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Short explanation to the Quaternary Map of Greenland

by

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SHORT EXPLANATION TO THE QUATERNARY MAP OF GREENLAND

by

Anker Weidick

Supplementary notes to the
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scale 1 : 2 500 000
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Abstract

A map of Quaternary deposits in Greenland is published at a scale of 1 : 2 500 000, summarising the main information to around 1969. The notes presented furnish a review of the source material used in the compilation of the map.

INTRODUCTION

The investigations on the Quaternary deposits of Greenland must be considered as being still at the reconnaissance stage. Most data hitherto presented are incidental observations made during botanical, geographical, geological or glaciological investigations. This is especially true for much information obtained up to the second world war. Following the war Quaternary mapping of certain areas was begun, but so far complete mapping only covers fragments of the country and for the greater parts of West Greenland and North Greenland only certain features are known.

It is not possible in these short notes to refer to all the sources of information which have been used in the preparation of the map, and this is particulary regrettable since a general review of the Quaternary of Greenland has yet to be published. A selection of the most important references is given at the end of the text.

Comments on the sources of information for the ice-free coastal stretch of Greenland are given below. With respect to other parts of the map, references are given under the headings: map base (p. 6), existing glaciers (p. 6) and sea bottom (p. 10).

SOURCES OF INFORMATION ON THE ICE-FREE COASTAL STRIP

Published sources

For certain areas in West Greenland data are available from as early as the beginning of the 19th century (Giesecke, 1910; Rink, 1853). More detailed information resulted from the establishment of the "Commission for the Geographical and Geological Investigations in Greenland" (1878-1931) and the systematic investigations guided by this commission. The main investigations in West Greenland were carried out by Bloch (1893), Engell (1910), Hammer (1889), Jensen (1881, 1889), Jessen (1896), Kornerup (1879, 1881), Pjetursson (1898), Porsild (1902), Ryder (1889), Steenstrup (1881, 1883, 1901, 1910) and Sylow (1889) and in East Greenland by Knutsen & Eberlin (1889), Freuchen (1915), Jensen (1917), I. P. Koch (1916), L. Koch (1928a & b), Kruuse (1912) and Nordenskiöld (1909).

Additional information was collected by other expeditions covering more restricted areas of which the following workers must be mentioned: Drygalski (1897), Cham-

