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SOME NEW INVESTIGATIONS
OF THE DEVONIAN STRATIGRAPHY AND
TECTONICS OF EAST GREENLAND

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WITH 17 FIGURES IN THE TEXT

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PREFACE

In 1927 Dr. L. KOCH (7, p. 127) observed folds in the Devonian beds at the western entrance to Sofia Sound, the origin of which he ascribed to a post-Devonian faulting activity. During his journeys in the Devonian area in East Greenland, E. WEGMANN ascertained that a folding-zone not yet examined existed here. In agreement with him and with Dr. KOCH I undertook the task of investigating the Devonian stratigraphy between Strindberg Land and Kongeborgen. A study of the geological map of the Musk-ox Fjord area by H. BACKLUND (3) and an inspection of the air photographs of Gauss Peninsula during my wintering on Ella Island convinced me that similar stratigraphical complications to those observed in King Oscar Fjord must exist in the Devonian of Musk-ox Fjord. I therefore extended my journeys to these northern folding areas also, and in this way I succeeded in solving various problems which could not be elucidated farther south.

In compliance with a wish expressed by the leader of the expedition, Dr. LAUGE KOCH, I shall give below a brief survey of the results of my observations of the Devonian stratigraphy and tectonics. A detailed account of the individual areas will be published later when the whole material has been worked up. My observations were chiefly made on a sledge journey in April, 1934, during a six weeks' stay at the coast of Kongeborgen at the time of the melting of snow and ice, and on two long motorboat-trips in July and August, 1934.

I am greatly indebted to the leader of the Danish Three-Year Expedition to East Greenland, Dr. LAUGE KOCH, for the liberty and travelling facilities allowed me for my work. In acquainting me with the working area and in outlining the working programme E. WEGMANN afforded me great help. I wish to thank Dr. WEGMANN most sincerely for the stimulating interest he has taken in my work. I owe a great debt of gratitude to my two companions on the Ella Island station, A. DE LEMOS and F. SØGAARD ANDERSEN, who facilitated my

work in many ways. The two Greenlanders at the station, JØRGEN PETERSEN and JØRGEN BARNABAS, were my faithful companions on the sledge journeys. I also wish to thank the Geodetic Institute of Copenhagen for placing maps and sketches at my disposal, especially Mr. O. SIMONSEN and Mr. S. O. STENØR of the Ella Island station and Mr. TH. JOHANSEN and Mr. V. DEVANTIER of the Eskimonæs station have rendered me great services.

Schaffhausen, January 20, 1935.

I. INTRODUCTION

The main area of the East Greenland Old Red extends between Wor-die Glacier and the bend of King Oscar Fjord at the south end of Konge-borgen (fig. 1). The main object of my work was an investigation of the tectonics and sedimentation within the western boundary zone of the Devonian from Kongeborgen to Strindberg Land. Gauss Peninsula and the eastern part of Ymer Island have been carefully investigated by SÄVE-SÖDERBERGH and his assistants (19, 20). Furthermore, in the summer of 1934 SÄVE-SÖDERBERGH undertook the task of studying the eastern boundary of the Devonian along the large fault, and for this reason I excluded the investigation of this region from my working programme. For the reconstruction of the development of the Devonian basin and of the conditions for deposition in Devonian and Carboniferous times the knowledge of this eastern area is indispensable.

The Devonian conglomerates and sandstones occupy a basin extending in a north-and-south direction and almost parallel to the strike of the Caledonian folding. The present western boundary almost coincides with an old Devonian coast line. To the east, however, the Devonian is cut off by faults. From Traill Island to Gauss Peninsula the Devonian is bounded on the east by continental Carboniferous, while north of Cape Franklin, towards Musk-ox Fjord, crystalline rocks and probably also parts of the Eleonore Bay Formation appear. Whether the Caledonides cropping out here formed from the outset the eastern boundary of the Devonian basin, has not yet been ascertained. It is a fact, however, that during the deposition of the Devonian movements took place, arising from this eastern region and continuing in a westward direction. These movements gave rise to the formation of mountain ranges, the disintegration products of which were conveyed to the Devonian basin. Through elevation of the substratum, through bottom-shearing and folding of the Devonian series the area of sedimentation was at times narrowed and separated into basins and bays. Also the direction of transport of the detritus changed, and Devonian eruptive material sometimes mingled with the sandy deposits. Younger series transgressed

