Glaciations of Northern Greenland - New Evidence

By Anker Weidick *

Summary: Field investigations on the Quaternary deposits of North Greenland are still scarce and scattered, but a number of pre—10.000 B. P. radiocarbon dates are reported. These favour a concept of a small Late Wisconsin/Würm extent of the Inland Ice.
In North-West Greenland a new deposit in Olrik Fjord, only 160 km due west of Camp Century, is dated to 18.990 B. P. and demonstrates the possibility of a reduced Late Wisconsin/Würm Inland Ice, though it cannot at present be demonstrated with certainty that it was not overridden by a subsequent glacier readvance. The content of shells reveals climatic conditions close to the present ones, and if the age determination is correct, the contemporaneous interstadial of the Camp Century record (approximately 28.000 — 18.000 B. P.) has too small an amplitude.
In North-East Greenland, occurrence of driftwood aged at more than 35.000 years B. P. in the central parts of Peary Land and high, presumably interstadial or interglacial, terrace levels in Independence Fjord is reported. The last glaciation (Late Wisconsin/Würm) of Peary Land was dominated by a local glaciation centered over Frederick E. Hyde Fjord. Combining this information, an interstadial survival of a local ice cap over Peary Land is envisaged.

Zusammenfassung: Auch wenn Felduntersuchungen an Quartär-Ablagerungen in Nord-Grönland bisher nur vereinzelt vorgenommen worden sind, liegt inzwischen doch eine Reihe von Radiocarbon-Datierungen mit Altersangaben von mehr als 10.000 v. h. vor. Sie sprechen für die Vorstellung von einer geringeren Spät-Wisconsin/Würm-Ausdehnung des Inlandeises.
In Nordwest-Grönland erbrachte eine neue Ablagerung im Olrik Fjord, nur 160 km westlich von Camp Century, eine Datierung von 18.990 v. h. und unterstreicht damit die Möglichkeit eines geringeren Spät-Wisconsin/Würm-Inlandeises, obgleich bisher noch nicht mit Sicherheit nachgewiesen werden konnte, daß es nicht durch einen erneuten Gletschervorstoß überfahren wurde. Der Gehalt an Muscheln deutet auf der heutigen Situation ähnliche klimatische Verhältnisse, und sofern die Altersbestimmung zutrifft, hat das gleichzeitige Interstadial des Camp Century-Befundes (ca. 28.000—18.000 v. h.) eine zu kleine Amplitude.
Für Nordost-Grönland wird über das Vorhandensein von Treibholz in den zentralen Teilen von Peary Land, das eine Altersangabe von mehr als 35.000 Jahren v. h. erbrachte, sowie über hochgelegene, vermutlich interstadiale oder interglaziale Terrassenniveaus im Indpendence Fjord berichtet. Die letzte Vereisung (Spät-Wisconsin/Würm) von Peary Land wurde beherrscht von einer lokalen Vereisung mit dem Zentrum über dem Frederick E. Hyde Fjord. Zusammengenommen scheinen diese Belege für ein interstadiales Überleben einer lokalen Eiskappe über Peary Land zu sprechen.

Introduction

The glaciations of North Greenland are still little known; the scarcity of data has led to the differing opinions on the extent of even the last glaciation: Wisconsin/Würm. A recent review of the same subject for the area between Greenland and Ellesmere Island has been given by PATERSON (in press) and for this region the present

