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Under Ledelse af Lauge Koch

A GEOLOGICAL RECONNAISSANCE OF THE REGION AROUND THE INNER PART OF DANMARKS FJORD, NORTHEAST GREENLAND

BY

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WITH 4 FIGURES IN THE TEXT AND 2 PLATES

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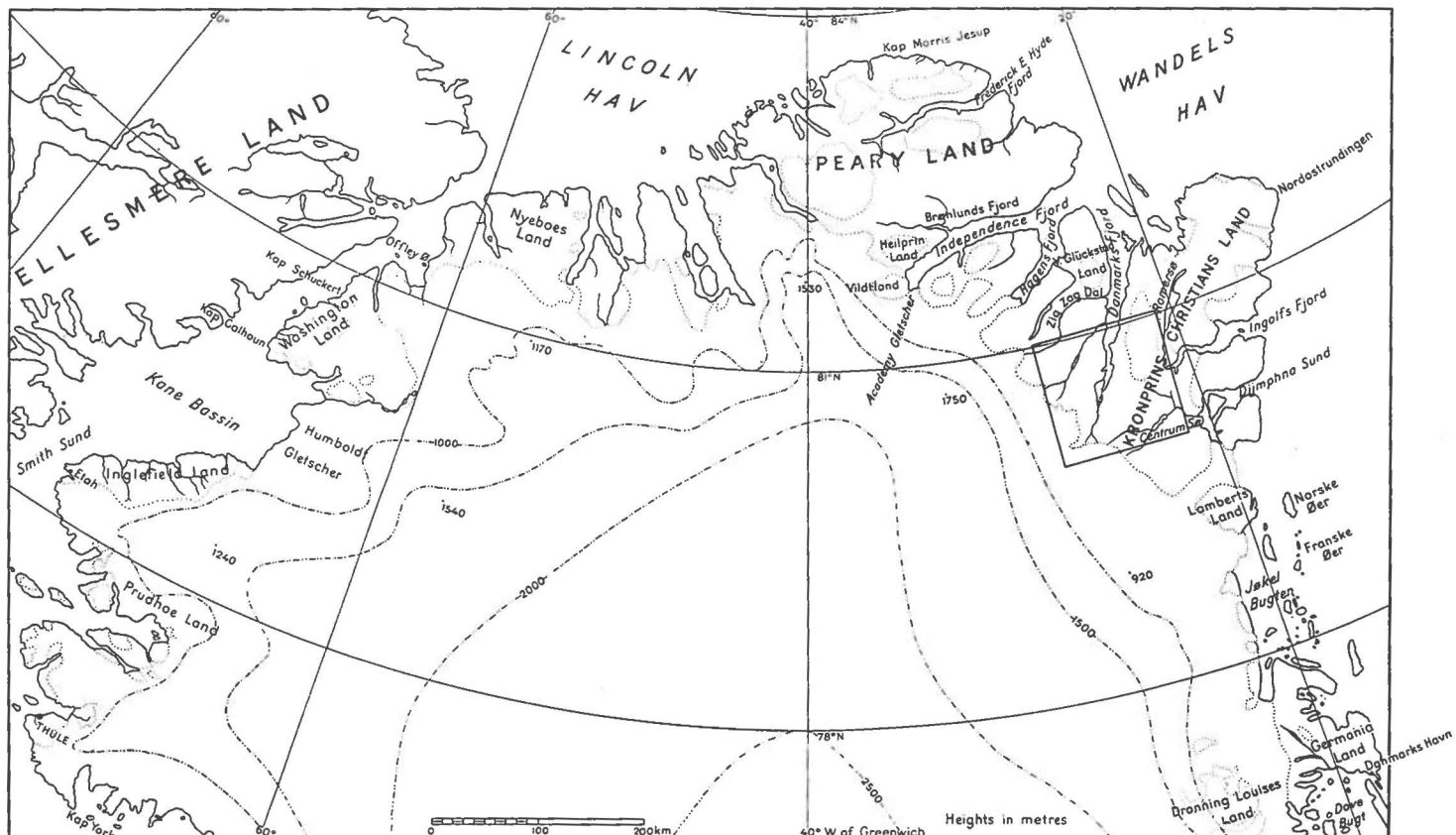

Fig. 1. Map of northern Greenland, scale 1:7,000,000 (1 cm to 70 kms), showing the principal places mentioned in the text, and location of region covered by Plate I.

I. INTRODUCTION

In the summer of 1952 the authors, as members of a Danish expedition to East Greenland under the leadership of Dr. LAUGE KOCH, made a geological reconnaissance of an unexplored region in Northeast Greenland, situated at the southern end of Kronprins Christians Land and around the inner part of Danmarks Fjord, and approximately bounded by latitudes 80° and 81° North, and longitudes 22° and 27° West (fig. 1).

Centrumsø, a large lake draining eastwards into Dijmphna Sund, was the base of operations and was reached by flying-boat from Ella Ø in East Greenland. The lake was nearly ice-free by the end of July, and a small seaplane which was maintained here in August enabled field-parties to be transported to other ice-free lakes and fjord-heads. Two geological parties were in the area for three weeks; one, led by E. FRÄNKL, concentrated upon the intensely folded zone east of Centrumsø, while the writers, assisted by a Greenlander, worked in the comparatively unfolded and shallow-dipping strata north-west of the lake. The large fault at the east end of Centrumsø (Plate I) has been agreed upon as a convenient boundary between the areas considered by FRÄNKL and ourselves.

