HÖGSKOLAN DALARNA

Arbetsrapport

Field report from sediment coring in peat for landscape analysis in Hjaltadalur, Skagafjörður, north Iceland 2010

Sediment drilling in Hólar, Viðvik and Kolkuós, Hjaltadalur.

Magnus Hellqvist
Jenny N. Johansson

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Abstract

This field report presents fieldwork undertaken in Hjaltadalur, Skagafjördur, northern Iceland during summer 2010. The main aim was to initiate coring in selected mires in order to determine the composition of organic material and sediments in the mires, sub-sample for sedimentological and palaeoecological analyses, and initiate advanced landscape analysis of Hjaltadalur. Three mires were selected for sediments coring in Hjaltadalur: Ástunga close to Kolkóus, Hólakot at Viðvik, and Hólar. All three represented a landscape transect in NW to SE direction, from close to the coast to valley interior, *i.e.* close to the old settlement at Hólar.

Key words:

Quaternary, Iceland, coring, Hólar, Kolkuos, Vidvik

Magnus Hellqvist

Fil Dr. Quaternary Geology
Uppsala University
Institution of Earth Science
Villavägen 16
752 36 Uppsala
E-mail: magnus.hellqvist@geo.uu.se

Jenny N. Johansson

Studentstaden 13, 133
752 33 Uppsala
E-mail: jenny.n.johansson@hotmail.com

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1. Introduction

The main aim of the project was to present a picture of landscape development in Hjaltadalur, a valley in NW-SE direction connected to Skagafjörður, north Iceland, and highlight the history of the environment through analysis of sediment, pollen and macrofossils. The main interest was the Landnam period and human impact during prehistoric and historic time and to integrate this with the archaeological work at Hólar, within the Hólar project (Holarannsóknin), including investigations from several sites in Skagafjörður, such as Kolkuos and Keldudalur. One important attempt within the Hólar project is to develop interaction between practical and theoretical work in archaeology and different scientific methods, such as earth science and palaeoecology, history, geography, and literature, to create a multidisciplinary approach to the project (Hellqvist, unpubl.).

The parallel work between different disciplines in archaeology, science, written records, and landscape mapping creates understanding between archaeological fieldwork and different analytical methods. This in turn presents the opportunity for direct dialog during fieldwork and the interpretation of different stratigraphical units: interpretation in the field can change during fieldwork and methods can change during excavation. This is a crucial method for creating development within the project. Another important aim within the Hólar project is to use as many different methods and modern techniques as possible to both test and develop the work in an interdisciplinary environment: this involves testing various methods of sampling in the field. From the beginning of excavations at Hólar in 2002, there have been rescue excavations on other sites in Skagafjörður; primarily at the old harbour situated at Kolkuós, dating back to at least the 11th century (Traustadottir, 2009), and the old settlement in Keldudalur, dating to at least the 10th century (Traustadottir & Zoëga, 2007).

The primarily aim presented in this report was to collect samples and data to be able to view the landscape development in a broader perspective, historically, geographically and over a longer period, and through the interaction between human settlement and the environment and how this changed due to cultural, economic and political factors. Future analysis of sediment cores drilled from peat and older wetlands will present an opportunity to gain an overview of the former environment and provide an age reference. The study of environmental change will be combined with appropriate dating, through tephrachronology and ^{14}C-analysis, to obtain an accurate time chronology of changing landscape development in the area.

2. Background and field area

The study area was located in the valley of Hjaltadalur, where the village and University of Hólar is positioned centrally in the area. The valley is situated in the central part of the Tröllaskagi peninsula in northern Iceland (Figure 1) and is bound to the west by Skagafjörður.

Figure 1. Geographical position of Skagafjörður and Hólar in northern Iceland. (Map from National land Survey of Iceland.)

The peninsula is 4800 km^2 and is characterised by an alpine landscape with altitudes exceeding 1 500 m above sea level (m.a.s.l). Glacial valleys deeply incised into the old flood basalts (c. 7 MA), that are susceptible to both chemical and frost weathering. There are approximately 150 active rock glaciers and creeping ice-cored moraines due to the active periglacial environment (Kellerer-Pirklbauer *et. al*., 2007).

The Hjaltadalur valley is strongly affected by former glaciations and has a clear U-shaped form (Figure 2).

Figure 2. View over the U-shaped valley form in the inner part of Hjaltadalur (SE). (Photo: Jenny N. Johansson.)

