Quaternary geology of parts of central and western North Greenland: a preliminary account

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The whole region, perhaps except for northern Nansen Land, was covered by the Inland Ice in ?pre-Eemian time. A much younger stage, characterised by fresh moraines at the fjord mouths and along Robeson Kanal, is assigned a Late Weichselian age. Deglaciation began *c.* 10 000 years B.P.
Reworked pre-Holocene shells are rather common, and Holocene marine deposits occur sporadically. The marine limit varies from *c.* 125 m to *c.* 60 m.

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In the 1984 field season, parts of the region between Nansen Land and Hall Land were mapped from fixed camps supplemented by helicopter reconnaissance ground stops. These field data provide a framework for continuing photogeological and geochronological studies. The first results of the latter are given in the appendix. The data so far suggest the following broad sequence of events.

Glacial events

The distribution of erratics indicates that the glacierisation of the region has primarily been by extensions of the Inland Ice, rather than by local ice caps. The critical erratics are Precambrian basement rocks which have a limited exposed outcrop near the Inland Ice margin at the head of Victoria Fjord (Dawes, 1976; Henriksen & Jepsen, 1985), but which probably outcrop widely beneath the Inland Ice along the whole southern margin of the area. The presence of these erratics on hill summits over 800 m within a few kilometres of the north coast, on Hall Land, Nyeboe Land and Wulff Land, indicates that virtually all of the area has been glaciated by the Inland Ice which must have extended out to the shelf edge. Whether northern Nansen Land should be included, or whether it maintained a separate ice cap (Koch, 1928) is not known. Extensive till deposits up to around 400 m above sea level on the northern ends of Hall Land and Nyeboe Land also have been laid down by an extension of the Inland Ice. This extension may or may not be younger than the former. Notably, these tills in places contain a reworked marine fauna, characterised by *Balanus balanus*.

A different and younger state of glacierisation is represented by ice margin features and

deposits formed by fjord glaciers, i.e. by tongues of ice extending along the fjords from an Inland Ice margin which lay further to the south. The low longitudinal gradients of many features indicate that the lobes commonly were floating as they are today. Evidence of these fjord glaciers exists in all fjords of the area, and it may derive from more than one distinct glacial event. Extensive glacial lake systems were developed on the intervening land areas at this time, especially across the central lowlands of Nansen Land, Wulff Land and Hall Land, where they were dammed up by ice at both ends, as well as in the interior valleys on Nyeboe Land, Warming Land and Nares Land.

A stage of glaciation when the glaciers reached to the fjord mouths is indicated by well preserved moraines and glaciofluvial deposits at Kap Sumner (Newman Bugt) and Kap Fulford (Sankt George Fjord). The presence of a moraine at Kap Ammen at the north end of Hall Land, reported by Dawes (1977), has been confirmed. From its fresh morphology it appears to correlate with the Kap Sumner moraines, and it indicates the existence of a considerable thickness of ice (>540 m) in Robeson Kanal at this stage. Glacial deposits laid down by a fjord glacier at the mouth of J. P. Koch Fjord, on Nares Land and John Murray Ø may also correlate with this stage.

Well developed moraine systems occur in all fjords in their middle reaches. Whilst there is evidence that some were formed by readvance of fjord glacier margins, the significance of any time gap between these and outer fjord deposits cannot yet be assessed. The moraine systems include those on west and east Hall Land mapped partly by Koch (1928), Davies (Davies *et al.*, 1959; Davies, 1972) and Dawes (1977). On the west is the Polaris Bugt moraine system which can be traced northwards from the valley immediately south of Kap Tyson. Up this valley a lobe of the fjord glacier extended for 11 km. North of Kap Tyson the moraine system appears to have been deposited partly subaerially and partly subaqueously. The moraine system continues uninterruptedly from the central lowlands up the northern plateau. In Newman Bugt the outer part of the 'Graasten Elv' moraine system on Hall Land, and the corresponding deposits on the east side of the fjord, also were laid down subaqueously. Moraine systems, which are possibly of a comparable age, occur also at the north end of Warming Land, at Kap Wallén (Wulff Land), and in Brainard Sund and J. P. Koch Fjord at either end of the south-east Nansen Land lowlands.