The first week was occupied by a journey on foot along the northern shores of the large braided river Saefaxi Elv, followed by a flight to Kap Holbæk, on the west side of Danmarks Fjord, for a stay of five days. Aerial reconnaissance during the flight formed the basis of the geological mapping around the Bristol Plateau and on the north-west of Norsemandal. The party was next flown to Fyns Sø, and three days were occupied in making an investigation of the country lying to the east as far as 24° West, which established a connection between the older succession, examined at Kap Holbæk and Campanuladal, and the younger strata in Saefaxi Elv valley and on the shores of Centrumsø. The last days of the three weeks were spent around Centrumsø.

Between Centrumsø and Bred Flod, the physiography is characterised by gently undulating uplands, which, except for small, winding streams, are predominantly featureless, and covered with loose shattered rock and glacial debris. The only rocks *in situ* occur as cliffs in the

Fig. 2. Aerial view of Saefaxi Elv valley, looking westwards from Centrumsø.

main valleys or as occasional impersistent bands on the uplands (fig. 2). However, a steep cliff forms the east coast of Danmarks Fjord at the Sjællands Fjeldene, and inland from this for a few kilometres outcrops are more abundant. In contrast, Kap Holbæk, Sneuglefjeld, the Bristol Plateau and the Fynske Alper have a more mountainous topography and the rocks are well-exposed.

The main purpose in visiting the area was to examine the Lower Palaeozoic rocks and to establish a preliminary stratigraphical succession. Middle Silurian rocks were known to exist in the valleys at the head of Ingolfs Fjord (Nielsen, 1941); it was our aim to discover if Cambrian, Ordovician and older and younger Silurian strata were present in the region.

In the construction of the accompanying geological map all available topographical information has been utilised, but the main source has been the United States Air Force World Aeronautical Chart No. 9 (scale 1:1,000,000). A number of new place-names have been given in order to facilitate the geological descriptions.

II. HISTORICAL REVIEW OF GEOLOGICAL OBSERVATIONS IN NORTHEAST GREENLAND[1])

Peary crossed the inland ice from his winter quarters in Prudhoe Land in Northwest Greenland to the head of Independence Fjord, and found ripple-marked red sandstone in Vildtland (PEARY, 1898). He observed the southern shores of Peary Land, across the fjord, and later remarked on their striking resemblance to the cliffs of Prudhoe Land, which are chiefly composed of the red sandstone of the Thule Group (late Pre-Cambrian).

Members of the Danmark Expedition discovered Danmarks Fjord and Hagens Fjord in 1907 (AMDRUP, 1913). Although MYLIUS ERICHSEN's party spent some time in the region and one of their cairn reports mentions animal and plant fossils, the geological results were lost when the party perished on the return journey. A few years later EINAR MIKKELSEN sledged through Danmarks Fjord, and north of Kap Holbæk, on the coast at the eastern end of the Bristol Plateau (Plate I), he observed that "all the light-coloured stones which we found at the foot of the mountain contained marks of fossil shells", and suggested that they were derived from layers in the cliff wall (MIKKELSEN, 1922, p. 81). The aerial reconnaissance made in 1952 indicates that this stretch of coast consists of the Norsemandal Sandstones and Limestones and Fyns Sø Dolomite, but no fossils were found by us when these formations were examined in Campanuladal. MIKKELSEN collected geological specimens which unfortunately were lost on his journey home.

RASMUSSEN and FREUCHEN in 1912 descended from the inland ice through Zig-Zag Dal to Danmarks Fjord, and passed through Independence Fjord (RASMUSSEN, 1915). Sandstone and diabase were reported among specimens collected from Zig-Zag Dal, Heilprin Land and Vildtland (BØGGILD, 1915).

LAUGE KOCH sledged through Independence Fjord and visited Vildtland in 1921. He collected Ordovician and Silurian fossils on the

[1]) An appreciation of investigations made in the eastern part of Kronprins Christians Land is omitted from this review but will probably be included by Dr. FRÄNKL in a forthcoming paper.

south coast of Peary Land, but these had to be abandoned on the difficult return journey to Northwest Greenland; the Thule Group was identified in Valdemar Glückstadts Land, J. C. Christensens Land, Vildtland and the southern part of Heilprin Land (Koch, 1926). Twelve years later Koch made an aerial reconnaissance of Kronprins Christians Land and part of Valdemar Glückstadts Land from Norske Öer, east of Lamberts Land. Slightly folded sediments of considerable thickness were observed in southern Kronprins Christians Land, underlain by presumed Thule Group sandstone near Danmarks Fjord (Koch, 1935).

Eigil Nielsen travelled up the east coast of Greenland from Germania Land in 1939, and penetrated to the head of Ingolfs Fjord. He found Silurian fossils in the mountains flanking the "Sødalen" valley.

The succession he ascertained consists of 500—600 metres of limestones at the base, overlain by 300—400 metres of dark limestone containing coelenterates and brachiopods of Niagaran age. The highest subdivisions comprise 150 metres of unfossiliferous light-grey limestone overlain by 300—400 metres of shales. The first proved occurrence of Silurian rocks in Northeast Greenland south of Independence Fjord is thus due to Nielsen (1941, pp. 21—25).

Troelsen investigated the geology of parts of southern Peary Land around Jørgen Brønlunds Fjord (Troelsen, 1949). The Brønlund Fjord Dolomite, resting on the Thule Group, was tentatively assigned to the Cambrian[1]), and is succeeded by the Wandel Valley Limestone, which is probably of Upper Canadian age. The youngest formation described is the Børglum River Limestone of Middle or Upper Ordovician age.

[1]) In a communication from Dr. J. C. Troelsen in 1953 he states that olenellid trilobites have been found in the basal layer of the Brønlund Fjord Dolomite.

