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UNDER LEDELSE AF LAUGE KOCH

SOME GENERAL REMARKS ON
THE CALEDONIAN MOUNTAIN CHAIN
OF EAST GREENLAND

BY

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WITH 4 FIGURES IN THE TEXT

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PREFACE

In the years 1948–53 the present author was a member of the Danish East Greenland Expeditions under the direction of Dr. LAUGE KOCH.

Our investigations were directed on the Caledonian folding belts of East Greenland and North Greenland.

At the end of 1953 the author compiled a geological map of these two belts of orogeny. For large areas the only informations were those gained either from oblique aerial photographs or during flights over northeast Greenland.

The printing of this map was delayed considerably, and Dr. KOCH concentrated the work of his expeditions on the crucial points of the uninvestigated regions. Therefore the map became partly outdated.

The present paper originally was a sort of an extended legend to accompany the map. It was published without the map on request of the expedition leader.

Acknowledgements.

The present author is greatly indebted to Dr. LAUGE KOCH for helpful discussions and for unfailing support during the field work.

The following geologists of the expedition contributed unpublished data: P. ADAMS, H. BÜTLER, J. COWIE, P. GRAETER, J. HALLER, M. SOMMER, E. WENK. In addition the author recieved valuable notes from J. O. PEACOCK (Newcastle) and J. C. TROELSEN (Copenhagen).

The field work was rendered possible by cooperation with P. BRAUN (1950–51), F. MÜLLER (1952–53) and F. H. SCHWARZENBACH (1949–52).

Maracaibo, Venezuela, April 1956.

INTRODUCTION

The main structural elements of East Greenland and North Greenland.

The area under discussion comprises the northern part of South Greenland, Central East Greenland, Northeast Greenland, and the eastern part of North Greenland.

Within this area three structural elements of the first order occur, viz. (fig. 1):

- 1) The geosyncline of East Greenland ($\pm$ N—S-striking).
- 2) The geosyncline of North Greenland ($\pm$ W—E-striking).
- 3) The Hagen Fjord Geanticline, which is wedged in between the two geosynclines.

The orogeny of the two geosynclines fell in the Caledonian phase (see below).

The Caledonian movements in the geosynclines of East and North Greenland.

The present paper mainly deals with the Caledonian movements. Therefore a definition of the concept “Caledonian” as applied here was found necessary.

		North America	Europe	Present paper	
Devonian	U	Acadian	Acadian	Acadian	} Caledonian
	M				
	L				
Silurian	Downt.	Caledonian	Erian	Erian	
		(s. s.)	Ardennian	Ardennian	
Ordovician		Taconean	Taconean	Taconean	

It turns out that the comprehensive concept "Caledonian" is absolutely necessary for the East Greenland geosyncline, for here the movements started in Taconean times and continued during the Erian to the Acadian phase. The tectonic phenomena within the North Greenland geosyncline can be summarized as follows: Taconean movements have, at the most, appeared as fluctuations of level along the edge of the geosyncline, the main phase seems to be early Erian, though various signs also indicate that the movements continued till well into the Acadian phase.

The sediments of the geosynclines.

East Greenland.

Within the East Greenland geosyncline we distinguish between three almost N—S-running basins of sedimentation separated by ridges. The basins are as follows, beginning from the east (fig. 1):

- 1a) The Eleonore Bay Trough. This is the actual centre of the geosyncline. A sedimentary series at least 15,000 m thick occurs here; 12,000 m of these belong to the Greenlandian (uppermost Algonkian), and 3,000 m to the Cambrian and Ordovician.
- 1b) The Dronning Louise Land Ridge.
- 1c) The Hekla Sund Basin. A marginal basin of the geosyncline. So far only sediments of the Keweenawan (Thule Formation) (+ 2,000 m) and the Greenlandian (+ 4,000 m) are known from this region.
- 1d) Sæfaxi Ridge.
- 1e) The Danmark Fjord Basin. A shallow basin containing the Thule Formation (+ 1,000 m), a thin Upper Greenlandian or Lower Cambrian sequence, and an Ordovician-Silurian limestone series ca. 2,500 m thick.

This basin is limited to the N.W. by the Hagen Fjord geanticline (3).

North Greenland.

From north to south the following structures are distinguishable:

- 2a) The trough of North Peary Land. This trough forms the southern portion of the central trough of the geosyncline. It is filled by a clayey-sandy sequence more than 4,000 m thick, the uppermost part of which is considered to belong to the Upper Silurian.
- 2b) The Wulff Land Line. This term designates the boundary between the slightly folded shelf to the south and the geosyncline to the north.

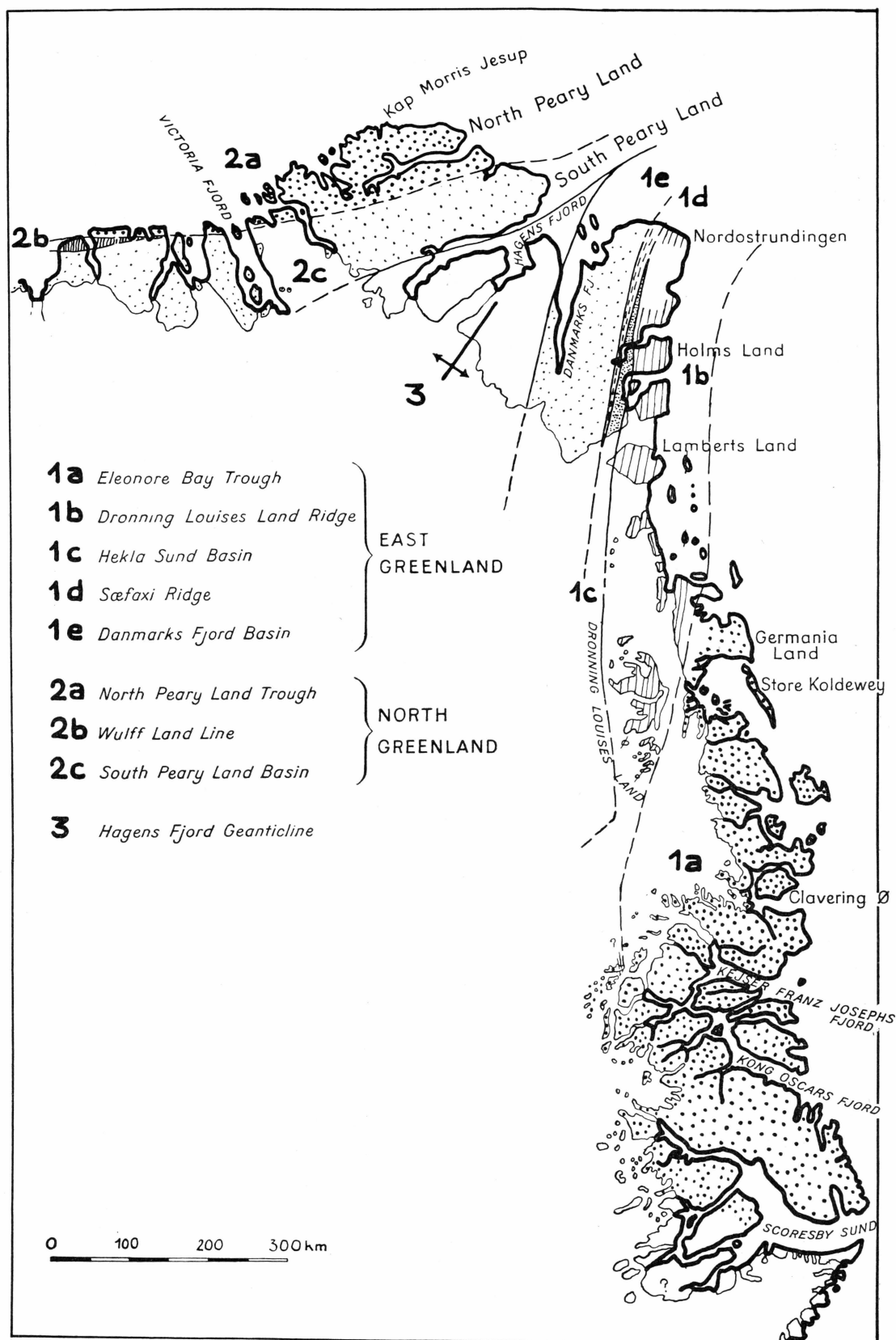


Fig. 1. The structural units of the Caledonian chains of East Greenland and North Greenland.

		Eleonore Bay Trough	Dronning L. Land Ridge	Hekla Sund Basin	Sæfaxi Ridge	Danmarks Fjord Basin	Hagen Fjord Geanticline	South Peary Land Basin	Wulff Land Line	North Peary Land Basin
post-orogenic sediments	Tertiary	Shaded						Shaded		
	Cretaceous	Shaded	Shaded					Shaded		
	Jurassic	Shaded								
	Triassic	Shaded						Shaded		
	Permian	Shaded	Shaded					Shaded		
	Carboniferous	Shaded	Shaded					Shaded		
syn-orogenic sediments	Devonian	Shaded								
	Silurian				Shaded	Shaded	?	Shaded	Shaded	?
pre-orogenic rocks	Ordovician	Shaded			Shaded			Shaded		?
	Cambrian	Shaded								?
	Greenlandian	Shaded	?	Shaded	Shaded	Shaded	Shaded			?
	Keweenawan		Shaded	Shaded	Shaded	Shaded	Shaded	Shaded		
	pre-Keweenawan		Shaded	?	?	?	?	?		