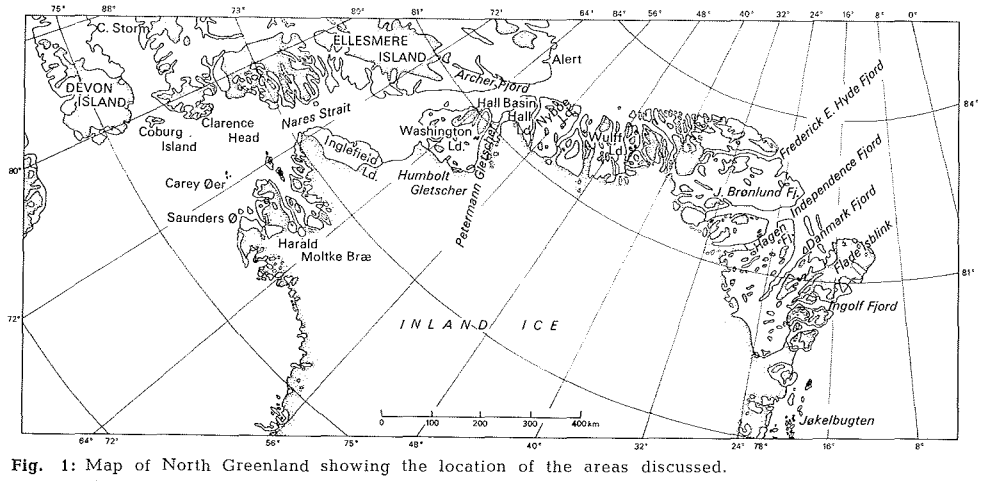

Fig. 1: Map of North Greenland showing the location of the areas discussed.
Abb. 1: Nord-Grönland mit den im Text genannten Gebieten.

* Dr. Anker Weidick, Grønlands Geologiske Undersøgelse, Østervoldgade 10, DK — 1350 Copenhagen K.

paper only adds new information derived from the field work by the Geological Survey of Greenland (GGU) in the summers of 1974 and 1975.

With regard to the former extension of the Inland Ice, one hypothesis favours the concept of an Inland Ice, which in older glacial ages as well as during Early and Late Wisconsin/Würm inundated the present ice-free coastal stretch out to the open sea. A second hypothesis envisages a Late Wisconsin/Würm Inland Ice with an extent not much beyond the present one, and ascribes the evidence of glaciation over the present coastline to glacial ages or stages older than Late Wisconsin/Würm.

The extensive Late Wisconsin/Würm Inland Ice

A Late Wisconsin/Würm ice load is indicated by a postglacial emergence of the coastland (see fig. 2b) of approximately the same magnitude and rate as farther south in Greenland, where an extensive ice cover over the coastal stretch is demonstrated. It should be mentioned, however, that in East Greenland this Late Wisconsin/Würm ice cover was not as extensive as during older glaciations and the Inland Ice did not reach the sea (FUNDER & HJORT, 1973).

With respect to North-West Greenland the concept of a large ice cover is shown on the map of speculative ice-marginal positions by PREST (1969). On this map an outer ice margin at approximately 15.000 B. P. at the Carey Øer (islands) indicates a merging of the Inland Ice and the Innuitian ice cover over Ellesmere Island. Approximately the same boundary is given by ANDREWS (1975), here estimated at 14.000 B. P.

The same tentative date is also given by Andrews for the northern limit of the unified ice cover connecting the northern part of Ellesmere Island with northern Peary Land.

According to BLAKE (1972) recession of ice from the Carey Øer must have taken place relatively early, for the sea had reached into the southern parts of Nares Strait by about 9.500 B. P. whereas the northern Nares Strait may still have been closed at 8.000 B. P. This recession is in agreement with the minimum ages of deglaciation obtained by radiocarbon dates of samples from marine deposits in the front of Harald Moltke Bræ (9.880 ± 500 B. P., CRANE & GRIFFIN, 1959; 9.000 ± 350 B. P., GOLDTHWAIT, 1960), Inglefield Land (7.800 ± 200 to 5.900 ± 150 B. P., NICHOLS, 1969) and Hall Land (6.100 ± 300 B. P., DAVIES, in RUBIN & ALEXANDER, 1960).

Also, marine terraces up to 60 m a. s. l. close to the north side of the front of Humboldt Gletscher, which were investigated during GGU field work in 1975 (HENRIKSEN, pers. comm.) fit into this pattern of recession, provided the isobase map presented here as fig. 2b, can be accepted.