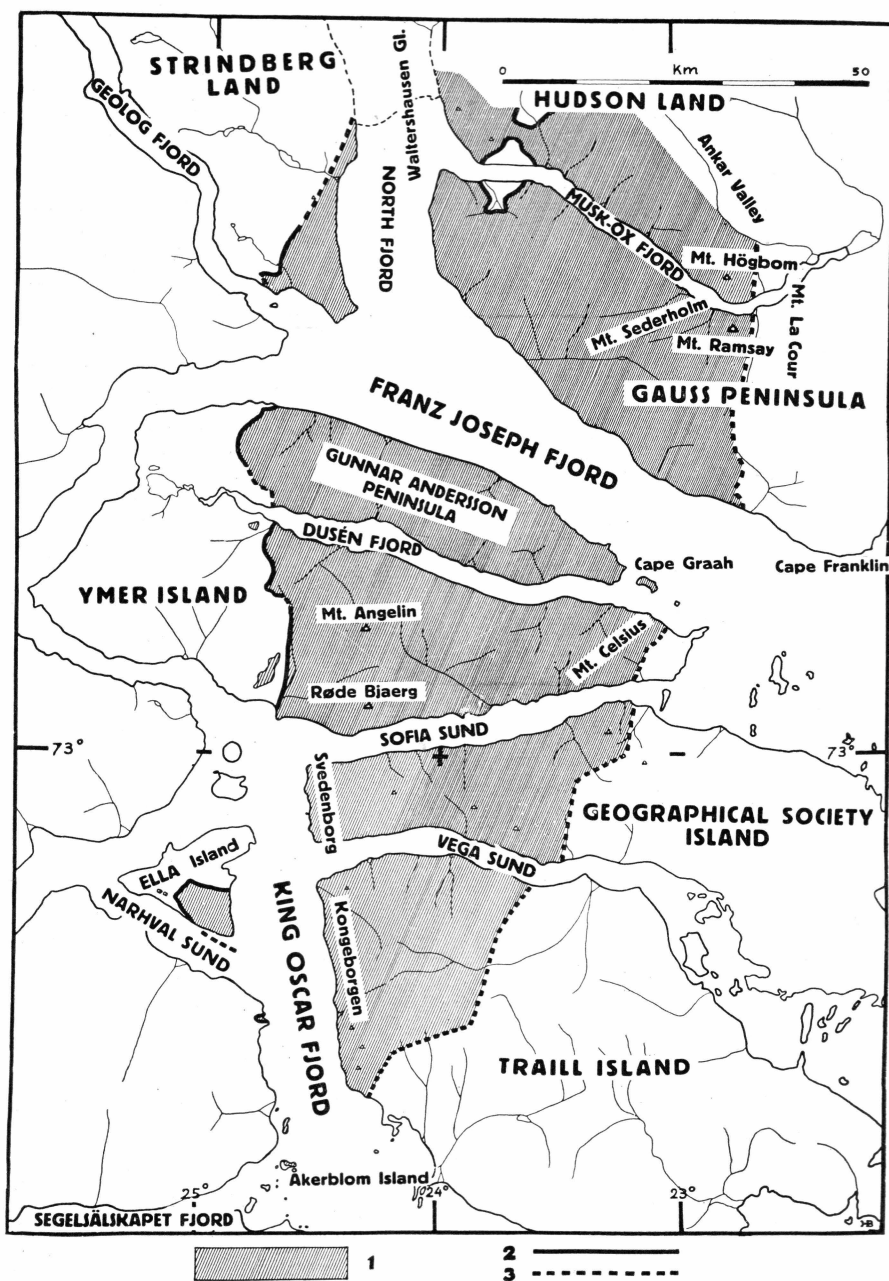


Fig. 1. Distribution of the Devonian between Hudson Land and King Oscar Fjord.

1 = Devonian; 2 and 3 = Boundary of the Devonian; 3 = Faults.

Map based on the maps of the Geodetic Institute, Copenhagen.

again across the denuded folds and the edges of the basins. Simultaneously with the accumulation of material the bottom of the basin subsided, and some thousand metres of conglomerates and sandstones were deposited. However, the thickness of the series varies from place to place. The Devonian of East Greenland is a typical orogenic sediment.

