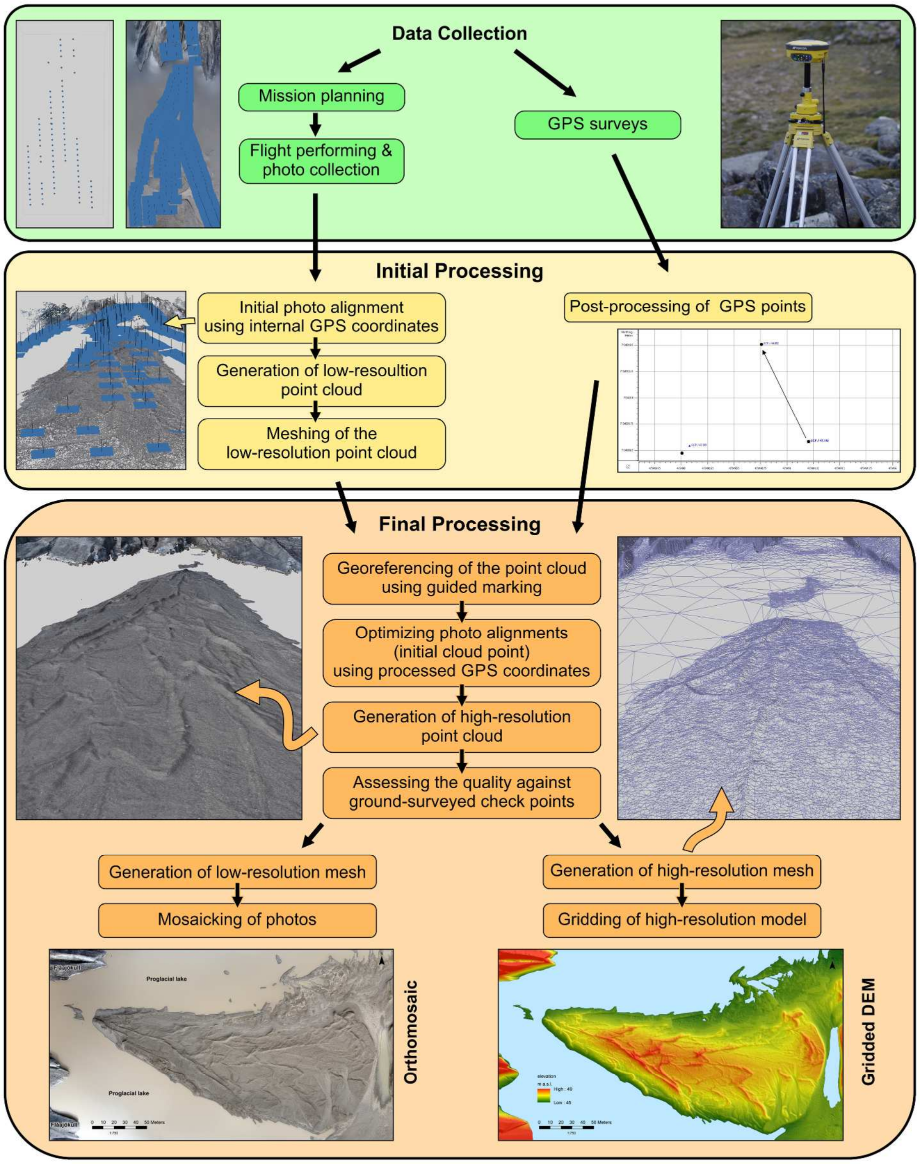

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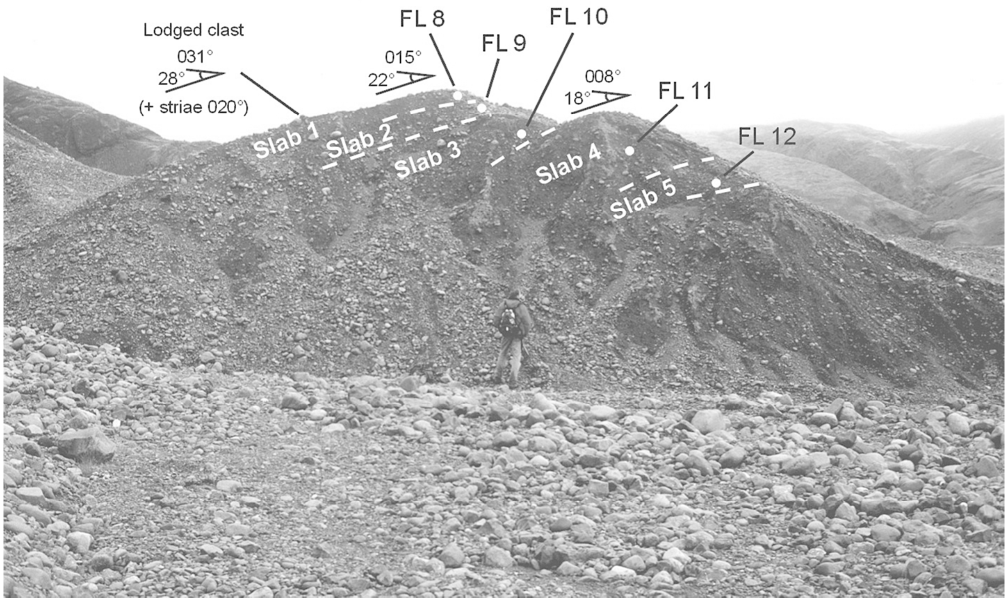