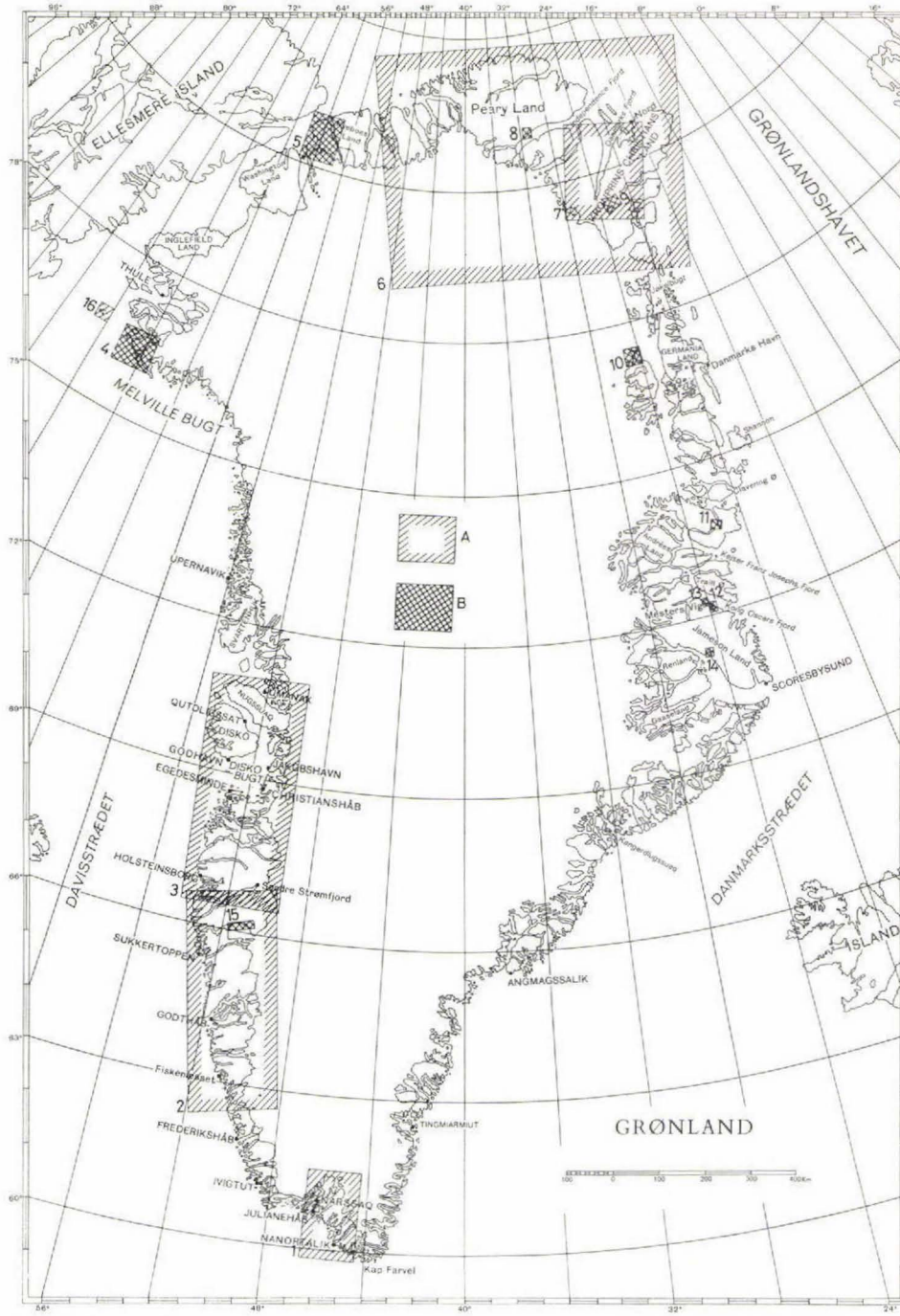

Fig. 1. Index map showing the position of published maps used in the compilation of the Quaternary Map of Greenland. *Continued bottom p. 5.*

berlin (1894/97), Salisbury (1895), Belknap (1941), Jahn (1938), Gripp (1932), Nordenskiöld (1914), Paterson (1951), de Quervain & Mercanton (1925), Etienne (1940) and Sugden & Mott (1940).

During the early systematic investigations a tendency to undertake special Quaternary investigations was already apparent, and became an important aspect of succeeding expeditions, such as the 7th Thule Expedition and the Norwegian investigations in south-east Greenland (Bøgvad (1940) & Vogt (1933) respectively); the Lauge Koch and L. Boyd Expeditions to East Greenland (Backlund, 1931; Bretz, 1935; Flint, 1948; Noe-Nygaard, 1932 and Poser, 1932) and the Danish Nûgssuaq Expeditions of West Greenland (Laursen, 1944, 1950). The same remarks can be applied tõ North Greenland where Quaternary investigations have been undertaken in connection with the Thule Expeditions (Koch, 1928a & b) and the Peary Land Expeditions (Troelsen, 1952, Laursen, 1954).

Mapping of Quaternary features, especially marine deposits and glacial features already found their place on early geological maps, amongst others, those of Kornerup and Steenstrup. This tradition has been continued with the most recent geological maps and map descriptions of the Geological Survey of Greenland such as those of Escher (1966) or Weidmann (1964).

A special treatise on glacial striae has been presented for a restricted area in West Greenland by Graff-Petersen (1952), and Quaternary deposits of the Scoresby Sund – Mesters Vig region have been described by Sugden & John (1965), Lasca (1966) and Washburn (1962, 1965), those of Dronning Louise Land by Lister & Wyllie (1957) and those of several small areas between Scoresby Sund and Peary Land have been presented by Hartshorn *et al.* (1961), Davies (1963) and Krinsley (1961). A special treatise on the Quaternary of the Carey Øer, off Thule, has been given by Bendix-Almgreen *et al.* (1967).