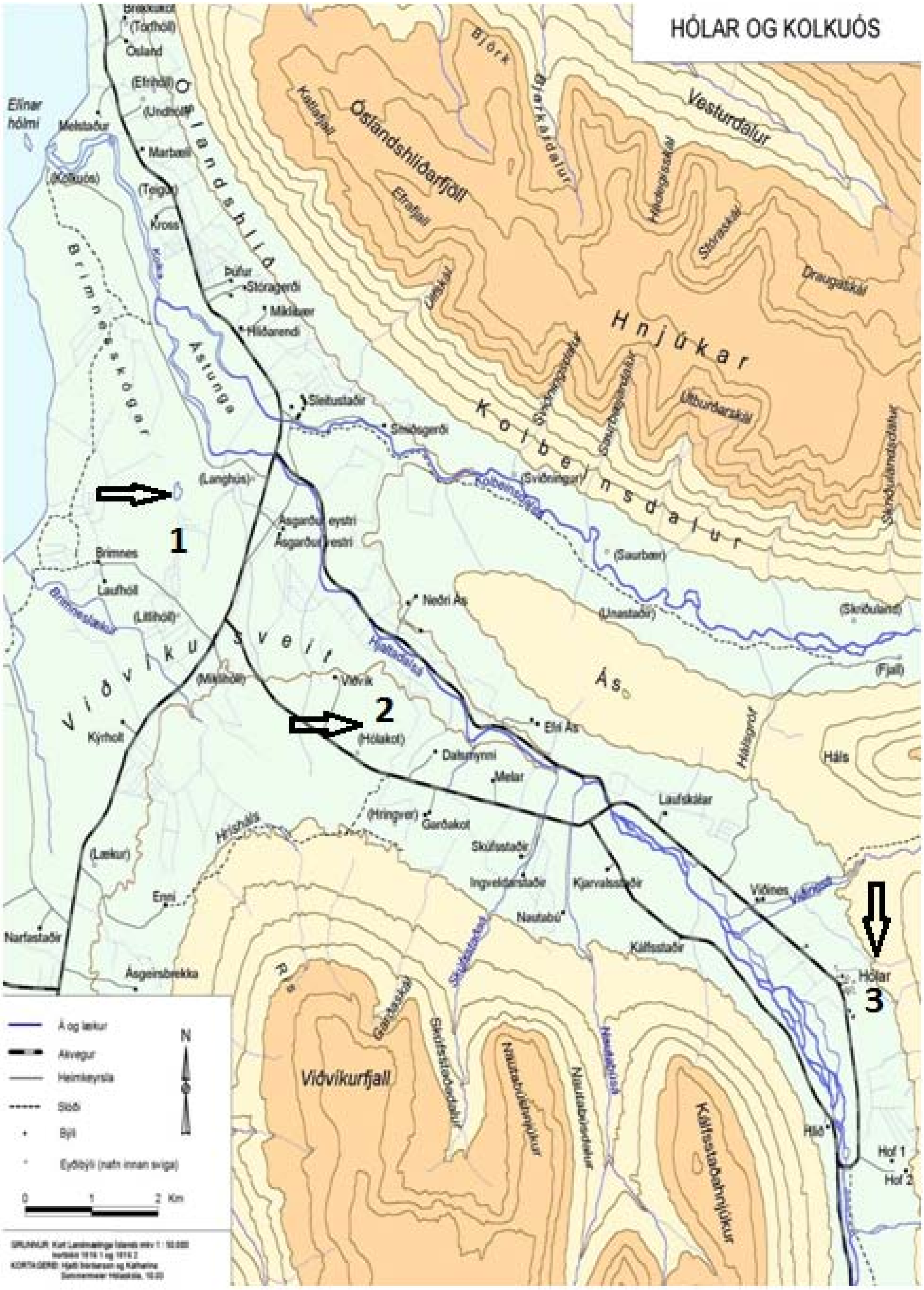
During the major glacial periods in the Pleistocene, the main ice flow followed Skagafjörður and Eyjafjörður, leaving the peninsula with relatively limited ice cover and probably large ice-free areas. The Hólar site is situated on a platform created by landslides from Hólabyrða Mountain, the highest mountain in the area, which also gave the name to the village Hólar. The equilibrium line altitude (ELA) along the coast of Tröllaskagi is measured to about 800 m.a.s.l., increasing to 1200 m.a.s.l. in the interior and more continental parts of the peninsula (Kellerer-Pirklbauer *et. al*., 2007).

Iceland is situated between two climatic zones, the temperate zone and the arctic zone. The climate is cool temperate and maritime, with constantly changing weather and high precipitation. The summers are cool (mean annual temperatur: 8.8°C in June, July, August) and the winters mild (mean annual temperature: -1.9°C in December, January, February) (Einarsson, 1994; Kellerer-Pirklbauer *et. al*., 2007). For the period 1961-1990, the mean air temperature at Hólar is 2.7 °C and the mean annual precipitation is 485 mm (data from Iceland Meteorological Office).

Iceland is young geologically and is almost entirely composed of lava flows and eruptive móberg (hyaloclastites) interspersed with widespread, thin sedimentary beds (Einarsson, 1994). Weathering and erosion are strong forces but have not been able to wear down the volcanic structures as new volcanic beds rapidly build up through ongoing volcanism. The fluvial processes in Iceland are apparent and are constantly changing the form throughout the whole country. During interglacial periods, fluvial processes dominate the erosional process and the rivers in Iceland are considered one of the most effective destructive processes in changing the landscape of the country. The glacial rivers have high velocity and transport eroded material from the mountain down to the sea eroding the landscape along the riverbeds in the process.

Hólar in Hjaltadalur is described in early written sources and in 2006 celebrated 900-years as Iceland's second Episcopal see and important religious centre, with a continuity of church history at the site dating back to the 12th century. However, there are settlement and housing remains dating back to at least the 11th century (Hellqvist, unpubl.). The first bishop in Hólar, Jón Ögmundsson the holy, took office in 1106 (Hellqvist, 2003), where he administered the church and started a school for priests. Hólar was an Episcopal see from 1106 to 1802 and 36 bishops, both before and after the reformation, were positioned here (Hellqvist, 2003). During the time as the Episcopal see, Hólar was an important and powerful centre in northern Iceland and a cultural centre for the area. Today, Hólar is a parish, and the existing school became a university in 2003.

