

Late Quaternary Geology and Glacial History of Hornstrandir, Northwest Iceland: A Reconnaissance Study

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ABSTRACT

The northern part of the northwest (Vestfirðir) peninsula of Iceland is a basalt plateau dissected by fjords and rather short, glacially eroded valleys. Its northern coast is called Hornstrandir. Its Quaternary geology was reconnoitered by the authors in 1982 and 1983.

No signs of glacial erosion or deposition were found on the high (400–500 m) plateaux and it is therefore concluded that these were not inundated by actively eroding glaciers, at least not during the last (Weichselian) glaciation. Using altitudes of glacially unaffected plateaux as a measure of the absolute maximum thickness of the outlet glaciers, their maximum horizontal extent can be approximated. It is then found that the glaciers could only have reached about halfway to the edge of the shelf, and it is possible that they did not even reach that far. The time of general deglaciation could not be absolutely dated, but by analogy with other areas in Iceland, and around the Northeast Atlantic, it most probably took place during the latest Weichselian and earliest Flandrian. The sea then stood 26–15 m higher than today and at least in some valleys the retreat of the glaciers was interrupted by a readvance – perhaps an equivalent to the Younger Dryas readvance elsewhere. The equilibrium line altitude (ELA) at the end of the Weichselian was around or below the present 150 m level. A heavy influx of basaltic tephra, the Haelavík tephra, took place shortly after deglaciation.

During the Little Ice Age glaciers were re-established in 7–10 cirques on northern Hornstrandir. The ELA in these cirques varied with exposure between 300 and 500 m, and some glaciers descended as much as to 150 m below their basin-floor altitudes. Lichenometric studies at one site indicate that the Little Ice Age glacial maximum was reached around 1860 AD, perhaps a little earlier. The retreat, at that place, was largely finished by 1920, when the glacier had almost disappeared. Today glaciers are found in only four cirques, but small firns exist on some high plateaux and mountain ridges.

INTRODUCTION

Hornstrandir is the northernmost part of the northwest, Vestfirðir peninsula of Iceland (Fig. 1), and is here defined as the coastal area from Ritur eastwards to Hornbjargsviti (Fig. 2).

Little has been known about the Quaternary geology and glacial history of Hornstrandir. Scattered references to glacial deposits and striae in the area can be found in the literature, but detailed stratigraphical and morphological information has been lacking. This paper attempts to fill some of the gaps. It is based on two short reconnaissances of the area, combined with extensive air-photo interpretation and a re-examination of the scattered data available in the geological literature. During one week in July 1982 CH and HN studied the Adalvík-Rekavík area in the west (Fig. 2), and during

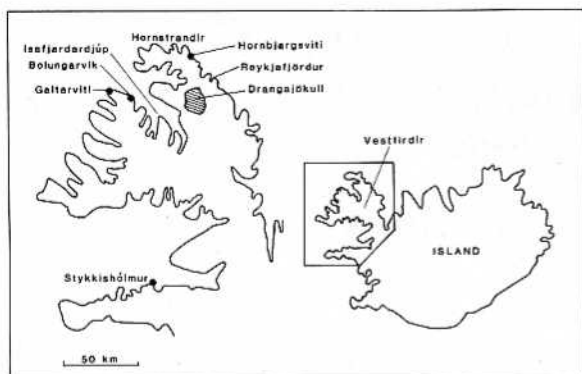


Fig. 1. Location map for Northwestern Iceland, indicating places mentioned in the text which are located outside the study area on Hornstrandir. *I. mynd. Staðsetningarkort fyrir Hornstrandir.*

one week in July 1983 CH and ÓI studied the Haelavík-Hlöðuvík area on the north coast.

Altitudes at sections along the coast were measured with hand level and/or measuring tape, those inland with a Paulin altimeter. The high water mark was used as base level. Chronostratigraphical terminology is according to *Mangerud et al.* (1974) and, as regards the Weichselian, *Mangerud and Berglund* (1978).

