Glacial history of the lower Borgarfjörður area, western Iceland

ÓLAFUR INGÖLFSSON


The glacial development of the lower Borgarfjörður region, western Iceland, was investigated with regard to morphology, lithostratigraphy and chronology of glacial events. The maximum glacial situation is outlined, and a synthesis of all available evidence on the deglaciation is proposed. It is concluded that after an initial deglaciation of the coastal lowlands, some time prior to 12,500 BP, glaciers again advanced to the outer coastal areas between 12,000 and 11,700 BP, and, after a minor retreat between 11,700 and 11,000 BP, retained nearly their former positions between 11,000 and 10,300 BP. The marine maximum limit, at 80–90 m a.s.l., was reached in connection with the former advance, and the regional marine limit, at 60–70 m, at the end of the latter advance. A raised beach at 40 m a.s.l. possibly relates to an Early Flandrian glacial episode. These results imply a more extensive glaciation in coastal western Iceland at the end of the Late Weichselian than hitherto assumed. Glacial geology, chronology, radiocarbon dates, lithostratigraphy, Late Weichselian, deglaciation, sea level changes, Borgarfjörður, Hvalfjörður, Iceland. Ólafur Ingölfsson Lund University. Department of Quaternary geology, Sílvtgatan 13. S-223 62 Lund, Sweden. July 10, 1987. Manuscript received 27 July 1987, revised manuscript received 19 September 1988.

The lower Borgarfjörður area, western Iceland, lies between two large fjords, Borgarfjörður and Hvalfjörður (Fig. 1). The Hafnarfjall–Skardsheidi massif (1053 m) and Mount Akrafjall (643 m) are covered with a scree of colluvium, alluvial cones and rockfall debris. At higher levels, large and small pinacles of bedrock protrude. The local bedrock is mostly basalts of Late Pliocene age. The coastal and valley lowlands are blanketed by extensive bogs, and meadows and heaths with occasional brush. Outcrops of basaltic ridges and dykes are frequent. Natural exposures of sediments are found in riverbanks and along the coast. The coastal erosion rate in the area is among the highest in Iceland, at places along the Melabakkur–Asbakkar coastal cliffs up to 1.5 m/yr.

In a review of the history of Quaternary research in the lower Borgarfjörður region (Ingölfsson 1984), I concluded that there are controversial interpretations of its glacial history, and in two recent papers (Ingölfsson 1985, 1988) I proposed that western Iceland was subject to an extensive glaciation during the last stages of the Late Weichselian. The present paper presents a summary of morphological, stratigraphical and chronological data on the Weichselian glacial development, from Ingölfsson (1987, 1988). A new synthesis of the Late Weichselian glacial development and sea level changes is discussed in the light of recent data from Iceland and western Norway.

Glacial geomorphology

Landscape and bedrock

The landscape of the region has been shaped by glaciers that have been constrained by topography (Fig. 2). The large fjords/valleys of Borgarfjörður, Hvalfjörður and Svinadalur are glacial troughs, eroded by large outlet glaciers. Hvalfjörður (35 km long) is an overdeepened trough, barred at the mouth by a bedrock threshold with present waterdepth of 20 m, but with a waterdepth of >80 m at the head. The Borgarfjörður fjord is very shallow due to infilling of sediments. According to data from seismic soundings and boreholes on a transect across the fjord between Sceyri and Borgarnes (Figs. 1 and 3), the fjord is an up to 100 m deep rock trough, almost completely filled with sediments (Hreinn Haraldsson, Reykjavik, pers. comm. 1986).

The Hafnarfjall–Skardsheidi scenery is characterized by glacial cirques, horns and arêtes, created by interaction of glacial and periglacial activity. The dimensions of the Hafnarfjall–Skardsheidi cirques vary considerably, and fluv-
Fig. 1. Location and general physiography of the lower Borgarfjörður region. 1: outcrops of bedrock, 2: town, 3: section described, 4: location of profiles, 5: locality discussed in text, 6: lake, 7: elevation above sea level, 8: meadows and heaths, 9: bogs, 10: eolian dunes, 11: approximate meadow/bog boundaries, 12: contour lines, 100 m interval.

...ial erosion, landslides and colluvial deposits have influenced their form in various degrees. Most cirques have floors around 400 m a.s.l. and headwalls going up to 700–900 m a.s.l. A distinct basin threshold is usually absent. This can indicate that the cirque glaciers fed and merged with outlet glaciers during the glaciation, as cirque glaciers confined to hollows are more likely to erode a rock basin than those flowing out of a corrie (Evans 1969).

Cirque recession has resulted in the formation of horns and arêtes where headwalls converge and intersect. The central part of Skardsheidi is a series of horns, at four places reaching above...
1000 m a.s.l. The Leirárdalur valley, separating the Hafnarfjall mountain from the Skardsheiði massif, probably developed into a col when cirques from north and south coalesced. Glacial striae in Skorradalur indicates that Leirárdalur has at some time conducted a major glacial stream towards the south.

Large rockslides are characteristic for glacial landscapes in Tertiary basalt plateau areas of Iceland. They occur where glacial erosion has undercut valley slopes and cliffs (Thorarinsson 1954). Conditions for rockslides are favorable due to a combination of a dipping lava pile intersecting one or more gullies and interbeds of basaltic clastic beds which can serve as slip surfaces.

The pattern of glacial striae (Fig. 2) suggests a situation where glaciers from Borgarfjörður, Svinadalur and Hvalfjörður coalesced. The only indications of glacial activity above 400-600 m a.s.l. are in the glacial cirques. On the eastern slopes of Akrafjall, in a zone between c. 300 and 450 m a.s.l., there are many large, subrounded to angular erratics. Kjartansson (1955) suggested that Akrafjall divided the Hvalfjörður ice stream during the last glaciaion, and that the zone of erratics marks the thickness of the ice as it passed the mountain. Thorarinsson (1937) estimated the upper limit of glacial grinding along the northern side of the Skardsheiði massif at 400-500 m a.s.l. I estimated the boundary zone between glacially abraded and striated bedrock and periglacially sculptured terrain along the southern side of Skardsheiði to be at about 500 m a.s.l.

Glacial drift was not found above 200 m a.s.l. and meltwater channels were not recognized above 500 m (Fig. 4). The glacial landscape reflects a full glacial situation, with an extensive ice cover. My reconstruction of the Weichselian maximum ice cover, based on the morphological evidence, is outlined in Fig. 5.