III. STRATIGRAPHY

The general succession is tabulated below:

	Thickness in metres	Lithology	Age
e. Centrum Limestone	*circa* 2500	Limestone with occasional dolomite bands	Niagaran (Silurian) ↕ U. Canadian (Ordovician)
d. Kap Holbæk Sandstone (135 m) — Upper Sandstone ...	25	Sandstones, quartzites and dark-grey shales	?
Upper Quartzite ...	10		
Middle Sandstone ..	50		
Lower Quartzite ...	20		
Lower Sandstone ...	30		
c. Fyns Sø Dolomite (324 m) — Shale	4	Dolomites	?
Cone-in-cone horizon	20		
Dolomite	300		
b. Campanuladal Sandstones & Limestones (250 m) — Reddish-brown Limestone	100	Sandstones and limestones	?
Green Sandstone ...	150		
a. Norsemandal Sandstone	300 + (base not seen)	Sandstones and quartzites with basic dykes	? Late Pre-Cambrian

a. Norsemandal Sandstone.

The upper part was examined in one locality on the north side of Campanuladal, where the rocks are red, maroon and grey sandstones weathering predominantly red, associated with grey and white quartzites, weathering yellow and grey. The bedding is well-marked, and weathering reduces the strata to large blocks; ripple-marking and current-bedding were also observed. These sandstones and quartzites are

traversed by numerous basic dykes of fine-grained black dolerite and dark, reddish-brown, green-flecked, occasionally amygdaloidal, porphyrite. The dykes were not found in the overlying strata, a fact which suggests an unconformity at the base of the Campanuladal Sandstone, although no angular discordance was observed.

The subdivision can be tentatively correlated with the lower part of the Thule Group of North and Northwest Greenland, which is composed of sandstones with basic dykes, and may be considered to be late Pre-Cambrian in age although no Cambrian fossils have been found in our area; the Thule Group in Northwest Greenland occurs below the fossiliferous Lower Cambrian and has in the past been considered as Lower Cambrian, as Eocambrian or as late Pre-Cambrian (Koch, 1929 a; Troelsen, 1950).

b. Campanuladal Sandstones and Limestones.

The Green Sandstone consists of grey-green, thinly bedded, fine-grained, micaceous, glauconitic, calcareous sandstones and grey-green, micaceous, arenaceous shales. The succeeding Reddish-brown Limestone is composed of fine-grained, thinly-bedded limestone, sometimes streaked with green; shale bands are occasionally encountered but intraformational conglomerates are abundant. Near the top, the bedding becomes more massive and stromatolites occur. There is no sharp junction between these two lithological subdivisions; in fact a transition takes place upwards which is expressed chiefly by an increase in the percentage of carbonate.

c. Fyns Sø Dolomite.

The Dolomite is light-grey, fine-grained, massive, and weathers yellow-buff. Stromatolites are abundant in most parts and weathered bedding-planes show that often the whole rock is built up of concentric stromatolitic structures.

The Cone-in-cone horizon shows nests of cones, which have an exceptional vertical persistence throughout the thickness of approximately 20 metres (figs. 3 & 4). The height of individual cones is 80—100 mm., with a basal diameter of 60—80 mm., the apical angle being between 50° and 60°. The basal parts of the cones show no flare, and no fluting or striations were observed. The cones are massive, show concentric microstructure parallel to the sides, are separated from one another by red argillaceous material, and from an examination of thin-sections they appear to be composed almost entirely of carbonate with disseminations of haematite, staining tests indicating a predominance of dolomite. Some horizons within the bed are more resistant than others, and stratification can be seen at right-angles to the cone-axes. Carbonate

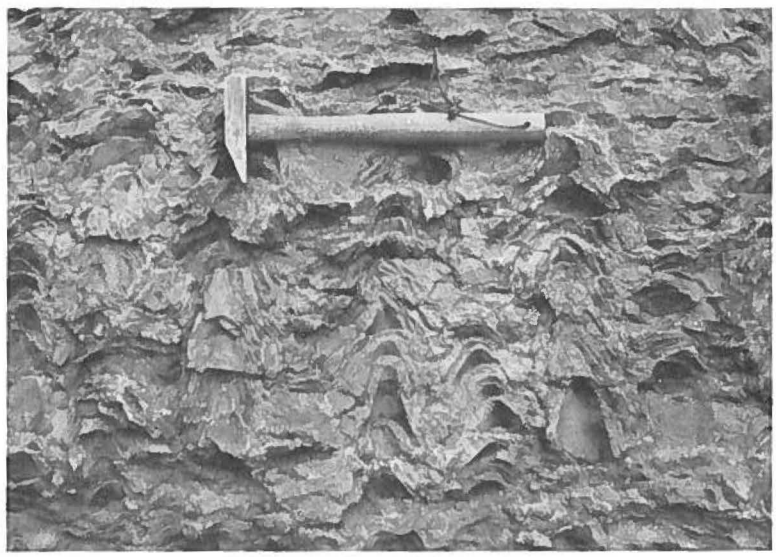

Fig. 3. Section of the Cone-in-cone horizon, Fyns So Dolomite, at Kap Holbæk.

streaks and veins are also present, some of which are possibly stylolitic. The junction with the bed below is gradational and the cone-in-cones appear by transition from normal, through undulating, bedding. The structure appears to be unique in two respects; the cones are composed

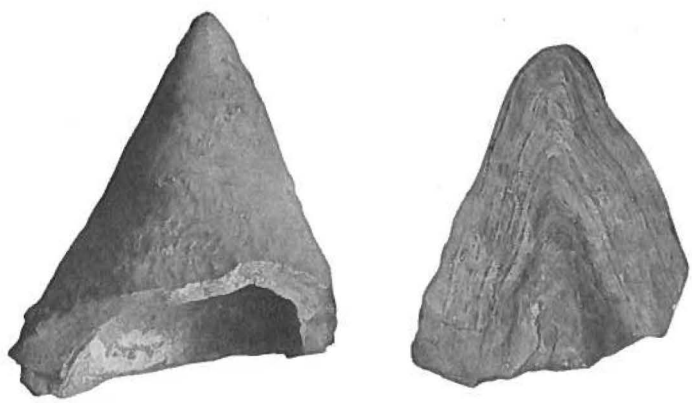

Fig. 4. Cone-in-cone horizon, Fyns Sø Dolomite:
a. individual cone (× ½), b. weathered cross-section (× ½).

of massive dolomite, and are orientated with their apices upwards in an undisturbed stratigraphical succession. Previous occurrences of cone-in-cone structure developed in single layers show the apices directed downwards (TARR *in* TWENHOFEL, 1932, p. 716; PETTIJOHN, 1949, p. 155).

