Macrofossil Studies of lacustrine Sediments from Skálafjørður, the Faroe Islands: preliminary Results

Makrosteinrenningarrannsóknir av vatnsáløgum úr Skálafirði í Føroyum: fyribils úrslit

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Úrtak

Ein røð úr Skálafirði í Eysturoy er greinað fyri at finna makroskopiskar plantu- og djóraleivdir. Røðin inniheldur eitt úrval av plantum og dýrum, sum eru í ósøltum vatni, men ongar steinrenningar av sjóplantum og -dýrum. Røðin vísir sostatt eitt vatnsumhvørvi, og vit koma til ta niðurstøðu, at tann núverandi gáttarfjørðurin var eitt vatn, meðan botnsetingin í hesi røð fór fram. Ein fyribils tíðarskipan bendir á, at vatnið myndaðist beint eftir avglasiatiónina um 10.000 kolevni 14-ár BP, og sjógvur fløddi yvir gáttina um 8.000 ár BP; eftir tað var tað sjógvur. Floran og faunan fevna um nakrar plantur og nøkur dýr, sum eru nýggj í steinrenningarbiotuni í Føroyum, og tvey mosadýr, ið liva í ósøltum vatni, sum higartil ikki hava verið skrásett í Føroyum.

Abstract

A sequence from Skálafjørður on Eysturoy in the Faroe Islands has been analysed for macroscopical plant and animal remains. The sequence contains a range of obligate fresh water plants and animals, and no marine fossils, thus the sequence represents a lacustrine environment, and we conclude that the present threshold fjord was a lake during deposition of this sequence. A preliminary chronological framework suggests that the lake formed just after deglaciation at around 10,000 radiocarbon years BP, and the threshold was inundated by the sea around 8,000 years BP, after which marine conditions were established. The flora and fauna comprise a number of plants and animals that are new to the fossil biota of the Faroes, and two fresh water bryozoans that have not been recorded from the archipelago at the present time.

Introduction

At several occasions over the past decade marine geological work has been carried out in Faroese fjords. Shallow seismic investigations were carried out by Larsen (1991), and sediment cores were collected during cruises of R/V Håkon Mosby in 1988, R/V Pelagia in 1993, R/V Skagerak in 1995 and R/V Dana in 1997. During the 1995-cruise of R/V Skagerak, surface sediment was sampled by box coring, and in addition 10 cores were sampled with a 3-m piston corer in Skálafjørður and adjacent waters. The cores retrieved on the cruises mentioned above contained Holocene marine sediments (e.g. Juul, 1992; Fleischer, 1997). The only exception is a core, which was taken in Skálafjørður off Skáli during