To be able to provide a better picture of the landscapes transformations during former periods, three drilling sites were chosen along the valley of Hjaltadalur. The three drilling sites are located at Ástunga (65°47'13'' N, 19°19'88'' W, S-SO of Kolkóus), Viðvik (65°45'61'' N, 19°15'53'' W), and Hólar (65°43'93'' N, 19°06'68'' W), and are presented in Figure 3.



Figur 3. View over Hjaltadalur and the three drilling sites Ástunga (1), Viðvik (2) and Hólar (3).

3. Methods

The drilling sites at Ástunga, Viðvik and Hólar are today old wetlands and the main material of the cores that will be used in the analyses is peat. Peat is the name for dead and comparatively humified plant material that glomerates in wet areas. Due to the high water content and lack of oxygen, the plants mouldering process stops and the plants becomes preserved (TorvForsk, 2010). In Iceland, peat started to grow after the last glaciation and peat growth and accumulation is ongoing. The highest peat formation is found in wetlands, areas with high or fluctuating groundwater appearing at the surface, and former lakes that have dried up due to land uplift and drainage. The peat structure is usually dominated by *Carex* in colder climate or *Sphagnum* in warmer areas (Swedish peat producer society, 2010). However, in most peat bogs in Iceland, two layers with birch stems are present that formed in the warmest and driest periods of the Holocene, i.e. the early and late birch periods (Einarsson, 1994).

Icelandic peat lands cover almost 10% of the land area and the ash content in the peat is usually high. Icelandic peat formed before settlement contains 10-30% ash and peat formed later contains 50-70% ash (Einarsson, 1994). Peat was used as a fuel in Iceland and as a construction material for buildings (International peat society, 2010). As there was a lack of wood for building material, peat was an excellent replacement material easily to cut out from the mires, and the compact peat (turf) was effective in insulating houses from the wind and low temperatures.

The coring was preceded by a general field survey of the valley to identify and select the best coring sites within a transect from the coast at Skagafjördur and further into the valley (NW to SE direction). As there is a lack of previous coring sites and descriptions of cores in mires from the area, the focus during the initial field mapping was on sites around small lakes and wetlands. Complementary studies of maps and satellite pictures of the area supported the field survey. In this project, only local maps of the area around the valley of Hjaltadalur were used. After visiting and testing several suitable areas, three sites was chosen for further studies through judging whether successful coring results could be obtained, these sites were Ástunga close to the former harbour site at Kolkuós, Hólakot at Viðvik, and Hólar and were located from the coast in the NW to a central position in the Hjaltadalur valley further the SE.

The corer, a Russian sampler (Jowsey, 1966) with a diameter of 10 cm and length of 100 cm, was pressed into the ground and turned 180° to collect and fold sediment samples of 100 cm long. The stratigraphy and sediments was described in the field to avoid later problems due to change in the sediment during transport and storing, loss of colour on exposure to oxygen, and difficulty in observing obvious optic characters that may be disturbed by package and handling before laboratory description. The core was transported to field laboratory at Hólar for sediment description and sub-sampling for pollen and macrofossil analysis.

3.1 Ástunga

This sampling site was in the centre of a drained wetland containing a very compact organic deposit. Around the wetland, there was a 100 cm wide ditch for drainage. In older and some recent maps of Hjaltadalur, the mire was presented as a lake, indicating the ditch was relatively new. Grass and tuft of grass dominated the vegetation with horsetail, ground brich, and fluff present. The dominant plants on the site were *Equisetum palustre*, *Carex capillaris*, *Carex* spp, and *Betula nana*.

The core at Ástunga reached a depth of 150 cm, but the bottom of the mire and sediments, the silty sediments underlying the peat, were not reached. The Russian corer could not handle the high degree of compaction in the peat at this site. From the field description, made the sampling date 2010-06-29, two distinct layers of lighter material were observed and classified as sand. In addition, an overlap between the first and second core could be correlated with the two sandy layers. The peat at the top of the core, below the ground surface level, had a high degree of humification. The complete laboratory descriptions of stratigraphy in the cores can be seen in Table 5.

The sub-sampling for pollen was every 5 cm throughout the entire sediment core, starting at 40 cm below the ground surface and was adapted to the stratigraphy of the sampled core. Organic material between 0-39 cm below the ground surface was lost during coring. Macrofossil samples were collected in 5 cm wide samples throughout the core, starting at 35 cm below the ground surface.

3.2 Hólakot

At Hólakot, two sampling sites were chosen, sites 1 and 2. The sampling date for both sites were 2010-06-29. Groundwater was occasionally exposed at ground surface and flowed over the mire and into a small brook running across the mire. The direction of flow of the surface and ground water was generally south to north. Sampling site 1 was further south and higher up the valley than sampling site 2 situated about 100 meters to the north and about 1-2 meters lower than sample site 1.

3.2.1 Sampling site 1

Field description of sediment cores with a total depth 100 cm (Table 1).

The site was a temporary water-covered wetland with a sloping surface and surrounded by two smaller hillsides. The vegetation was generally composed and dominated by grass and tufts of grass together with fluff. The dominant plants were *Cardamine nymanii*, *Alopecurus geniculatus*, *Carex capillaris*, *Carex limosa* and *Carex* spp. Due to high compaction and limited stratigraphy for further sampling and analysis, the sediment core from sampling site 1 was considered unsuitable for further studies. The limited stratigraphy was similar to the stratigraphy at described site 2 in the uppermost part the core, after moving the sample site at Hólakot further north. The laboratory description from site 1 was discontinued as the core from site 2 provided a more suitable sampling core for Hólakot.