The Shale horizon is composed of hard maroon and green shales with laminae of approximately 1 mm. in thickness.

d. Kap Holbæk Sandstone.

The Lower Sandstone consists of light-grey, cross-bedded, thinly-bedded sandstones and dark-grey arenaceous shales, and is succeeded by the Lower Quartzite comprising light-grey to white quartzites weathering grey to light-brown. At some horizons imperfectly developed tubes were seen situated at right-angles to the bedding, similar in some respects to the 'scolithid' tubes in quartzite found as loose blocks in East Greenland around latitude 74° North. The Middle Sandstone, consisting of thinly-bedded sandstones, with quartzites and some arenaceous shales, is light-grey to white at the base and becomes darker in colour upwards; cross-bedding and ripple-marks were observed. Massive light-grey to white quartzite, which weathers orange and yellow, forms the Upper Quartzite. The Upper Sandstone is glauconitic and composed of thinly-bedded sandstones with arenaceous shales, and a quartzite band near the top. There is a sudden change of lithology to the overlying Centrum Limestone.

e. Centrum Limestone.

The great thickness of limestone and occasional dolomite bands has not been divided into smaller stratigraphical units, and although the better examined strata at the base and top might be separated into formations, it is hoped that a thorough examination may be possible in the near future which will enable reliable subdivisions of the whole thickness to be defined. Upper Canadian and Middle Ordovician fossils were found near the base, and Niagaran faunas were collected in the upper part; the absence of the faunas of the Upper Ordovician and Lower Silurian is possibly due to the cursory examination which the middle part of the section received, but on the other hand, there may be a break in the stratigraphical succession.

Height in metres above base.	Lithological descriptions and faunas.
2350—2500	From a horizon at about the middle of 150 metres of light-grey limestone weathering light-grey (locality 9, Plate I), a large Niagaran fauna was collected: *Bumastus* aff. *ioxus* Hall, *Cheirurus hyperboreus* Poulsen, *Encrinurus moderatus* Poulsen, *Encrinurus* sp. indet., *Proetus* sp., *Scutellum* sp. nov., *Brachyprion* cf. *profunda* (Hall), *Crispella* sp. indet., ? *Delthyris* sp., *Harpidium rotundatum* Poulsen, *Leptaena* sp., ? *Merista brevirostris* Poulsen, ? *Triplesia* sp., ? *Armenoceras* sp., *Favosites gothlandicus* Lamarck, ? *Ctenodonta* sp.
1800	Another, presumably Niagaran, fauna was collected from a dark-grey limestone weathering brown (locality 8):

Actinostroma sp. nov., *Amplexus* cf. *offleyensis* (Etheridge), ? *Dalmanophyllum* sp., *Favosites gothlandicus* Lamarck, *Favosites* sp.

1400 Dark-grey limestone weathering brown yielded a Niagaran fauna (locality 7): *Entelophyllum* cf. *rugosum* Smith, *Entelophyllum* sp., *Favosites* cf. *gothlandicus* Lamarck, *Favosites* sp., *Halysites catenularia* (Linnaeus), ? *Pycnactis* sp.

1050 A fauna, probably of Niagaran age, was collected from very dark-grey, hard, well-bedded limestone with dark-brown weathered surfaces, abundant chert and minor bands of rubbly limestone (locality 6): *Amplexus offleyensis* (Etheridge), *Favosites* cf. *gothlandicus* Lamarck, *Halysites escharoides* (Lamarck), *Heliolites* sp., ? *Pycnactis* sp., *Stauria favosa* (Linnaeus).

1000 A dark-grey, hard limestone, weathering dark-brown, with chert and minor bands of rubbly limestone yielded only indeterminable cephalopods (locality 5).

300 Dark-grey to black massive limestone carrying dolomitic streaks and patches, provided *Gonioceras wulffi* Troedsson and *Calapoecia* cf. *borealis* Whitfield, which suggest a Black River-Lower Trenton age (locality 4).

250 Thinly-bedded, medium-grey, dolomitic limestone, with shaly partings, gave *Calliops* sp., ? *Isotelus* sp., *Öpikina* sp., ? *Plectorthis* sp., suggesting a Black River age (locality 3).

200 Medium-grey limestone, weathering grey, with many intraformational conglomerates, yielded the following Upper Canadian fauna (locality 2): *Bathyurellus teicherti* Poulsen *Bathyurus* sp. nov., *Benthamaspis* aff. *problematica* Poulsen, *Cybelopsis speciosa* Poulsen, *Goniotelus* cf. *marionensis* Cullison, *Isoteloides* cf. *whitfieldi* Raymond, *Didymograptus* cf. *extensus* Hall, indeterminate orthids.

10 A fauna indicating an Upper Canadian age was recovered from grey to light-grey limestone, weathering grey (locality 1): *Bathyurellus teicherti* Poulsen, *Bathyurus amplimarginatus* Billings, *Cybelopsis speciosa* Poulsen, *Goniotelus* cf. *marionensis* Cullison, *Hormotoma* sp. indet., indeterminate orthids.