Shaded areas: sediments (and basalts) present.

- 2c) The basin of South Peary Land. A shallow basin lying in front of the geosyncline. The sediments belong to the Thule Formation, the uppermost Greenlandian, the Lower Cambrian, the Ordovician, and the Silurian. In contrast to the trough of North Peary Land, the Palaeozoic series are rather calcareous here.

The basin of South Peary Land borders on the Hagen Fjord geanticline (3).

STRATIGRAPHY

The Caledonian orogeny forms the main subject of the present paper, we distinguish between the following three groups:

- 1) Rocks formed before the Caledonian movements.
- 2) Rocks formed during the Caledonian movements.
- 3) Rocks formed after the Caledonian movements.

Groups (1) and (2) will be treated at some length, while the series of group (3) will be treated more briefly.

The table on p. 10 shows the distribution of the sediments over the above-mentioned three groups.

From this table it will be seen that we regard the Silurian in the north as belonging to the pre-orogenic rocks, while in East Greenland it belongs to the syn-orogenic group.

Rocks formed prior to the Caledonian movements.

- 1) Older gneisses (pre-Keweenawan).

East Greenland: The existence of older gneisses in East Greenland was not ascertained till 1952. Detailed investigations are still lacking. The gneisses occur principally in the region of the Dronning Louise Land Ridge.

The gneiss ridge of East Greenland forms the boundary between the actual geosyncline and the shallow basin situated in front of it. (Literature: L. KOCH 1918, 1929b, E. FRÄNKEL 1954, 1955a).

Thule Formation (Keweenawan).

The oldest sediments of East and North Greenland belong to the Thule Formation. We correlate this formation with the Keweenawan of Canada and the Jotnian of Scandinavia.

Greenlandian.

		Central East Greenland		Northeast Greenland				North Greenland		
		Eleonore Bay Trough	Dronning Louise Land Ridge	Hekla Sund Basin	Sæfaxi Ridge	Danmark Fjord Basin	Hagen Fjord Geanticline	South Peary Land Basin		
Lower	Camb.	Bastion Quartzite			Kap Holbæk Sandstone	Kap Holbæk Sandstone		Brønlund Fjord Dolomite		
Greenlandian	Upper	Tillite Formation	Eleonores Sø Series	Green- stone Series	Fyn Sø Dol. Campa- nuladal Lime- stone Ulve- bjerg Tillite	Fyn Sø Dol. Camp. Lime- stone	Fyn Sø Dol. Camp. Lime- stone	Fyn Sø Dol. (Camp. Lime- stone)	Mud- stone	
									Tillite Yellow Sand- stone	
	Lower	Upper		Eleonore Bay Formation	Lime- stones and Dolo- mites	Riviera- dal Sand- stones				
						Taage- fjeldene Gray- wackes Sydvej- dal Marbles Sten- ørkenen Phyllites				

It consists of light-coloured sandstones and arkoses, which are penetrated locally by acid sills and dykes. The Thule Formation may attain thicknesses of more than 3,000 m. It represents continental sediments which were deposited either subaerially or in very shallow basins.

To-day the Thule Formation can be found only on the stable block which is bounded on the north by the Wulff Land Line and on the east by the Dronning Louise Land Ridge.

(Literature: L. KOCH 1918, 1929b, E. NIELSEN 1941, J. C. TROELSEN 1949, ADAMS and COWIE 1953, FRÄNKEL 1955a).

Greenlandian.

The Eleonore Bay Trough.

Eleonore Bay Formation (fig. 2).

The Eleonore Bay Formation is subdivided into the Lower and the Upper Eleonore Bay Formation. The Lower Eleonore Bay Formation was deposited during the actual geosynclinal phase. The Upper Eleonore Bay Formation is a shallow-sea deposit. It is subdivided into strata 1—19.

a) Lower Eleonore Bay Formation (+ 9,000 m).

A thick clayey-sandy sequence with a calcareous-marly series. This latter series constitutes an important guide horizon for the study of the metamorphic Lower Eleonore Bay Formation, where it occurs as a series of marbles and chlorite schists.

Of the sediments of the Eleonore Bay Trough, the uniform Lower Eleonore Bay Formation represents the actual geosynclinal series. It can only be subdivided by means of the aforementioned limestone layers.

(Literature: FRÄNKEL 1951, 1953b, HALLER 1953, 1955).

b) Upper Eleonore Bay Formation (ca. 4,000 m).

Quartzite Series (2,000 m) (Nos. 1—6). Fine-grained, light-coloured sandstones alternating with green, red, and greyish-green sandy shales. The quartzite series with its lithological units, traceable over great distances, presents the picture of a quiet sedimentation in a gradually subsiding shallow basin.

Multicoloured Series (1,000 m) (Nos. 7—13). A multicoloured sequence of shales, dolomites, limestones, and sandstones. Here too, the individual beds are uniformly developed over great distances. The Multicoloured Series is characterised by the first appearance of algal biostromes, which here attain their maximum development. The Multicoloured Series was deposited in a warm shallow sea.

Limestone-Dolomite Series (1,000 m) (Nos. 14—19). Grey limestones and dolomites, the latter often yellowish on weathering, make up the

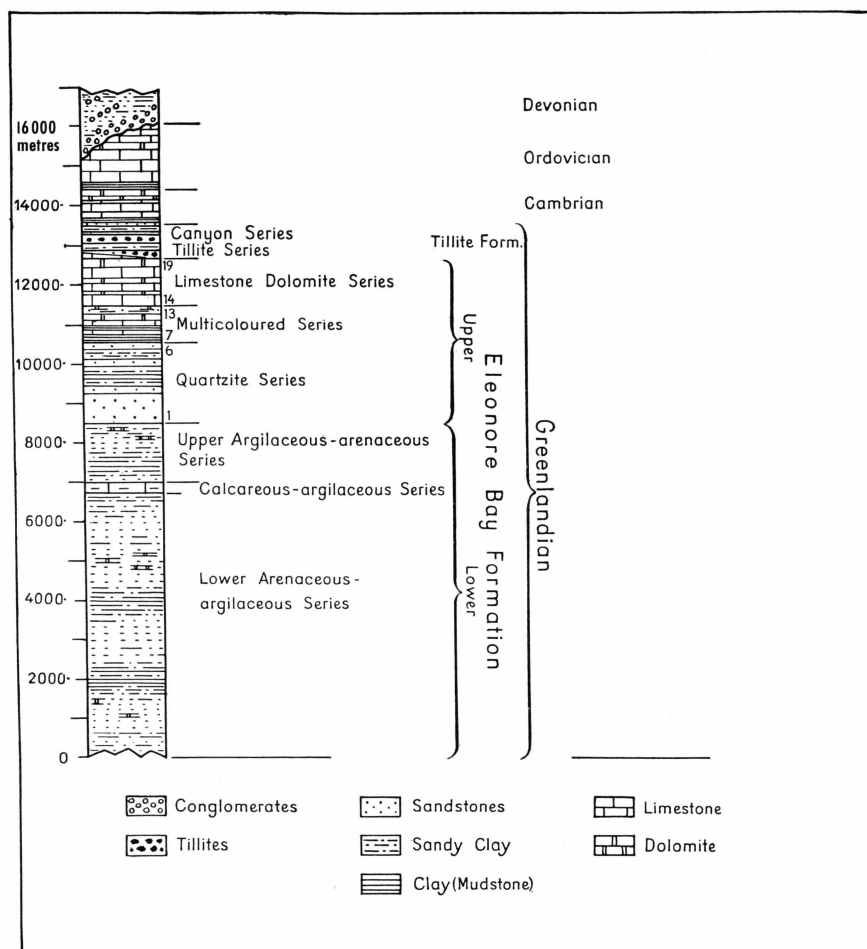


Fig. 2. The sediments of the Eleonore Bay Trough.

Limestone-Dolomite Series. The lithofacies varies considerably, within the different beds, so we assume that basins and ridges were formed during the sedimentation.

(Literature: KATZ 1952, EHA 1952, FRÄNKEL 1953a, b).

Tillite Formation.

Under the name Tillite Formation we include a tillite series and an overlying very heterogeneous sequence of shales, sandstones, and dolomites. Both at the base and at the top of the tillite series occurs a boulder bed, between these beds sandstones and shales are found.

Canyon Series. Overlying the tillite series is the clayey-sandy Lower Canyon Series; the Upper Canyon Series is composed of dark limestones.

The Spiral Creek Series with its flaggy red clays and dolomites is the youngest series of the Greenlandian sequence of strata. It contains salt-casts on the bedding planes. The Spiral Creek Series was deposited in a highly saline lagoon at the end of the pre-Cambrian period.

Within the Eleonore Bay Trough the Tillite Formation attains its greatest thickness (+ 1,000 m) in the axial Royal Bay Depression (72°—73°30' N. lat.).