Table 1. Field description of sediment core from Hólakot, sample site 1.

Core 1	**Depth in cm**	**Description**
	0-24	Lost material
	24-58	Low humification. Affected by surface material. Roots and plant materials visible.
	58-100	Compact! The rate of compaction increases with depth. Higher humification. High quantity of plant material. Mixed layers: 80 cm - low humification; 83-88 cm - wood fragments; 91 cm - lighter layer; 93.5 cm - black band.
Core 2		*Maximum 20 cm extra material.*
	0-96	Overlap
	96-100	High humification, dark brown colour, with plant parts. Lighter olive-green band at 96 cm.

3.2.2 Sampling site 2

Field description of the sediment cores from sampling site 2 with a total depth 290 cm (Table 2).

As with sample site 1, this site proceeded in south-north direction at Hólakot, but the mire expanded over a larger surface area. Site 2 was temporarily water-covered with a sloping surface in a northerly direction and was dominated by *Carex* and tufts of grass with carex. The dominant plants at the site were *Candamine nymanii*, *Alopecmus genitulatus*, *Carex capillaris*, *Carex limosa*, *Carex spp,* and *Salix phylicifolia*. The complete laboratory descriptions of stratigraphy in the cores can be seen in Table 6. The sub-samples for pollen was sampled every 5 cm throughout the core, starting at 15 cm from the top and adapted to changes in the stratigraphy: three additional pollen samples were taken at 117 cm, 157 cm, and 227 cm. The macrofossil samples were collected in 5 cm wide samples throughout the core, starting at 15 cm from the top.

Table 2. Field discription of sediment core from Hólakot, Viðvik, sample site 2.

Core 1	**Depth in cm**	**Description**
	0-15	Lost material
	15-33	Very low humification with visible parts of plants.
	33-100	Higher and lower humification rates than the overlaying layer with banded layers of low humification and fragments of plants. Layers of low humification with visible moss fragments at; 41-42.5 cm, 49-52 cm, 64-65.5 cm, 72.5-73.5 cm. At 90 cm, there was a layer with visible plants.
Core 2	0-17	Overlap
	17-30	High humified peat with fragments of plants
	30-39	Lower degree of humified peat
	39-41,5	High humified peat with part of plants
	41.5-43	Lighter coloured high humified peat layer
	43-50	Higher humification with less parts of plants
	50-55.5	Olive-green sandy layer
	55.5-100	Layer with varied humification and dominated by a low degree of humification. An olive-green band at 76 cm.
Core 3	0-47.5	Overlap
	47.5-92	Layer with varied degree of humification.
	92-95	Olive-green silty band
	95-100	Layer with varied degree of humification.
Core 4	0-45.5	Overlap
	45.5-100	Homogenous, dark brown layer with visible part of plants. Medium to high degree of humification.

3.3 Hólar

As the Hólar project is centred on Hólar, finding suitable wetlands for coring and sampling at Hólar was a primary objective. A wetland was identified close to, about 100 meters, and north of the settlement. This mire was selected for coring as the character was similar to typical cars and bogs in Sweden and as such differed from the previous cored mires: this was considered as a good sampling opportunity for further analysis. The difference in character meant the mire had probably not suffered human interference in earlier times (peat cutting) and there was no obvious signs of peat cutting. The others mires were more typically peat, characterised in Iceland as turf, which is traditionally used as material for turf buildings and are often affected by turf cutting, which is as problematic factor for identifying unaffected peat and sediment stratigraphy.

The type of plants in the mire surface varied, and at this site, sphagnum peat was occasionally present, which is typical of classical bogs. A detailed field description of the sediment stratigraphy from the coring at the mire north of Hólar is presented in the Results, Table 7.

The ambition at this site was to core a more detailed transect over the whole mire to produce a detailed picture of the stratigraphy and depth of peat and sediments. The compaction degree in the peat was high and presented difficulties for coring with the available coring equipment. These practical problems demanded alternative solutions; thus, one coring spot was selected and a transect, with just the stage of the core, was used and not the core itself. Therefore, the depth of the mire and boundary between peat and silt were detected.
The transect system was lined up from three transects over the wetland at Hólar, from which it was possible to measure the total depth of the wetland and determine the depth of the peat without drilling along all transects. Figure 4 is a simple picture over the wetland and the three different transects, marked A, B and C.