The next distinctive stage of glaciation is denoted by historic moraines along the margins of the present ice cover. Although the long tongues of floating glacier ice extending from the Inland Ice still reach to their historic maxima, they are thinning and breaking up. The glaciers from local ice caps either show minor retreats from a recent maximum or are still at this position. These observations are in accordance with the conclusions of Davies & Krinsley (1962). Older local glacier moraine systems are absent and in many places the present local glaciers override deposits and features formed by the early stages of fjord glacier development, clearly indicating that they are at their maximum extent since retreat from the early fjord glacier stage. Moraine systems close to the present ice margin, of an unknown age but older than the historic moraines, occur in front of outlet lobes on land of the Inland Ice in Hall Land and Wulff Land.

Marine events

Marine deposits occur sporadically throughout the region in suitable low lying coastal areas and, notably, across the central lowlands of Hall Land. The *in situ* marine deposits that

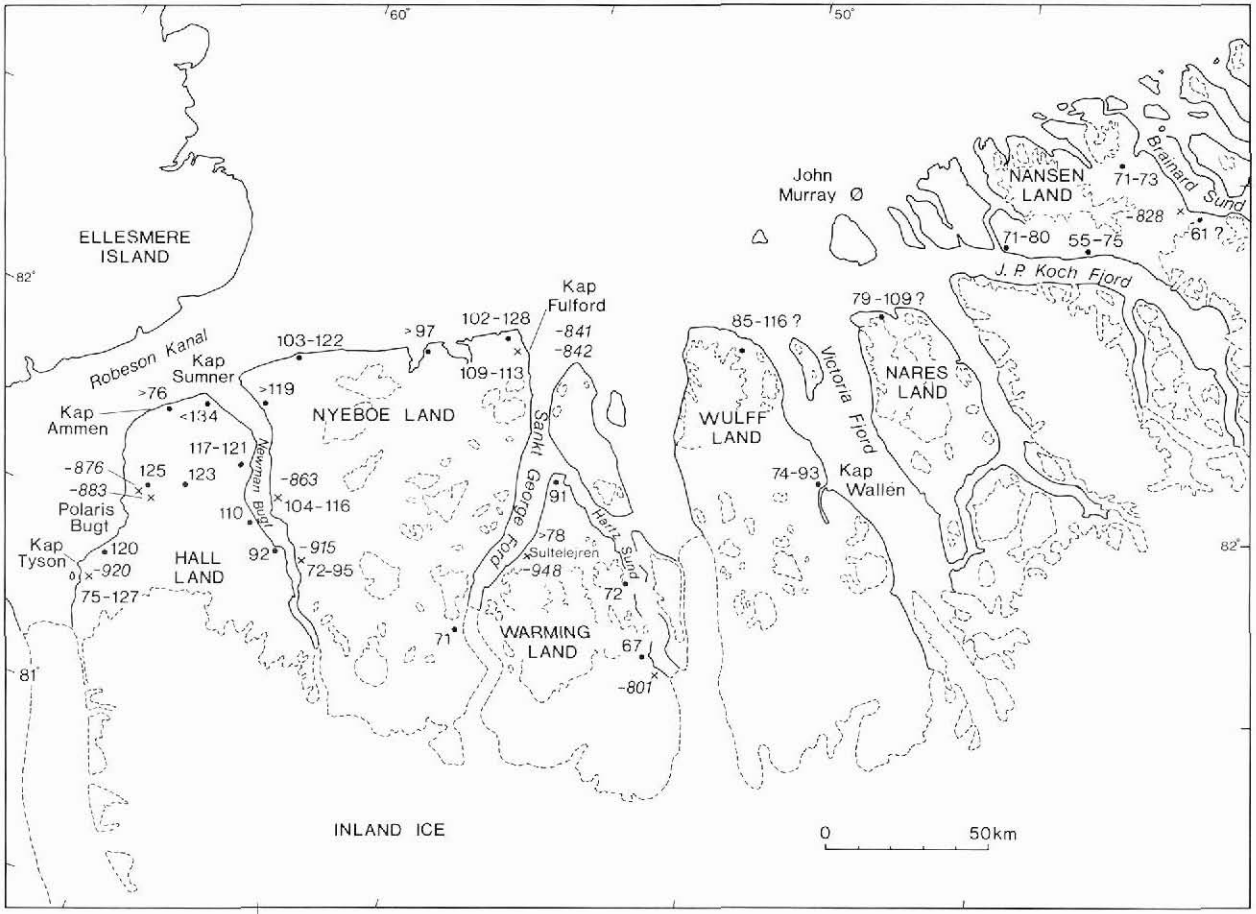

Fig. 1. Elevation of marine limit (m) and location of ^{14}C dated samples.