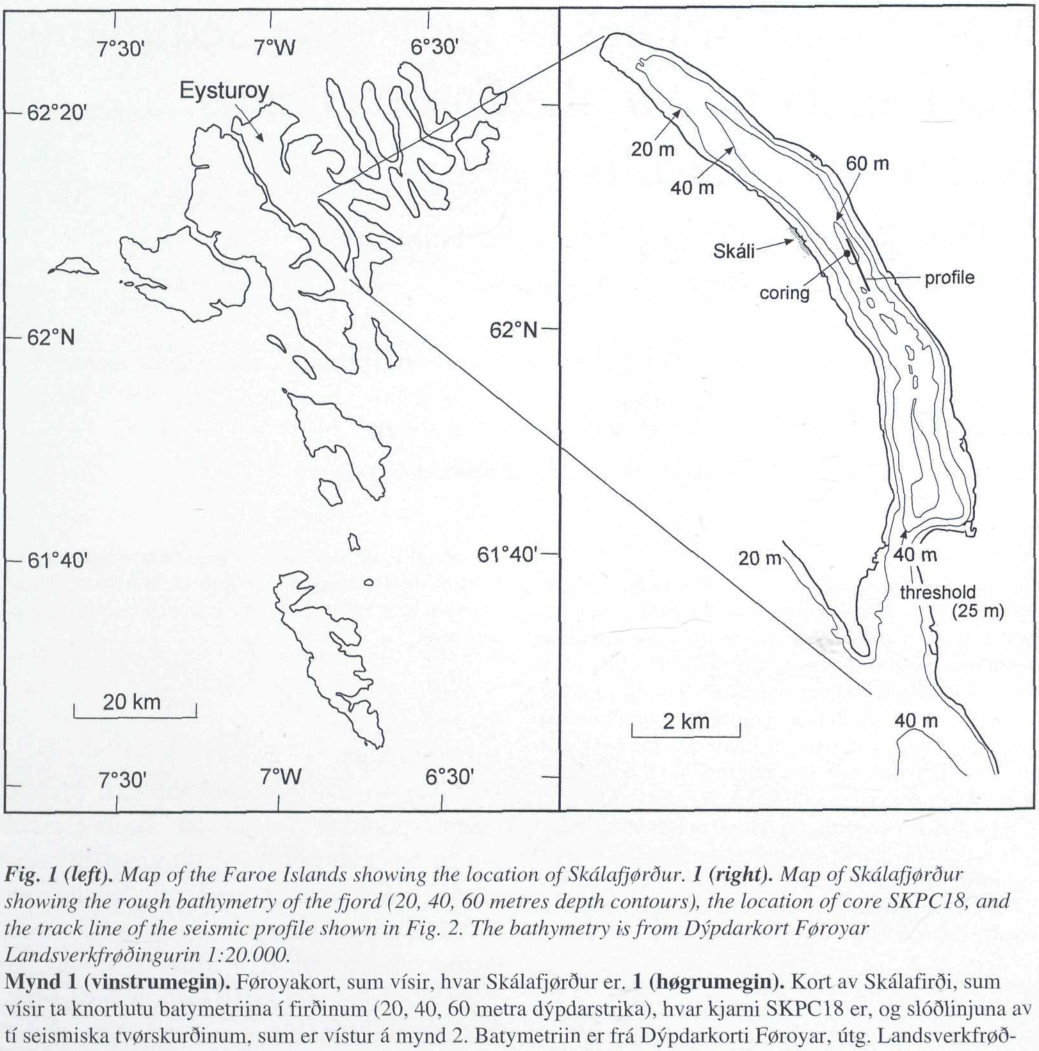

*Fig. 1 (left). Map of the Faroe Islands showing the location of Skálafjørður. **1 (right).** Map of Skálafjørður showing the rough bathymetry of the fjord (20, 40, 60 metres depth contours), the location of core SKPC18, and the track line of the seismic profile shown in Fig. 2. The bathymetry is from Dýpdarkort Føroyar Landsverkfrøðingurin 1:20.000.*

Mynd 1 (vinstrumegin). Føroyakort, sum vísir, hvar Skálafjørður er. **1 (høgrumegin).** Kort av Skálafirði, sum vísir ta knortlutu batymetriina í firðinum (20, 40, 60 metra dýpdarstrika), hvar kjarni SKPC18 er, og slóðlinjuna av tí seismiska tvørskurðinum, sum er vístur á mynd 2. Batymetriin er frá Dýpdarkorti Føroyar, útg. Landsverkfrøðingurin 1:20.000.

the R/V Skagerak 1995 cruise. This 172 cm long core contains an older unit of non-marine sediments. The upper 87 cm of the core consists of olive gray silty clay with shell fragments of marine molluscs. This part of the core was not analysed during this investigation and will not be discussed further. Below the marine sediments dark olive gray silty clay without shell fragments is found; this deposit is characterised by layers rich in fine grained organic detritus. At 130-131 cm below the core top a prominent black layer of volcanic ash is found, which is correlated with the Saksunarvatn ash that