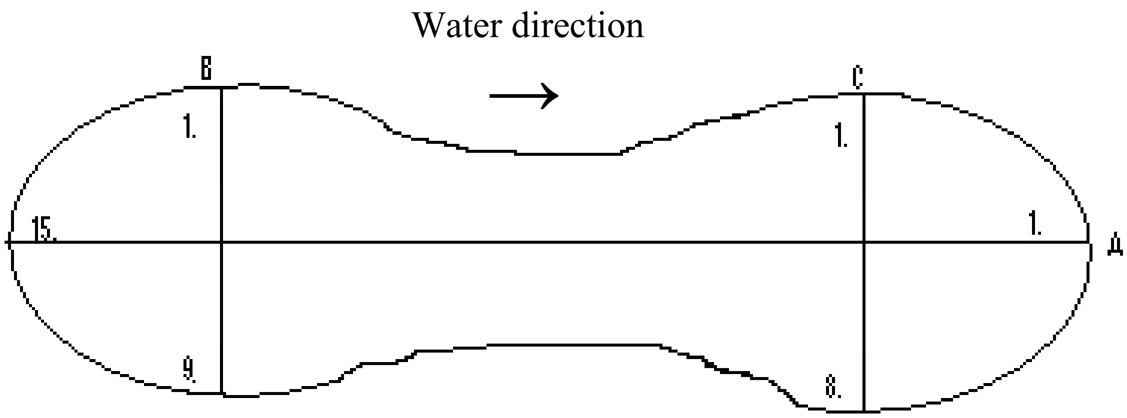


Figure 4. Simplified picture over the wetland at Hólar, with the three cored transects.

Transect A (Figure 5) was 70 meters long and has 15 sampling points, transect B (Figure 6) was 40 meters long and has 9 sampling points and transect C (Figure 7) was 34 meters long and has 8 sampling points. The depth was measured from corings every five meters, except between sample points C:1 and C:2, where the distance was four meters. All the samples were taken on the same sampling date; 2010-07-01. Notes from the transects is shown in tabel 3.

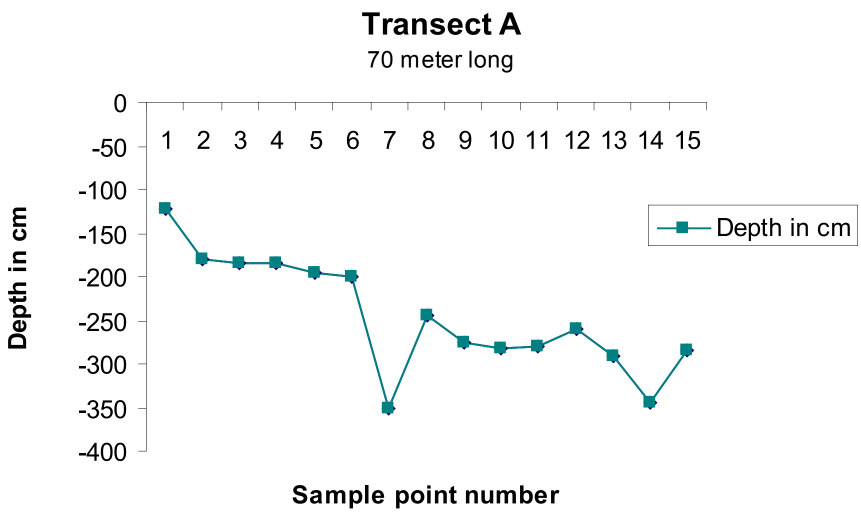


Figure 5. The depth of transect A. Sample point A:7 is the coring site.

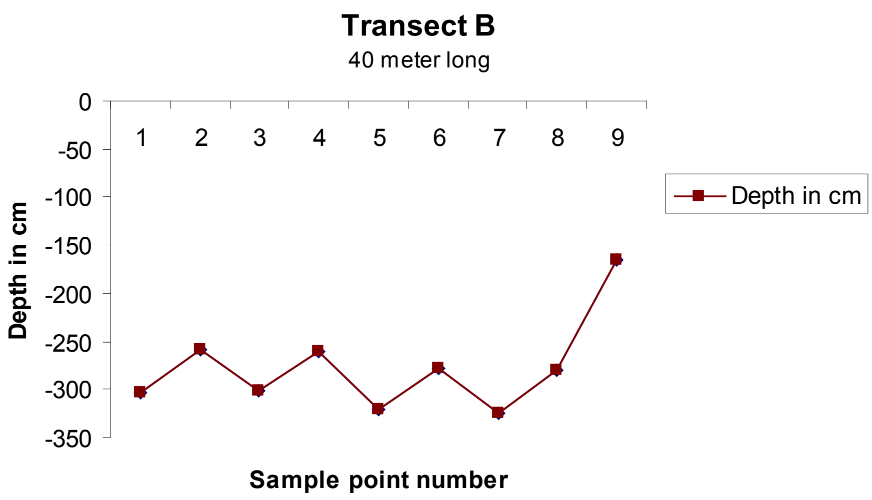


Figure 6. The depth of transect B.

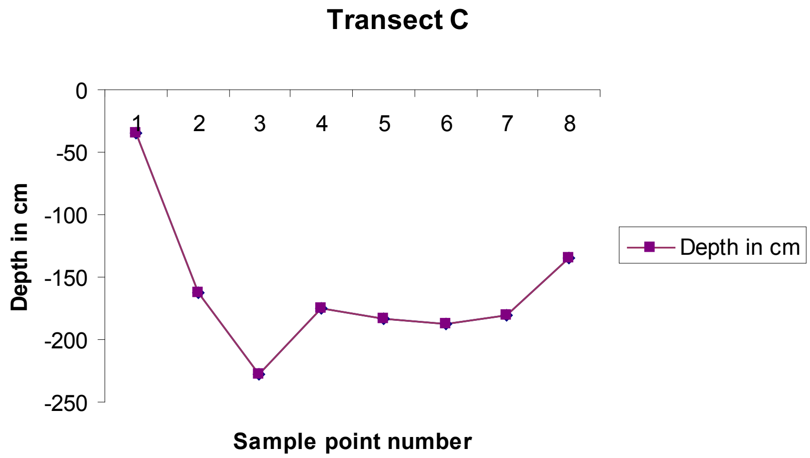


Figure 7. The depth of transect C.