have been dated so far are all of Holocene age (appendix; Weidick, 1978). However, at least one older marine event is represented by the commonly occurring reworked shells in older glacial deposits, and *in situ* deposits of such events may yet be shown to occur.

The marine limit in the area is generally difficult to define precisely. Raised beaches are rarely developed, except along the Robeson Kanal coast, indicating the general occurrence of fjord and sea ice during the Holocene. Uncertainty also arises where fossiliferous marine silt grades upwards into unfossiliferous silt which may be either glaciomarine or glaciolacustrine. Fig. 1 shows the distribution of values which have been conservatively arrived at. They suggest that the marine limit elevation decreases both towards the head of the fjords and from west to east across the region, with maximum values of 125 ± 5 m in the northwest.

Chronology

A detailed discussion of the chronostratigraphy of the area, in the context of previous ideas (e.g. Davies, 1972; Weidick, 1978; England, 1982), is premature. However, the following general comments can be made.

The ice sheet or sheets which extended out on to the continental shelf must have been coincident with an ice sheet over northern Ellesmere Island. The general featureless nature of the low lying ice sheet deposits and high degree of clast weathering, suggest a significant age for them, perhaps preceding the last interglacial or earlier. Locally occurring degraded fjord glacier moraines may be a retreat stage from this event.

The fresh glacial deposits and landforms along the fjords appear to belong to a much younger glacial event or events. The initial stage of development which brought tongues of ice from the Inland Ice out to fjord mouths is undated, except that it appears to pre-date or relate to the marine limit in the region, as given by fig. 1. It is therefore probably older than 10 000 years B.P.

Although the stratigraphic sequence of the ice margin features and deposits in the middle fjord reaches has still to be fully evaluated, it is clear that ice was absent from central Hall Land, middle Newman Bugt and outer Sankt George Fjord, at least by ~9000 years B.P. (appendix; Weidick, 1978). By ~8000 years B.P. the glaciers had retreated to the heads of these and the other fjords, perhaps reaching the position of the present margin by ~7000 years B.P. Deglaciation probably continued for some considerable time before a subsequent climatic deterioration brought the ice to its present extent.

References

Davies, W. E. 1972: Landscape of northern Greenland. *Spec. Rep. Cold Reg. Res. Engng. Lab.* **164,** 67 pp.

Davies, W. E. & Krinsley, D. B. 1962: The recent regime of the ice cap margin in North Greenland. IASH Symposium, Obergurgl. *Publs Ass. int. Hydrol. scient.* **58,** 119–130.

Davies, W. E., Needleman, S. M. & Klick, D. M. 1959: Report on Operation Groundhog (1958), North Greenland; investigations of ice free sites for aircraft landings, Polaris Promontory, North Greenland. U.S. Air Force, Cambridge Research Centre, 45 pp.

Dawes, P. R. 1976: Precambrian to Tertiary of northern Greenland. *In* Escher, A. & Watt, W. S. (edit.) *Geology of Greenland,* 248–303. Copenhagen: Geol. Surv. Greenland.

Dawes, P. R. 1977: Geological photo-interpretation of Hall Land: part of the regional topographical–geological mapping of northern Greenland. *Rapp. Grønlands geol. Unders.* **85,** 25–30.

England, J. 1982: Postglacial emergence along northern Nares Strait. *In* Dawes, P. R. & Kerr, J. W. (edit.) Nares Strait and the drift of Greenland: a conflict in plate tectonics. *Meddr Grønland, Geosci.* **8,** 65–75.