The idea of an extensive Later Wisconsin/Würm ice cover over North-West Greenland to Ellesmere Island is also supported by a comparison between the oxygen isotope records of the ice cores from Camp Century (North Greenland), Devon Island, and Antarctica. The Camp Century core showed a markedly greater difference between glacial (Wisconsinan) and postglacial (holocene) isotope temperatures than other cores. This has been explained by a greater difference in the elevation of the Inland Ice surface between the Wisconsin/Würm and the present day than at the other localities. The consequence of this is the possibility of a high ice ridge over the Nares Strait connecting the Inland Ice with the Innuitian Ice Sheet even during the Late Wisconsin/Würm (DANSGAARD et al., 1973). The elevation of the ice ridge has been estimated to be as much as 3.000 m, whereas PATERSON (in press) suggested a model closer to an extensive Inland Ice, but without the requirement of a high ice ridge between the two islands.

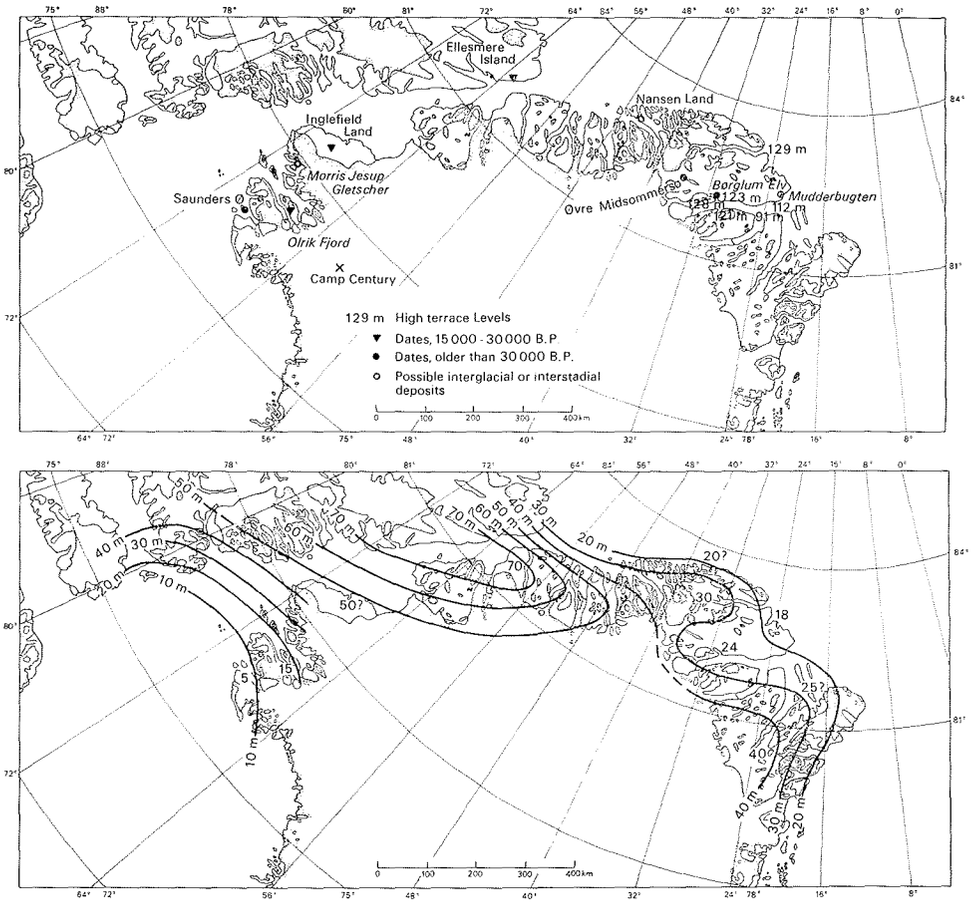

Fig. 2: a. Location of deposits older than 10.000 years in North Greenland according to the following sources:

Olrik Fjord: 18.990±280 B. P. (shells)
Inglefield Land: 20.800±2.900 B. P. (soil), TEDROW (1970).
Ellesmere Island: 27.950±5.400 B. P. (shells), ENGLAND (1974).
Saunders Ø: > 32.000 B. P. (shells), DAVIES et al. (1963); BLAKE (1975).
Øvre Midsommersø: > 35.000 B. P. (driftwood), KNUTH in FREDSKILD (1969).
Børglum Elv: > 35.000 B. P. (driftwood), FREDSKILD (1969).
Mudder Bugt: > 32.000 B. P. (wood), DAVIES in TRAUTMAN & WILLIS (1966).
Furthermore the location of Morris Jesup Gletscher between Olrik Fjord and Inglefield Land and the southwest point of Nansen Land where relative warm loving species are found.

b. Tentative minimum isobase for 6.000 B. P.