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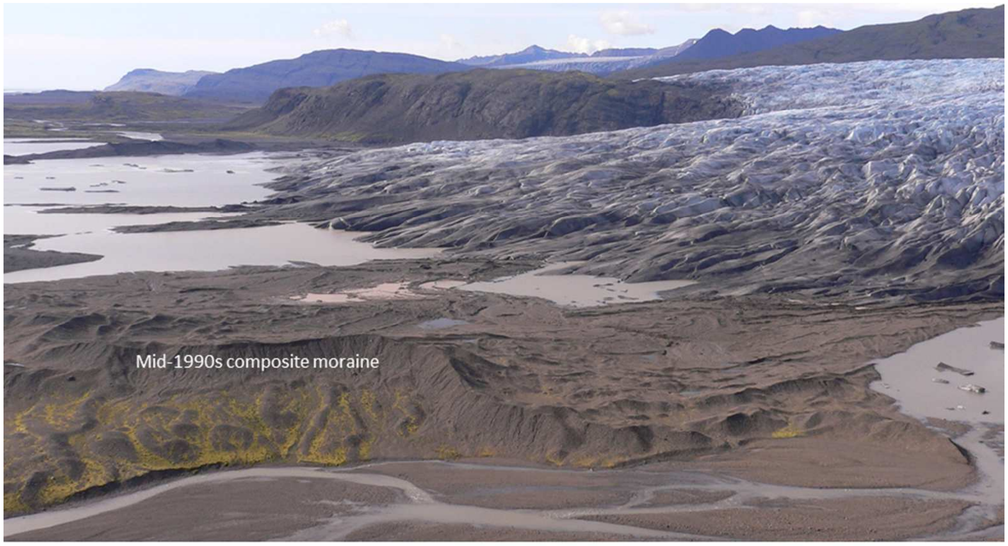

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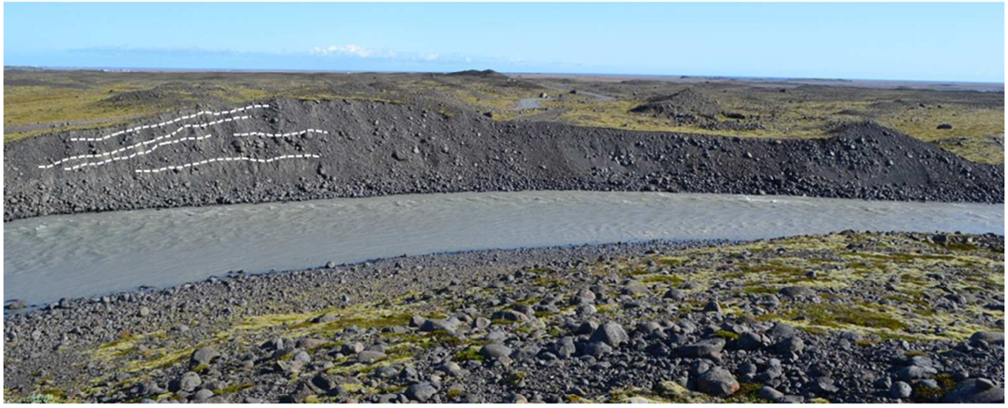