The mire was situated in a natural depression, surrounded by smaller hillsides with birch forest or open grassy areas. In the area, the vegetation varied with a predominance of

Sphagnum, *Salix* and *Carex*. The dominant plants at the site were *Salix phylieifolia*, *Equisetum palustre*, *Hippuris valgaris*, *Caltha pakustris,* and *Vaccinium uliginosum*.

Table 3. Notes from the three transects A, B and C.

Point	*Comment*
A:1	125 cm from solid ground.
A:15	0 cm from solid ground.
B:1	Sediment with peat and silt blends in the surface.
B:9	Sediment with peat and silt blends in the surface.
B:6,	Peat 200 cm, sediment down to 278 cm.
B:7	Peat, 250 cm, sediment 325 cm
B:8	Peat 250 cm, sediment 280 cm
C:8	Sediment at 118 cm, silt. Washed down?

The sub-samples for pollen were collected in each different layer throughout the sediment core and at least one sub-sample per layer, starting at 35 cm below the mire surface. The sub-samples and their depth in the core are presented in Table 4. The macrofossil samples were collected from 5 cm wide samples throughout the whole core, starting at 25 cm from the surface.

4. Results

Peat growth at Tungusveit northern Iceland, further north than Hólar at the Tröllaskagi peninsula, has been calculated by Tara Carter (*pers. com. 2010*). Peat growth was 0.0066 cm/yr during prehistoric times (4500-2900 BP) while the average growth in modern times (1766-today) is 0.05 cm/yr. This indicates an increase in peat growth: the measured peat growth is presented in Appendix 2, Table 9.

During scanning and analysis of samples for macrofossils, both insects and seeds were chosen for further identification and analysis. The content of the macrofossil samples was, except for insect (dominated by beetles) and different kind of seeds, dominated by pieces of wood and moss fragments. In some samples, the moss fragments were highly preserved and identifiable to species level.

4.1 Laboratory descriptions of stratigraphy in the cores.

Ástunga:

Table 5. Laboratory description of sediment core from Áustunga.

Colour	Depth in cm.	Description
	0-35	Lost material, empty.
	35-82	Low humification. Visible roots and part of plants. Dark brown peat material.
	82-92.5	Medium humification, part of plants can be observed. Dark brown material.
	92.5-96	Sand layer, light grey, H3 (2800 BP)
	96-105	Medium humification, part of plants can be observed. Dark brown material with a red tone.
	105-108,5	Beige/yellow, silt layer (medium-fine silt) H4 (4000 BP)
	108.5-163	Medium humification, part of plants can be observed. Dark brown material with a red tone

Hólakot, Viðvik:

Table 6. Laboratory description of sediment core from Viðvik, sample point 2.

Colour	Depth in cm	Description
	0-15	Lost material, empty
	15-32	Unhumified peat material, a lot of plant parts.
	32-114	Medium degree of humified dark brown peat. Visible parts of plants and roots.
	114-116	Lighter brown, lower degree of humified peat.
	116-118.5	Darker brown. Higher degree of humified peat.
	118.5-121	Lighter brown, lower degree of humification. Denser parts of plants.
	121-132	Darker brown. Higher degree of humified peat. Denser parts of plants (stems etc.)
	132-138	Lighter olive-green to light beige "sandy" layer. The colour lightened with depth. (H3?)
	138-148	Dark brown, medium degree of humification. Visible parts of plants.
	148-157	Slightly lighter brown, lower degree of humified peat with denser part of plants.
	157-159	Slightly lighter brown, lower degree of humified peat with denser part of plants. Ended with a light sand-silt band (H4?)
	159-165	Dark brown high humified peat with less part of plants
	165-177	Slightly lighter, low humified peat with visible part of plants
	177-227	Dark brown, medium degree of humification. Visible parts of plants.
	227-228.5	Light olive-green layer, silt (H5?).
	228.5-277	Dark brown, medium degree of humification. Visible parts of plants.
	277-290	Darker brown high humified peat with less visible part of plants. The peat had a "clayey" feel.

Hólar:

Table 7. Field description of sediment core from Hólar.