Glacial and marine landforms and sediments

The distribution and pattern of glacial and marine landforms and surface sediments is outlined in Figs. 4 and 6, with a close-up of the
Skorholtsmælar area in Fig. 7. The glacial deposits are mainly ice marginal sediments of tills and glaciofluvial outwash. The marine landforms and sediments are abrasion cliffs and raised beaches and terraces with littoral sands and gravels.

The Skorholtsmælar area is a c. 5 km long and up to c. 2.5 km wide terminal moraine complex, of arcuate ridges traversing across the Leirarveit lowland (Fig. 7). The ridge-trough amplitude is usually 15–20 m, with the largest ridge rising c. 40 m above the surroundings. Maximum drift thickness of about 60 m have been reported from seismic soundings on a traverse across the ridge zone (Gislason 1973). Large erratics are common, some of which are of granophyre. The only known occurrence of granophyre in the region is in the central western slopes of Hafnarfjall. Proximally to the ridges the terrain is hummocky, with large, water-filled kettle holes.

There are no natural exposures in the moraine complex. In two small gravel pits, superimposed sequences of crudely bedded sandy gravels were exposed. Thin lenses of stratified silty-sandy diamicton and sand occur within the gravel sequences. I interpret the gravels as glaciofluvial outwash, and the interbedded diamicton as flow-till. A major component of the Skorholtsmælar complex are glaciofluvial delta sediments. In a gravel pit on the southern margin of the arc (Fig. 1A), a 20 m thick planar cross-stratified forest delta sequence is exposed. The forest beds are 20–100 cm thick and dip towards SE. The material is sandy-pebbly with frequent cobble trains, and occasional lenses of stratified to massive sandy-silty diamictons. The foresets are truncated by a gravel lag horizon of wave erosion at 52 m a.s.l.

The morphology of the Skorholtsmælar complex suggests a deposition in front of a lobate glacier tongue extending from the Borgarfjörður valley onto the lowland. The granophyre erratics also suggest debris transport down the Borgarfjörður valley. The arcuate ridges probably formed due to a combination of glacier push on ice marginal outwash deposits and supraglacial melt out of debris. Boulton (1986) has pointed out that the development of large push-moraines is promoted by the presence of large accumulations of ice marginal outwash deposits. The delta deposits on the distal side of the complex indicate a sea level of at least 52 m above the present at some time during its formation.

Another ridge zone extends from the Middelfellsmúli ridge towards Akrafjall (Fig. 4). The
ridges rise to 30–40 m above the surroundings, and proximally embay a lowlying mire with two small lakes. The ridges are made up of dislocated and folded diamicton, containing abundant cobbles and larger clasts in a silty-sandy matrix. The deforming push has come from an easterly direction, and I interpret them to be terminal moraines, pushed up by a glacier tongue from a Hvalfjörður glacier.

Surface outcrops of glacial drift also occur in the Svinadals valley and the Andakill-Skórradalur area (Figs. 1 and 4). They are diamictons of angular to subrounded gravels and boulders in sandy-silty matrix, often with intrabeded lenses and tongues of stratified diamicton, sands and gravels. Large erratics are common on the surface. I interpret the sediments mainly to derive from meltout, debris flows and meltwater reworking during ice disintegration and retreat. The drift sediments are often reworked by cryoturbation and, below the regional marine limit, abraded and modified by wave action. Large erratics occurring in trains or zones (Fig. 4) may be residuals from frontal, medial or lateral moraines.

At Stóra Fellsöxl, on the eastern flank of Akrafjall (Fig. 1B), there is a large delta deposit of single-set, planar cross-stratified glaciofluvial gravels and sands (Fig. 8). The set thickness is up to 25 m. The foresets are 0.3–1.0 m thick, angular to tangential based, and dip towards N–NE. The topset-foreset contact is at 80 m a.s.l. A delta body with a northwesterly foreset dip at this location requires that meltwater has been conducted by a glacier occupying the Hvalfjörður trough. I interpret the delta to be an ice lateral deposit, relating to a marine level of 80–90 m above present sea level. At Hólabri, on the central south-eastern flank of Mount Akrafjall (Fig. 1C), there is an extremely coarse grained deposit of crudely stratified, clast supported cobble gravels and boulders. The clasts are sub-rounded to well rounded and often show imbricated fabrics, indicating a deposition stream direction from east. Boulders of 0.5–1.0 m in diameter are frequent, while granules and sands are almost entirely lacking. I interpret this to be an ice marginal stratified drift deposit of glaciofluvial outwash, deposited as fast flowing meltwater streams entered a marine environment during a rapid wastage of the Hvalfjörður glacier. Its surface at 58–60 m a.s.l. has been levelled by wave action and carries beach ridges.

Raised beaches are met with at three altitudes: at 80–90 m, 60–70 m and around 40 m a.s.l. (Fig. 6). The marine maximum limit at 80–90 m is marked by a raised abrasion cliff on the northern slopes of Akrafjall. The delta platform at Stóra Fellsöxl and a shoreline cut into outwash deposits in front of the Leiðadalsur valley are at similar elevations. The Leiðadalsur shoreline is an elongated gravel plane, bounded at about 85 m by a 3–4 m high backslope. The 80–90 m shoreline is only found in the outer coastal areas and distally of ice marginal deposits, and thus predates a later glacial event.

The 60–70 m shoreline is found as raised marine terraces throughout the region (Fig. 6), and it represents the regional marine limit. It is at 60 m a.s.l. in the southern part of the investigated area, and rises with a gradient of c. 0.9 m/km to the north. At Ardalur it is at about 70 m a.s.l., and in the mouth of the Skórradalur valley at about 80 m a.s.l. The terraces are usu-
ally flat platforms, bounded to higher terrain by a steep backslope, or by boulder lag concentrations. The platforms are usually covered with well rounded pebble gravels and sands, and frequently carry a system of beach ridges. The littoral sediments are stratified, poorly sorted sands and gravels. Distinct marine terraces occur on both the proximal and distal sides of the Skorholtsmælar terminal moraine complex.

Although similar as landform elements, the marine terraces vary considerably with respect to internal structure and material. At Leirði (Fig. 1D), the terrace platform has developed on a hummocky moraine, which constitutes its backslope. The terrace (Fig. 9) is built of stratified silty sand and sandy silt, with occasional thin, matrix-supported gravel beds and pebble trains. It is capped by 2 m of sandy beach gravels. I interpret it as a foreshore platform, accumulated from backwash transport of eroded moraine material. The deposit is about 18 m thick, and rests unconformably on silty-sandy diamicton. Similar terraces are met with in the Svinadalsur valley and distally on the Skorholtsmælar moraine arch.