Abb. 2: a. Lage der mehr als 10.000 Jahre alten Ablagerungen in Nord-Grönland nach den folgenden Quellen:

Olrik Fjord: 18.990±280 v. h. (Muscheln).
Inglefield Land: 20.800±2.900 v. h. (Boden), TEDROW (1970).
Ellesmere Island: 27.950±5.400 v. h. (Muscheln), ENGLAND (1974).
Saunders Ø: > 32.000 v. h. (Muscheln), DAVIES et al. (1963), BLAKE (1975).
Øvre Midsommersø: > 35.000 v. h. (Treibholz), KNUTH in FREDSKILD (1969).
Børglum Elv: > 35.000 v. h. (Treibholz), FREDSKILD (1969).
Mudder Bugt: > 32.000 v. h. (Holz), DAVIES in TRAUTMAN & WILLIS (1966).
sources: Olrik Fjord: 18.990±280 B. P. (shells)
Dazu die Fundorte relativ wärmeliebender Arte am Morris Jesup Gletscher zwischen Olrik Fjord und der SW-Spitze von Nansen Land.

b. Vermuteter Verlauf der Minimum-Isanabase für 6.000 v. h.

With regard to Peary Land, eastern Nort Greenland (cf. p. 3), there is little doubt that the northern part of this area has been glaciated by only a local ice cap (e. g. CHRISTIE, 1975) whereas the southern parts at same time were inundated by the Inland Ice, which

in places extended 100 km farther north than today. However, the age of this maximum glaciation has not yet been dated, although a measured marine limit of 110—130 m a. s. l. in Independence Fjord and in the eastern parts of Peary Land (TROELSEN, 1952; DAVIES, 1963; cf. fig. 2a here) would suggest an extensive glaciation of this area even during Late Wisconsin/Würm, if the high terrace levels are postglacial in age as presumed earlier by WEIDICK (1972b).

The reduced Late Wisconsin/Würm Inland Ice

In North-West Greenland, the radiocarbon dating of shells on Saunders Ø, older than 32.000 years (DAVIES et al., 1963), led to the conclusion that this island, like the Carey Øer farther to the west, was not glaciated during Late Wisconsin/Würm. However, the freshness of glacial striae and the moraines on the Carey Øer could contradict this (BLAKE, 1975a). Since the date from Saunders Ø concerned a till-like deposit, the evidence is inconclusive and subsequent investigation of the locality has indicated a more complicated history (BLAKE, 1975a). For the date of 20.800 ± 2.900 B. P. on soil in Inglefield Land (fig. 2a; TEDROW, 1970) contamination cannot be excluded although this date is nearly the same age as that of shells from the Canadian side of Hall Basin published by ENGLAND (1974) of 27.950 ± 5.400 B. P.

New evidence is now available from Olrik Fjord, Thule district (fig. 2a); marine shells, collected by P. R. Dawes during the GGU field season 1974, have been dated. A marine silt 2.5 m a. s. l. containing shell fragments of *Chlamys islandica, Hiatella arctica* and *Mya truncata* furnished an age of 18.990 ± 280 B. P. (I—8894). This deposit is overlain by marine silt terraces at 6, 9, 15 and 21 m a. s. l., shells from which give ages of 5.240 ± 100, 5.550 ± 100, 5.765 ± 100 and 7.065 ± 110 years B. P. (I—8895, I—8896, I—8897 and I—8898 respectively). Although contamination cannot be excluded, the sequence of younger dates on top of the old deposit seems to support the validity of the dates, thus implying an extent of the Inland Ice less than 35 km beyond its present extent within at least the last 19.000 years. The locality is situated only 160 km due west of Camp Century and 60 km due north of the present front of Harald Moltke Bræ.