At the base. Highly siliceous contorted limestone, weathering a rusty brown, occurs with chert and flint; many large-scale intraformational conglomerates combined with the highly contorted bedding and the sudden change of lithology suggest

a disconformity, or unconformity, at the top of the Kap Holbæk Sandstone, although there is no observable change of dip.

In estimating the approximate total thickness of the Centrum Limestone the width of the outcrop was combined in a large-scale horizontal section with the dips observed in the Sjællands Fjeldene, Saefaxi Elv valley, and around Centrumsø. Allowance was made for the broad folds which were observed between longitudes 22° and 24° West. The thickness is probably between 2000 and 3000 metres, and for convenience is given as *circa* 2500 metres.

IV. STRUCTURE

The structure of the area is simple (plate I); the strike is uniformly to the east-north-east, with an eastward regional dip of less than five degrees. The oldest lithological unit, the Norsemandal Sandstone, occurs in the valley-bottoms and lower slopes of the mountains to the west of Danmarks Fjord. Successively younger formations are encountered eastwards, the youngest part of the Centrum Limestone being found near the tops of the mountains at the eastern end of Centrumsø, faulted against the tectonically disturbed area around the fjords of the east coast.

In Norsemandal, the sandstones of that name are overlain by the Campanuladal Sandstones and Limestones in the upper valley-walls, and the peaks are outliers of the Fyns Sø Dolomite. The eastern part of the Bristol Plateau is largely composed of the Fyns Sø Dolomite, thrown down by a south-easterly trending fault. Campanuladal is a fault-valley, and the downfaulted block to the south-east brings in, at Kap Holbæk, the most westerly outcrop of fossiliferous strata, where the Upper Canadian limestone is underlain by the Kap Holbæk Sandstone. Flexuring of the beds at the northern side of the cape, with minor faulting, is probably due to the close proximity of two major faults in the small branch of the fjord. The fault which crosses the eastern part of the Bristol Plateau may continue across Danmarks Fjord, giving rise to the abrupt northern termination of the Sjællands Fjeldene coastal cliffs, and to the south-easterly trending valley.

The lower slopes of the hills overlooking the innermost parts of Danmarks Fjord, Fyns Sø and the upper flood-plain of Bred Flod, are formed in the Kap Holbæk Sandstone, and the overlying Centrum Limestone has a gentle eastward dip of two to three degrees. On the northern side of Centrumsø, and in Saefaxi Elv valley east of 24° West longitude, the limestones are broadly folded into a series of anticlines and synclines with local dips of up to twenty-five degrees. This folding causes the middle and upper parts of the Centrum Limestone to occupy a greater width of outcrop, east to west, than its estimated thickness, coupled with the regional dip, would suggest.

V. CORRELATION WITH OTHER AREAS

a. Stratigraphy.

The lowest unit of the stratigraphical column in Northwest Greenland, Jørgen Brønlunds Fjord and Danmarks Fjord is composed of sandstones with basic dykes (Plate II). In the Thule District, the dykes traverse both the red sandstone and the overlying dolomite (Munck, 1941, p. 26, fig. 16), but probably the intrusions are not all of one age, and younger dykes and sills, possibly related to the basalts and dolerites found in the neighbourhood of Disko Ø and Nûgssuaqhalvø in West Greenland, are also represented. It appears from an examination of the literature, that in Inglefield Land and Washington Land the intrusions are found only in association with red sandstone (Koch, 1929 b, p. 8; 1933, p. 21), and the sills and dykes do not transgress into the overlying dolomite. Near Jørgen Brønlunds Fjord, only one dyke has been observed cutting the sandstones of the Thule Group but it fails to penetrate the dolomite (Troelsen, 1949, p. 10). West of Danmarks Fjord the basic dykes traversing the Norsemandal Sandstone are not found in younger formations. These facts, although not firmly established in all areas, suggest that an unconformity exists at the top of the Rensselaer Bay Sandstone of the Thule Group in Northwest Greenland, the lower part of the Thule Group near Jørgen Brønlunds Fjord, and the Norsemandal Sandstone near Danmarks Fjord. The dolomites are succeeded by sandstones and dark shales, in the Thule District, near Jørgen Brønlunds Fjord, and near Danmarks Fjord, but in Inglefield Land and Washington Land these appear to be absent (Troelsen, 1950, pp. 35—36). Thus the sequence of sandstone with basic dykes, dolomite with stromatolites, sandstones and dark shales, with local variations which may be partly ascribed to disconformities, is found throughout Northwest, North and Northeast Greenland in the lowest part of the sedimentary column.

In Washington Land and Inglefield Land, the Thule Group is separated from the fossiliferous Lower Cambrian by a stratigraphical break, which may cut out the sandstones and dark shales found at the top of the Thule Group in the Thule District. Around Jørgen Brønlunds Fjord the Thule Group is overlain disconformably by the Brønlund Fjord

Dolomite, (TROELSEN, 1949, p. 14), which is Lower Cambrian at the base (see footnote p. 8). In the vicinity of inner Danmarks Fjord the upper part of the unfossiliferous sequence, the Kap Holbæk Sandstone, is overlain disconformably by the Centrum Limestone which, 10 metres above the base, is Upper Canadian in age. The lowest beds of the Centrum Limestone closely resemble those described by TROELSEN from the lower part of the Brønlund Fjord Dolomite, and strong disconformities occur at the base of both units.

The Ordovician and Silurian rocks of the Centrum Limestone cannot be correlated lithologically with subdivisions established elsewhere, and the palaeontological evidence is not yet sufficiently detailed to establish a definite comparison with rocks in North and Northwest Greenland. In Kronprins Christians Land, however, the light grey limestone, some 150 metres thick, described by Nielsen (1941, p. 24), is equated on its similar lithology and faunas with the uppermost 150 metres of the Centrum Limestone. A comparison of vertical sections from Northeast Greenland and East Greenland reveals no direct correlation.

b. Palaeontology.