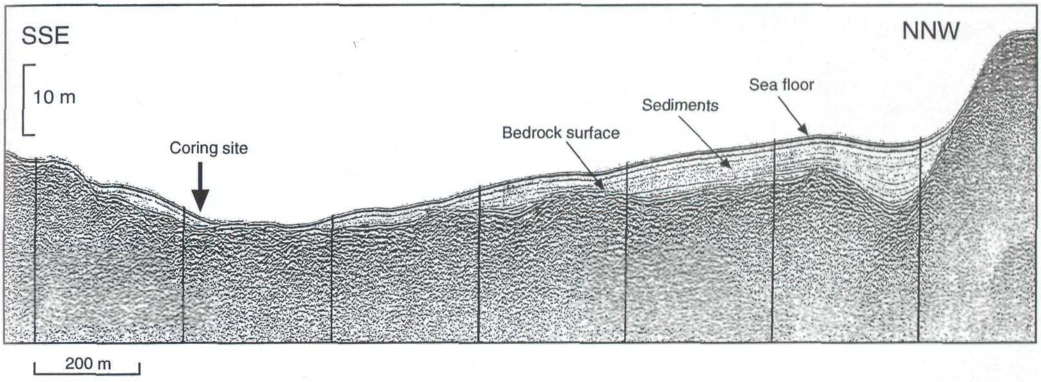

Fig. 2. Shallow seismic (boomer) profile along the fjord axis (for location, see Fig. 1) indicating a condensed postglacial sediment sequence (light coloured upper unit). The arrow shows the approximate location of core SKPC18.

Mynd 2. Grunnur seismiskur (boomer) tvørskurður eftir fjarðarásinum (á mynd 1 sæst, hvar hann er), sum bendir á tættaða eftirglasiala áløgurøð (ljóslittur yvirpartur). Pílurin vísir, hvar á leið kjarni SKPC18 er.

is usually 5-10 mm thick on the Faroe Islands.

The Saksunarvatn ash was first recognised on the Faroe Islands, and it has been dated to *c.* 9,000 radiocarbon years BP (Birks *et al.*, 1996), which corresponds to *c* 10,000 calendar years. The ash layer that originates from central Iceland has now been widely recognised in the eastern North Atlantic, as far away from Iceland as northern Germany (ref. Wastegård, 1998, this vol.). The presence of this ash layer allows us to date the lower part of the core to the early Holocene.

In order to shed light on the local environments and biotas, a series of samples have been analysed with respect to macroscopical plant and animal remains. Redeposition and long distance transport is generally a smaller problem with macrofossils than with microfossils, and macrofossil analyses can be a good supplement to other analyses.

Setting

The climate of the Faroe Islands is oceanic, with a mean July temperature around 11°C. The present vegetation is strongly influenced by sheep, but the pre-landnám, natural vegetation on well drained sites on the islands would be dominated by shrub heaths with *Juniperus, Salix, Empetrum, Calluna, Poaceae* and *Cyperaceae* (Jóhansen, 1985).

Skálafjørður is a U-shaped through that was eroded during the Pleistocene glaciations. The valley slopes are steep, and the mountains around the fjord reach altitudes of 5-600 meters. The fjord is a 13 km long threshold fjord situated on Eysturoy (fig. 1). The fjord is up to about 70 m deep, whereas the threshold is at *c.* 25 m depth.

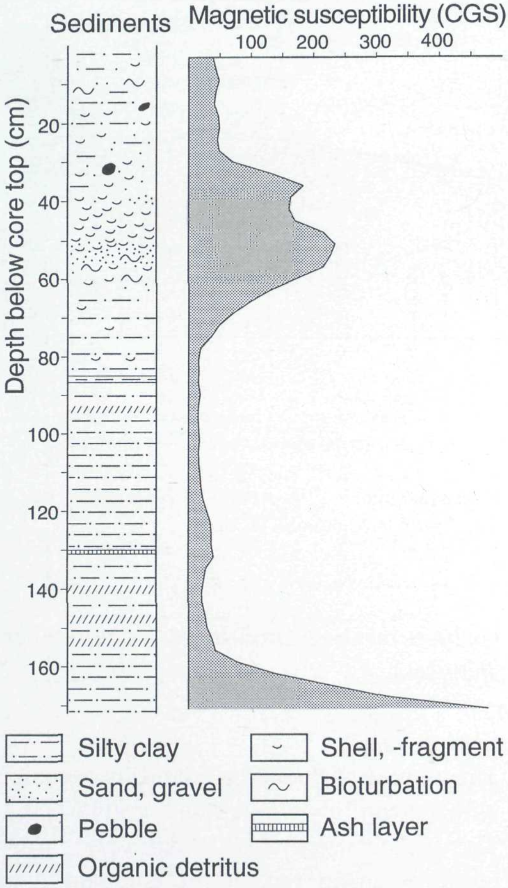

Fig. 3. Sedimentological log and magnetic susceptibility profile of core SKPC18. For further explanation, see text.
Mynd 3. Áløgufrøðilig skrá og magnetiskur árinstvørskurður av kjarna SKPC18. Gjøllari frágreiðing í tekstinum.