(Literature: BACKLUND 1930, HUBER 1950, SCHAUB 1950, KATZ 1952, FRÄNKEL 1953a, b).

Dronning Louise Land Ridge.

Eleonore Sø Series.

We are inclined to regard the Eleonore Sø Sediments discovered by KATZ (1952b) as Greenlandian deposits overlying the southward-dipping Dronning Louise Land Ridge.

This series is built up of algae-bearing limestones and dolomites, overlain by greenstones. KATZ correlates the former with the Upper Eleonore Bay Formation, the latter with the Tillite Formation.

The fact that the Lower Eleonore Bay Formation and the Quartzite Series in approximately the same development as farther east occur immediately south of these sediments, suggests that the ridge did not become an active element until the time of deposition of the Multicoloured Series.

(Literature: WENK and HALLER 1953, KATZ 1952b).

Hekla Sund Basin.

Kap Holbæk Sandstones (? Lower Cambrian)

Fyn Sø Dolomites, 250 m

Campanuladal Limestones, 130 m

Ulvejerg Sandstones and Tillites, 20—35 m

Rivieradal Sandstones, 1,000—2,000 m

Taagefjeldene Greywackes, + 1,000 m

Sydvejdal Marbles, 100—500 m

Stenørkenen Phyllites, + 1,000 m

Thule Formation (Keweenawan)

The sequence of the Stenørkenen Phyllites and the Sydvejdal Marbles has many features in common with the Lower Eleonore Bay Formation.

The Taagefjeldene Greywackes were deposited in a closed basin under unstable conditions of sedimentation. A thick stratum of alum

shales in pyritic greywackes bears evidence of an euxinic milieu of deposition.

The Rivieradal Sandstones are made up of alternating light-coloured sandstones and dark shales.

The Ulvebjerg Sandstones and Tillites, light sandstones and two thin tillite beds overlain by shales, are correlated by us with the Tillite Formation of the Eleonore Bay Trough.

The red marly Campanuladal Limestones and the grey, yellowish-weathering Fyn Sø Dolomites (with algal biostromes) are referred by us to the uppermost Greenlandian.

(Literature: E. NIELSEN 1941, FRÄNKEL 1954, 1955a).

Sæfaxi Ridge.

The Campanuladal Limestones and the Fyn Sø Dolomites here transgress over the Thule Formation.

Danmark Fjord Basin.

Above the Thule Formation follow the Campanuladal Sandstones, which are overlain by the Campanuladal Limestones and the Fyn Sø Dolomites. Locally the latter contain at the top the "cone in cone horizon".

(Literature: ADAMS and COWIE 1953).

Hagen Fjord Geanticline.

Here the Thule Formation is transgressed from the east, at least marginally, by the Campanuladal Limestones and the Fyn Sø Dolomites.

South Peary Land Basin.

Brønlund Fjord Dolomites (Lower Cambrian)

Light-coloured sandstones (250 m)

Bedded dolomites, sometimes oolitic (250 m)

Yellow sandstones (100 m)

Red shales (25 m)

Tillites (ca. 0.4—100 m)

Yellow sandstones

Thule Formation (Keweenawan).

We are indebted to Dr. J. C. TROELSEN for the above section (private information).

The development of the Greenlandian farther northward, is still unknown.

Cambrian.

Eleonore Bay Trough.

Cass Fjord Formation (Ordovician)

Dolomite Point Formation (300 m)

Hyalolithus Creek Formation (300 m)

Ella Island Formation (100 m)

Bastion Shales (ca. 100 m)

Bastion Quartzites (ca. 100 m)

Tillite Formation (Greenlandian).

The uniform Bastion Quartzites transgress with hardly distinguishable unconformity over the various units of the Tillite Formation.

The sandy-glauconitic Bastion Shales have yielded Lower Cambrian fossils; the overlying sandy limestones of the Ella Island Formation are likewise of Lower Cambrian age.

The Hyalolithus Creek Formation is made up of dark, often dolomitic limestones, the overlying Dolomite Point Formation consists mainly of light-coloured dolomites. Up to the present no identifiable fossils have been found in the two last-mentioned formations.

Sæfaxi Ridge and Danmark Fjord Basin.

The Kap Holbæk Sandstones are hesitantly referred to the Lower Cambrian. In the Danmark Fjord Basin the Kap Holbæk Sandstones constitute a 135 m thick sequence of sandstones and shales; on the Sæfaxi Ridge they are represented by a bed, 5 m thick, of coarse-grained sandstones. The surface of this bed exhibits an erosion relief, over which the Danmark Fjord Dolomites (Lower Canadian?) transgressed.

(Literature: ADAMS and COWIE 1953, FRÄNKEL 1955 a).

South Peary Land Basin.

Lower Cambrian fossils were found at the base of the Brønlund Fjord Dolomites (according to TROELSEN, private information).

The rocks in the trough of northern Peary Land will be dealt with in the section entitled "Silurian", though the Cambrian may quite well be represented there.

Ordovician.

Eleonore Bay Trough.

Devonian

Heimbjerg Formation (ca. 320 m)

Narhval Sound Formation (ca. 300 m) (? 800 m)

Cape Weber Formation (ca. 600 m)

Cass Fjord Formation (120 m)

Dolomite Point Formation (Cambrian).

The Cass Fjord Formation (Lower Canadian) is made up of marly knotted limestones, which are overlain by the reddish weathering limestones of the Cape Weber Formation. The Narhval Sound Formation and the Heimbjerg Formation consist of flaggy light-coloured limestones and dolomites.

The youngest beds may belong to the upper Middle Ordovician. With the Heimbjerg Formation ended the deposition of pre-orogenic rocks in the Eleonore Bay Trough.

(Literature: POULSEN 1930, ADAMS and COWIE (in press)).

Sæfaxi Ridge and Danmark Fjord Basin.

Upper Centrum Limestones (Silurian)

Lower Centrum Limestones (Upper Canadian) (ca. 800 m)

Danmark Fjord Dolomites (10—30 m)

Kap Holbæk Sandstones (? Lower Cambrian).

The unfossiliferous Danmark Fjord Dolomites transgress over the Kap Holbæk Sandstones; they are closely associated with the dark, bedded lower Centrum Limestones of Upper Canadian age.

(Literature: ADAMS and COWIE 1953, FRÄNKEL 1955 a).

Southern Peary Land Basin.

Kjoveslette Sandstones (Silurian)

Børglum River Formation (Upper Ordovician)

Wandel Valley Formation (Upper Canadian)

Brønlund Fjord Dolomites (Lower Cambrian).

The limestones and dolomites of the Wandel Valley Formation attain a thickness of 350 m; the thickness of the Børglum River Formation amounts to 800 m, according to TROELSEN.

Silurian.

Silurian rocks were deposited under quiet conditions of sedimentation in the Danmark Fjord Basin, in the southern Peary Land Basin, on the Wulff Land Line, and in the northern Peary Land Trough.

Danmark Fjord Basin.

Profilfjeldet Shales (300 m)
 Drømmebjerg Limestones (150 m)
 Upper Centrum Limestones (1,700 m)
 Lower Centrum Limestones (Canadian)

The Upper Canadian Lower Centrum Limestones pass into the Upper Centrum Limestones, which have supplied Upper Niagaran fossils. The light-coloured reefy Drømmebjerg Limestones and the sandy-marly, green-weathering Profilfjeldet Shales (Wenlock) likewise belong to the Niagaran.

Southern Peary Land Basin.

Carboniferous
 Kjoveslette Sandstones (+ 50 m)
 Børglum River Formation (800 m) (Upper Ordovician).

The sandy shales of the Kjoveslette Sandstones may correspond to the Profilfjeldet Shales.

Wulff Land Line and Northern Peary Land Trough.

Sydgletscher Sandstones (Polaris Harbour Formation) (+ 300 m)
 Nysne Gletscher Graphite Slates (Cape Tyson Form.) (550 m)
 Brown Series (ca. 300 m)
 Friggs Fjord Mudstones (400 m)
 Grønnemark Slates (500 m)
 Grønnemark Sandstones (+ 1,000 m).
 — — — — — ? — — — — —

We have decided to treat here the whole, as yet only superficially known, sedimentary sequence of the northern Peary Land Trough. The stratigraphical sequence given above has been established in the southern half of the mountainous zone of North Peary Land. We compare the Sydgletscher Sandstones to the Polaris Harbour Formation (? Ludlow). The Nysne Gletscher Graphite Slates are regarded by us as metamorphic

graptolite shales and are tentatively correlated with the Cape Tyson Formation (Niagaran and Lower Ludlow) of western North Greenland.

The age of the older series is not determined; we assume that the rocks are of post-Precambrian age.

The phyllites and marbles of the northern half of the mountain chain of northern Peary Land may in part be correlated with the aforementioned sediments (cf. FRÄNKEL 1955 b).

(Literature: L. KOCH 1918, 1929b, FRÄNKEL 1955 b).

Rocks formed during the Caledonian movements.

This rock group is primarily found in the Eleonore Bay Trough and the trough of North Peary Land viz. in the actual geosynclines.

In the South Peary Land Basin and in the Danmark Fjord Basin the sandy Silurian series (Kjoveslette Sandstones, Profilfjeldet Shales) occupy an intermediate position between the pre-orogenic and the syn-orogenic rocks; they are referred here to the first-mentioned group.