The lower Devonian series rises with its substratum from Gauss Peninsula axially towards the north. In Musk-ox Fjord, therefore, the lower Devonian series, with their folds and disconformities, are exposed. In the western part of the fjord, in the so-called inlier, even the Caledonian crystalline crops out in the core of a Devonian fold. The area towards Wordie Glacier, where the Devonian disappears on account of the above-mentioned axial elevation, has so far been but slightly investigated. The transformations of the bottom of the Caledonian basin in Devonian time may possibly be observed there.

At their southeastern boundary the Devonian strata are cut off by the large fault which south of Vega Sound bends from a SSW. direction towards the southwest (fig. 1). The continuation of the fault points towards the Segelsälskapet Fjord. At the south end of Kongeborgen step-like subsided and slightly bent continental Carboniferous beds abut on the lower grey Devonian sandstone.

The connection with the Devonian of Wegener Peninsula, investigated by NOE-NYGAARD (15) at the mouth of Davy Sound, is not yet clear. Between the two areas the Devonian was probably partially removed by a pre- or early Carboniferous denudation, and in the area thus laid bare Carboniferous strata were deposited. The remnants of the Devonian basal conglomerate that have escaped erosion are still found in the abrupt slopes of Syltoppene.

II. THE DEVONIAN BASAL CONGLOMERATE

1) Topography of the substratum.

The surface over which the Devonian sea transgressed has been thoroughly investigated by KULLING (12). On Ymer Island he found some ancient remnants of valleys filled with Devonian strata, and at a rather considerable height, west of the continuous area, small remnants of Devonian beds, resting disconformably on the substratum. From this KULLING inferred that the present western boundary of the Devonian is a mere limit of erosion. KOCH, however, was of opinion that the present boundary corresponds to the Devonian coast line. Conditions in Musk-ox

Fjord made KOCH assume that the Devonian was deposited in large valleys in the Caledonian mountains. Here the Devonian basin is divided lengthwise by a crystalline fold. These crystalline rocks were regarded by WORDIE (23, 24) as Archæan, and by KOCH and BACKLUND (7, 2) as Caledonian. The highly sloping conglomerates at the sides of the fold were taken to be talus cones originating from the mountain slopes.

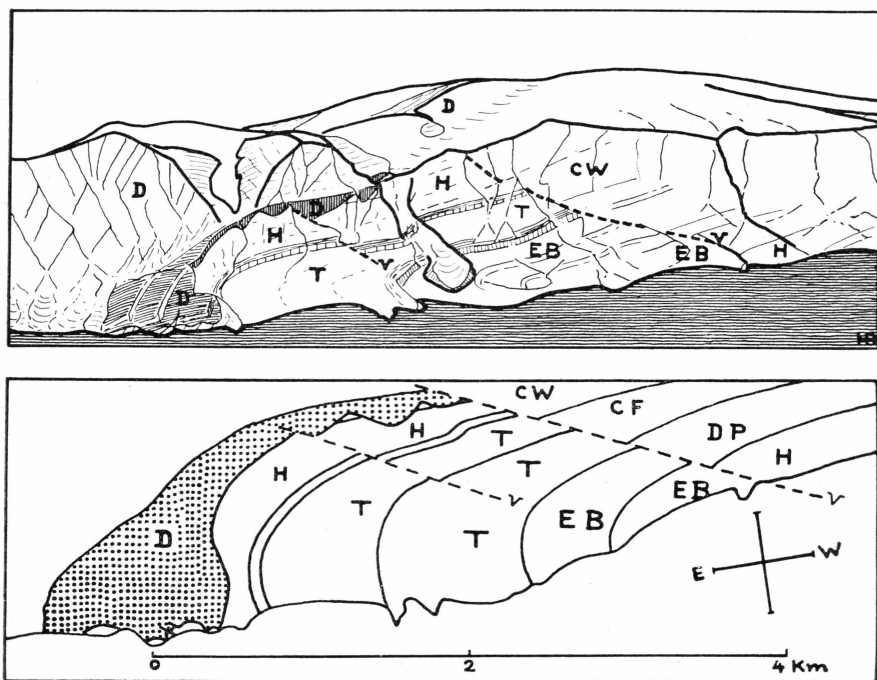


Fig. 2. The transgression of the Devonian basal conglomerate at the north coast of Gunnar Andersson Peninsula.