Fig 1 shows the location of the coring site, where the water depth is 61 m. Due to the presence of the threshold, bottom water exchange in the fjord is limited. A stratification of the water masses is present most of the year, and it only disappears during the winter months (DHI, 1986; Hansen *et al.*, 1990).

Results from the shallow seismic survey made in Skálafjørður in 1991 (Larsen, 1991) indicate the presence of two larger depositional basins, where the maximum thickness of sediments deposited after deglaciation is between 15 and 20 m. The sediments cored here are predominantly dark olive gray marine silty clays. The core discussed here was sampled from the margin of the innermost depositional basin, where the shallow seismic (boomer) record shows the presence of only a few metres of postglacial sediments (fig. 2).

Material and methods

The core (SKPC18) was sampled by R/V Skagerak of Göteborg University on October 5, 1995, using a piston corer with an inside PVC liner (diameter 75 mm). The location of the core is at 62°09.4'N, 6°45.8'W. After retrieval, the core was cut into two sections, which were split lengthwise, and the core was visually described (fig. 3), and subsampled in the laboratory. Magnetic susceptibility was measured at 3 cm intervals using a portable Bartington MS2 Meter. Only the lowermost core section was subsampled for the present study. The volume of most of the macrofossil samples was 2 ml, but larger samples were collected at 154 and 140 cm (20 ml) and at 148 cm (5 ml), where layers of organic detritus were present. The sediment samples were wet sieved on 0.4, 0.2 and 0.1 mm sieves, and the residue left on the sieves analyses using a dissecting microscope. In the somewhat simplified diagram (fig. 4),

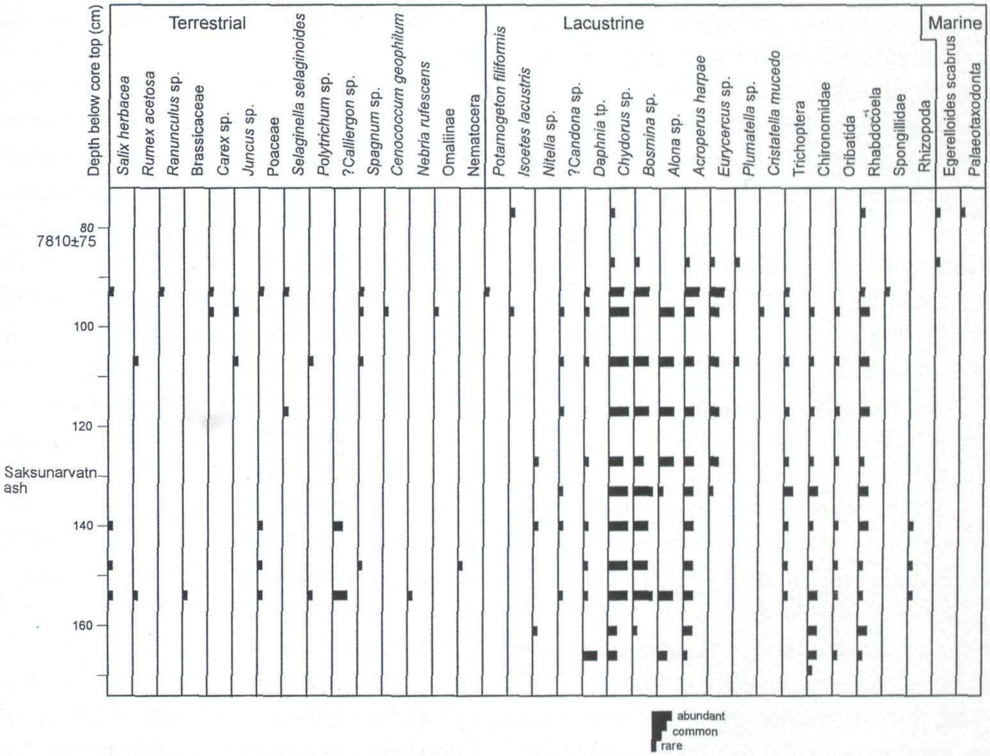

Fig. 4. Macrofossil concentration diagram of the lower part of core SKPC18 from Skálafjørður (62°09.4'N, 6°45.8'W)

