

Observations on the Quaternary geology around Nioghalvfjærdsfjorden, eastern North Greenland

Ole Bennike and Anker Weidick

In North and North-East Greenland, several of the outlet glaciers from the Inland Ice have long, floating tongues (Higgins 1991). Nioghalvfjærdsfjorden (Fig. 1)



Fig. 1. Map of northern North-East and eastern North Greenland showing localities mentioned in the text.

is today occupied by a floating outlet glacier that is about 60 km long, and the fjord is surrounded by dissected plateaux with broad valleys (Thomsen *et al.* 1997). The offshore shelf to the east of Nioghalvfjærdsfjorden is unusually broad, up to 300 km wide (Cherkis & Vogt 1994), and recently small low islands were discovered on the western part of this shelf (G. Budeus and T.I.H. Andersson, personal communications 1998). Quaternary deposits are widespread around Nioghalvfjærdsfjorden and include glacial, glaciofluvial, marine, deltaic and ice lake deposits. Ice margin features such as kame deposits and moraines are also common (Davies 1972). The glaciation limit increases from 200 m a.s.l. over the eastern coastal islands to 1000 m in the inland areas; local ice caps and valley glaciers are common in the region, although the mean annual precipitation is only about 200 mm per year. Most of the sea in the area is covered by permanent sea ice, with pack ice further east, but open water is present in late summer in some fjords north of Nioghalvfjærdsfjorden, and in the Nordøstvandet polynia.

Earlier information on the Quaternary geology of the region north of Nioghalvfjærdsfjorden has been given by Davies (1963), Funder & Hjort (1980) and Hjort (1997); the region south of Nioghalvfjærdsfjorden has been reported on by Landvik (1994) and Weidick *et al.* (1996). During field work in 1987, some pieces of drift wood (undated) and an occurrence of marine shells were located at Blåsø (Bennike 1987). In connection with the glaciological work in 1996 samples of marine shells and driftwood were collected between the 'Midgardsormen' base camp and Blåsø. In 1997 Quaternary field work was conducted around Blåsø, on southern Hovgaard Ø, on eastern Lambert Land and on Norske Øer. Supplementary Quaternary field work was undertaken in 1998 on Søndre Mellemland and on Île de France (Fig. 1).

Methods

Samples were collected along a transect between Blåsø in the inland area and the outer coast, and 48 samples of shells, driftwood, plant remains and bones have so far been radiocarbon dated. Special attention was given to collecting material that could shed light on the timing of the deglaciation, and on the timing of the onset of the neoglaciation. Most samples were dated by accelerator mass spectrometry (AMS) radiocarbon dating, but some samples were dated by conventional radiocarbon dating. All dates have been calibrated according to dendrochronology, and in this article only the calibrated dates are discussed.

Results

Heavily abraded bedrock with perched boulders and glacial striae indicative of former ice movement towards the east are found on Norske Øer and on eastern Lambert Land at the outer coast (Fig. 1). The freshness of these features point to a Late Weichselian age, and a subsequent major recession of the Inland Ice can also account for the Holocene glacio-isostatic rebound. Thus the marine limit was found to decrease from *c.* 65 m a.s.l. at the outer coast to *c.* 40 m a.s.l. in the inland areas. The marine limit is dated to the early Holocene, and since the eustatic rise of sea level since the early Holocene amounts to *c.* 50 m (Fairbanks 1989), the isostatic rise must be at least 100 m. Several of the radiocarbon dates obtained pertain to the timing of the deglaciation of Nioghalvfjærdsfjorden. The oldest date obtained near the outer coast is *c.* 9.7 cal. ka BP (calibrated kilo years before present), which is more than 1000 years younger than in areas further to the south and north. This indicates that the eastern margin of the

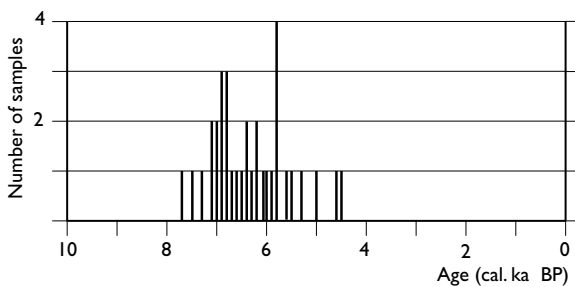


Fig. 2. Diagram showing the temporal distribution of radiocarbon dates from the inner part of Nioghalvfjærdsfjorden. Only datings of mollusc shells, bones of marine mammals and driftwood are included.

Greenland ice sheet was still located on the shelf in the early Holocene and perhaps buffered against the shallow part of Belgica Bank.

The oldest date obtained near Blåsø is *c.* 7.7 ka BP (Fig. 2), which indicates that the deglaciation of the fjord took about 2000 years, corresponding to a recession rate of 30–40 m/year. During the deglaciation, moraine ridges were formed east of Blåsø, and a giant ice-dammed lake occupied some of the valleys north-east of Blåsø.