In the Eleonore Bay Trough deposition of new sediments, transformation of older sediments, and intrusions of igneous rocks took place during the orogeny. In the trough of North Peary Land only the metamorphism of pre-orogenic sediments has been ascertained so far. Only the Eleonore Bay Trough will be dealt with below; as to North Peary Land the reader is referred to the paper on this region (FRÄNKEL 1955 b).

Eleonore Bay Trough.

		Sediments	Metamorphics	Igneous Rocks
Devonian	U	Sandstones, Tuffs, Conglomerates (Old Red Facies)	Contact-metamorphic Devonian Sandstones	Devonian volcanics
	M			
	L			
Silurian	U		Caledonian Gneisses (transformed pre-orogenic Sediments, predom. Lower EBF)	(Devonian Granites)
	L			Late-orogenic Granites (Marginal Granites)
Ord.	U			Syn-orogenic, Caledonian Granites

Caledonian Gneisses.

- 1) Para rocks, originating mainly from sediments of the Lower Eleonore Bay Formation and clearly recognisable as a former sedimentary sequence. (Locally the front of transformation extends as far as the Quartzite Series (southern Andrées Land)).
- 2) Gneisses of doubtful origin with a complex history of genesis. Their present character, however, is the result of the Caledonian orogeny.

Synorogenic Granites.

Migmatites of granitic composition, often with parallel structure. They occur for the most part as conformable bodies in the Caledonian gneisses, and are the actual centra of the Caledonian metamorphism.

(Literature: WEGMANN 1935, HUBER 1950, WENK and HALLER 1953, HALLER 1953, 1955).

Late-orogenic Granites (Marginal granites).

A number of discordant granite bodies which during the late phases of the Caledonian orogeny intruded across the front of the synorogenic granites into the higher structural units (Caledonian Gneisses, Eleonore Bay Formation, Devonian). Where the granites occur in the Caledonian gneisses or in the Eleonore Bay Formation, they are termed "marginal granites", in other places similar granites that have intruded into Middle Devonian formations (Gauss Halvø) are designated "Devonian granites".

(Literature: WEGMANN 1935, HUBER 1950, KATZ 1952, FRÄNKEL 1953, WENK and HALLER 1953, HALLER 1953, 1955, BÜTLER 1954).

Devonian of Old Red Facies.

Conglomerates, sandstones, and tuffites build up this predominantly continental series. The Devonian attains thicknesses of up to 10,000 m. Discordances, various accumulations of pebbles, and wedge-like upthrusts mainly of older rocks show that movements were constantly going on during the deposition of the Devonian rocks.

BÜTLER subdivides the Devonian, according to tectonic points of view, into various series, separated from one another by five phases of movement. Excellently preserved fish remains render a dating of the Old Red Series possible; thus Middle Devonian (Canning Land, Gauss Halvø) and above all Upper Devonian are represented.

(Literature: BÜTLER 1940a, b, 1948a, b, 1954, STENSIÖ 1940).

Rocks of the Devonian Volcanism.

Basalts and rhyolites are found in the Devonian deposits in several places. The tuffite beds in the sandstones likewise bear evidence of volcanic activity.

(Literature: BÜTLER 1948a, b, c, MAYNC 1949, RITTMANN 1940).

Rocks formed after the Caledonian movements.

These series transgress as continental deposits or as shallow-sea sediments over the base-levelled Caledonian chain. Large areas are covered by young basalts and (nepheline-) syenites.

Upper Palaeozoic.

Rocks of undetermined age.

The Røde Ø Conglomerate, red-coloured conglomerates and sandstones, is found in a graben-like N—S striking depression in the region of the inner part of the Scoresby Sund area.

Carboniferous.

Continental sandstones and plant-bearing shales, for the most part belonging to the Namurian, occur between Clavering Ø in the north and Scoresby Sund in the south. From the area of Kong Oscars Fjord WITZIG (1952) records Westphalian and Permo-Carboniferous.

Namurian also occurs around the 80th parallel on Holm Land and Amdrup Land.

The regions around Station "Nord" (western part of Nordostrundingen) are made up of sandy, carbonaceous shales, probably belonging to the Carboniferous (L. KOCH, verbal information).

From southern Peary Land TROELSEN mentions marine Middle Carboniferous.

Permian.

Between Scoresby Sund and Clavering Ø the Permian exhibits a Zechstein facies. On Clavering Ø a reefy zone exists, north of which Permian with Thetys fossils were found; this northern facies resembles the Permian of Spitsbergen.

Mesozoic.

Triassic.

Triassic deposits with a Germanic facies occur between Scoresby Sund and Clavering Ø. The Triassic deposits of southern Peary Land were investigated by TROELSEN; no details are known to us so far.

Jurassic.

Jurassic marine sediments occur in various places between Store Koldewey Ø in the north and Scoresby Sund in the south.

Cretaceous.

Cretaceous deposits are found in the region between Scoresby Sund and Kuhn Ø. Two major phases of transgression are known. The first one falls in the Infravalangian, lasting till into the Albian, the Cenomanian is hardly developed, whereas the Senonian transgressed again over the marginal areas, primarily on Traill Ø. The youngest Cretaceous sediments belong to the Campanian (DONOVAN 1953).

Doubtful Senonian is recorded by WAGER and DEER from Kangerdlugssuaq. From the north E. NIELSEN records Cretaceous-Tertiary from Nakkehoved, and TROELSEN ?Cretaceous-Tertiary from southern Peary Land.

Tertiary.

Paleocene.

The extrusion of the plateau basalts in Southeast Greenland and Central East Greenland took mainly place in Paleocene times.

Of uncertain age are the syenite plutons of Werner Bjerre, Kap Simpson, Kap Parry, and the subvolcano of Kap Broer Ruys. These rocks may be referred to the uppermost Cretaceous—Eocene period.

The intrusions in the surroundings of Kangerdlugssuaq are younger than the basalts.

Eocene.

Eocene sediments are found in various parts of the coast on top of the basalts, thus at Kap Dalton, Kap Brewster, Myggbukta, and on Sabine Ø.

Doubtful Tertiary (probably Eocene) is recorded by E. NIELSEN from Nakkehoved and by TROELSEN from southern Peary Land.

Oligocene-Miocene.

Oligocene-Miocene deposits are described by HASSAN from Kap Brewster.

Quaternary.

Late Tertiary or early Quaternary breccia-like conglomerates were found in the Skeldal (Scoresby Land).

The most important Quaternary events, however, are the formation of the inland ice and the phenomena associated therewith. According to the seismic and gravimetric investigations of the French Polar Expedition (P. E. VICTOR), the bed-rock of Greenland forms a cup-

shaped depression, filled with the inland ice. The centre of the depression lies below sea-level; the ice cap there attains a thickness of more than 3,000 m.

Deposits of the ice age and the sub-recent period occur as ground moraines (rarely terminal moraines) and raised beaches (up to 55 m above sea-level) distributed over the whole area.

Noteworthy is the occurrence of mud and talus cones, resembling mud volcanoes. These features are associated with soil affected by permafrost. Indications of solfataric activity are mentioned by TROELSEN from the south shore of Jørgen Brønlund Fjord (Peary Land).