The terraces along Hafnarfjall are primarily of coarse, cross-stratified sands and gravels, resting locally on fossiliferous diamicton and locally on bedrock. In a gravel pit east of Seleyri (Fig. 1E), at 50−60 m a.s.l., the terrace is made up of a 12−15 m thick sequence of planar cross-stratified delta foresets, which I interpret as glaciofluvial outwash. The foreset strike changes upwards in the sequence: The lower sets strike 170°−350° and dip 15° towards the west, which is roughly perpendicular to the present coastline. The upper sets strike 80°−260° and dip 20° towards the present coast. There is no sign of any stream having entered this locality from the slopes of Hafnarfjall. I interpret the sediments to be an ice marginal delta, deposited by lateral meltwater during an ice retreat. The change in strike upwards could reflect reworking of glaciofluvial outwash by littoral processes. Lat-

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**Fig. 8.** Large-scale planarcross-stratified glaciofluvial outwash in the Stóra-Feltsöxl gravel pit (Fig. 1B).

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**Fig. 9.** Generalized block diagram of the 60−70 m marine terrace, developed on a hummocky terrain at Leirði (Fig. 1D). 1: fossiliferous glaciomarine diamicton, 2: interstratified silt and sand, 3: beach sediments, 4: terrace platform, 5: boulder and cobble lag at the former strandline, 6: hummocky terrain.
eral meltwater channels, eroded in bedrock, occur in the vicinity of the delta deposits, at 80–100 m a.s.l. (Fig. 4). Marine terrace of coarse cross-stratified glaciofluvial outwash is also found at Kjalardalur (Fig. 1G), below the north slope of Ákrafjall.

The 40 m shoreline is regional in extent, but poorly preserved and found only intermittently. In the southern part of the area it is found as a shallow wave cut bench at 36–40 m above present sea level, with concentration of large, well rounded boulders (Fig. 10). No obvious platforms of littoral sediments are found in connection with the shoreline. In the Andakill area (Fig. 1F), isolated terraces occur, with platform elevation at 42–44 m a.s.l. They are delta bodies of planar cross-stratified, poorly sorted sands and gravels. The foreset-topset contact is at c. 40 m a.s.l. Beach ridges occur at altitudes between 60 and 40 m a.s.l. in the Melasveit area, west of the Skorholtsmelar moraines (Fig. 7).

Glacial stratigraphy

**Melabakkur-Asbakkar**

The most important section in the area is the Melabakkur-Asbakkar coastal cliffs, a 5 km long and up to 30 m high, almost continuous exposure, described in details by Ingólfsson (1988). A composite stratigraphic column for the cliffs is shown in Figs. 11 and 13–5, and a diagrammatic section in Fig. 12.

The lowest stratigraphical unit, the Asbakkar diamict, accumulated from suspension, random underflows and ice rafted debris in a glaciomarine fjord/bay environment, ca. 12,500–12,000 BP. The diamict is fossiliferous, with boreal to arctic mollusc species (Fig. 14-1a). In connection with a glacial advance down the Borgarfjörður valley/fjord around 12,000 BP, subaqueous ice marginal stratified sediments (the As beds) were deposited from meltwater streams and debris flows to form proglacial shoals or banks. Continued advance of the glacier beyond the cliffs towards the Leirárvogar cove caused heavy glaciectonic deformation of the strata. Around 11,700 BP the glacier had retreated to a position somewhere north of the Melabakkur-Asbakkar section. In the course of retreat, the esker fan facies of the Látar bed was deposited, and subsequently the Látar bed glaciomarine facies. The glaciomarine facies is fossiliferous (Fig. 14-1b), with similar faunal composition as the Asbakkar diamict, but with fewer species and individuals. Some time after ca. 11,400 BP the basin was re-invaded by a glacier advancing from Borgarfjörður. In connection with this readvance, the Melar diamictodn lodgement till and the Lándholmi ice-proximal delta sands were deposited. The glacier advanced at least about halfway across the section. A transverse ridge of glaciofluvial outwash (the Asgl gravel) marks the position of the ice margin during some stage in its retreat. The third glaciomarine sequence in the cliffs, the Melabakkur glaciomarine facies, accumulated in connection with the retreat of the glacier from the basin, some time before 10,000 BP. It carries a spread of fragmented mollusc shells (Fig. 14-1c). The isostatic rebound of the basin is registered in the sequence as glaciomarine sediments grade to sub-littoral sands, finally to be truncated by an emergence facies association of beach gravels and sands (the Melagil gravels and sands).

I have concluded (Ingólfsson 1988) that this sequence, bounded downwards by a surface of glacially sculptured bedrock and upwards by a regional gravel lag of wave erosion, contains a fairly continuous record of glacial episodes in the lower Borgarfjörður region for the later part of the Late Weichselian. Other sections in the region are generally restricted by the same horizons. Logs and correlations for sections described below are shown in Fig. 13.

**Sections north of the Melabakkur-Asbakkar cliffs**

**Ardalur.** The Ardalur exposure (Fig. 1-1) is about 40 m high and about 100 m long. The lowest unit
exposed is a 8 m thick massive to crudely stratified diamicton with fossil shells (Fig. 13-1). The fossil fauna composition (Fig. 14:15) and its radiocarbon age, 12,100±150 BP (Table 1:20), is similar to the fauna and age of the Asbakkar diamicton. I interpret it as a glaciomarine deposit with dropstones.

The fossiliferous diamicton is overlain by a massive, nonfossiliferous, silty-sandy diamicton with heavy concentration of outsized clasts. The diamicton is compact and has a maximum thickness of about 8 m. It is conformably overlain by a 1 m thick, laminated, silty sand. I interpret the massive diamicton as a large scale slump deposit, probably derived from an unstable morainal slope close by, deposited in a near shore glaciomarine environment. The laminated sand could indicate a deposition in an environment influenced by meltwater input. The laminated facies is conformably overlain by a 1 m thick unit of stratified, sandy-pebble gravels. Imbricated horizons give a paleocurrent direction towards the present coastline.

The gravel is conformably overlain by a 9 m thick, massive to crudely stratified diamicton, very similar to the lowest diamicton and containing the same fossil fauna assemblage. Deformation structures indicate post-depositional slumping. A radiocarbon dated sample from the diamicton (Table 1:23) gave a similar age to the sample from the lower fossiliferous diamicton. I interpret the two diamictons to belong to the same depositional event, interrupted by a short-lived episode of slumping and meltwater input. The diamicton is overlain by a 17 m thick unit of beach gravels and sands.