Chlamys inlandica also occur in a sample collected by P. R. Dawes in grey mud in a mound just outside the neoglacial moraines at Morris Jesup Gletscher near Qânâq (now: Thule) near 78° N in North-West Greenland. *Lima subauriculata* in a sample collected by K. Ellitsgaard-Rasmussen on the south-west point of Nansen Land, at the entrance of J. P. Koch Fjord, near 83° N, is reported by LAURSEN (1954). Neither *Chlamys islandica* (LAURSEN 1944) nor Lima subauriculata (LAURSEN, 1944, 1954) are high arctic species so they must represent either Holocene hypsithermal or possibly interglacial or interstadial faunas. So far no C^{14} datings have been made on the shells from these two localities.

In Peary Land CHRISTIE (1975) demonstrated through his investigations of the boulder content in moraines in the Børglum Elv valley north of Independence Fjord, that the last glaciation of this area came from the north and reached down to Jørgen Brønlund Fjord. The same glaciation explains the form of moraine lobes in the southern tributaries of the valley system from Øvre Midsommersø (lake) to Jørgen Brønlund Fjord (WEIDICK, 1975).

Old dates have also been reported from Peary Land. Three samples of driftwood from the east end of Øvre Midsommersø at an altitude of about 100 m a. s. l. and one piece of driftwood in the delta of Børglum Elv at 45 m a. s. l., all gave ages of > 35.000 years B. P. (FREDSKILD, 1969).

The occurrence of old driftwood at Øvre Midsommersø is enigmatic since the only

explanation is that they were brought to these central inland parts by the sea (presumably 110—130 m a. s. l.) and at the same time as the Inland Ice had shrunk to nearly its present size.

Field investigations (KIRKEBY, 1963; WEIDICK, 1975) indicate that the postglacial marine limit revealed by clear marine features is only 70 ± 10 m a. s. l. in the Jørgen Brønlund Fjord, and this marine incursion marks the end of the glaciation from the north. East of the mouth of Jørgen Brønlund Fjord indistinct but extensive terrace levels occur at 110 and 130 m a. s. l. (TROELSEN, 1952; DAVIES, 1963).

In the western parts of Peary Land, a single old date (> 32.000 years B. P.) of willow in moraine has been reported (DAVIES in TRAUTMAN & WILLIS, 1966). This moraine may have originated from the local ice cap over Peary Land and not from an Inland Ice lobe out through Independence Fjord.

Discussion

North-West Greenland: The date sequence from Olrik Fjord favours the concept of a small Late Wisconsin/Würm glaciation of this area.

"Old dates" also occur in the sounds between Ellesmere Island and Devon Island. In this area BLAKE (1975b) listed 15 occurrences of old radiocarbon dates, predating the Late Wisconsin/Würm, with ages varying between 19.100 and more than 40.000 years B. P. Some occurrences are shell-bearing till but undisturbed deposits occur at Cape Storm and on Coburg Island. In this area there seems to be a general agreement for glaciation during the Late Wisconsin/Würm, burying an interstadial or interglacial complex. Such could also be the explanation for the less known region between Ellesmere Island and Greenland.

ENGLAND (1974), as well as TEDROW (1970), strengthen the argument for non-glaciation of the Nares Strait — Hall Basin during Late Wisconsin/Würm by evidence of isolated areas of advanced surface weathering. However, these observations might reflect only local physical conditions, and it is not substantiated that the bedrock and soil outside the postulated margins of the Late Wisconsin/Würm ice cover are generally different to those proximal to these margins.