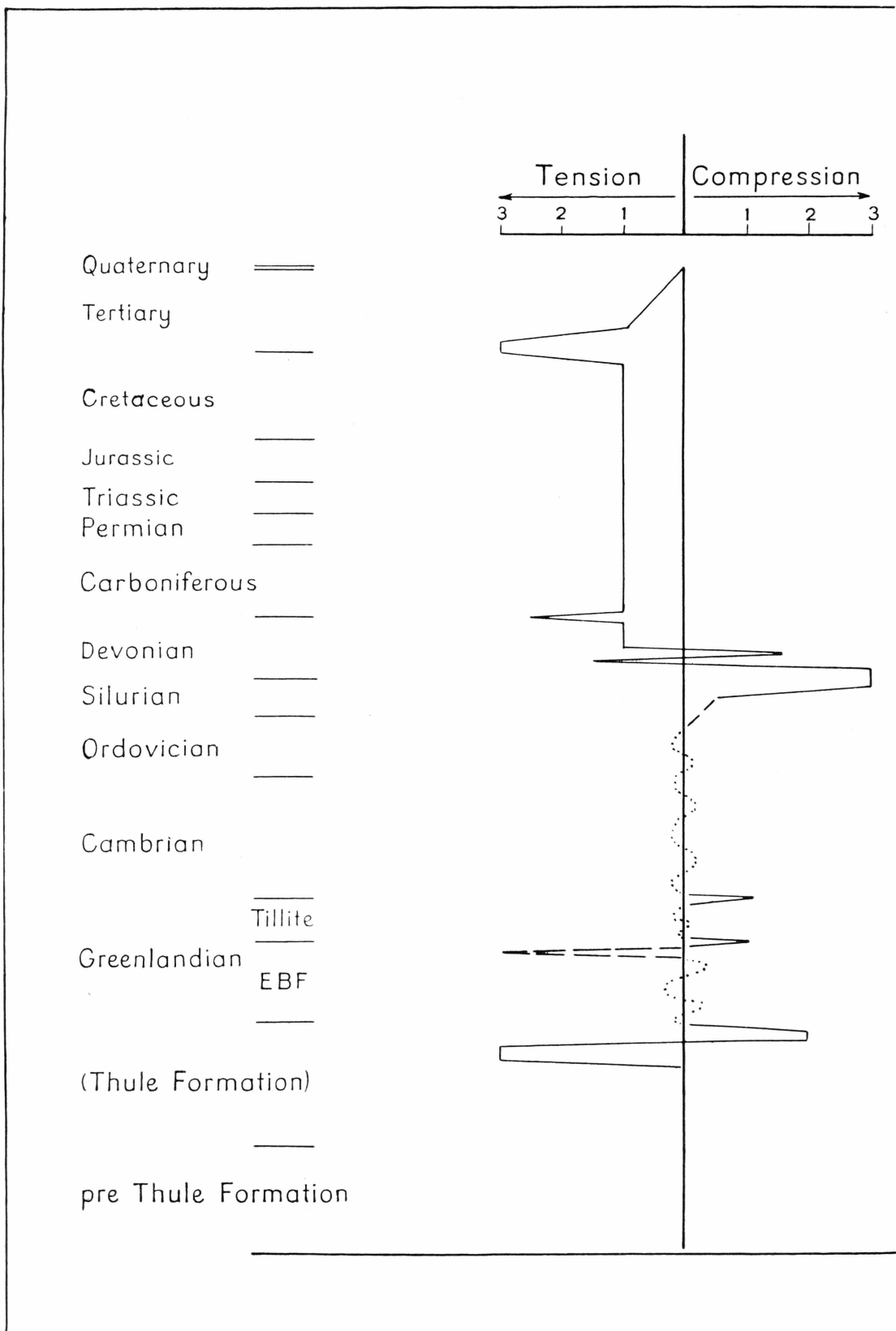


Fig. 3. Diagram of the tectonic
(The scale of the vertical is chosen arbitrarily for the pre-Cambrian, but from and

— Penepplain, cut by Fjords

Forming of the flexure along the southeast coast

== Plateau basalt

Forming of the fault zone
along the northeast coast

== Post-Devonian main fault

Intensive compressions and tensions alternating

— Paroxysm of the Caledonian orogeny

== Disconformity (local)

== ? Disconformity

== ? Basic intrusions and volcanism

— Hekla Sund Phase

— Basalts of the Thule Formation

— Penepplain

Caledonian
movements
Gradually subsiding
geosyncline

development of East Greenland.

including the Cambrian it corresponds to the absolute ages of the formations).

TECTONICS

I) Systematics of the movements.

We distinguish between two types of movement: 1) tensions, and 2) compressions. As to the compressions, we distinguish between three stages:

- 1) Warping, resulting in minor discordances.
- 2) Superficial but intense folding.
- 3) Orogenies with deep-reaching compression.

The tensions are similarly classified:

- 1) faults, e. g. step-faults.
- 2) Intensive faulting with local rise of basalt, or tension faults paving the way for granitic intrusions (marginal granites).
- 3) Deep-reaching tensions associated with rising of basalt masses (pre-Cambrian Thule basalts, Tertiary plateau basalts).

As for East Greenland we have attempted to represent the tectonic events in accordance with the diagram in fig. 3.

The tectonic development of East and North Greenland, like the sediments, can be divided into the following three main groups:

- 1) Pre-Caledonian movements.
- 2) Caledonian movements.
- 3) Post-Caledonian movements.

II) Pre-Caledonian movements.

A) The whole Arctic Continent.

1) The existence of an ancient Arctic continent comprising Scandinavia, the Scandic Ocean, Greenland and Canada is assumed. In this continent developed positive erosion areas as well as depressions in which predominantly continental sediments accumulated. To-day these sediments are known as Keweenawan Sandstones, Thule Sandstones, and Jotnian Sandstones.

2) Strong tensions affected this Arctic continent. Huge basaltic masses are found from Canada to Scandinavia; in Greenland the Thule Sandstones together with these basalts form the Thule Formation.

3) Locally the tensions were succeeded by compressions (Hekla Sund Phase in East Greenland).

B) East Greenland.

1) Hekla Sund Phase: Development of basins and ridges in the Arctic continent.

To-day the Sæfaxi Ridge and the Hekla Sund Basin, adjacent to the east, furnish the best examples of the movements during this period.

In our opinion the formation of the geosyncline of East Greenland began with the Hekla Sund Phase.

2) Different development of the basins and ridges that were initiated during the Hekla Sund Phase.

a) Eleonore Bay Trough.

At first the Eleonore Bay Trough subsided rather rapidly and received abundant supplies of fine-grained, but poorly sorted material, sandy shales and clayey sandstones being deposited.

After the deposition of these huge (+ 9,000 m) arenaceous-argillaceous series, the conditions of sedimentation grew more quiet, though the stratigraphy of the Quartzite Series points to oscillations at the margin of the trough.

The Multicoloured Series shows hardly any lateral variation of the lithofacies. In the overlying limestone-dolomite series, however, frequent changes of facies can be observed. The movements which gave rise to these changes led to a differentiation of the Eleonore Bay Trough itself into various basins.

These movements continued during the deposition of the Tillite Formation. In the Royal Bay Depression between 72°30' and 73°30' N. lat. the Tillite Formation attains a much greater thickness than in the more northerly and more southerly tracts.

In the centre of the Royal Bay Depression the sedimentation continued uninterruptedly from the pre-Cambrian till well into the Cambrian period, while in the other areas the Lower Cambrian Bastion Sandstones rest with a slight discordance on various members of the Tillite Formation.

The Cambrian and Ordovician deposits are shallow-sea sediments, which were laid down during a quiet period.

b) Dronning Louise Land Ridge.

The history of this ridge is, so to speak, unknown. KATZ records a "limestone-dolomite series" developed in reef-facies; the same author found greenstones instead of the Tillite Formation.

From the striking similarity between the older sediments of the Hekla Sund Basin farther westward and the lower Eleonore Bay Formation we are led to the conclusion that it was not till after the deposition of the lower Eleonore Bay Formation that the Dronning Louise Land Ridge acted as a separating element.

c) Hekla Sund Basin.

In this basin an uninterrupted sedimentation took place from the Stenørkenen Phyllites and the Sydvejdal Marbles (both resemble the lower Eleonore Bay Formation) to the Ulvebjerg Sandstones and Tillites. During the deposition of the Taagefjeldene Greywackes, movements took place somewhere, which gave rise to the transportation of coarse clastic material into the basin and to the isolation of the latter (alum shales). During the time of deposition of the Campanuladal Limestones and the Fyn Sø Dolomites the Hekla Sund Basin was covered by a warm shallow sea, which spread over the Sæfaxi Ridge into the Danmark Fjord Basin. In the whole area the aforementioned two formations were deposited with a hardly varying lithofacies.

So far we know no beds younger than the Fyn Sø Dolomites from the area of the Hekla Sund Basin; there is a possibility, however, that also the Kap Holbæk Sandstones and later on the upper Centrum Limestones (Niagaran) were deposited at any rate in the western part of the Hekla Sund Basin.

d) Sæfaxi Ridge.

This ridge was formed during the Hekla Sund Phase, and was flooded for the first time in late Greenlandian time. The Centrum Limestone is only rudimentarily developed on the Ridge; the Profilfjeldet Shales are again absent.

e) Danmark Fjord Basin.

Above the Thule Formation, Upper Greenlandian sediments are known from the Danmark Fjord Basin; the greater bulk of the sediments, however, belong to the Canadian and the Silurian. The considerable subsidence of the Basin in Ordovician and Silurian times must be associated with the orogeny that set in farther eastward in the Eleonore Bay Trough.

C) North Greenland.

Little is known of the pre-Caledonian movements in this region. According to L. KOCH, a rather unstable shelf zone extends along and near the north coast of Greenland, in which zone several transgressions and regressions took place during the Lower Palæozoic.

III) Caledonian movements.

A) East Greenland.

The Caledonian movements within the area of the East Greenland geosyncline are characterised by compressions. We distinguish between three periods of movements and granite intrusions (marginal granites) occurring at fairly great intervals of time. The three periods of movement are as follows:

1) The paroxysm of the Caledonian orogeny, affecting the Eleonore Bay Trough in the interval between the Upper Ordovician and the Middle Silurian (? late Taconean) time.

2) Compressions resulting in the overthrusts in the Hekla Sund Region; these movements took place in late Silurian time (? Ardennian).

3) In the Eleonore Bay Trough compressions again made themselves felt during the deposition of the Middle and Upper Devonian.

As already mentioned, the intrusions of the late orogenic granites were distributed over a long interval of time (? Silurian-Middle Devonian).

1) The Caledonian orogeny.

In the Eleonore Bay Trough the Caledonian orogeny gave rise to

- a) folding,
- b) intrusion of synorogenic granites, and
- c) regional metamorphism.

Characteristic of the folding within the Eleonore Bay Trough is the "Stockwerk" folding, that is, the movements gave rise to different types of folding within the various storeys of the mountains (mobile basement: migmatite-granites and -gneisses; relatively rigid supra-structure: light- or non-metamorphic sediments) (cf. HALLER 1955, fig. 11).