Funder, S. 1982: ^{14}C-dating of samples collected during the 1979 expedition to North Greenland. *Rapp. Grønlands geol. Unders.* **110,** 9–14.

Henriksen, N. & Jepsen, H. F. 1985: Precambrian crystalline basement at the head of Victoria Fjord, North Greenland. *Rapp. Grønlands geol. Unders.* **126,** 11–16.

Koch, L. 1928: Contributions to the glaciology of North Greenland. *Meddr Grønland* **65,** 181–464.

Weidick, A. 1978: Comments on radiocarbon dates from northern Greenland made during 1977. *Rapp. Grønlands geol. Unders.* **90,** 124–138.

Appendix

^{14}C dates of material collected in 1984 by M. Kelly and O. Bennike. The samples have been dated at the Isotope Measurements Laboratory in Harwell, England (samples marked HAR) and at the Carbon-14 Dating Laboratory of the Geological Survey of Denmark and the National Museum (sample marked K, by courtesy of the Geological Survey of Denmark).

The ^{14}C dates have been corrected for isotopic fractionation and for oceanic reservoir effect, following the recommendations by Funder (1982) for eastern North Greenland. See fig. 1 for localities.

GGU 313801: HAR–6287. South-east Warming Land **6480±100 B.P. $\delta^{13}C = +2.3‰$**
corr. 5930

Shells of *Mya truncata,* partly in life position, from marine silts at 26 m above sea level, 81° 30.8′N, 51° 4.7′W.

GGU 313828: HAR–6288. Brainard Sund **7980±120 B.P. $\delta^{13}C = +1.7‰$**
corr. 7430

Shells of *Mya truncata,* partly in life position, from marine silts at 41 m above sea level, 82° 55.6′N, 41° 46.8′W.

GGU 313841: HAR–6289. Kap Fulford **9390±90 B.P. $\delta^{13}C = +1.4‰$**
corr. 8840

Shells of *Hiatella arctica,* partly paired valves, from marine silts at 92-93 m above sea level, 82° 17.8′N, 55° 3.8′W.

GGU 313842: K–4339. Kap Fulford **10030±175 B.P. $\delta^{13}C = -1.0‰$**
corr. 9880

Shells of *Portlandia arctica* from marine silts at 87 m above sea level, from the same locality as GGU 313841 but stratigraphically below, 82° 17.8′N, 55° 3.8′W.

GGU 313863: HAR–6291. East side Newman Bugt **9060±100 B.P. $\delta^{13}C = +0.8‰$**
corr. 8510

Shells of *Hiatella arctica,* paired and in life position from marine silts at 104 m above sea level, 81° 42.9′N, 58° 50.3′W.

GGU 313876: HAR–6292. Polaris Bugt **8090±120 B.P. $\delta^{13}C = +2.1‰$**
corr. 7540

Shells of *Mya truncata* and *Hiatella arctica* with a secondary surface encrustation collected from the surface of a morainic ridge at 105 m above sea level, 81° 34.7′N, 61° 10.4′W.

GGU 313883: HAR–6293. Polaris Bugt **8420±200 B.P. $\delta^{13}C = +1.9‰$**
corr. 7870

Shells of *Mya truncata,* in life position, from marine silts at 82 m above sea level, 81° 34.8′N, 61° 7.3′W.

GGU 313915: HAR–6294. South-east side Newman Bugt **8060±170 B.P. $\delta^{13}C = +2.4‰$**
corr. 7510

Shells of *Mya truncata* and *Hiatella arctica,* in life position, from marine silts at 59 m above sea level, 81° 32.8′N, 58° 2.0′W.

GGU 313920: HAR–6295. Kap Tyson **8040±150 B.P. $\delta^{13}C = +2.3‰$**
corr. 7490

Shells of *Mya truncata* and *Hiatella arctica,* partly in life position, from marine sediments at 69 m above sea level, 81° 18.8′N, 61° 35.7′W.

GGU 313948: HAR–6290. Sultelejren **8210±120 B.P. $\delta^{13}C = +1.3‰$**
corr. 7660

Shells of *Mya truncata* and *Hiatella arctica* from marine silts at 68–70 m above sea level, 81° 45.5′N, 53° 54.0′W.