D = Devonian; CW = Cape Weber Formation; CF = Cass Fjord Formation; DP = Dolomite Point Formation; H = Hylithus Creek Formation; T = Tillite Canyon Formation and tillite; EB = Limestone of the upper part of the Eleonore Bay Formation. V = Faults.

However, the investigation of the Devonian stratigraphy shows that this crystalline fold was not formed till Devonian time.

At the western margin of the Devonian area the substratum can only be observed in a narrow boundary zone with deposition of conglomerates and sandstones. From observations here the following sub-Devonian topography may be reconstructed: The bottom of the basin consists of a deeply eroded and rather base-levelled landscape with mountain crests and small valleys, which mostly extend parallel to the strike of the beds. This land surface slopes towards the east, as already observed by KOCH. The lower Devonian sandstones, which in

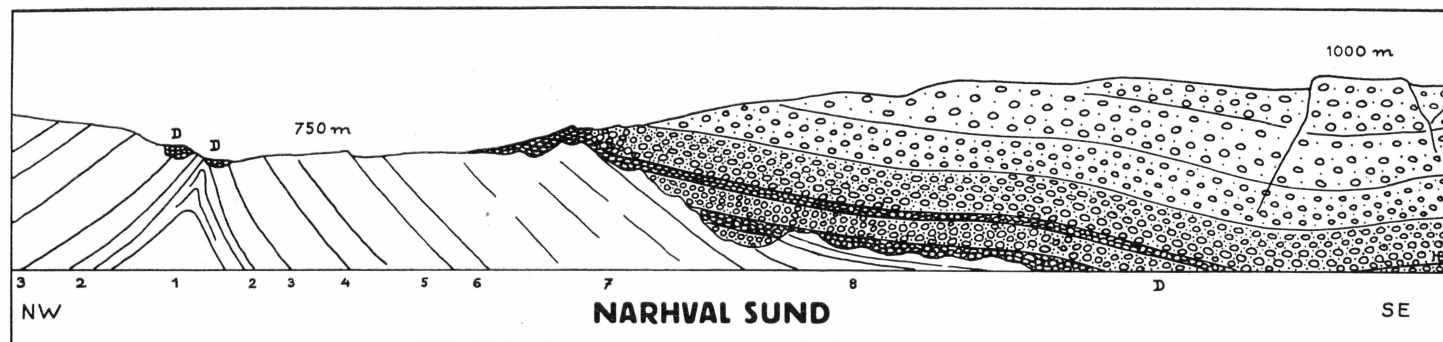


Fig. 3. The transgression of the Devonian across the Silurian and Cambrian on Ella Island by Narhval Sound.

D = Devonian conglomerate; 1-8 = the Cambro-Silurian beds (cf. the section in POULSEN: the Lower Cambrian Faunas of East Greenland.

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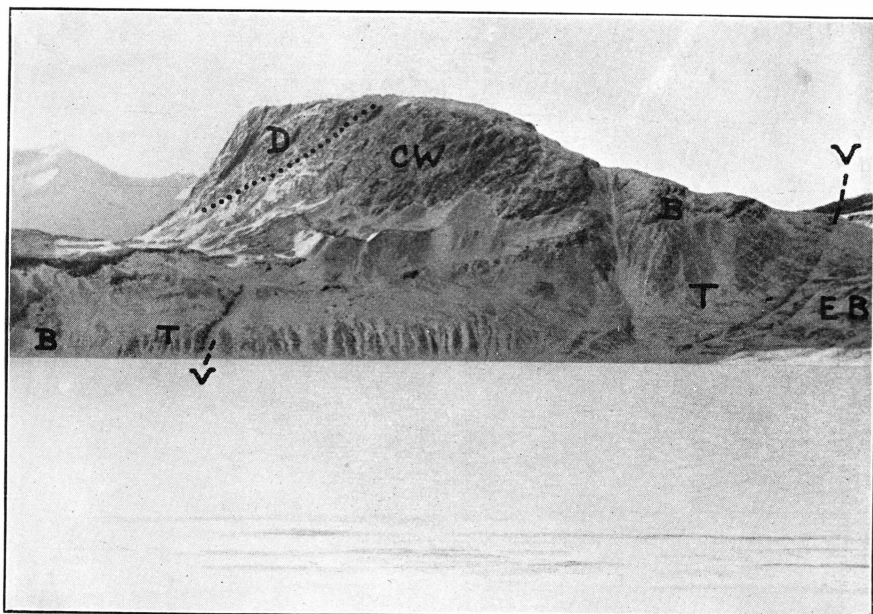


Fig. 4. The transgression of the Devonian basal conglomerate on the south side of the interior of Dusén Fjord.