	Colour	Depth in cm	Description
Core 1		0-27	Lost material, empty
		27-48	Low degree of humified peat, much visible parts of plants and roots
		48-57	Darker brown, slightly degree of humified peat.
		57-60	Lighter brown, low degree of humified peat with visible parts of plants
		60-68	Darker brown, slightly degree of humified peat.
		68-70.5	Lighter brown, low degree of humified peat with visible parts of plants
		70.5-76	Darker brown, slightly degree of humified peat.
		76-79	Lighter brown, low degree of humified peat with visible parts of plants
		79-86	Darker brown, slightly degree of humified peat.
		86-87	Lighter brown, low degree of humified peat with visible parts of plants
		87-100	Darker brown, slightly degree of humified peat.
Core 2		0-4	Darker brown, slightly degree of humified peat.
		4-7.0	Lighter brown, low degree of humified peat with visible parts of plants
		7-28.5	Darker brown, slightly degree of humified peat.
		28.5-33	Lighter brown, low degree of humified peat with visible parts of plants
		33-37	Darker brown, slightly degree of humified peat.
		37-51	Lighter brown, low degree of humified peat with visible parts of plants
		51-100	Very low degree of humified peat with clear layers. Visible and identifiable mosses etc. Darker bands at: 64-65 cm, 74.5-76.5 cm, 86-90 cm and 95 cm.
Core 3		0-60	Overlap
		60-86.5	Very low degree of humified peat with clear layers. Visible and identifiable mosses etc. Darker bands at: 61.5-63 cm and 71-72.5 cm. Darker band but lighter than the previously darker layers at 72.5-76 cm
		86.5-92	Darker brown, high degree of humified peat with visible parts of plants
		92-96	Lighter brown, low degree of humified peat.
		96-98	Darker brown, high degree of humified peat with visible parts of plants
		98-100	Change? New layer or just the bottom of the core?
Core 4		0-78	Overlap
		78-91.5	Low degree of humified compact peat. Darker band at 79-80 cm.
		91,5-95	Darker brown, high degree of humified peat. Loose material (silt/tephra?)
		95-100	Low degree of humified compact peat.
Core 5		0-77	Overlap
		77-100	Low degree of humified compact peat. (At 69-70 cm silt/tephra layer?)
Core 6		0-80	Overlap
		80-85	Dark brown, low degree of humified peat with visible parts of plants
		85-89	Light, very low humified peat layer with clear parts of moss and plant fragments
		89-91	Junction region between low and high humification
		91-99	Medium- to high-humified brown layer with some visible parts of plants. Two black bands at 97.5 cm and 98.5 cm.
		99-100	Silt! Down to 350 cm.

Table 4. Pollen samples in sediment core from Hólar.

Pollen sample nr	Depth in cm
1	35
2	40
3	45
4	53
5	58.5
6	64
7	69
8	73
9	83
10	86.5
11	92
12	97
13	102
14	105.5
15	113
16	119
17	125
18	131
19	135
20	142
21	147
22	161
23	171
24	181
25	191
26	205
27	215
28	225
29	230
30	234
31	237
32	239
33	245
34	250
35	259
36	269
37	276
38	283
39	288
40	292
41	295
42	299.5
43	304.5

5. Discussion

Compaction of the peat was higher than expected, which rendered coring with available coring equipment difficult. A Russian corer with a narrower diameter or drilling equipment adapted for coring in hard soil could be a way to overcome this problem in future. The preservation degree in the sediment cores and sub-samples analysed was generally good. On reason is the mires and sediments have been covered by water, which creates good preservation potential through anaerobic conditions represented by colour and morphological features on the macrofossils being visible allowing subfossils and different kinds of mosses to be identified.

It is important to avoid as many sources of errors as possible and to describe the drilled core, in a "fresh condition" in field. The cored organic material and sediments, when re-examined in the laboratory, had darkened in colour due to the oxygen and clear layers in the field became more difficult to identify. The rate of humification of peat in the sediment cores changed from between low and high humification and although more humification occurred away from the ground surface, layers of non-humified peat were present deep in the stratigraphy. This change was caused by changes in climatic conditions and saturation of the peat during different periods. The tephra layers in some cores require further analysis to identify tephra layers connected to particular volcanic eruptions. The identification of the tephra layers presented in the laboratory descriptions of the cores is an interpretation from discussion with colleagues, but are considered accurate.

Further research and more fieldwork should be performed in the area to provide an increased understanding of landscape development in the area around Skagafjördur. There are few investigations currently available and further sediment coring and analyses would facilitate the interpretation. Paleoecological analysis of pollen and macrofossils (*eg*. both insects and plant macrofossils) and further dating of identified tephra and ^{14}C analysis would increase understanding of the environmental and climatic development.

6. Conclusion

From this study, it is possible to draw following conclusions and make suggestions for further work:

- The high degree of preservation in the samples from cored mires is advantageous for identifying insects, pollen and other macrofossils.
- Proceed with analysis of pollen and macrofossils and complementary dating, including ^{14}C-dating.
- The interpreted tephra layers need to be further analysed to establish the identification of the tephra layer according to present tephrachronology in Iceland.
- Further drilling in other places to determine the degree of compaction and obtain more material from sediment cores.

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9. Appendices

Appendix 1: Coring depths at Hólar.

Table 8. Depth in cm for transect A, B and C i Hólar, Iceland.

A, sample point nr.	Depth in cm	B, sample point nr.	Depth in cm	C, sample point nr.	Depth in cm
1	122	1	303	1	35
2	180	2	258	2	163
3	185	3	301	3	228
4	184	4	260	4	175
5	195	5	320	5	184
6	200	6	278	6	187
7	350	7	325	7	181
8	245	8	280	8	135
9	275	9	116		
10	282				
11	280				
12	260				
13	290				
14	345				
15	284				

Appendix 2: Peat growth measurements (T. Carter, pers. com.)

Table 9. Peat growth from Tungusveit in northen Iceland. Calculations presented by Tara Carter (T. Carter, *pers com. 2010*).