The re-activated basement rocks supplied the synorogenic migmatite-granites. These granite bodies are very often mushroom-shaped (HALLER). Such forms may primarily arise as a consequence of compressions affecting the deepest-lying mountain storeys (fig. 4).

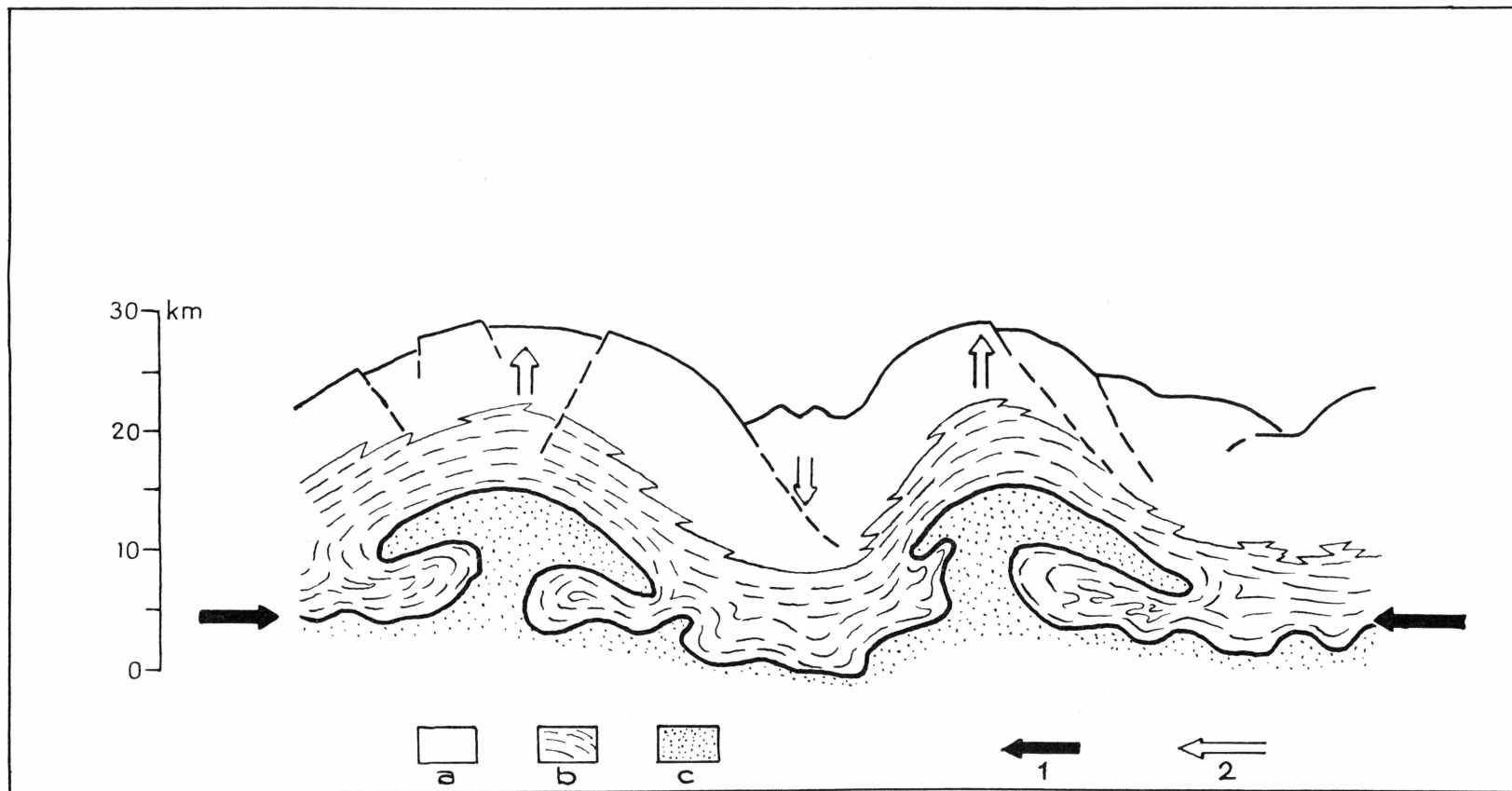


Fig. 4. Diagrammatic sketch of the tectonic forces affecting the Caledonian geosyncline of Central East Greenland.

a) Sediments and Parashists. b) Caledonian Gneisses. c) Synorogenic granites and mobile basement.

1) Active compression. 2) "Passive" bulging.

The deeper-lying beds of the Caledonian gneisses enclose conformably the Caledonian granite bodies, though in the upper parts they smooth out the often very complicated mushroom folds. The regional metamorphism associated with the formation of the gneisses took place in connection with the rise of the granitic neosome (migmatite front).

The uppermost "stockwerk", the sediments and the epi-metamorphic schists, lay outside the deep seated active compressive movements. The folding of these rocks is the result of secondary uplifting movements, caused by the squeezing out, rising, and "swelling" of the Caledonian granites (fig. 4).

Neither the front of the Caledonian granites nor the front of the regional metamorphism follow stratigraphic boundaries, both of them cut discordantly through the rocks of the Eleonore Bay Trough.

Summing up, we may say that in the centre of the East Greenland Caledonides the orogeny included strong compression in the deeper-lying highly metamorphic structural elements, while the higher-lying series reacted with slight tension movements to the vertical thrusts from the substratum.

2) The Caledonian Movements in the Hekla Sund Basin.

The Hekla Sund Basin was subjected to compression at a later date, viz. in late Silurian time (Ardennian ?), than the Eleonore Bay Trough. The active thrusting here affected the uppermost storey, the non-transformed sediments. The Hekla Sund Basin was compressed into a narrow zone, its sediments were thrust westward so as to form a nappe on the Sæfaxi Ridge. From the crest of the ridge the younger bed groups of the nappe, owing to gravity sliding, slipped into the Vandredalen Syncline. This syncline was formed during the early phases of the above-treated movements along the eastern edge of the Danmark Fjord Basin.

3) The Middle to Upper Devonian movements in the Eleonore Bay Trough.

On the basis of the Devonian sediments of the Eleonore Bay Trough BÜTLER distinguishes between five phases of movement during the deposition of the Devonian.

In Hudson Land thrusts from the east are distinctly recognisable, while elsewhere the direction of thrusting, similarly as in the sediments from the time of the orogeny, is less marked.

On Gauss Halvø and in the Moskusoksefjord region, Middle Devonian granite intrusions and gneissified Devonian sediments occur. Referring the Devonian movements (Acadian phase) to the Caledonian movements, we follow the view generally held to-day. The intensive faulting during Devonian times will be treated below (p. 35).

- 4) The intrusions of late orogenic granites (marginal granites, Devonian granites).

The late orogenic granite bodies hardly differ petrographically from the synorogenic granites. From this it can be concluded that in regard to material the former are of the same provenance as the latter.

Tectonically, however, the "marginal granites" are in most cases readily distinguishable from the synorogenic granites, as the former discordantly penetrate the various series; they also lack the parallel texture which is marked in the synorogenic migmatites.

The "mise en place" of the young granites did not occur at the same time everywhere, but always as a consequence of deep-going space-providing extensions. These movements took place along tectonic zones traceable over wide distances. The significance of these "intrusive granite lines" has not yet been elucidated.

B) North Greenland.

In North Greenland the Caledonian orogeny took place in the Upper Silurian (Ardennian phase) or in the lowermost Devonian (Erian phase); to the west, on Ellesmere Land (Canada), the movements continued till well into the Upper Devonian period.

The structure of the trough of North Peary Land is characterised by intensive superficial thrusting from the south (probably due to movements at greater depths towards the south). This thrusting gave rise to the formation of highly compressed folds at the southern margin, while farther northward overthrusts towards the north are frequently met with, which may attain the dimensions of actual nappe structures.

The intensity of metamorphism increases rapidly from the south towards the north; thus, garnet-micaschists occur at the mouth of Sands Fjord.

The basin of southern Peary Land does not seem to have been affected by the Caledonian folding activity.

C) Faulting during the Caledonian Movements in North and East Greenland.

During the Caledonian movements, faulting, in part fairly intensive, went on in several places.

In Central East Greenland a great many faults are found in the non-metamorphic series of the Eleonore Bay Trough. As regards age, many of these faults date back to the time of the actual Caledonian orogeny. Their formation is due to the reaction of the stiff sedimentary sheet on the movements of the mobile substratum (fig. 4).

In addition to these faults, some conspicuous NW—SE-striking lines are known, separating the Caledonian mountain chain into blocks. However, these lines of regional importance are for the most part to be found below the ice (Wordie Gl., Waltershausen Gl.), only the Junctional fault, which extends in a NW—SE direction through Andrées Land, can be directly observed.

As regards the Wordie Gl.- and the Waltershausen Gl.-lines, the rocks occurring to the southwest (Ole Rømers Land, Strindbergs Land) are much younger than those on the opposite, northeast, side. These lines seem to indicate the boundaries between northwestward-tilted blocks.

As to the age of these lines it can only be said that they are cut across by undisturbed Devonian faults.