D = Devonian conglomerate; CW = Cape Weber Formation; B = Bastion Formation; T = Tillite Canyon Formation and tillite; EB = Eleonore Bay Formation; V = Faults.

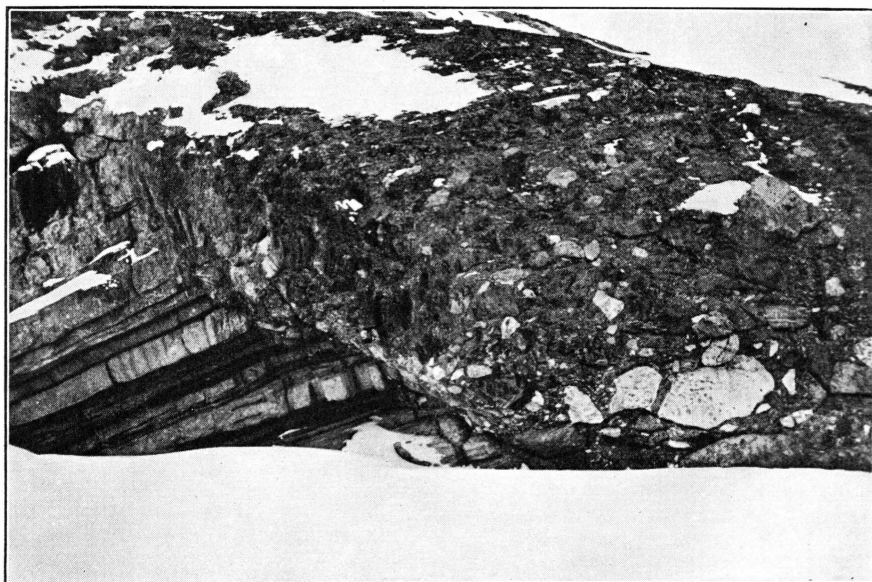


Fig. 5. The breccia at the base of the Devonian, north side of Gunnar Andersson Peninsula.

the interior of the basin are horizontal, thus taper towards the west or pass into conglomerates. This flat basin bottom continues to the west in a distinct steep slope some hundred metres high, and above this there follows a much broken plateau (figs. 2 and 3). After the depression had been covered with detritus, the valleys debouching in the steep wall began to be filled with detritus. The deposits rose constantly higher and gradually moved across the crest of the slope and spread over the plateau beyond. How far these Devonian deposits extended towards the west, can hardly be ascertained now. The present western boundary of the Devonian coincides with the steep wall.

2) The western boundary of the Devonian.

As a whole the Devonian steep wall runs nearly in a north-and-south direction without following the curves and axial bends of the Caledonian anticlines. Consequently it mostly runs at acute angles to the strike of the beds of the anticlines. The direction of the strike of the Devonian strata and that of the Caledonian substratum may be parallel over large distances. TEICHERT (22), however, is in error when from the apparent conformity with the subjacent limestone he infers a particular stratigraphic position of the basal conglomerate. The disconformity of the basal breccia can moreover be ascertained almost everywhere.

To the south of Ymer Island the Devonian marginal area rests on lower members of the limestone-dolomite series of the Eleonore Bay Formation. To the north it abuts on the Ordovician limestones of the Cape Weber Formation. The tillite and the Palæozoic limestones are exposed at a fault on the south side of Dusén Fjord (fig. 4).

3) The material of the basal conglomerate.

As observed by KOCH, KULLING, and some other investigators, the Devonian series begins with a coarse basal breccia, which fills up the irregularities of the substratum (fig. 5). All the blocks and pebbles of this breccia originate from the nearest surroundings. It is mostly overlain by stratified conglomerates interbedded with red and grey lenses and beds of sandstone (fig. 6). On Ella Island and on Strindberg Land at the mouth of Geolog Fjord the thickness of these conglomerates exceeds 1000 m (fig. 7). WEGMANN assumed that this accumulation marks the mouths of some large Devonian valleys.