After deglaciation, molluscs and marine mammals were able to live in Nioghalvfjærdsfjorden, and driftwood could enter the fjord. Twenty shell samples, nine samples of driftwood, five bones of seals and bone of a whale, collected on raised beaches, on raised marine deposits and along the shore of Blåsø, have been dated (Figs 2, 3); these yielded ages between *c.* 7.7 ka BP and 4.5 ka BP. The distribution of dates shows that the fjord was not glaciated during this period in the middle



Fig. 3. **A:** Fragments of two ribs of a whale, probably Greenland right whale (*Balaena mysticetus*), found on raised beaches. Matchbox for scale. **B:** Thigh bone of a seal, probably ringed seal (*Pusa hispida*), and shells of *Mya truncata*, found on raised marine deposits. Pencil for scale. Both found near Blåsø in the inner part of Nioghalvfjærdsfjorden.

Holocene. Molluscs and ringed seals may have lived in the fjord during periods of permanent sea ice, whereas driftwood and whales could only enter the fjord during periods of open water. The driftwood and whale dates are restricted to the period 7.0–5.4 ka BP, and it is possible that this period was preceded and followed by periods when the fjord was covered by sea ice throughout the year. On Norske Øer, where the presence of permanent sea ice hinders the formation of beach ridges at the present time, a series of raised beach ridges are found that were presumably formed during the middle Holocene. The mollusc fauna during the middle Holocene included the bivalves *Macoma calceola* and *Serripes groenlandicus* that have not previously been reported from Holocene deposits this far north in East Greenland, and it is possible that these species were only able to live here during the middle Holocene warmth optimum. Fruits of two species of southern extra-limital plants, *Empetrum nigrum* and *Potamogeton filiformis*, that were recovered from foreset beds in a raised delta near Blåsø and dated to c. 5.1 ka BP, are also indicative of summer temperatures higher than the present in the middle Holocene. In a small lake near Blåsø clay gyttja is overlain by clay at 60 cm below the lake bottom. This lithological change is somewhat younger than 4 ka BP, and it appears to post-date the onset of the neoglaciation; since then Nioghalvfjerdingsfjorden has been occupied continuously by a floating glacier. The neoglaciation culminated during the Little Ice Age, probably at around AD 1900, after which a slight thinning and recession has occurred. Fresh strandlines along Blåsø show that during the Little Ice Age the lake was dammed with a water level about 1 m higher than at present.

Jøkelbugten

Observations on the Quaternary deposits in Søndre Mellemland were conducted from one field camp in Sanddalen, and an unnamed island in Jøkelbugten was visited during two short ground stops. The first radiocarbon dates now available show that Jøkelbugten was not deglaciated until well into the Holocene. Thus the oldest shell date from Søndre Mellemland is c. 8.1 ka BP. West of Sanddalen an area of around 15 km² with ice cored moraines is found. Scattered shells and shell fragments of *Hiatella arctica*, *Mya truncata* and *Astarte borealis* are found on the terrain surface up to 200 m above sea level, and a single radiocarbon dating has yielded a mid-Holocene age. This indicates that the area was a fjord arm in the middle Holocene, and that the ice cored moraines were formed during the neoglaciation. Fresh moraines that presumably date from the Little Ice Age are found adjacent to the margin of the Greenland Inland Ice, which indicates that the neoglaciation maximum in this area predates the Little Ice Age.

Île de France

Sediments assigned a Late Pliocene or Early Pleistocene age were reported from this island by Landvik (1994). We found rich, though not very diverse, marine macrofaunas in sections near the northern tip of the island (Fig. 4). Preliminary identifications show that the fauna includes *Spirorbis* sp., Decapoda indet., *Boreocingula* sp., *Trichotropis bicarinata*, *Euspira* cf. *E. pallida*, *Cryptonatica* aff. *C. affinis*, *Trochon* cf. *T. truncatus*, *Neptunea* sp., *Admete* sp., *Oenopota* sp., *Nucula*



Fig. 4. General views of exposures of Pliocene sediments near the northern tip of Île de France. Height of sections around 40 m, with the top c. 80 m above sea level.

(*Lamellinucula*) cf. *N. (L.) jeffreysi*, *Nuculana pernula*, *Portlandia arctica*, *Yoldiella intermedia*, *Yoldiella* sp., *Astarte borealis*, *A. montagui*, *Astarte domburgensis*, *Astarte alaskensis*, *Arctinula greenlandica*, *Clinocardium ciliatum*, *Serripes groenlandicus*, *Arctica islandica*, *Hiatella arctica*, *Mya truncata* and ?*Terebratula* sp.

Wood remains are fairly common and a few seeds and fruits were also found; the latter include *Picea* cf. *P. mariana* (black spruce), *Menyanthes trifoliata* and *Potamogeton filiformis*. The fauna shows similarities to the older part of the Kap København Formation (Bennike 1989, 1990; Simonarson *et al.* 1998), and to Neogene deposits in North-West Europe, and a Pliocene age is suggested. The marine fauna indicates a shallow shelf environment and a subarctic climate much warmer than that of the present. Further work is in progress on the fauna, flora and chronology of this sequence that appears to be the first Pliocene sequence located in Greenland.

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Authors' address

Geological Survey of Denmark and Greenland, Thoravej 8, DK-2400 Copenhagen NV, Denmark. E-mail: obe@geus.dk