Peat Growth

1. Modern rates (Average)

Surface (below root zone horizon) and 1766 tephra:
11.8 cm / 234 yr = 0.05 cm/yr

2. Early historic- Medieval

Between 1766 an H1 (1104 AD) tephra:
10.5 cm / 662 yr = 0.0159 cm/yr

3. Medieval- Prehistoric

Between H1 and H3:
38.4 cm / 2004 yr = 0.0192 cm/yr

4. Prehistoric

Between H3 and H4:
10.5 cm / 1600 yr = 0.0066 cm/yr

Notes:
- From Tungusveit
H3 = 2900 BP (900 BC)
H4 = 4500 BP (=2500 BC)

Appendix 3: Weather data from Hólar, 1961 to 1990

Table 10. Weather data from Hólar in Hjaltardalur for 1961 to 1990. Data from Iceland Meteorological Office.

Annual average for site 385 - Hólar í Hjaltadal																	
site	year	month	t	tx	txx	txxD1	tn	tnn	tnnD1	rh	r	rx	rxD1	p	n	sun	f
385	1961	3.2	6.8	20.2	19-07	-0.1	-19.0	28-12	NA	637.6	106.4	14-11	NA	6.5	0.0	NA	
385	1962	2.8	NA	17.6	04-07	-0.5	-14.9	06-02	NA	472.8	78.3	19-09	NA	6.6	0.0	NA	
385	1963	2.7	6.4	22.0	03-06	-0.2	-18.7	18-11	NA	442.2	91.0	19-09	NA	6.6	0.0	NA	
385	1964	3.8	7.6	21.6	21-07	0.8	-16.3	05-02	NA	533.7	73.8	08-03	NA	6.5	0.0	NA	
385	1965	2.5	6.3	20.1	13-08	-1.0	-19.9	26-12	NA	403.8	128.3	04-11	NA	6.2	0.0	2.8	
385	1966	1.8	5.4	23.1	07-07	-1.3	-20.0	21-01	NA	468.5	110.4	26-08	NA	6.4	0.0	3.1	
385	1967	2.0	5.7	20.0	13-07	-1.4	-20.5	08-12	NA	491.9	96.5	11-12	NA	6.5	0.0	NA	
385	1968	2.4	6.1	21.6	19-07	-1.4	-22.0	03-01	NA	428.2	86.5	27-02	NA	6.3	0.0	NA	
385	1970	2.3	5.7	20.0	22-06	-0.9	-22.5	09-01	NA	491.3	85.6	20-11	NA	6.1	0.0	3.4	
385	1971	2.5	5.8	20.0	04-06	-0.7	-20.9	30-01	NA	567.0	94.7	02-01	NA	6.5	0.0	NA	
385	1972	4.0	7.1	20.2	27-07	1.2	-15.4	16-02	NA	575.5	107.0	12-10	NA	6.7	0.0	NA	
385	1973	2.2	5.6	21.4	11-07	-0.9	-20.2	24-11	NA	520.4	83.9	01-10	NA	6.5	0.0	NA	
385	1974	3.7	6.9	25.0	23-06	0.8	-21.3	22-12	NA	529.3	121.7	05-03	NA	6.6	0.0	NA	
385	1975	2.6	6.2	21.9	05-07	-0.4	-17.6	07-01	NA	469.0	77.4	12-11	NA	6.7	0.0	2.4	
385	1976	3.7	7.1	22.8	10-07	0.5	-21.2	12-01	NA	506.8	96.2	05-02	NA	6.5	0.0	2.2	
385	1977	2.8	6.0	21.8	14-08	-0.3	-22.6	19-12	NA	379.8	100.8	13-09	NA	6.3	0.0	1.4	
385	1978	2.9	6.1	21.0	03-08	-0.2	-19.0	03-01	NA	390.0	70.4	20-05	NA	6.4	0.0	NA	
385	1979	0.9	4.1	18.0	04-06	-2.0	-21.8	07-02	NA	349.9	142.0	28-11	NA	6.4	0.0	NA	
385	1980	3.0	6.1	25.0	01-08	-0.2	-19.6	19-12	NA	371.2	9.0	25-12	NA	5.8	0.0	NA	
385	1981	1.6	4.8	22.8	24-07	-1.8	-18.8	15-01	NA	499.9	87.8	12-09	NA	5.9	0.0	2.3	
385	1982	2.5	5.7	20.5	20-07	-0.7	-18.2	17-12	NA	461.5	115.0	23-07	NA	5.9	0.0	NA	
385	1983	2.1	5.4	20.5	20-07	NA	-15.8	23-12	NA	723.9	93.8	22-01	NA	6.0	0.0	3.0	
385	1984	3.3	6.5	23.2	05-06	0.0	-19.2	17-01	NA	520.5	91.6	15-02	NA	5.8	0.0	2.8	
385	1985	2.6	5.8	20.6	19-05	-0.6	-18.8	01-02	NA	494.1	150.3	22-10	NA	5.6	0.0	NA	
385	1986	2.7	6.0	22.0	28-06	-0.6	-17.0	02-12	NA	460.5	74.4	15-11	NA	5.6	0.0	NA	
385	1987	4.0	6.9	21.2	26-05	0.8	-15.4	26-12	NA	365.4	23.5	07-07	NA	6.0	0.0	2.6	
385	1988	2.4	5.8	23.3	10-06	-1.0	-20.7	23-01	NA	461.4	98.0	02-10	NA	5.8	0.0	NA	
385	1989	2.6	5.8	20.6	13-07	-0.7	-19.5	20-12	NA	523.4	39.1	31-08	NA	6.1	0.0	NA	
385	1990	3.0	6.1	22.8	14-07	-0.2	-19.5	28-02	NA	530.0	30.3	30-08	NA	6.3	0.0	NA	

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