Gjöteyri. - At Gjöteyri (Fig. 1-2) the lowest unit is a 5-6 m thick deformed, crudely stratified, fossiliferous, silty-sandy diamicton (Fig. 13-2). The fossil fauna composition (Fig. 14:14) is similar to the fauna in the Ardalur fossiliferous diamicton and the Asbakkar diamicton. A radiocarbon dated sample (Table 1:27) gave the age of 12,465±110 BP, which is compatible
Fig. 13. Stratigraphical logs and correlations. Log numbers correspond to sections marked in Fig. 1. Legend: 1: bedrock, 2: massive diamicton, 3: stratified diamicton, 4: dropstones, 5: till, 6: silt, 7: sand, 8: gravel, 9: beach sediments, 10: planar cross stratification, 11: trough cross stratification, 12: lamination, 13: fossil molluscs, 14: location and no. of radiocarbon dated sample in Table 1, 15: unit contacts: a) crosive, b) sharp, c) graded, d) not observed. Log 5 is a composite stratigraphic column for the Melabakkar-Asbakkar section. Note that it has a different scale.

to the dates from the Asbakkar diamicton and Ardalsa diamicton. I interpret the unit as a glaciomarine deposit with ice rafted clasts. It is overlain by a 3 m thick rhythmic deposit of laminated sand and silt. Small scale load casts and flame structures indicate gravitational instability during or shortly after deposition. I interpret the laminated facies as pro-delta sediments. It is overlain by a 5–7 m thick sequence of planar cross stratified sands and gravels which I interpret as glaciofluvial delta foresets. The foresets generally dip 20–25° towards north, but locally the sequence is tectonized, and a dip of 40° towards west was measured on one occasion.

The delta foreset sequence is discordantly overlain by a 0.5–1.5 m thick massive diamicton. The diamicton is lithified and impervious and conducts a small stream on its upper surface. The diamicton is a silt-sand-gravel-boulder admixture. Crushed and fragmented shells occur, but could not be identified to species. The diamicton is weakly jointed. I interpret the diamicton to be a lodgement till.

The till is overlain by a 2–3 m thick planar cross-stratified gravel and sand, which dip towards the present coast. The cross-stratified facies could be

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Table 1. Radiocarbon dates from the lower Borgarfjördur region. Samples marked (*) from Ashwell (1975). Sample marked (**) from Olsson et al. 1969. The base year is 1950. The values of 5568 and 5570 used for the half life of $^{14}C$. Corrections for deviation from standard $^{13}C$-$^{12}C$ ratio and apparent age of living marine organisms (Håkansson 1983) applied, except for samples marked (*).

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<td>Lu-2395</td>
<td>6.060±80</td>
<td>Peat</td>
</tr>
<tr>
<td>3. Akranes 1a</td>
<td>-3.1</td>
<td>Lu-2395AI</td>
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<td>4. Akranes 1a</td>
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<td>5. Skipanes 1</td>
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<td>Lu-2197</td>
<td>10.005±90</td>
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<tr>
<td>6. Skipanes 3</td>
<td>3-4</td>
<td>Lu-2378</td>
<td>10.155±150</td>
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<tr>
<td>7. Súlur</td>
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<td>8. Ægirshókur</td>
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<td>Lu-2524</td>
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<tr>
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<td>Lu-2195</td>
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<td>Mollusc</td>
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</table>

glacioluvial delta foresets or sub-littoral beach facies. It is discordantly overlain by 1 m thick beach gravels and sands.

Sælveyr. In a coastal exposure on the western edge of the large Sælveyr fan delta (Fig. 1-3), the lowest unit (Fig. 1-3), resting on striated bedrock at sea level, is about 1 m thick, massive and lithified, non-fossiliferous diamict. It has a silty-sandy-granule matrix and carries rounded to angular pebbles and cobbles. Some of the clasts are glacially abraded. I interpret it to be a till deposit.

The till is overlain by a 5-10 m thick unit of alternating 1-5 cm thick sandbans and laminae and thin beds of sandy silt. No fossils were found in the unit. I interpret it to be a pro-delta sediment, deposited in a marine environment from slumps, underflows and suspension. It is overlain by a 6 m thick planar cross-stratified sand facies, dipping towards the present coastline. It could either be beach or delta foresets.

Belgkoll. At Belgkoll (Fig. 1-4), there is a 150 m long and up to 11 m high coastal section. Three stratigraphic units are exposed in the cliffs (Fig. 1-4): the lowest unit is a 2 m thick, massive, fossiliferous diamict, similar in lithology and fossil content (Fig. 14: 2) to the Asbakkar glaciomarine diamict, and I correlate the two. It is unconformably overlain by a soft, laminated silt, which grades upwards to interstratified, non-fossiliferous, laminated silt and sand. The laminated and graded facies is 6-8 m thick. It is similar to the glaciomarine and sublittoral facies of the Melabakkar silts and sands, and I correlate the two. The unit is overlain by about 2 m thick beach gravel and sands.

Sections around the Leirarvogar cove

Súlunesvogur and Súlú. The Súlú river enters the Leirarvogar cove through a 10-15 m deep ravine, and the about 1 km long coastal stretch towards Asbakkar. Súlunesvogur, is fringed by 5-10 m high cliffs. A schematic transect between points E and F in Fig. 1 is shown in Fig. 15, and a composite stratigraphic column in Fig. 13-6. The base of the sequence is of massive to weakly stratified sandy-silty diamict, up to 6 m thick. At places it is heavily contorted. The diamict is fossiliferous with similar mollusc fauna composition as the Asbakkar diamict (Fig. 14: 3 (Súlunesvogur) 4a (Súlú). 5 (Bakkjí)). On the basis of similarities to the Asbakkar diamict in stratigraphic position, lithology and fossil fauna content I correlate the two.