The tentative isobase map for 6.000 B. P. in fig. 2b is constructed on the basis of the current information of radiocarbon dated material from northern Greenland and is related to the emergence as determined by the upper shell dates. It is possible that the isobases for 6.000 B. P. might be situated at somewhat higher elevations than is shown in the figure. However, in spite of errors due to the scatter and the scarcity of dates, the heights are in general agreement with those given for Devon Island and southern Ellesmere Island by BLAKE (1975b), and the trend of the isobases is comparable with those shown by ANDREWS (1975) and WALCOTT (1975) for Ellesmere Island, indicating a maximum over Ellesmere Island with an offshoot towards Hall Land. This trend could be explained by the fact that Ellesmere Island today is deglaciated to a greater extent than North-West Greenland and that the effects of the former ice load merged over the Hall Basin. This does not imply that the ice covers themselves merged, but at least that they had here the relatively greatest Late Wisconsin/Würm extension in the areas along the Nares Strait.

The maximum uplift in North-West Greenland is given by shell dates from Hall Land from around 80 m a. s. l. with an age of 6.100 ± 300 years B. P. (DAVIES in RUBIN & ALEXANDER, 1960). The restricted extent of the Inland Ice as given by Davies (1972) reveals only an extent of the glacier lobes on both sides of the Hall Land peninsula 50—60 km down the fjords from their present fronts, just as ENGLAND (1974) on the

opposite side of Hall Basin presumes that the contemporaneous ice sheet only locally reached the outer coast. If these extensions of the Late Wisconsin/Würm glaciation caused this maximum uplift the even slighter emergence near Olrik Fjord can scarcely account for much expansion of the Inland Ice beyond its present limitations which agree with the Olrik Fjord date.

Eastern North Greenland: The determination of the last glaciation in the Jørgen Brønlund Fjord — Øvre Midsommersø region from a local ice cap in the north, the differentiation of the low Holocene marine limits from the older higher terraces, and the Holocene emergence as given fig. 2b do not seem to be contradictory. The best fit of these observations is the tentative sequence, shown in fig. 3. In the first phase (a), the northern

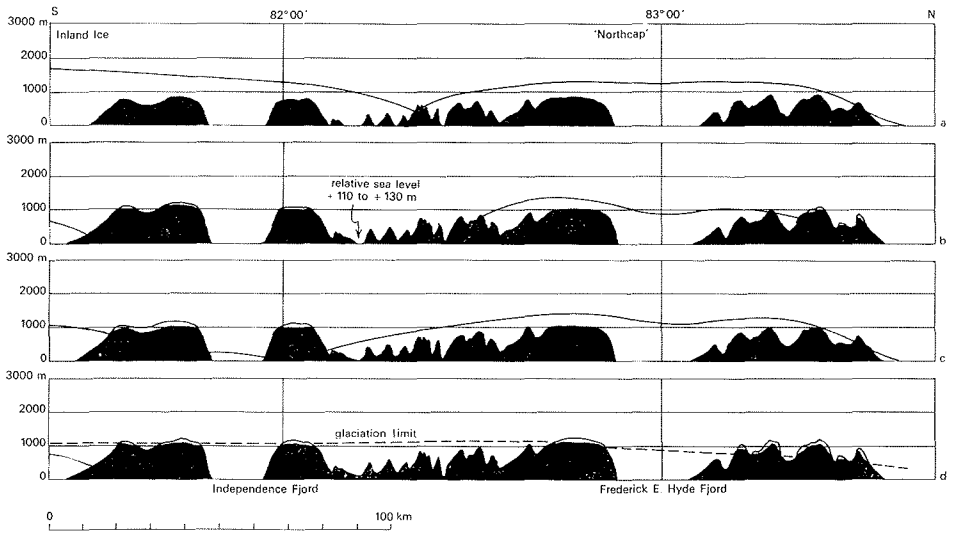

Fig. 3: N-S going section through Peary Land along 33° Longitude.
a. Maximum extent of the Inland Ice and the northern local ice cap (the "North Cap").
b. Recession of the Inland Ice and "North Cap". Marine inundation at Øvre Midsommersø at relative sea level of 110—130 m a. s. l.
c. The latest (Late Wisconsin/Würm) expansion of the "North Cap". Only slighter increase of the Inland Ice.
d. Present situation.