Mynd 4. Strikumynd av konsentratiónini av makrosteinrenningum í tí lægra partinum av kjarna SKPC18 úr Skálafirði (62°09,4'N;6°45,8'V).

only the relative frequency of the taxa is given, although some remains were counted. Remains of terrestrial plants (*Salix herbacea*) from two levels have been submitted for AMS radiocarbon dating. The radiocarbon dates performed on shells of marine molluscs have been corrected for a sea water reservoir effect of 500 years.

Results and discussion

The chronology of the core is based on two AMS radiocarbon datings, one of which was made in the upper part of the core (5,630 years BP, at 50 cm depth), and the other made in the lowest marine sediments at 87 cm depth (fig. 4). Additional chronological control is provided by the presence of the Saksunarvatn ash (*c.* 9,000 years BP) at a depth of 130-131 cm.

The magnetic susceptibility (MS) profile shows highest values at the bottom of the core, where glaciolacustrine silty clay is present (fig. 3). Generally, the marine sediments display higher MS values than the lacustrine sediments below, in which the Saksunarvatn ash layer shows only slightly elevated values. In the marine part, an interval with high MS values corresponds to coarser-grained sediments contaning, amongst others, gravel-sized basaltic material.

Considering the extremely small sample size, the diversity of macrofossils is surprisingly high, and the concentration of remains of lacustrine animals is high.Some of the taxa recorded undoubtedly represent several different species. The preservation is usually good to excellent, although the *Salix* leaves were fragmented, and only a few leaf fragments retained the dentate leaf margin and could be safely identified as belonging to *Salix herbacea*. A few small, worn twig fragments were present at 140 cm, these were avoided for dating.

The lowest sample, from 170 cm, only contained two head capsules of midge larvae, and these sediments were probably deposited in a glaciolacustrine environment. The sediments between *c.* 167 cm and 87 cm are characterised by a diverse and rich flora and fauna of obligate freshwater taxa that clearly indicate that these sediments were deposited in a former lake basin. At 87 cm the first marine fossils occur, and at the same time lacustrine fossils become rare. This shows that the threshold was transgressed by the sea. The rare lacustrine fossils present at this level and above could represent redeposition or inwash from freshwater basins in the drainage area.

Salix herbacea leaves were also recorded from early Holocene lake sediments by Jóhansen (1985), and this species was also an early immigrant to Iceland and East Greenland (M. Rundgren, personal communication, 1997; Bennike *et al.* in press). *S. herbacea* is an indicator of snow-patch vegetation, and the species is common on high elevation sites in the Faroe Islands at present. Jóhansen did not separate pollen grains of *Oxyria digyna* and *Rumex acetosa*, but he suggested that most pollen came from *Oxyria digyna*. The presence of a few nutlets and perianths of *Rumex acetosa* shows that this species that often grows as a weed, is native to the Faroes, and that it arrived early. Microspores of *Selaginella selaginoides* were reported from the early Holocene by Jóhansen (1985), and the presence of macrospores in the Skálafjørður sediments shows that it grew locally.

Coleoptera remains include three elytra, of which one could be identified as *Nebria rufescens*. This is a medium sized ground beetle that is common in Faroe Islands at the present (West, 1937: *Nebria gyllenhali*). It is most frequent in damp biotopes, but is geographically and ecologically widespread on the archipelago. Its geographical range is circumpolar, including Iceland and southwest Greenland, and it lives in northern temperate and low arctic climates (Böcher, 1988).