The diamict is unconformably overlain by a 2-4 m thick unit of cross stratified and planar parallel stra-
Fig. 15. Schematic profile of the Súlunes-Súlunesvogur section between points E and F in Fig. 1. 1: bedrock, 2: massive, fossiliferous diamicton, 3: gravelly sand, 4: cross stratified sand, heavily brecciated, 5: interstratified silt and sand, 6: till, 7: beach sediments, 8: section covered, 9: location and no. of radiocarbon dated sample in Table 1.

tified sand and gravel facies, interpreted as a glaciolaeuvial deposit. The unit is heavily tectonized. The tectonic displacement is related to the contortion of the underlying diamicton. Undulations in the diamicton surface topography are expressed in horst and graben structures in the sand and gravel unit. The glaciolaeuvicm is overlain by a unit of interstratified silt and sand, containing subfossil molluscs and numerous gravel clasts. In the Súlunesvogur part of the section it is 1.5 m thick, but up to 15 m thick in the Súluses ravine. In the eastern part of the section, the interstratified silt and sand rests unconformably on the lower diamictic unit. The interstratified unit is a glaciomarine deposit, probably deposited via a combination of sedimentation from suspension, subflows and ice rafting. The fossils are not in situ: locally, only occasional shells are found, and locally whole and broken shells are found in abundance. The fossil fauna (Fig. 14: 4b) indicates a cold environment as arctic to high-arctic species occur (Glaucocystis groenlandicum, Portaludia arctica). A sample was radiocarbon dated to 10,965±80 BP (Table 1: 7). I correlate this unit with the glaciomarine facies of the Látrar beds in the Melabakkar/Asbakkar sequence (Fig. 11 and 12).

In the western part of the section, a 1.5-2.0 m thick diamictic unit, containing sub-angular to rounded gravel clasts, discordantly overlies the sand and gravel unit and the interstratified silt and sand unit. It has a weakly stratified silty-sandy matrix, is non-fossiliferous, compact and impervious. I suggest that it is a till deposit. The whole section is overlain by 2-4 m of beach gravels and sands.

Fig. 16. Schematic cross section of the Skipesnes cliffs. 1: massive, fossiliferous diamicton, 2: interstratified unit of silt, sand, gravels and diamicton, 3: lodgement till, 4: laminated silt, grading upwards to stratified sand, 5: gravelly sand and sandy gravel, 6: beach sediments, 7: section covered, 8: faults, 9: location and no. of radiocarbon dated samples in Table 1.

Skipesnes - East of the mouth of the Geldaingá river, towards the farm of Skipesnes, a coastal section rises from 3-4 m to about 14 m (Figs. 13-8 and 16). The lowest unit is a 2-10 m thick compact to lithified, fossiliferous diamicton. It is jointed and faulted, and in the Skipesnes cliffs, intensely deformed. The fossils are not in situ, and shells are often broken and pitted. The fossil fauna composition (Fig. 14: 7a) is similar to the fauna of the Asbakkar diamicton. A sample was radiocarbon dated to 11,885±100 BP (Table 1: 15). This is a radiocarbon age somewhat lower than obtained from the lithologically and structurally similar Asbakkar diamicton, but I correlate the two.

The diamicton is overlain by a multistorey sequence of interstratified diamictons, silts, sands and gravels. Lithofacies thicknesses are 5-30 cm, and lateral extent varies from tens of cm to tens of m. The sand facies often grade to laminated silt. Imbricated gravel trains occur, as well as isolated cobbles and larger clasts. The contact between the lowest fossiliferous diamicton and the multistorey sequence is locally sharp, locally graded, and locally deformed. I interpret the transition from the lowest fossiliferous diamicton to the interstratified sequence to indicate an increased proximity to meltwater streams capable of carrying gravels into the depositional basin.

The fossiliferous diamicton and the interstratified unit at Skipesnes have been subjected to a large scale deformation (Fig. 16): the diamicton has a nappé-like geometry, and the interstratified unit forms a basin structure. At the nappé-basin contact, a large scale translational flexure structure has developed, and the interstratified sediments are curved, outdrawn and
thinned due to vertical and sub-vertical strain. Similar structures have been described from outer zones of large scale load casts (Brodzikowski & Van Loon 1985).

The interstratified unit is unconformably overlain by an up to 2.5 m thick, heavily sheared and jointed diamicton, containing broken shell fragments and stratified clasts in a silty-sandy matrix. Shear planes are spaced 20–40 cm apart and strike between 30°–310° and 90°–270°. The joints occur in two sets; a sub-horizontal set and sub-vertical to vertical set. The former set occurs as lensoid slabs, 5–20 cm thick and 50–150 cm long. The later set occurs as sub-parallel columns, spaced at 10–25 cm intervals, which sometimes cross shearplanes and can be traced across the entire unit. I interpret the diamicton to be a lodgement till, deposited beneath a glacier advancing from a north westerly direction. The presence of till in this stratigraphic and geographical position confirms with the Melabakkur-Askabbak evidence of an ice advance after the deposition of the Askabakkar diamicton.

The sequence is discordantly overlain by a 1–4 m thick unit of soft and tight laminated silt. It grades upwards to interbedded laminated silt and sand which in turn grade to stratified with intrabeds and lenses. The laminated silt and the stratified sand have in situ fossil shells (Fig. 14: b). A radiocarbon dated sample from the laminated silt gave the age of 10,155±150 BP (Table 1: 6) and a sample from the stratified sand gave the age of 10,000±90 BP (Table 1: 5). I interpret the unit to be a distal glacimarine to sublittoral sediment. I correlate it with the Melabakkur silts and sands (Fig. 11). It is overlain by littoral sands and gravels.

**Geldingaá.** The fossiliferous diamicton at the base of the Skipanes sequence can be recognized intermit-
tently in the Geldingaá river channel. Below the fan of Geldingaá (Fig. 1-7) it is overlain by a 8–10 m thick sequence of massive to planar parallel stratified and cross-stratified sand facies (Fig. 13-7). Facies contacts are locally erosive, locally graded and locally sharp. I interpret this unit to be a distal outwash fan deposit.

The sand is discordantly overlain by a 30–50 cm thick, massive gravelly diamicton. The diamicton is a silt-sand-gravel-boulder admixture, with clast-to-clast contact rounded to angular boulders. One large, angular and striated boulder was observed. I interpret the diamicton to be an ice-proximal to ice contact deposit, either a till or coarse debris flow off moraine slope or ice front.

The diamicton is unconformably overlain by a 1 m thick, laminated sandy silt facies. I interpret it as a glacimarine deposit, possibly a pro-delta sequence. It is discordantly overlain by a 1.5–2 m thick sequence of stratified diamicton. The diamicton is silty-sandy, with sub-rounded to angular pebble clasts and occasional cobbles. Some of the clasts are of silty-sandy diamicton and contain shell fragments. The diamicton has been deposited as a succession of tongues and lenses, 2–15 cm thick. I interpret it as a glaciogenic sediment debris flow, probably originated from the distal side of the Skorholtsmælor moraine arch.

The diamicton is overlain by a 3 m thick, massive to stratified sandy silt, with intrabeds and lenses of poorly sorted sand. The silt has a spread of broken and pitted shell fragments (Fig. 14: 6). It can be followed towards the Skorholtsmælor moraines, where it constitutes the lowest facies of the 60 m marine terrace on the distal side of the arc.