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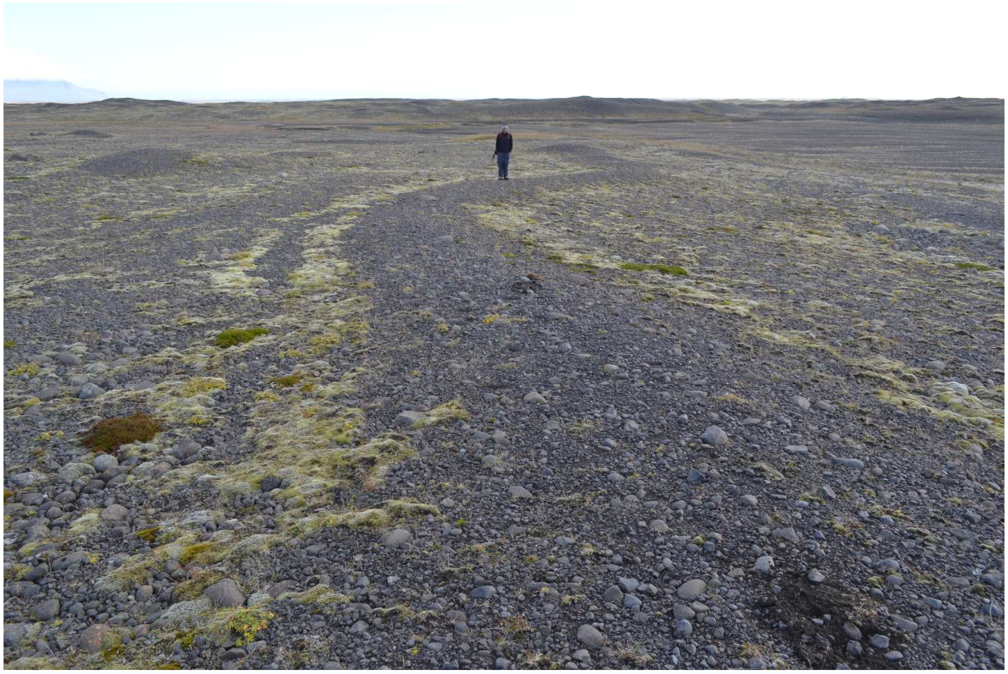

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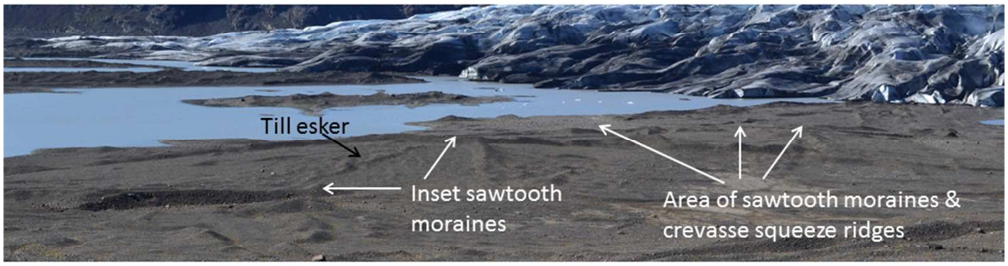

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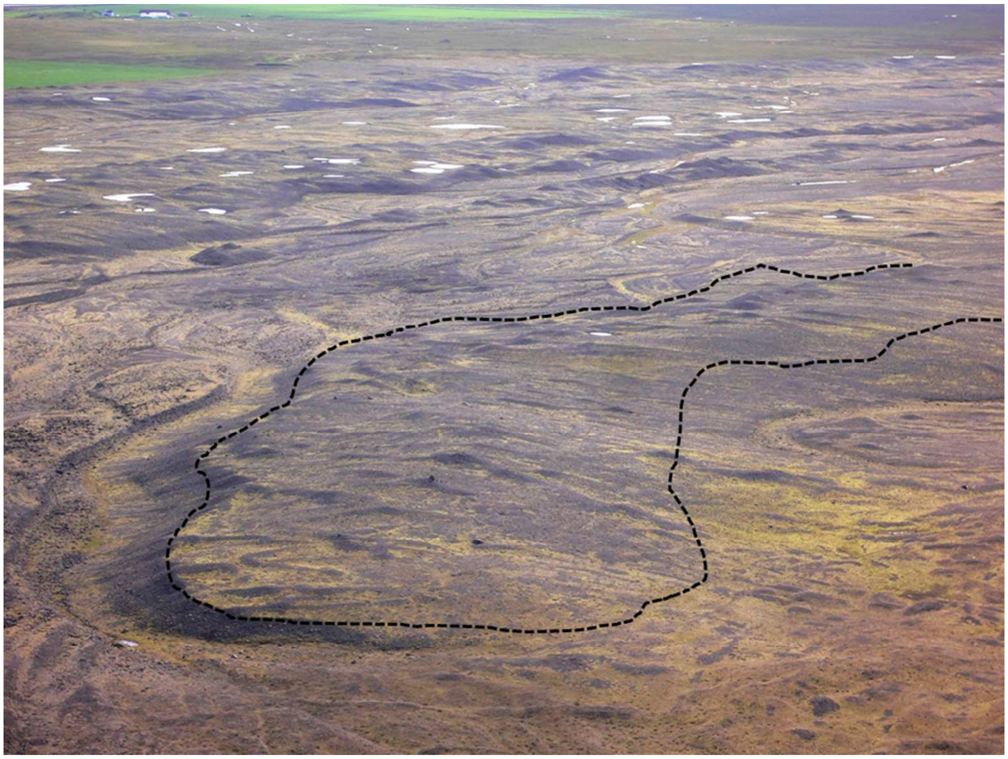