General geology and morphology

Hornstrandir is a dissected Tertiary basalt plateau, its bedrock being at least 14 million years old (*Th. Einarsson* 1968, *Kjartansson* 1969, *Simonarson* 1979, *Saemundsson* 1979). The general topography of the area and the more important place names used in the text are shown in Fig. 2. Around Adalvík in the west the plateau surface lies around 400 m. It rises towards the east and gets more and more dissected in that direction. In the rugged 700 m high mountains south of Hornvík not much is left of the original plateau surface.

The valleys on Hornstrandir are rather short, the longest being the one inside Fljótavík – 8 km long and 3 km wide at the entrance. They are all glacially sculptured. A characteristic feature of the landscape are the cirques. These occur either single or as composite ones. The short and relatively wide valleys often end with rather broad coastal lowlands. Inside Adalvík, Fljótavík and Hornvík these are about 2 km wide.

The shelf around Hornstrandir is rarely deeper than about 100 m and the 50 m depth curve lies about 5 km off the coast in the west and northwest. It comes closer

only off Hornvík, where a northwest trending basin, overdeepened by some 50 m and with depths down to 105 m, reaches into the bay.

The general pattern of short, steeply ending valleys with well developed cirques indicates that glaciation on Hornstrandir was of a predominantly local character.

Present climate

Both according to the mean air temperature in July and the temperature of the sea, Hornstrandir lies within the low-arctic zone (e.g. *Freuchen and Salomonsen* 1959).

The climatic tree-line probably runs somewhere through central Hornstrandir (*E. Einarsson* 1975). At present there are two meteorological stations close to Hornstrandir and with similar exposure, one at Galtarviti south of the entrance to Ísafjardardjúp, another at Hornbjargsviti immediately east of Hornbjarg (Fig. 1).

Recorded annual mean temperatures at Galtarviti and Hornbjargsviti are +3.8°C and +3.1°C, respectively, with the highest monthly mean temperatures in August, +9.6°C and +8.2°C, and the lowest in February, -0.8°C and -1.1°C (*M.Á. Einarsson* 1976). Annual mean precipitation values at Galtarviti and Hornbjargsviti have been recorded as 1265 mm and 1373 mm, respectively. The prevailing wind direction on Hornstrandir is probably from the northeast.

Permafrost occurs on the high plateaux. On Fljótsheidi east of Látrar, 450–500 m above sea level, ice was encountered at a depth of 15–30 cm on 23rd of July 1982. Large stone polygons and stone stripes are common.

WEICHSELIAN GLACIATION AND MARINE LEVELS

Research history

The Icelandic geologist Thorvaldur Thoroddsen, travelling on Hornstrandir during the summers 1886 and 1887, made numerous observations on its geology and morphology (*Thoroddsen* 1892a, 1892b, 1906). He recognized that the whole landscape of the Vestfirðir peninsula is characterized by glacial erosion, and he observed glacial striae and glacial deposits at numerous localities. From a monoglacialistic point of view, he concluded that during „the Ice Age“ the area had been covered by an extensive ice cap, which he considered to have been independent of the main Icelandic ice sheet. He estimated the thickness of this ice cap to 400–500 m, and assumed that outlet glaciers from it had extended into the valleys and fjords. He noted the absence of submarine valleys on the shallow banks off the Horn-