**Leirá and Laxá.** In the riverbanks of the Leirá- and Laxá rivers there are a number of small exposures where massive fossiliferous, contorted, sandy diamictons are exposed (Fig. 13-9 and 13-10). In respect to lithology, fossil fauna assemblage (Fig. 14: 8 (Leirá) and 9 (Laxá)) and radiocarbon age of fossil shells (Fig. 10: 38) the fossiliferous diamicton is overlain by a thin (0.5 m) massive and sheared, non-fossiliferous diamicton. The unit contact is erosional. The diamicton is lithified and contains pebble and cobbles clasts in a sandy matrix. This diamicton is possibly a till deposit, relating to a glacier extending out of the Svinadalur valley.

**Urridáa.** In the banks of the Urridáa river (Fig. 1-11) there is a 30 m long and 3 m high exposure (Fig. 13-11), where the sediments rest on striated bedrock. The lowest unit is a 0.5 m thick planar parallel stratified and trough cross-stratified sand. The depositing stream or current flowed towards west. In the uppermost part of the unit, thin beds (2–4 cm) of well rounded, clast supported pebble gravels occur.

The sand is overlain by a 2 m thick massive and compact diamicton of cobble clasts in a matrix of silt, sand and granules. Upwards in the diamicton there is an increasing fissility, with conspicuous sub-parallel lenticular joints. Shell fragments occur in the matrix, but too crushed to identify to species. I interpret the diamicton as a lodgement till. The Urridáa section transsects a terminal moraine ridge related to a Hallajárfjördur glacier, and a depositing glacier flow from east tentatively suggested.

The diamicton is overlain by a thin (<0.5 m thick), weakly stratified, sandy silt. It is fossiliferous (Fig. 14: 10), with in situ molluscs. *Mya truncata* is found in life position and bivalves of *Chlamys islandica* are found carrying individuals of *Balanus balanus*. A radiocarbon dating of a sample from the sediments gave the age of 11,155±100 BP (Table 1: 10). I correlate the silt facies with the Lárrar glacimarine facies in the Melabakkur-Askabakkar sequence. The Urridáa sequence is unconformably overlain by 2–4 m of littoral sands and gravels.

**Arkarlaakur.** At Arkarlaakur (Fig. 1-12) the lowest stratigraphic unit is a c. 2 m thick silty-sandy diamicton (Fig. 13-12). It is compact and lithified. Intrabedded in the diamicton are small lenses and tongues of sorted sand, and a striated clast of granophyre was observed. Deformation structures indicate postdepositional slumping. The facies is fossiliferous (Fig. 14: 1-1), and a radiocarbon date of a mollusc sample gave the age of 10,985±100 BP (Table 1: 8). I interpret the diamicton as a glacimarine sediment with dropstones.

Above the fossiliferous diamicton in the strata is a 2–5 m thick rhythmic unit of soft, dense and impervious laminated silt and sand. It grades upward to stratified sand and granule-pebble gravels before being truncated by a lag horizon of wave erosion. The sequence above the fossiliferous diamicton is similar to the glacimarine to sublittoral facies of the Melabakkur silts and sands.
Sequences south of Mount Akrafjall

There are two major sediment exposures in coastal cliffs south of Mount Akrafjall, at Gröf (Fig. 1-13) and Heynes (Fig. 1-14). They are separated by the Hölalbrú stratified drift deposit.

Gröf. - The sediments are exposed in a 500 m long and up to 25 m high coastal section. The lowest stratigraphic unit, resting on striated bedrock (Fig. 13-13), is a 3-5 m thick, compact, sandy-silty diamicton. The diamicton is fossiliferous (Fig. 14: 13), and in situ individuals of Mya truncata occur. In lithology, fossil fauna assemblage and radiocarbon age (12,475±110 BP, Table 1: 29) it is similar to the Askakkar diamicton and I correlate the two.

The diamicton becomes more sandy upwards, and is conformably overlain by a 4 m thick planar cross stratified, pebbly sand. Its foresets are angular to tangential based, 2-5 cm thick. Crushed fragments of Balanus spp. form bands or laminae in the foresets. The cross stratified facies dips towards the present coastline. I interpret it as beach foresets.

The cross stratified sand facies is discordantly overlain by a 0.6 m silty-sandy diamicton. At the base of the unit there is a concentration of pebbles and cobbles in a sandy-silty matrix, and clast-to-clast contact fabric occurs. The number and size of clasts diminishes upwards and the unit grades to poorly sorted silty sand with occasional pebbles. I interpret this to be a deposit from a fluid debris flow, where the concentration of large clasts at the base is due to traction during transport. The debris flow deposit has a deformed contact to a roughly 2 m thick diamicton. Its matrix is silty-clayey, brownish in color, and greasy to touch. The diamicton contains angular clasts of all sizes, from pebbles to boulders. The number and size of clasts, as well as the compactness of the sediment, increases upwards, and clusters of boulders occur. The diamicton is heavily jointed. I interpret this diamicton to be a lodgement till.

The till has a sharp contact with a 1.5 m thick unit of massive silt. Discontinuous bandings of fine sand and clayey silt occur within the unit. The unit is deformed, and small scale intra-formational folds and diapiric structures were recognized. This could be a sequence of fine grained sediment debris flow deposits (flow till), deposited in connection with the retreat of the glacier that deposited the underlying till. It is unconformably overlain by a 1 m thick unit of massive, openwork pebble gravel with occasional cobble clasts. Pore spaces between gravel clasts are filled with silt from overlying sediments. The gravel unit is probably a outwash deposit.

The gravel facies is conformably overlain by a 4-5 m thick, light and impervious, laminated silt facies. Only a few shell fragments were found in this unit. I interpret it to be a glaciomarine-sublittoral deposit. It is conformably overlain by littoral sands and gravels.

Heynes. - The sediments are exposed in a c. 1 km long and 10-15 m high coastal cliff. The strata rest on striated bedrock at sea level. The bulk of the cliff is a stratified deposit (Fig. 13-14) of alternating massive and laminated silt facies. It is fossiliferous (Fig. 14: 12) with species of similar faunal composition as the Valøya interstratified silt and sand deposit. In situ molluscs occur, and individuals of Balanus balanoides were found in life position on the striated bedrock below the sediment pile. Portlandia arctica, an indicator species of high-arctic environment, was sampled from the lowest part of the strata. A radiocarbon dated sample from that part of the strata gave the age of 11,063±140 BP (Table 1: 9). The silt strata is truncated by a sharp gravel lag horizon and overlain by littoral sands and gravels.