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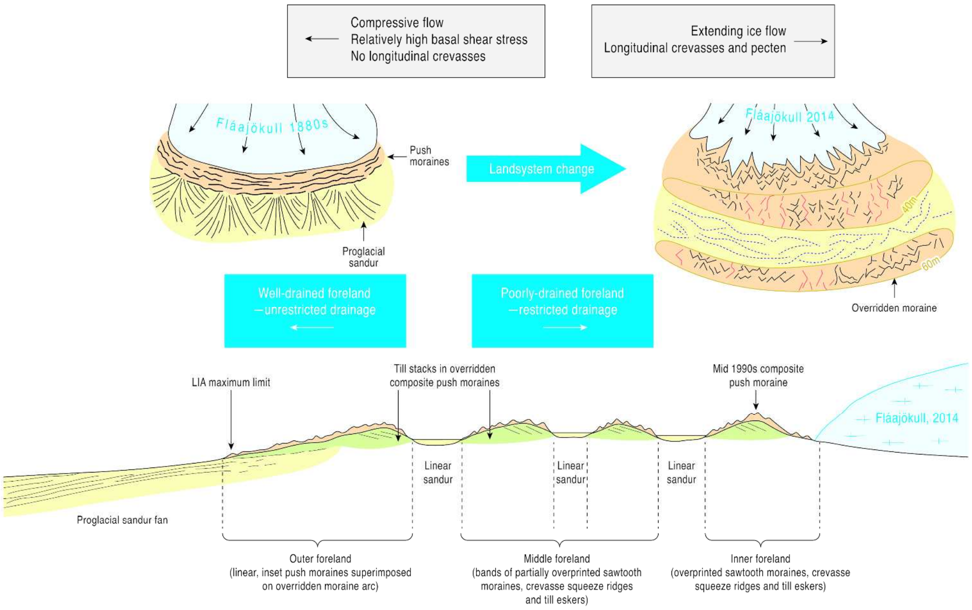