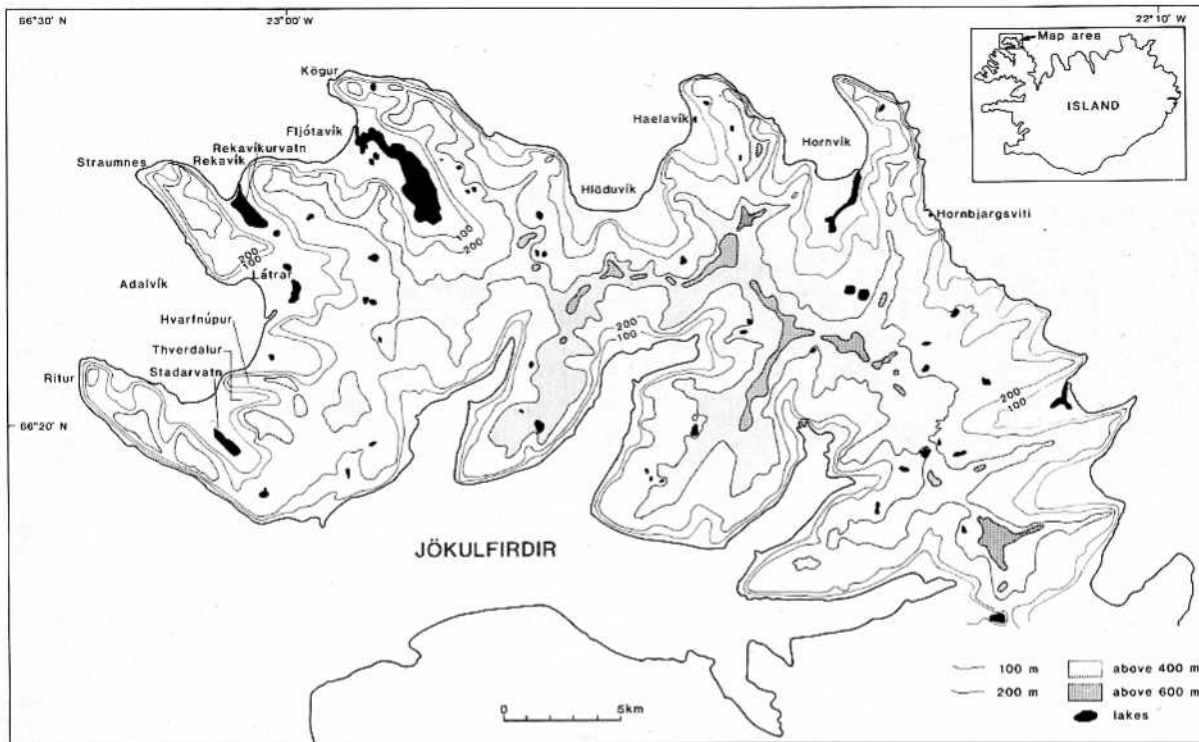


Fig. 2. The main topographical features of northernmost Vestfirðir and placenames mentioned in the text. Based on the 1982 Geodetic Survey of Iceland 1:100 000 map of the area. 2. mynd. Höfuðdrættir landslags á nyrsta hluta Vestfjarða og staðarnöfn er koma fyrir í greininni.

strandir coast and, furthermore, seems to have been of the opinion that the ice cap had not extended far beyond the present coast. He also thought that the ice cap had been continuous and that nunataks could only have existed between the outlet glaciers, close to the edge of the ice cap.

Thoroddsen's views were later modified by *Thórarinsson* (1937), who suggested that during the last glaciation the Vestfirðir peninsula was characterized by small ice-fields on the plateaux between the fjords, while the whole central area was covered by a large continuous ice cap. Outlet glaciers flowed from the central highlands through the fjords, gradually leaving more space for local glaciers and nunataks. *Thórarinsson* also drew attention to observations made by *Keilhack* (1933) and *Iwan* (1936) on the number and distribution of cirques on Vestfirðir. These become more numerous towards the mouths of valleys and fjords.

Later workers (*Th. Einarsson* 1961, 1963, 1967, 1968,

John 1977a, *Hoppe* 1968, 1983, *Andersen* 1981) have to a large extent echoed *Thórarinsson's* (1937) results, though with some modifications. *Andersen* (1981) and *Hoppe* (1983) suggested a larger extent of the ice onto the shelf during the Weichselian maximum than can be inferred from *Thórarinsson's* (1937) or *Th. Einarsson's* (1967, 1968) results.

Th. Einarsson (1961) and *Steindórsson* (1962, 1963) suggested the possibility of relatively large ice-free areas on Vestfirðir during the Weichselian. *Sugden and John* (1976) used Vestfirðir as an example of glacial landscape evolution in mountains near the periphery of an ice sheet; a point of view which recognizes ice-free areas in environments with predominantly alpine-type glacial erosion. *John* (1975) recognized three different types of glacial erosion on Vestfirðir. He included Hornstrandir among alpine-type landscapes, where glaciation was characterized by a high density of glaciers with a low to moderate discharge. In a later paper (*John* 1977a) he stated that it was unlikely that there were any large