The Junctional fault of Andrées Land forms the boundary between a high-lying block to the southwest and a down-faulted block to the northeast.

A detailed discussion of these fault lines is given by HALLER (1955).

In the Eleomore Bay Trough the Devonian movements were accompanied by intensive faulting. In regions without any covering of Devonian beds it is often impossible to distinguish between early Caledonian and late Caledonian (Devonian) faults. The largest unmistakably dated faults are probably the Upper Devonian faults which were associated with the subsidence of the Ole Rømers Land—Nordfjordgraben.

Mention should further be made of a group of tectonic lines that are traceable over great distances northward from Germania Land. These SSW—ENE-striking lines here generally follow the strike of the Caledonian mountains. In several places the lines were found to indicate faults that came into existence during the Caledonian movements. As an example the line East Lamberts Land-Hovgaards Land-Holm Land may be mentioned, along which older gneisses to the east were forced on to the Thule Formation farther west. In Holm Land Carboniferous and Permian beds a few kilometres east of this line are almost horizontal.

In North Greenland minor faults occur which strike SW—NE; they were formed during or shortly after the Caledonian orogeny.

IV) Post-Caledonian movements.

The post-Caledonian movements took place within the time interval Carboniferous-Quaternary. They were for the most part tensions, resulting primarily in step-faults, though large faults and flexures also occur.

Three regional tectonic systems, formed during the post-Caledonian movements, are recognisable, viz.

- 1) The faults of North Greenland. In the west they strike W—E, while farther eastward they assume a NW—SE direction.
- 2) The faults of East Greenland between Scoresby Sund and Germania Land. Here the N—S-direction is generally predominant, but NW—SE and NE—SW-striking lines also occur.
- 3) The flexure of Southeast Greenland, extending from Angmagssalik to Kangerdlugssuaq and onwards, though much less marked, to Kap Dalton.

These three elements determine the present-day course of the coasts of Greenland between Angmagssalik to the south and Germania Land to the north, and along the north coast from Kap Morris Jesup to Nordostrundingen.

Of the significance of the faults in North Greenland nothing can be said so far. But the origin of the faults of East Greenland and the formation of the flexure of Southeast Greenland were associated with the subsidence of the Scandic block.

A) The Faults of North Greenland.

Here two major faults may be mentioned, the Harder Fjord fault and the Kap Bridgman fault.

The Harder Fjord Fault exhibits a downthrow towards the south; it is traceable from Harder Fjord along the southern foot of the mountains from North Peary Land to some distance into the northeastern corner of South Peary Land. Eastward from Sands Fjord the north coast of North Peary Land almost follows the Kap Bridgman Fault, which shows a downthrow towards the north. Between these two faults the mountain chain of North Peary Land was elevated as a block.

The age of the faults has not yet been determined; the solution of this problem may probably be found in the eastern part of South Peary Land.

B) The Faults of East Greenland.

Between Scoresby Sund to the south and Germania Land to the north the younger faults generally strike N—S, intersecting the older, Caledonian, structures at acute angles. Thus, from the south towards the north constantly more western units of the Caledonian mountains to-day strike into the sea.

The most marked line of the younger faults is the system of the post-Caledonian main fault, discussed at length by KOCH, BÜTLER, and VISCHER. This tension element of second order was formed in Carboniferous times. The striking increase of basic dykes in the area of the main

fault shows that we are here confronted with an important deep-striking structural element.

The system of the post-Devonian main fault is traceable from Gaasefjord in the south along the Staunings Alper, across Gauss Halvø with minor faults as far as Koldewey Ø in the north. Along this stretch the main fault separates a rigid block to the west from a labile zone to the east. After the Devonian time the rigid western block became an erosion area, or at any rate a region without any recognisable sedimentation.

In the labile zone to the east faulting took place from the Carboniferous to well into the Tertiary period; sediment series, in part of great thickness, were also deposited here.

The block-faulting in East Greenland progressing from the west towards the east has been treated at length by VISCHER. The faults generally dip towards the east, the downthrown side lying to the east, though the blocks are predominantly tilted towards the west.

C) The Flexure of East Greenland.

This flexure, which was treated in detail by WAGER (1947), represents the youngest tectonic element of East Greenland. The amount of the flexure can be seen from the fact that the gneisses and basalts west of the flexure lie more than 4,000 m higher than to the east.

The subsidence of the eastern area commenced in the Eocene, and lasted till well into the Oligocene time.

Between Angmagssalik and the region around Kap Dalton the convex bend of the flexure is cut radially by a swarm of dykes. These dykes penetrated into the weak zones which resulted from the tensions during the downthrow.

THE GEOLOGICAL DATA OF EAST GREENLAND AND THE FORMATION OF THE SCANDIC OCEAN

Two views exist as to the formation of the Scandic:

- 1) The Scandic was formed as a result of continental drift, Greenland drifting westwards.
- 2) The Scandic covers the area of a downthrown block.

Considering now the east coast of Greenland, the geological data tell in favour of a downthrow of a Scandic block; no positive argument for the continental drift is found.

Before briefly discussing the downthrow of the Scandic block, that is, reconstructing the events, on the basis of the data known from East Greenland, we must analyse WEGMANN's hypothesis (1948), in which WEGMANN attempts to gather arguments for the continental drift.

WEGMANN regards the De Geer Line¹⁾ as a track along which the drift took place. The pre-drift position of Spitsbergen, which is found north of the De Geer Line, would then be located in the angle between Grant Land (Canadian Archipelago) and Northwest Greenland. WEGMANN says: "Thus, according to the drift hypothesis Peary Land and Grant Land play the role of the Scandic Land, as they come to lie outside Spitsbergen. It is the Scandic Land which has supplied the Mesozoic and Tertiary sediments (of Spitsbergen)". Accordingly the drift should have taken place in the younger Tertiary-Quaternary time.

According to our present knowledge of the pre-Cambrian stratigraphy of Grant Land, Northwest Greenland, North Greenland, East Greenland, Spitsbergen, and Norway, the area of Spitsbergen must, at any rate already in upper pre-Cambrian time, have been situated between East Greenland and Norway. The lower Hekla Hook Formation of Spitsbergen shows great affinity on the one hand to the Greenlandian of the

¹⁾ A line extending westward from northern Norway, following the margin of the Barents Sea shelf and traceable farther on along North Greenland to Grant Land.

Eleonore Bay Trough in East Greenland, on the other hand to the Varanger Formation of northern Norway.

A contrast to the tillite-bearing, well developed Greenlandian beds within the above-mentioned region is formed by the pre-Cambrian sections of Grant Land and Northwest Greenland, whence only slightly developed Greenlandian in the form of a thin dolomite series is known.

If ever drift-movements should have occurred along the De Geer Line, they must have taken place before the deposition of the Greenlandian.

The objections diminish if the origin of the Scandic in the sense of DE GEER is associated with the downthrow of an extensive block complex.

In East Greenland the Scandic is to-day bounded by three tectonic elements:

- 1) From Nordostrundingen to Germania Land by tectonic lines, which were formed during the Caledonian movements.
- 2) From Germania Land to Scoresby Sund by faults originating in the Carboniferous-Cretaceous period.
- 3) From Kap Dalton to Angmagssalik by a flexure formed in Eocene time and active till well into the Oligocene period.

The coast-forming elements in East Greenland accordingly grow younger from the north towards the south.

Parallel with this tectonic observation go the stratigraphic data.

We have assumed above (p. 20) the existence of an Arctic continent in the Keweenaw-Jotnian time. The Hekla Sund Phase formed part of the movements which broke up this continent into blocks. The periscandic, Caledonian geosynclines were formed in the weak zones between the blocks. In the area of the Scandic, an elevated area no doubt occurred at that time.

It was not till after the Caledonian orogeny that the Scandic block gradually subsided.

In Central East Greenland the Devonian and Carboniferous beds are developed in continental facies, still, however, marine Carboniferous is known from North and Northeast Greenland.

In the Permian deposits, a sharp boundary line is found in the area of the 74th parallel. North of this line marine Permian beds with Thetys fossils occur, to the south, however, the lagoon facies of the Zechstein sea is met with.

After a far southward, extending invasion of the Eotriassic sea similar conditions to those of the Permian prevailed again during the Triassic period.

Not till the Jurassic time did the sea penetrate farther southward; from the region of Scoresby Sund, however, continental Rhætic as well as Lower Liassic are still known.

The Cretaceous sediments are generally of marine origin. As to the conditions during the Tertiary, nothing can be said in this connection, owing to the basalts.

The geological data from East Greenland speak strongly in favour of a gradual subsidence, progressing from the north towards the south, of a Scandic block.

The southern edge of this block, the South Greenland-Iceland-Scotland-ridge, did not subside definitively till the Oligocene time, and up to that time it may repeatedly have served as a migratory path for various faunas.

LIST OF REFERENCES

MoG: Meddelelser om Grønland, udgivne af Kommissionen for videnskabelige
Undersøgelser i Grønland. Reitzels Forlag, København.