Very detailed maps of the Thule area and Hall Land have been prepared by Davies *et al.* (1959, 1963). Less detailed mapping of north-east Greenland, also by American groups, is described by Goldthwait (1961), Davies (1959, 1962, 1963), Krinsley (1961) and Stoertz (1959), and covers large areas including Peary Land

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A: Sketch map giving the outlines for the geographical distribution or extent of one or more Quaternary features or deposits.

B: More detailed information.

The numerals refer to the following sources:

1. Weidick (1963)
2. Weidick (1968)
3. Weidick (1968)
4. Davies *et al.* (1963)
5. Davies *et al.* (1959)
6. Davies (1963)
7. Krinsley (1961)
8. Stoertz & Needleman (1957)
9. Krinsley (1961)
10. Lister & Wyllie (1957)
11. Stoertz (1959)
12. Washburn (1965)
13. Lasca (1969)
14. Sugden & John (1965)
15. Goldthwait *et al.* (1964)
16. Bendix-Almgreen *et al.* (1967)

and Kronprins Christian Land; information on the marine, lacustrine and glacigene deposits is given.

Large scale work has been carried out in West Greenland by GGU (Kelly, 1966, 1968; Weidick, 1963, 1968); it includes data on marine and ice contact deposits.

Unpublished sources

The most valuable source of information has been the aerial photographs in the archive of the Geodetic Institute, Copenhagen, Other unpublished data is found in diaries and reports in the GGU archive and, especially for the areas around the towns, in the reports of the Technical Organisation of Greenland (Ministry of Greenland). There are also individual observations, reported to and filed at GGU.

The remainder of these notes, with the exception of the first section (map base), follows the order of the map legend.

MAP BASE

The base map, giving the limits of land and glaciers and the surface contours of the Inland Ice, was prepared by A. Escher for the Tectonic/Geological Map of Greenland at a scale of 1 : 2 500 000. It was compiled from 1 : 1 000 000 maps of the Geodetic Institute and 1 : 2 000 000 USAF Jet Navigation Charts.

EXISTING GLACIERS

No distinction has been made between local glaciers and the Inland Ice since many of the local ice caps have connections with the Inland Ice, and a limit is difficult to ascertain.

The form of the surface of the Inland Ice is given by the contours at 300 m intervals. The position of some of the survey stations has been given because firn stratigraphy is becoming increasingly important as a key to the climatic history of the Quaternary (Dansgaard *et al.*, 1969). The positions of the stations are given according to Heuberger (1954), Schuster (1954), Fristrup (1966), Langway (1967) and Walker *et al.* (1968).

To illustrate the dimensions of the Inland Ice, the topography of its base has been plotted according to the published results of the Expéditions Polaire Françaises

(Holtzscherer & Bauer, 1954), The British North Greenland Expedition (Bull, 1955, 1957) and the investigations of the US Army (Clarke, 1966).

For some parts of the margin of the Inland Ice which are afloat, the position of the ice margin as given by early investigations varies to the extent that it can be shown on the 1 : 2 500 000 map. The variations are mainly a consequence of climatic changes in historical time. However, errors in early mapping of the ice margin cannot be excluded.

GLACIO-FLUVIAL AND ICE LAKE DEPOSITS

Much of the valley filling and the outwash at the heads of the fjords is of glacio-fluvial origin. No distinction has, however, been made between fluvial, glacio-fluvial and ice lake deposits because of insufficient information. A large number of former ice margin lakes have been reported from all parts of Greenland (Davies, 1963; Lister & Wyllie, 1957; Weidick, 1963; White, 1956), but the scale of the map and the uncertain mapping of some of the deposits does not allow them to be distinguished from those of glacio-fluvial or fluvial origin.