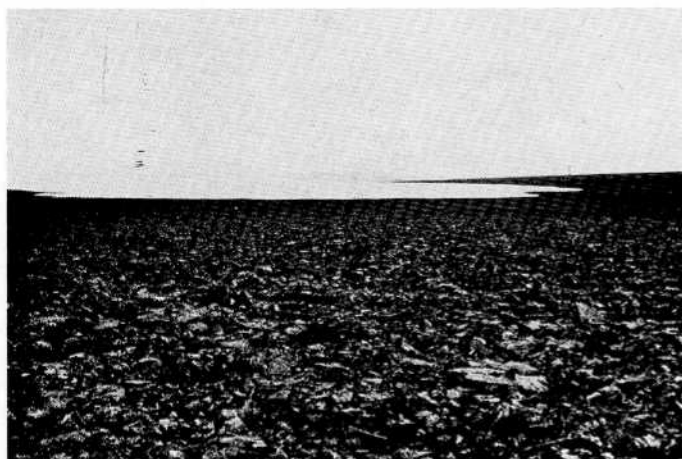


Fig. 3. Block-field on the high plateau 5 km northeast of Látrar in Adalvík. The altitude is about 500 m and the plateau lacks any sign of active glacial erosion or deposition. A small perennial snowfield can be seen in the background. 3. mynd. Stórgrytisdreif í um 500 m yfir sjó, um 5 km norðaustan við Látra í Adalvík. Á hásléttunni eru engin ummerki eftir virka jökla.

unglaciated enclaves or plant refugia during the Weichselian, anywhere in Iceland. Contrary to this, Sigbjarnarson (1983) emphasized the importance of alpine-type glacial erosion on Vestfirðir and stated that ice-free areas probably existed there throughout the Pleistocene.

Only limited work has been done on the deglaciation of the northern parts of Vestfirðir. Thoroddsen (1892a) suggested two major stages in the deglaciation. During an earlier phase the glaciers had retreated and the sea transgressed to 60–70 m above present sea level, with shorelines and terraces at those altitudes forming in the outermost coastal areas while the glaciers still remained in the valleys and fjords. During a later phase, when the glaciers retreated from the lowlands, shorelines and terraces were formed at 16–30 m above present sea level. Thoroddsen (1892a) reported features indicating ancient sea levels at 63 m above the present one in Rekavík, at 30 m at Látrar in Adalvík and at 16 m in Hornvík.

Kjartansson (1969) observed raised beaches in Hornvík and on the eastern flank of Kögur. He mapped outcrops of till in Haelavík and Hlöduvík, and alluvial and eolian deposits on most of the Hornstrandir lowlands. He also observed glacial striae around Hornvík, showing downvalley movements of the glaciers.

John (1974) stated that the highest marine terraces in the area north and west of Jökulfirðir reached only 10 m above present sea level, but Símonarson (1979), who reviewed the geology of Hornstrandir, reported a marine terrace at 16–20 m above the present sea level in Hornvík, and suggested a similar elevation for a marine terrace in Adalvík.

The present study

The maximum glaciation

As mentioned above, the morphology of Hornstrandir is characterized by unconnected short U-shaped valleys, with cirques in their sides and at their heads. The morphology indicates that cirque glaciers coalesced to form outlet glaciers which reached beyond the present coastline. But the high plateaux show no sign of having been inundated by active glaciers and are usually covered by mature block fields consisting of local bedrock (Fig. 3). The very flat surfaces of these plateaux contrast sharply with extensive lower areas which have been intensely eroded by glaciers (Fig. 4), and with cirques and different nivation features below the plateau edges (Figs. 4 and 7).

Today most of the shelf around Hornstrandir is shallower than 100 m. Thus it may have been dry, or at least under very shallow water, during the Weichselian maximum glaciation – provided that this coincided with the maximum glaciation elsewhere around the North Atlantic and with the contemporaneous global sea level low.

An empirically derived absolute upper limit of actively eroding ice at sites near the present coast, defined as plateau surfaces without signs of glacial erosion, plus the assumption that the ice was grounded, allows us to approximate the outer edge of the glaciated area at the maximum situation. Giving the large outlet glacier from the Vestfirðir ice cap, which must have existed in Ísafjardardjúp, an Antarctic type B overall gradient and a surface profile of a 60–100 km long Greenland outlet glacier (Buckley 1969; as used for central North Iceland by Norddahl 1983), it can be