Synthesis of the morphology and lithostratigraphy and a chronology of glacial events

Glacial landforms indicate a glaciation episode after the initial deglaciation of the coastal lowlands. The marine maximum limit at 80-90 m was reached prior to the formation of the Skørholtsemal moraines proper, but while the Hvalfjörður trough was filled with ice. The 60-70 m regional marine limit was reached in connection with the final deglaciation of the lowlands. The 40-50 m raised beach could be of Early Flandrian age, and indicate an interruption in the general trend of lowering of the relative sea level towards the present. Its cause could be isostatic, i.e. an episode of increased ice volume. Terminal moraines in the upper Borgarfjörður tributary valleys possibly relate to such glaciation episode. The relative sea level was more than 3-4 m below the present at around 6,300 BP and more than 0.7 m below the present at 2,000 BP, as dated by submerged peat deposits northeast of Akranes (Fig. 6 and Table 1: 1-4).

The most complete stratigraphical record comes from the Melabakkur-Askakkar coastal cliffs and the sections around the Leirárvogar cove. All other sections carry erosional unconformities at one or more stratigraphical levels, which complicates lithostratigraphical correlations.

The lowest fossiliferous diamicton, corresponding to the Askakkar diamicton in the Melabakkur-Askakkar cliffs, is radiocarbon dated by 16 samples to 12,800±200 BP=11,885 ±100 BP. The fossil fauna resembles the recent Macoma calcarea community, described in East Greenland by Thorson (1933) and Ockelman (1958). According to Thorson (1957) it occurs widely in the arctic seas. It has been described from Late Weichselian sediments in e.g. the Oslo Fjord area, Norway (Spjeldnaes 1978). An important component of the fauna is the panarctic, circumpollar Mya truncata var. addewallensis, which is a more northerly form than the typical Mya truncata (Simonarson 1981). I suggest that the Askakkar diamicton and corresponding sediments were deposited in a glacio-
marine fjord/bay, where sediment input was received from suspension, underflows and slumps off unstable coastal surfaces and ice rafting of debris. The relative sea level at c. 12,300 BP was above 62 m a.s.l. in the Andakill-Skorradalur area, as mollusc supporting glaciomarine sediments could accumulate in Skorradalur at that time (Table 1:25). I name this episode of glaciomarine deposition the Asbakkar event. The Asbakkar event is assumed to correspond to the Bölling interstadial in northwest Europe. The extent of glaciers during this event in the Borgarfjördur region is not known, other than the coastal areas and lowlands were ice free. The glacial development after the Asbakkar event in the Borgarfjördur subarea will be treated separately from the Hvalfjördur subarea.

Borgarfjördur, Melasveit and Leirårveit

Some time around 12,000 BP a glacier from Borgarfjördur overran the Melabakkar-Asbakkar section and reached beyond the Skorholtsmælar moraine complex, as far as Skipanes (Figs. 17 and 18). The indications for this advance are (1) a discordance of glacial erosion above the lowest fossiliferous diamict and (2) glaciotectonic deformation of subglacial sediments, as well as (3) glaciofluvial outwash sediments (Grjöteyri, As beds, Súlunesvogur, Geldingaá and Skipanes) and glaciogenic debris flows (As beds, Geldingaá, Skipanes) and (4) till deposits (Grjöteyri, Selyri and Skipanes). The glacier advanced into a submerged basin, and probably the marine maximum limit at 80–90 m was reached in connection with this advance. There are no ice marginal landforms which with certainty can be related to this advance. The very outermost ridges of the Skorholtsmælar arc (Fig. 7) may mark the position of the ice margin at that time. I call this glacial event the Skipanes event. It probably corresponds to the Older Dryas stadial in northwest Europe.

Around 11,700 BP, the Borgarfjördur glacier retreated to a position somewhere north of the Melabakkar-Asbakkar section. The relative sea level was high, and the glaciomarine facies of the Látrar beds, the interstratified glaciomarine silt and sand facies at Súlunesvogur-Súluá, the fossiliferous silt at Urríðaá and the fossiliferous diamict at Arkarlaekur were deposited. This period of glaciomarine sedimentation is radiocarbon dated by 8 dates to 11,715±120 BP–10,965±80 BP. The fossil fauna assemblage at Súluá (Fig 14:4b) best relates to a transitional mollusc community between the boreal-arctic Macoma calcarea community and the high-arctic Portlandia arctica community, described by Thorson (1957). I call this event of boreal-arctic to arctic glaciomarine sedimentation the Látrar event. I assume it to correspond to the Alleröd interstadial in northwest Europe. The
Fig. 18. Suggested positions of the lower Borgarfjörður ice margins at the (A) Skipes event, (B) Látrar event, (C) Skorholtsmélar event. Arrows indicate major ice streams. Areas above 100 m a.s.l. shaded gray.

position of the ice front in Borgarfjörður during the Látrar event is not known, and the position as drawn in Figs. 17 and 18 is speculative. Ice rafted debris in the Látrar event sediments indicates calving of glacier ice. I suggest that the Borgarfjörður ice front was grounded somewhere along the western edge of Hafnarfjall.

Some time around 11,000 BP the Borgarfjörður glacier readvanced. The appearance of *Portlandia arctica* indicates a cooling of the coastal waters towards the end of the Látrar event. The two radiocarbon dates from *Portlandia* bearing sediments (Table 1:9 and 7) coincide with the Allerød Younger Dryas boundary in Scandinavia. In the Melabakkar-Asbakkar sequence the Melar diamicton (lodgement till) and the ice marginal/ice-proximal Landhólmur sands and Asgil gravels (Figs. 11 and 12) were deposited in connection with the readvance. The glacier reached the Súltunesvogur section where patches of till were deposited. I interpret the Skorholtsmélar morainal arch to mark the terminal position of the glacier (Fig. 18). The sea level during the advance was above 52 m as suggested by the highest occurrence large scale cross stratiﬁed delta sediments in the moraines. I name this episode of glacial advance the *Skorholtsmélar event*, and regard it as a Younger Dryas episode. I suggest that the glacier retreated from the Skorholtsmélar moraines about 10,300 BP. The sea level was at the 60–70 m level in connection with the retreat, and around 10,200 BP–10,100 BP, boreal-arctic molluscs inhabited glaciomarine sediments at Skipes (Fig. 14:7b). In the Melabakkar-Asbakkar section, the Melabakkar silts and sands are distal glaciomarine to sub-littoral sediments deposited in connection with the retreat of the glacier and the isostatic rebound of the basin at the end of the glaciation. Subsequently the glaciomarine-sublittoral sequence in the area is overlain by beach gravels and sands, reflecting the postglacial regression. I call this event the *Melabakkar event*. It probably corresponds to the latest part of the Younger Dryas Chronozone and the Early Flandrian Substage.