A special problem arises at the coast where deltas merge with deposits of marine origin. In the case of developed beach ridges of marine origin, the deposits are referred to as marine in spite of a later development of deltas or fluvial cover. Many of the extensive areas given as marine deposits on the map comprise marine silt covered by a thin veneer of fluvial deposits (Weidick, 1968).

Eskers are glacio-fluvial features of special interest. The very few descriptions of such features from West Greenland (Kornerup, 1881; Milthers, 1949) gives the impression that these features are seldom found; however, on aerial photographs there occur several features in moraine-rich stretches which can best be interpreted as eskers. They have been found in areas deglaciated in Holocene time as well as in areas deglaciated by the glaciers in the last decades.

ÆOLEAN DEPOSITS

Æolean deposits in the form of dune landscapes have been reported from parts of the outer coast of West and East Greenland, but the most extensive areas are encountered near to the Inland Ice margin. The delineation of these deposits has been mostly made on the basis of aerial photographs which only includes the morphological forms giving dune landscapes and does not include the possible occurrence of

loess, a material which has been reported from West Greenland by Nordenskiöld (1914).

MARINE DEPOSITS AND FEATURES

The same symbols are used for abraded and accumulated marine deposits and features. These Quaternary deposits are those commonly subjected to detailed investigation and description. The most important works are those of Bretz (1935), Bøgvad (1940), Davies (1963), Harder & Jensen (1910), Jessen (1896), Laursen (1944, 1945, 1950, 1954), Steenstrup (1883) and Vogt (1933) which are outstanding among an increasing volume of description of marine localities because of their areal coverage.

The great volume of literature has led to much confusion regarding the definition of marine features. The criteria for distinguishing features of marine origin employed here are:

1) beach ridges
2) undisturbed shell-bearing beds
3) lower limit of perched boulders (for maximum marine transgression)
4) terrace levels of wide regional extent

The criteria applied may not completely exclude erroneous data, but will at least reduce it to a minimum. General statements about marine levels of regional extent have not been considered unless they have been documented by reference to specific localities.

Where former reports of outstandingly high marine limits have been controlled by later observers, they have often been revealed as ice margin features such as ice dammed lake and kame terraces. In general, the maximum heights of marine deposits occur at 100-200 m above sea level throughout most of Greenland. Exceptions are the low values of 50-60 m in southernmost Greenland (Jessen, 1896) and the fairly high value of 216 m in the fjord region of north-east Greenland (Noe-Nygaard, (1932).

Small local occurrences of marine deposits are localities where the extent of the marine deposits are too small to be given in their correct extent at the map scale given. They have been indicated as assumed marine deposits where information has been uncertain.

The values given for the uppermost known marine deposits refer to both isolated deposits and areas with more widespread deposits. The limit of transgression has only been indicated where moraine affected by wave action and moraine unaffected occur close to each other.

MORAINE COVER

Only two types of moraine cover have been distinguished: ground moraine covering extensive areas, and sporadic ground moraine forming only local cover in minor valleys, cirques or close to present glaciers. With the exception of the few areas which have been investigated all information is based on aerial photographs; where the moraine cover completely veils the structure of the bedrock it has been interpreted as continuous moraine cover, and where not as sporadic. This method of distinction has worked out to be satisfactory when ground control has been applied, especially in areas with Precambrian rocks. In areas of younger pre-Quaternary sediments, especially in North Greenland, the exact delineation of the limit may be somewhat arbitrary.

Ice margin deposits have also been indicated. Those formed by the Inland Ice can largely be shown, but the scale of the map does not allow for full representation of all ice margin deposits of minor local glaciations. However, in general it must be stated that there has been little development of local glaciations for most areas in Greenland after the recession of the Wisconsin ice cover. Only in southernmost Greenland (Julianehåb district) can significant variations in the extent of the local glaciers be traced in Holocene time.

With reference to northernmost Greenland; Peary Land seems to have been covered by a local ice cap during the Wisconsin.