Abb. 3: N-S-Profil durch Peary Land auf 33° W. L.
a. Maximal-Ausdehnung des Inlandeises und der nördlichen lokalen Eiskappe („North Cap").
b. Rückgang von Inlandeis und „North Cap". Marine Überflutung auf Øvre Midsommersø bei einem relativen Meeresspiegel von 110—130 m ü. N. N.
c. Jüngste (Spät-Wisconsin/Würm) Ausdehnung des „North Cap". Nur geringere Zunahme des Inlandeises.
d. Gegenwärtige Situation.

local ice cap (the „North Cap") merged with the Inland Ice (at its maximum extent). In the second phase (b), an incursion of the sea up to 130—110 m a. s. l. occurred in the southern parts of Peary Land (Jørgen Brønlund Fjord — Øvre Midsommersø). This marine inundation is here explained by a partial glacioisostatic depression caused by an existing, but reduced „North Cap". Formation of the „North Cap" requires only a slight depression of the present glaciation limit and the existence of this local ice cap might therefore be explained by an Arctic Ocean more open than today. In the subsequent phase (c), the "North Cap" expands towards the south where a slight contemporaneous expansion of the Inland Ice seems to be indicated by moraines at J. P. Koch Fjord (WEIDICK, 1975). The recession of the southern margins of this "North Cap" occurred around 8.000 B. P. at Jørgen Brønlund Fjord according to present information on postglacial emergence and it disappeared before 7.200 B. P. from the inner parts

of Frederick E. Hyde Fjord (DAWES in WEIDICK, 1973). The actual situation of the ice cover is shown in (d).

The Holocene recession of the Inland Ice and the local ice caps in Greenland generally seems to have continued until the glaciers were smaller than at present. The readvances after 6.000 B. P. brought the margins to their present limit (WEIDICK, 1972a). Into this pattern fits a new date on shells collected by the author in neoglacial moraines at the east side of Adam Gletscher, Peary Land; the shells furnished an age of 4.190 ± 140 B. P. (GSC—2279).

Conclusion and comparison to other areas

The present evidence in North Greenland essentially substantiates the concept of a reduced Late Wisconsin/Würm Inland Ice. This agrees with the observations in East Greenland (FUNDER & HJORT, 1973) although the Inland Ice there inundated greater areas and maintained its maximum extent until 10.000 B. P. In Baffin Island the Late Wisconsin/Würm ice cover also is reported to have been smaller than the older ones, and to have maintained its extent until around 8.000 B. P. (ANDREWS, 1975).

At the present stage of investigation it is not possible to decide whether the Olrik Fjord deposit marks the limit of the extension of the Inland Ice in the Thule area during the Late Wisconsin/Würm; the deposits could theoretically have been overridden by ice. However, if the dating of around 19.000 B. P. is correct the concept of a high ice ridge between Greenland and Ellesmere Island cannot be accepted as an explanation for the trend of the Camp Century curve. The faunal evidence of this interstadial deposit points to climatic conditions like the present one, which, if true, requires a re-evaluation of the isotopic temperature record of Camp Century. However, the possibilities of a mixed shell assemblage cannot be excluded, thus a closer investigation of the Olrik Fjord site is planned. In West Greenland, a maximum extent of the Inland Ice at 10.000 years B. P. might be possible, and a single locality (Sanerâta timâ at 63° N) at the outer coast a maximum extent of even 8.000 years B. P. seems acceptable. However, in general the land-based Inland Ice at 10.000 years B. P. still seems to have covered large areas of the coastland, whereas the ice margin in the main fjord complexes already at this time has a position closer to the present Inland Ice margin than to the coast. Because of the wide extent of the landbased ice 10.000 years B. P., it is reasonable to explain the position of the ice margin at this time as the result of a fast initial recession of ice prior to 10.000 B. P. through the fiords. The problem of delineating the ice margins positions in West Greenland prior to 10.000 years B. P. does not, on the basis of existing information, justify placing the position at this time as a maximum since, unlike East Greenland and Baffin Island, there is no geographical distribution of old dates in a zone distal to the post 10.000 years B. P. dates.

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