- ALDINGER, H. 1935, Geologische Beobachtungen im oberen Jura des Scoresby Sundes (Ostgrønland), MoG, Bd. 99, Nr. 2.
- ADAMS, P. and COWIE, J. 1953, A geological reconnaissance of the region around the inner part of Danmarks Fjord, Northeast Greenland, MoG, Bd. 111, Nr. 7.
- ADAMS, P. and COWIE, J. 1955, The Cambro-Ordovician of Central East Greenland, Part I, Stratigraphy and Structure (in preparation) MoG, Bd. 153, Nr. 1.
- BACKLUND, H. G. 1930, Contributions to the geology of Northeast Greenland, MoG, Bd. 74, XI.
- 1932a, Das Alter des "Metamorphen Komplexes" von Franz Josef Fjord in Ostgrønland, MoG, Bd. 87, Nr. 4.
- und MALMQVIST, D. 1932, Zur Geologie und Petrographie der nordostgrønlandischen Basaltformation, Teil I, Die basische Reihe, MoG, Bd. 87, Nr. 5.
- BIERTHER, W. 1941, Vorläufige Mitteilung über die Geologie des östlichen Scoresby Landes in Nordostgrønland. MoG, Bd. 114, Nr. 6.
- BRONNER, F. E. 1948, Contributions to the geology, in: BOYD, L. A. The coast of Northeast Greenland, Am. Geogr. Soc. Spec. Publ. No. 30, New York, N. Y.
- BÜTLER, H. 1948a, Die Westgrenze des Devons am Kejser Franz Joseph Fjord in Ostgrønland, Mitt. der Naturf. Ges. Schaffhausen (Schweiz).
- 1948b, Notes on the geological map of Canning Land (East Greenland), MoG, Bd. 132, Nr. 2.
- 1948c, see: KOCH, L. 1950.
- 1949, Über des Vorkommen von Mitteldevon im südlichen Teil der Giesecke Bjerger, MoG, Bd. 150, Nr. 4.
- 1954, Die stratigraphische Gliederung der mitteldevonischen Serien im Gebiete von Kap Franklin am Kejser Franz Josefs Fjord in Zentral Ostgrønland, MoG, Bd. 116, Nr. 7.
- COWIE, J. 1955, The Cambro-Ordovician of Central East Greenland. Part II. The Cambrian faunas. MoG, Bd. 153, Nr. 2 (in preparation).
- DONOVAN, D. T. 1953, The Jurassic and Cretaceous Stratigraphy and Palaeontology of Traill Ø, East Greenland, MoG, Bd. 111, Nr. 4.
- EHA, S. 1953, The pre-Devonian sediments on Ymers Ø, Suess Land and Ella Ø (East Greenland) and their Tectonics, MoG, Bd. 111, Nr. 2.
- FRÄNKEL, E. 1951, Die untere Eleonore Bay Formation im Alpeffjord, MoG, Bd. 151, Nr. 6.
- 1953a, Geologische Untersuchungen in Ost Andrées Land, MoG, Bd. 113, Nr. 4.
- 1953b, Die geologische Karte von Nord Scoresby Land, MoG, Bd. 113, Nr. 6.
- 1954, Vorläufige Mitteilungen über die Geologie von Kronprins Christians Land, MoG, Bd. 116, Nr. 2.

- FRÄNKEL, E. 1955a, Weitere Beiträge zur Geologie von Kronprins Christians Land, MoG, Bd. 103, Nr. 7.
- 1955b, Rapport über die Durchquerung von Nord Peary Land im Sommer 1953, MoG, Bd. 103, Nr. 8.
- GRAETER, P. 1956, Die sauren, devonischen Eruptivgesteine des Kap Franklin-Gebietes (Keiser Franz Josephs Fjord, Zentral-Ostgrönland), MoG, Bd. 155, Nr. 3, (in press).
- HALLER, J. 1953, Geologie und Petrographie von West Andréas Land und Ost Fraenkels Land, MoG, Bd. 115, Nr. 2.
- 1955, Der "zentrale metamorphe Komplex" von NE-Grönland, Teil 1: Die geologische Karte von Suessland, Gletscherland und Goodenoughs Land, MoG, Bd. 73, Første Afdeling, Nr. 3.
- 1956, Geologie der Nunatak-Region von Zentral Ostgrönland zwischen 72°30' und 74°10' n. Br. MoG, Bd. 154, Nr. 1 (in press).
- HASSAN, Y. 1953, Tertiary Faunas from Kap Brewster, East Greenland, MoG, Bd. 111, Nr. 5.
- HUBER, W. 1950, Geologisch-petrographische Untersuchungen in der inneren Fjordsregion des Keiser Josephs Fjordsystems in Nordostgrönland, MoG, Bd. 151, Nr. 3.
- HÜBSCHER, H. 1943, Zur Petrologie junger Sande aus Nordostgrönland, MoG, Bd. 115, Nr. 3.
- KATZ, H. R. 1952a, Zur Geologie von Strindbergs Land (NE-Grönland), MoG, Bd. 111, Nr. 1.
- 1952b, Ein Querschnitt durch die Nunatakzone Ostgrönlands, ca. 74° n. Br., MoG, Bd. 144, Nr. 8.
- KOCH, LAUGE. 1918, Oversigt over II. Thule Ekspeditionens videnskabelige Resultater, Naturens Verden, København.
- 1925, The Geology of North Greenland, Am. Jour. Sc. Vol. 9, New Haven.
- 1929a, Geology of East Greenland, MoG, Bd. 73, II.
- 1929b, Stratigraphy of Greenland, MoG, Bd. 73, II.
- 1935, Geologie von Grönland, in: Geologie der Erde, Verlag Bornträger, Berlin.
- 1940, Survey of North Greenland, MoG, Bd. 130, Nr. 1.
- 1945, The East Greenland Ice, MoG, Bd. 130, Nr. 3.
- 1950, Report on the Expeditions to Central East Greenland 1926—39 conducted by Lauge Koch, Part 1, Notes on some topographical and geological maps of East Greenland, MoG, Bd. 143, Nr. 1.
- LEEDAL, G. P. 1952, The crystalline rocks of East Greenland between latitudes 74°30' and 75° N., MoG, Bd. 142, Nr. 6.
- MAYNC, W. 1949, On the pre-Permian basement of the Giesecke Mountains (Gauss Peninsula) northern East Greenland, MoG, Bd. 114, Nr. 2.
- MITTELHOLZER, A. 1941, Die Kristallingebiete von Clavering Ø und Payer Land (Ostgrönland), MoG, Bd. 114, Nr. 8.
- NIELSEN, E. 1935, The Permian and Eotriassic vertebrate-bearing beds at Godthaab Gulf (East Greenland), MoG, Bd. 98, Nr. 1.
- 1941, Remarks on the map and the geology of Kronprins Christians Land, MoG, Bd. 126, Nr. 2.
- POULSEN, CH. 1930, Contributions to the stratigraphy of the Cambro-Ordovician of East Greenland, MoG, Bd. 74, XII.
- RITTMANN, A. 1940, Studien an Eruptivgesteinen aus Ost Grönland, MoG, Bd. 115, Nr. 1.
- ROSENKRANTZ, A. 1929, Preliminary account of the geology of the Scoresby Sound District, in: Koch, 1929a.

- SCHAUB, H. P. 1942, Zur Geologie der Traill Insel (Nordost Grönland), *Eclogae Geol. Helv.* vol. 35, No. 1. Basel.
- SOMMER, M. 1956, Geologie von Lyells Land (NE-Grönland) Map 1:250.000. MoG, Bd. 155, Nr. 2 (in press).
- STAUBER, H. see: KOCH, L., 1950.
- STENSIÖ, E. 1940, Über die Fische des Devons von Ostgrönland, *Mitt. Natf. Ges. Schaffhausen*, Bd. 16.
- TEICHERT, C. 1933, Untersuchungen zum Bau des kaledonischen Gebirges in Ostgrönland, MoG, Bd. 95, Nr. 1.
- TROELSEN, J. C. 1949, Contributions to the geology of the area round Jørgen Brønlunds Fjord, Peary Land, North Greenland, MoG, Bd. 149, Nr. 2.
- 1953, Private letter to Dr. L. Koch, 21.2.53.
- VISCHER, A. 1943, Die postdevonische Tektonik von Ostgrönland zwischen 74° und 75° n. Br., MoG, Bd. 133, Nr. 1.
- WAGER, L. R. 1934, Geological Investigations in East Greenland, Part I, General geology from Angmagssalik to Kap Dalton, MoG, Bd. 105, Nr. 2.
- 1947, Geological investigations in East Greenland, Part IV, The stratigraphy and tectonics of Knud Rasmussens Land and the Kangerdlukssuaq Region, MoG, Bd. 134, Nr. 5.
- WEGMANN, C. E. 1935, Preliminary report on the Caledonian orogeny of Christian X's Land (North East Greenland), MoG, Bd. 103, Nr. 3.
- 1948, Geological tests of the hypothesis of continental drift in arctic regions, MoG, Bd. 144, Nr. 7.
- WENK, E. and HALLER, J. 1953, Geological explorations in the Petermann Region Western part of Fraenkels Land, East Greenland, MoG, Bd. 111, Nr. 3.
- WITZIG, E. 1952, Einige jungpaläozoische Pflanzen aus Ostgrönland, MoG, Bd. 114, Nr. 11.