The lack of dating of the formation of the widespread ice margin deposits of the Inland Ice prevents a general correlation of the deposits in north-east, south-west and West Greenland. The most prominent feature is the zone of ice margin features in West Greenland running north-south parallel to the present ice margin of the Inland Ice for a distance of 10-40 km from it. The zone goes from Nûgssuaq peninsula in the north to just north of Fiskenæsset in the south. Radiocarbon dates of marine deposits in connection with these "Fjord stages" (Weidick, 1968) give strong evidence for the formation of these stages at the same time as the "Cockburn deposits" of Canada (Falconer *et al.*, 1965; Blake, 1966). A southern continuation of these stages has been mapped in the area south of Frederikshåb by Kelly (1966). In Peary Land, a main readvance marked by ice margin deposits has been dated to between 3700 and 6000 years B. P. (Davies, 1963).

The maximum altitude at which erratic boulders or glacial striae have been found is given for the coastal areas, giving an indication of the extent of the maximum glaciation of Greenland in a third dimension. The direction of glacial striae is only given when they indicate ice movement of general interest, e.g. where they are situated at the outer coast or on the top of high plateaux. The youngest movement, generally following the fjords, has not been shown.

The northern limit of erratic boulders for the Inland Ice is given after Troelsen

(1952), a limit somewhat further to the south than that proposed by Lauge Koch (1928a).

REPORTED INTERGLACIAL OCCURRENCES

There have been reported a number of interglacial occurrences of different character, namely the following: concretions transported to the margin of the Inland Ice from the substratum of the glacier (Inland Ice) in West Greenland (Bryan 1954), shells older than 32 000-35 000 years embedded in till-like deposits in North and West Greenland (Davies *et al.* 1963; Rosenkrantz, 1968), or caves of supposed interglacial origin in East Greenland (Davies & Krinsley, 1960).

The firn layers of interglacial age at Camp Century on the Inland Ice, reported by Dansgaard *et al.* (1969) should be referred to here; while they are only known at Camp Century their wide horizontal extent beneath the surface of the Inland Ice can be postulated.

SEA BOTTOM

The original base map employed was that published by the INQUA organisation at a scale of 1 : 5 000 000 over North America. Corrections have been made in the areas from the Lincoln Sea to the Davis Strait on the basis of the work by Pelletier (1964), and the areas closer to the shelf after the charts of the Royal Danish Hydrographic Office (sheets 1000 to 1600 over West Greenland and sheets 2000 to 2700 over East Greenland). For East Greenland the results of the Louise Boyd expeditions, and those by Litvin (1959), Svirenko & Soldatov (1964) and Laktionov (1959) have also been used.

The contours of the Polar Basin are those of the INQUA 1 : 5 000 000 map. The sources seem to have been the same as those employed by Stearns (1965) and Gakkel & Dibner (1967).

On the shelf off West Greenland the banks are indicated by symbols for depths over 50 m. On the basis of information collected on the banks, especially that of Rvachev (1963), and the detailed relief given on the charts, the possibility must be considered that the ridges can be interpreted as ice margin deposits laid down under the maximum expansion of the Inland Ice.

Many fjords are extremely deep. The greatest depths have been found in Kangerdluk fjord, Umanak district (1123 m; Sorge 1933) and Upernavik Isfjord (1055 m; Birket-Smith, 1928) in West Greenland, and in Nordvestfjord (1450 m) and Øfjord

(1050 m) in the inner part of Scoresby Sund in East Greenland (Ussing, 1934). These maximum depressions are found mostly in the inner narrow parts of the fjords and the scale of the map only makes it possible in a few places to illustrate the extent and the forms of the troughs.

The extent of the shelf is illustrated by the 100 and 200 m contours. It is apparent that the 200 m contour line in West Greenland gives the limits of the margin of the continental shelf, while in East Greenland the limit seems to be somewhat deeper, close to *c.* 400 m.

The form of the deep sea bottom is given by contours with an interval of 500 m. While the bottom deposits of the stretch Scoresby Sund to South Greenland is shown on the INQUA International Quaternary Map of Europe (Sheet 1, 1 : 2 500 000) there is at present insufficient information for the remaining waters around Greenland, in particular parts of the Polar Basin, for a complete coverage.

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