It appears that *Potamogeton filiformis* and *Nitella* sp. are new to the fossil flora of the Faroe Islands, but this merely reflects that few macrofossil studies of lake sediments have been carried out. It is not surprising that these taxa arrived early, since the fruits or oospores are effetively spread by migrating birds. Along the same line, most of the lacustrine animals recovered are new to the fossil fauna of the Faroes. Tha lacustrine sediments did not contain carbonates, but the inner chitinous linings of freshwater ostracodes were present in most samples. *Daphnia* was represented by ephippia, whereas the other cladocerans were represented by shells and head shields. *Eurycercus* remains were not present in the lower part of the sequence, and it is possible that this genus immigrated somewhat later to the Faroe Islands than the other taxa of Cladocera found during this study. Three statoblasts belonging to two taxa of freshwater bryozoa (*Plumatella* sp. and *Cristatella mucedo*) were found. These are present in low numbers, which makes it difficult to know when these taxa colonized the lake.

All taxa probably represent species that still live in the Faroe Islands, and thus a climate similar to that at the present is inferred. To our knowledge there are no records of freshwater bryozoa from the Faroes, but *Plumatella repens* is widely distributed in Europe and has been reported from the Shetland Islands and Iceland, and it also lives on Greenland (Lacourt, 1968; Røen, 1977; Steingrímsson, 1985). Finds of statoblasts of *Cristatella mucedo* from Iceland and Greenland indicate that this species also lives on these islands, and it has been reported from the Shetland Islands (Lacourt, 1968; Fredskild, 1983; Steingrímsson, 1985). *Cristatella mucedo* is the most warmth demanding species identified; its northern geographical range limit coincides more or less with the arctic tree line.

A sample from 87 cm below the core top contained a few specimens of the foraminifer *Egerelloides scabrus*. The shell of this species consists of small sand grains that are agglutinated togehter. The species can tolerate somewhat lowered salinities (Lutze, 1965), as would be expected just after the first inflow of marine waters into the former freshwater basin.

The origin of the flora and fauna of the Faroe Islands has been much debated, and it has been speculated if some species could have survived the last glacial stage in ice free refugia, or whether all species have immigrated after the last deglaciation. The sedimentary record on the islands holds a great potential to study the history of the flora and fauna. Whereas the history of the vascular flora has been studied in some detail (Jóhansen, 1985), few concrete data are available about the history of the fauna. The history of a number of taxa can now be extended back to the early Holocene.

Some insects have been reported from pre-landnám layers (Buckland, 1988), but it appears that the insect remains reported here are the first that are firmly dated to the early Holocene. It has been suggested that a major part of the fauna was ice rafted to the North Atlantic islands from northwest Europe at the transition from the last glacial stage to the Holocene (Coope, 1979; 1986; Buckland *et al.*, 1986). Although rafting by ice bergs or sea ice may account for the transport of some species, palaeoceanographic studies indicate that the directions of the surface currents in the eastern North Atlantic were not much different from those at the present during the late-glacial or Holocene (Koc *et al.* 1993; Hald and Aspeli, 1997).

The Faroe Islands were covered by a local ice sheet during the last glacial stage (Jørgensen and Rasmusen, 1986; Humlum *et al.*, 1996), and the oldest minimum dates for the deglaciation are slightly older than 10,000 radiocarbon years BP (S. Björck, personal communication, 1997). Jóhansen (1985) reports an age of 9,660 years BP for Hoydalar lake sediments, that were deposited after the area became ice-free. In our core, nearly 40 cm of lacustrine sediments is present below the Saksunarvatn ash, overlying the glaciolacustrine clay unit. A comparison with the thickness (*c.* 40 cm) of the lacustrine sediment section overlying the Saksunarvatn ash suggests that the deglaciation of Skálafjørður may also be dated at around 10,000 radiocarbon years BP.

There are no traces of marine deposits or shorelines above the present sea level in the Faroe Islands, whereas some submarine peat deposits are known (Jessen and Rasmussen, 1922), so the global eustatic rise of the sea level has surpassed the glacio-isostatic rebound. The presence of submarine lake sediments in Skálafjørður shows that the 25 m deep threshold of this fjord was transgressed by the sea in the early Holocene, around 7,800 radiocarbon years BP. Moreover, we may conclude that deglaciation of the Skálafjørður occurred at least c. 1,000 years before the Saksunarvatn ash was deposited, i.e. not later than about 10,000 radiocarbon years BP.

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