**Hvalfjörður**

The stratigraphic record from Hvalfjörður has major unconformities and is harder to interpret. Mount Akrafjall probably divided the Hvalfjörður ice stream during the Skipes event. A glacial tongue overran the Urriðafjörður section and deposited till there. I suggest (Fig. 18) that the Hvalfjörður glacier and the Borgarfjörður glacier merged north of Akrafjall during the Skipes event. South of Akrafjall, the glacier overran the lowest fossiliferous diamicton at Gröf, and I suggest that the glacier advanced beyond Heynes and Akranes. When the Stóravørn delta body was deposited, probably at the end of the Skipes event, the sea level was at 80–90 m, and Hvalfjörður was filled with ice, but the glacial tongue which had overrun the Urriðafjörður section had retreated. The position of the ice front during the Látrar event is unknown, except that about 11,000 BP it was somewhere east of the Heynes section, where fossiliferous glaciomarine sediments began to accumulate. The Heynes section spans the Skorholtsmélar and the Melabakkar events. I interpret the ice marginal stratified drift deposit at Hólabreið to mark the position of the Hvalfjörður ice margin at the Skorholtsmélar event maximum. The moraine ridges between the Stóravón and Mount Akrafjall were probably also pushed up by the Hvalfjörður glacier during the Skorholtsmélar event.

**Discussion**

The most important aspects of the present investigation are, that the lower Borgarfjörður region, and probably the whole of western Iceland, were
subject to an extensive glaciation during the latest part of the Late Weichselian Substage, and that the regional marine limit at 60–70 m in the lower Borgarjördur region was reached at the end of the Younger Dryas Chronozone. During the Látrar event, Hvalfjördur was probably glaciated and an outlet glacier extended into the upper reaches of the present Borgarjördur fjord. The fossil fauna indicates a cooling of the coastal waters towards the end of the Látrar event. The Látrar event thus does not define any climatostatigraphical interstadial. My interpretation suggests that glaciers were continuously present in the coastal areas in the period between the Asbakkar event and the Melabakkar event. The two peaks or advances, the Skipanes event and the Skorholtsmölur event, are Older Dryas and Younger Dryas events, respectively.

My interpretation of the glacial history of the lower Borgarjördur region goes in the same direction as Siggjarnarson’s (1976, 1978) proposal, viz. that two successive readvances down Borgarjördur, representing Older Dryas and Younger Dryas events, had entered the Melasveit area. He formulated his proposal as a matter of opinion, and his views have therefore not received much attention. Bárðarson (1923) and Ashwell (1975) have greatly influenced ideas on the deglaciation of the area. They considered the deglaciation of the Borgarjördur region to have been more or less continuous, and recognize primarily marine and littoral sediments in the strata, though Ashwell points out an important glacioluvial component. The deglaciation synthesis of Einarsson (1961, 1968, 1971, 1979) maintains that the Borgarjördur main valley/fjord was not glaciated after ca. 13,000 BP. He proposed that the Skorholtsmölur moraines mark the position of a Hvalljördur/Svinadalur ice front during the Alftanes stadial, correlated with the Older Dryas of Scandinavia. He maintained that the Borgarjördur region lowlands were not affected by glaciation during the Bødi stadial, correlated with the Younger Dryas of Scandinavia, and that the regional marine limit at 60–70 m was reached during the Sauðhöfn interstadial, correlated with Allerød of Scandinavia (Einarsson 1978, 1979).

Recent investigations in Iceland that suggest the deglaciation synthesis of Einarsson needs a revision. In northeast Iceland, Pétursson (1986) investigated the type locality for the Kópsker interstadial, correlated by Einarsson (1979) with Bölling of Scandinavia. There, Einarsson (1978) suggests that glaciomarine sediments of Kópsker age are overlain by a till deposit of Alftanes (Older Dryas) age. Pétursson suggests that the till relates to a Younger Dryas glacial episode, and dates the glacial retreat to 10,100 BP. Norddahl & Hjort (1987), also working in northeast Iceland, concur with Pétursson as their results indicate that Younger Dryas glaciers entered some fjords, reaching beyond the present coast, to a position which Einarsson relates to the Alftanes (Older Dryas) stadial. Norddahl & Hjort date the glacial retreat from this position to around 10,000 BP.

Hjartarson (1987) proposed a radical revision of the deglaciation scenario for the Reykjavik area in southwest Iceland. He got marine sediments, previously thought to be of interglacial (Emilian) age, radiocarbon dated to 11,500±100 BP. Hjartarson suggested that glaciers reached the Reykjavik coastal area during the Younger Dryas, and that the type locality for the Alftanes (Older Dryas) stadial, at Alftanes in the larger Reykjavik area, belongs to a Younger Dryas event. He also suggested that the marine maximum limit in the Reykjavik area, at 42 m a.s.l., was reached at about 10,200 BP, instead of 11,500–12,000 BP as follows from the deglaciation synthesis of Einarsson. Hjartarson’s (1987) conclusions agree with the present results which show that glaciers advanced in coastal western Iceland not only during the Older Dryas stadial but also during the Younger Dryas Chronozone.

The results of the present investigation also concur with recent evidence on climatic changes and glacier variations at the end of the Weichselian Stage in adjacent North Atlantic areas. Data from western and northern Norway indicate that the ice fronts retained similar positions during the Older Dryas and Younger Dryas stadials, and in parts of southwest Norway a major readvance occurred during the Younger Dryas (Mangerud 1980, Mangerud et al. 1979).

The North Atlantic deglaciation scenario of Ruddiman & McIntyre (1981) suggests a northward retreat of the marine polar front between 13,000 and 11,000 BP, a southwards advance of the front between 11,000 and 10,000 BP, followed by an interglacial norttherly position after 10,000 BP. This pattern fits well with the faunal evidence from Borgarjördur, with the appearance of high-arctic molluscs around 11,000 BP. The cooling of the coastal waters towards the end of the Látrar event also coincides with recent evidence from Britain (Atkinson et al. 1987) and southeastern Sweden (Björck & Möller 1987) on climatic deterioration towards the end of the Allerød interstadial.
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