An illustrated description of the faunas is outside the scope of the present paper, because a full palaeontological report can only be profitably undertaken when the stratigraphy has been established in detail, and additional material is collected from relatively unexamined parts of the succession. Many of the fossils obtained probably represent new species, but it has been considered advisable to refer questionable material to well-founded species which show the closest affinities. In a few cases, marked differences between certain specimens and related forms figured in the literature have precluded the use of the "cf." prefix, and "sp. nov." has been tentatively suggested. These principles have been adopted in order to derive information from the fauna which would enable some reasonably sound conclusion to be made regarding the age of the sediments.

The preliminary examination has shown that faunas of both Ordovician and Silurian age occur in the Centrum Limestone. Two distinct fossil assemblages, representing the Upper Canadian and Champlainian[1]), have been recognised in the lower beds, and a fauna from the stratigraphically widely separated localities in the higher strata seems to be entirely of Niagaran age. The considerable thickness of rocks which lies between these recognisable divisions has not provided any fossils of diagnostic value in the determination of age.

[1]) Pending publication of the Ordovician Correlation Chart for North America, now in preparation, no firm decision regarding stage names can be made.

i) The Ordovician Faunas.

Faunal synopsis	Locality	Recorded stratigraphical range	Europe	North America	N. W. Greenland & Ellesmere Island	East Greenland
TRILOBITA						
Bathyurus amplimarginatus Billings	1	Upper Canadian	..	S	G	G
Bathyurus sp. nov.?	2	..	..	..	..	..
Bathyurellus teicherti Poulsen	1	Upper Canadian	..	G	S	S
Benthamaspis aff. *problematica* Poulsen	2	Upper Canadian	..	..	S	(S)
Calliops sp. indet.	3	M.-U. Ordovician	..	G	G	(G)
Cybelopsis speciosa Poulsen	1—2	Upper Canadian	..	G	S	..
Goniotelus cf. *marionensis* Cullison	1—2	Upper Canadian	..	G	G	(G)
? *Isotelus* sp.	3	M.-U. Ordovician	G	G	G	..
Isoteloides cf. *whitfieldi* Raymond	2	Canadian	..	S	G	(G)
BRACHIOPODA						
Öpikina sp.	3	Middle Ordovician	G	G	..	(G)
? *Plectorthis* sp.	3	M.-U. Ordovician	G	G	G	..
Orthids indet.	1—2	..	..	..	..	..
COELENTERATA						
Calapoecia cf. *borealis* Whitfield	4	M.-U. Ordovician	G	G	S	..
GRAPTOLOIDEA						
Didymograptus cf. *extensus* (Hall)	2	Canadian	S	S	G	..
CEPHALOPODA						
Gonioceras wulffi Troedsson	4	Middle Ordovician	..	G	S	..
GASTROPODA						
Hormotoma sp. indet.	1	Ordovician-Silurian	..	G	G	G

S = species recorded.
G = genus recorded.
( ) = authors' unpublished determinations.

The synopsis shows that fossils from localities 1 and 2 are of Upper Canadian age. *Bathyurellus teicherti* has been recorded from the Kap Weber Formation of Northwest Greenland (Troelsen, 1950, p. 52) and East Greenland (Poulsen, 1937, p. 53); *Benthamaspis problematica* and

Cybelopsis speciosa are known from the Nunatami Formation of Northwest Greenland (POULSEN, 1927, p. 305; 1946, pp. 325, 326); *Bathyurus*, *Goniotelus*, *Isoteloides* and *Hormotoma* are genera represented in both the Kap Weber and Nunatami Formations, and *Didymograptus* is known only from the latter.

Two North American species of Upper Canadian age appear to be represented amongst the fauna; *Bathyurus amplimarginatus*, which occurs in the Beekmantown Group of Ontario and is also recorded from the Romaine Formation in the Mingan Islands (TWENHOFEL, 1938, p. 71), and *Goniotelus marionensis*, which is described from the Powell Dolomite of Missouri and Arkansas and is associated with a fauna claimed to include "species of genera of Upper Canadian age which have their affinities in the Arctic realm" (CULLISON, 1944, p. 46).

Isoteloides is represented in the collection from locality 2 by much fragmentary material, the condition of which only allows a tentative comparison to be made with the genotype, *I. whitfieldi*, described from the Canadian of Vermont and New York (RAYMOND, 1910, p. 36). The degree of variation shown by the fragments suggests that two or more species are present; a few specimens may be identical with *I.? polaris*, which was recorded by POULSEN (1927, p. 296) from the Nunatami Formation and stated by him to bear an unquestionable relationship to the genotype, even though the possibility of an entirely new genus was not excluded. In his description of *I. ? polaris* Poulsen remarks that "the species is very similar to an undescribed trilobite occurring in the Powell formation of Missouri, and may presumably be considered identical with it", a statement which gives added significance to CULLISON's later conclusions regarding the faunal affinities of the same formation.

The sparser fossil collections from localities 3 and 4, although containing no more than one specifically identified form, are without doubt of post-Canadian age. Locality 3 has yielded a few asaphid fragments which suggest *Isotelus*, in association with numerous specimens of the rafinesquinoid brachiopod *Öpikina*. The excellent preservation shown by some brachiopod individuals clearly reveals the diagnostic features of the genus, which is considered to be an important fossil in the Middle Ordovician of North America. *Öpikina* has been recorded from the Hatter Formation of Central Pennsylvania, presumed to be of late Chazyan or pre-Black River age (Kay, 1944, p. 12), but seems to attain a wider distribution, with a greater number of species, in the late Black River and lower Trenton deposits of north-eastern New York, Ontario, and the Upper Mississippi Valley (SALMON, 1942; WILSON, 1946). The genus rapidly becomes rarer in the younger Trenton rocks of these regions, until finally, in the uppermost beds of the group, it is no longer represented. Little is known of the Arctic distribution of

Öpikina, other than the new occurrence in East Greenland, but a re-examination of forms previously assigned to *Rafinesquina* may reveal the presence of the genus in Northwest Greenland.