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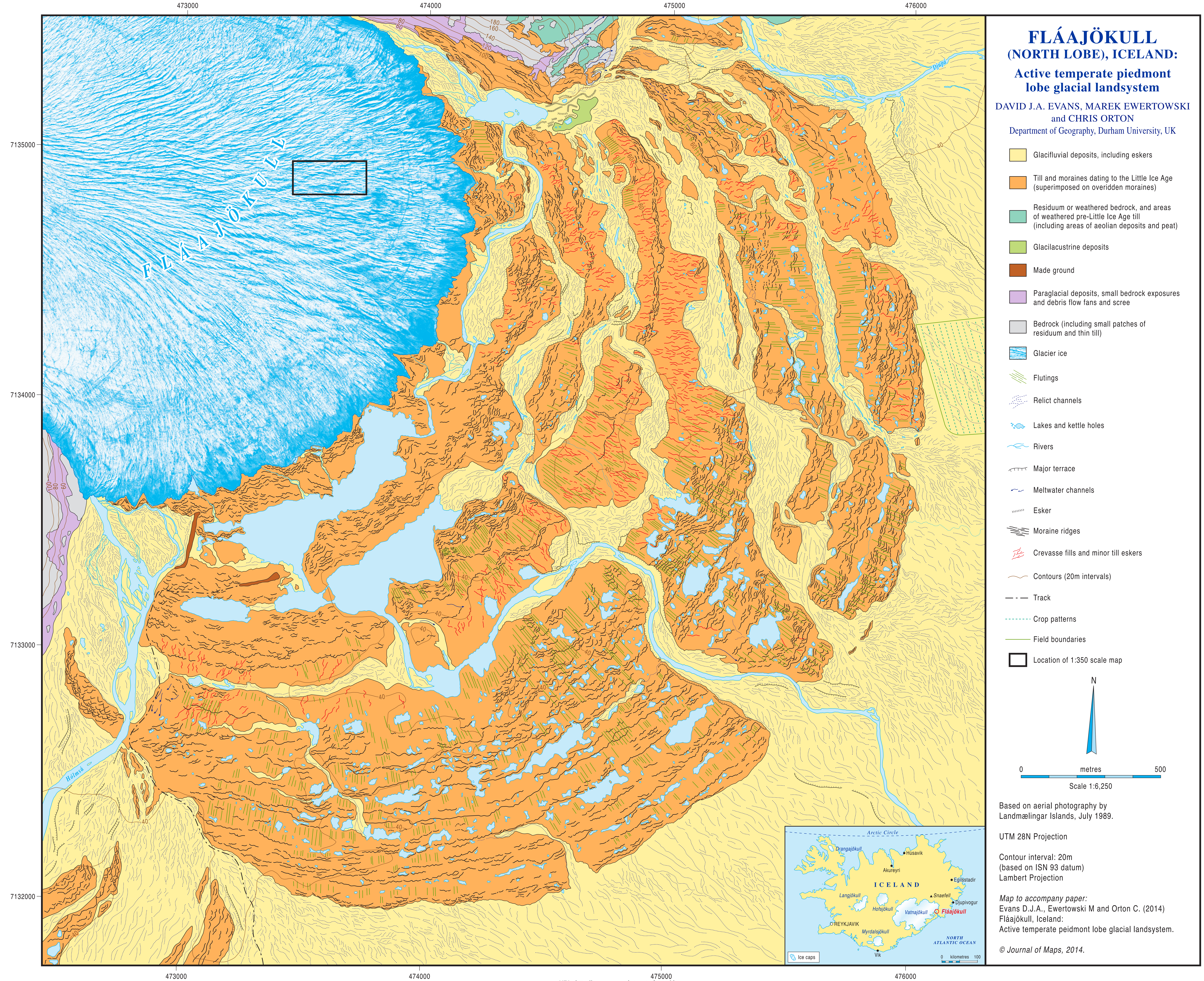
FLÁAJÖKULL
(NORTH LOBE), ICELAND:
Active temperate piedmont lobe glacial landsystem
DAVID J.A. EVANS, MAREK EWERTOWSKI and CHRIS ORTON
Department of Geography, Durham University, UK
Glacifluvial deposits, including eskers
Till and moraines dating to the Little Ice Age (superimposed on overidden moraines)
Residuum or weathered bedrock, and areas of weathered pre-Little Ice Age till (including areas of aeolian deposits and peat)
Glacilacustrine deposits
Made ground
Paraglacial deposits, small bedrock exposures and debris flow fans and scree
Bedrock (including small patches of residuum and thin till)
Glacier ice
Flutings
Relict channels
Lakes and kettle holes
Rivers
Major terrace
Meltwater channels
Esker
Moraine ridges
Crevasse fills and minor till eskers
Contours (20m intervals)
Track
Crop patterns
Field boundaries
Location of 1:350 scale map
N
0
metres
500
Scale 1:6,250
Based on aerial photography by Landmælingar Islands, July 1989.
UTM 28N Projection
Contour interval: 20m (based on ISN 93 datum)
Lambert Projection
Map to accompany paper:
Evans D.J.A., Ewertowski M and Orton C. (2014)
Fláajökull, Iceland:
Active temperate peidmont lobe glacial landsystem.
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FLÁAJÖKULL
Djúpá
Hólmsá
473000
474000
475000
476000
7135000
7134000
7133000
7132000
Arctic Circle
Drangajökull
Húsavík
Akureyri
ICELAND
Egilsstaðir
Langjökull
Snaefell
Hofsjökull
Vatnajökull
Djúpivogur
Fláajökull
REYKJAVIK
Myrdalsjökull
NORTH ATLANTIC OCEAN
Vík
Ice caps
0 kilometres 100


Fláajökull
Proglacial lake
Proglacial lake
Fláajökull
0 10 20 30 40 50 Meters
1:750
elevation
m a.s.l.
49
45
0 10 20 30 40 50 Meters
1:750
473450
473500
473550
473600
473650
473700
7134920
7134900
7134880
7134860
7134840
7134820
Geomorphic feature
Moraine - major ridge crest
Moraine - minor ridge crest
Fluting
Till esker (?)
Terrace
Surficial unit
Glacifluvial (gravels, sands)
Till
Projected Coordinate System: UTM 28N
0 10 20 30 40 50 Meters
1:350