Gonioceras wulffi, the only specifically identifiable fossil obtained from locality 4, is perhaps the most important age-indicator amongst the post-Canadian fauna. Holtedahl (1920, p. 89) describes two species of *Gonioceras* which occur in the Middle Ordovician (Tetradium Limestone) of Bear Island, and observes that the genus is of "more than common interest, as it seems to have a very restricted distribution, both vertically and horizontally". Although the known geographical limits of distribution of *Gonioceras* have been considerably extended, the stratigraphical range still remains within the Middle Ordovician; the youngest known representative is recorded from the Lower Trenton (Hull Formation) of Ontario and the Upper Mississippi Valley (Kay, 1937, p. 301). According to Troedsson (1929, p. 86), *G. wulffi* is a common fossil in the lower part of the Cap Calhoun Series of Northwest Greenland, considered to be Upper Black River-Lower Trenton in age, and, although no direct correlation is justifiable on the evidence afforded by one fossil, it seems likely that rocks of similar age occur in the Centrum Limestone. The general affinities of the faunas from localities 3 and 4 thus seem to indicate a Black River-Lower Trenton age, but at this stage no further subdivison can be attempted.

ii) The Silurian Faunas.

Faunal synopsis	Locality	Recorded stratigraphical Range	Europe	North America	Northwest Greenland
TRILOBITA					
Bumastus aff. *ioxus* Hall	9	Niagaran	G	S	G
Cheirurus hyperboreus Poulsen	9	Niagaran	G	G	S ..
Encrinurus moderatus Poulsen	9	Niagaran	G	G	S
Encrinurus sp. indet.	9	M. Ordovician-M. Silurian	G	G	G
Proetus sp.	9	U. Ordovician-Devonian	G	G	G
Scutellum sp. nov.?	9	Silurian	..	G	G
BRACHIOPODA					
Brachyprion cf. *profunda* (Hall)	9	Niagaran	G	S	..
Clorinda crassa Poulsen	9	Niagaran	G	G	S
Crispella sp. indet.	9	Silurian	G	G	G
? *Delthyris* sp.	9	M. Silurian-L. Devonian	G	G	..
Harpidium rotundatum Poulsen	9	Niagaran	..	G	S
Leptaena sp.	9	U. Ordovician-Devonian	G	G	G
? *Merista brevirostris* Poulsen	9	Niagaran	..	G	S
? *Triplesia* sp.	9	M. Ordovician-M. Silurian	G	G	..

(continued)

Faunal synopsis	Locality	Recorded stratigraphical Range	Europe	North America	Northwest Greenland
CEPHALOPODA					
? *Armenoceras* sp.	9	Ordovician-Silurian	..	G	..
COELENTERATA					
Actinostroma sp. nov.	8	Ordovician-Silurian	G	G	G
Amplexus offleyensis (Etheridge)	6	Niagaran	G	S	S
Amplexus cf. *offleyensis* (Etheridge)	8	Niagaran	G	S	S
? *Dalmanophyllum* sp.	8	Silurian	G	..	..
Entelophyllum cf. *rugosum* Smith	7	Niagaran	G	S	..
Entelophyllum sp.	7	Silurian	G	G	..
Favosites gothlandicus (Lamarck)	9	U. Ordovician-Silurian	S	S	S
Favosites cf. *gothlandicus* (Lamarck)	6	U. Ordovician-Silurian	S	S	S
Favosites sp.	7 & 8	U. Ordovician-Silurian	G	G	G
Halysites catenularia (Linnaeus)	7	Ordovician-Devonian	S	S	S
Halysites escharoides (Lamarck)	6	Ordovician-Silurian	S	S	G
Heliolites sp.	6	M. Ordovician-Silurian	G	G	G
? *Pycnactis* sp.	6 & 7	Silurian	G	..	..
Stauria favosa (Linnaeus)	6	Wenlock-Ludlow	S	..	..

S = species recorded.
G = genus recorded.

The faunas of localities 6, 7 and 8 consist entirely of coelenterates, indicative of a Niagaran age which is not determinably older than that of locality 9. *Amplexus offleyensis* is recorded from Offley Ø in Northwest Greenland (ETHERIDGE, 1878, p. 588); TEICHERT has also compared a specimen from Southampton Island, in the Arctic archipelago of North America, with this species (1937, p. 23). *Stauria favosa* has not been recognised in North America, and is of Wenlock-Ludlow age in Europe. *Entelophyllum rugosum*, to which one specimen is compared, is recorded from the Niagaran of the south-eastern United States (SMITH, 1933, p. 516).

The more extensive assemblage obtained from locality 9, in the higher beds of the Centrum Limestone, shows stronger Niagaran affinities. A number of the species are known from the Cape Schuchert and Offley Island Formations of Northwest Greenland, which have been correlated with the Middle Clinton of the American Silurian on the evidence provided by graptolite fragments (POULSEN, 1934; 1943). *Cheirurus hyperboreus* and *Encrinurus moderatus* occur in the Cape Schuchert Formation, and *Clorinda crassa*, *Harpidium rotundatum*, *Merista brevirostris* and *Favosites gothlandicus* are all recorded from the Offley Island Formation. *Bumastus*, *Proteus*, *Scutellum* [= *Goldius*],

Crispella and *Leptaena* are also represented in the faunas of these formations. The high proportion of Northwest Greenland forms present in the upper part of the Centrum Limestone is taken to indicate free faunal intercommunication between the two regions during Niagaran times.

Bumastus ioxus, a Niagaran index-fossil widely distributed throughout eastern and central North America, bears a strong resemblance to specimens from locality 9. Within the Niagaran the species is encountered in the Upper Clinton and Lockport of New York and Ontario (GILLETTE, 1947, p. 21; HALL, 1852, p. 303), the Upper Clinton of Arkansas (THOMAS, 1929), and the Upper Niagaran of Gaspé (NORTHROP, 1939, p. 87). These occurrences might suggest a post-Middle Clinton age for the assemblage from locality 9 but, owing to the lack of corrobatory evidence from other fossils, no stratigraphical limits within the Niagaran can be assigned.

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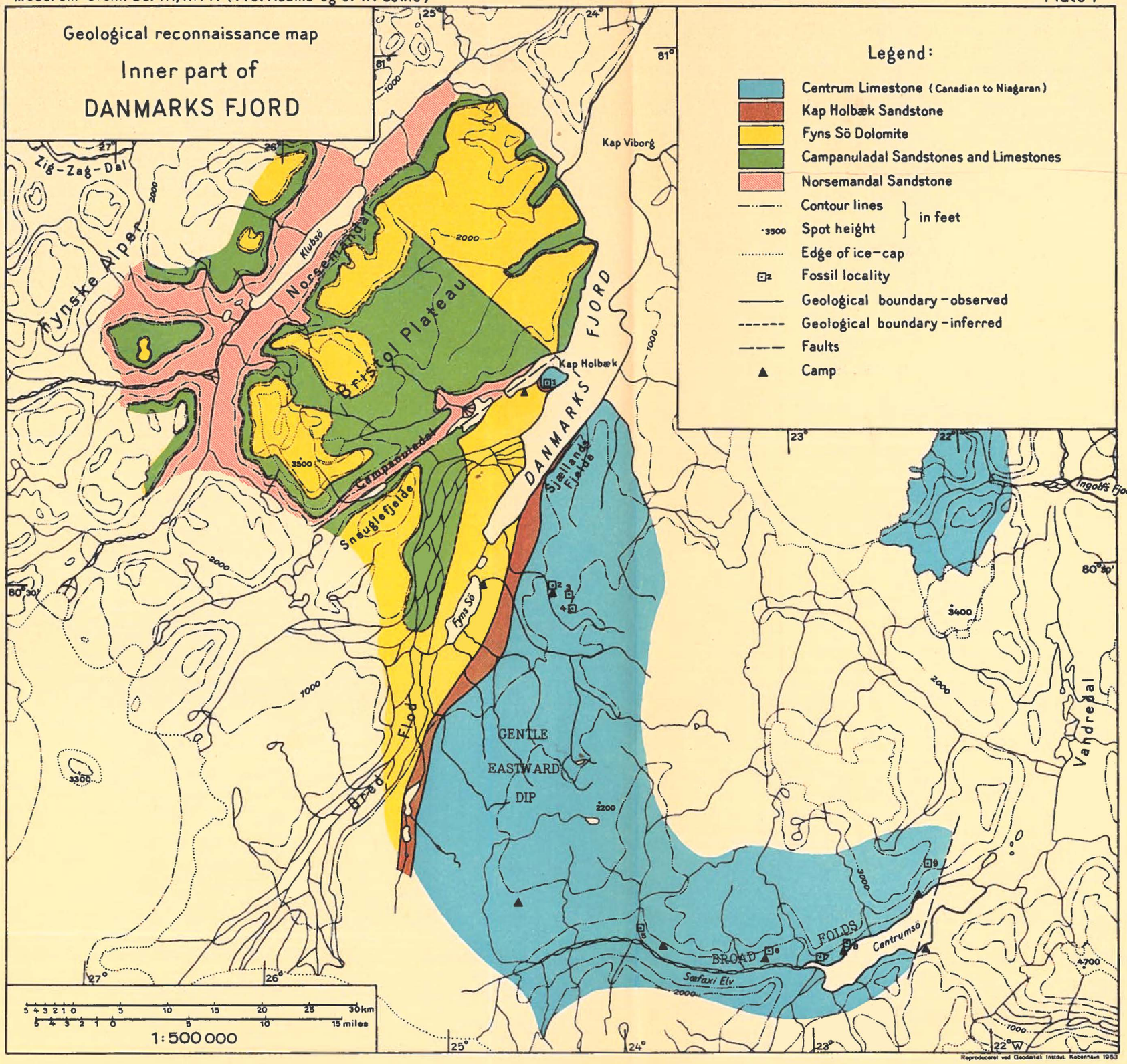
PLATES

Plate I.

Geological reconnaissance map of the inner part of Danmarks Fjord, 1 : 500.000.


Geological reconnaissance map
Inner part of
DANMARKS FJORD
Legend:
Centrum Limestone (Canadian to Niagaran)
Kap Holbæk Sandstone
Fyns Sö Dolomite
Campanuladal Sandstones and Limestones
Norsemandal Sandstone
Contour lines
Spot height
in feet
Edge of ice-cap
Fossil locality
Geological boundary - observed
Geological boundary - inferred
Faults
Camp
Kap Viborg
Kap Holbæk
Fynske Alper
Zig-Zag-Dal
Klubsö
Norsemandal
Bristol Plateau
Campanuladal
Snæuglefjelde
Fyns Sö
DANMARKS FJORD
Sjællands Fjelde
Ingolfs Fjord
Vandredal
Flod
Bred
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Centrumsö
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Plate II.

Comparative vertical sections, northern Greenland.