The coarse material of the conglomerates along the whole western margin of the Devonian is derived from the non-metamorphic part of the Eleonore Bay Formation and the Cambro-Ordovician. The clayey bands and the sandstone beds, however, point in places towards the presence of felspar and mica. This fine-grained material must have been

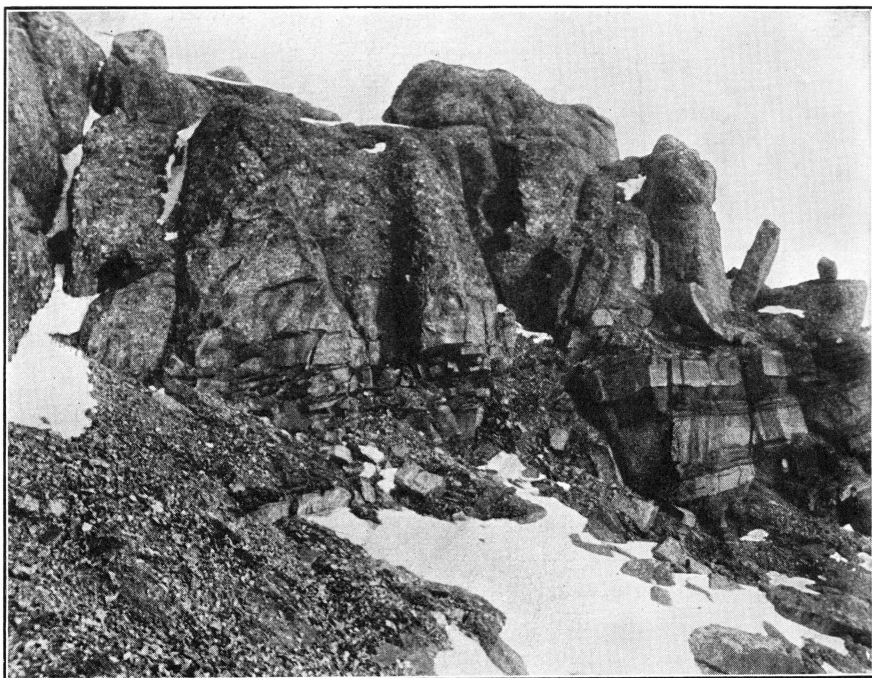


Fig. 6. Alternating beds of Devonian conglomerates and red and grey sandstone beds on Åkerblom Island.

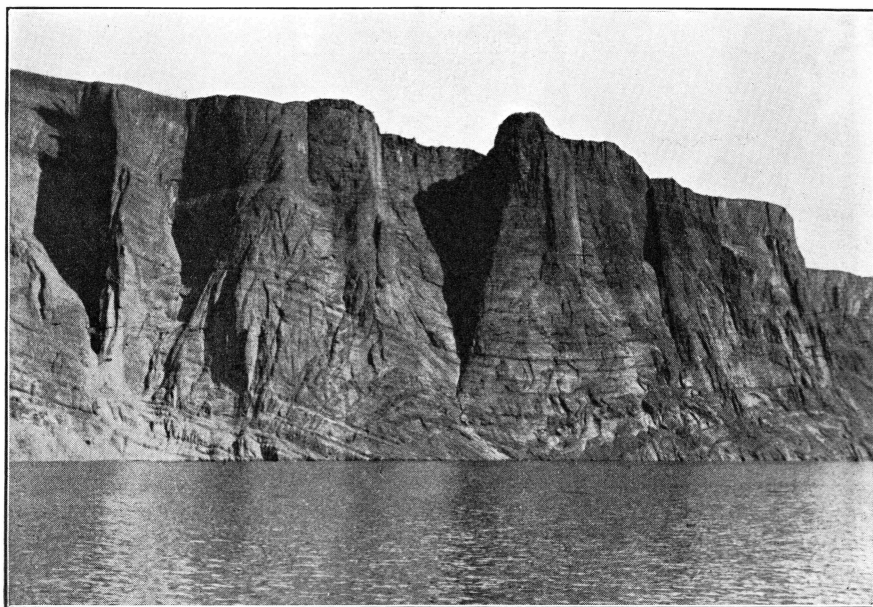


Fig. 7. Ella Island. The slightly folded Devonian conglomerate at Narhval Sound.

transported from some more westerly crystalline areas, while the coarse material originates exclusively from the vicinity of the basin. In Musk-ox Fjord there occur in the upper levels of the lower series, besides limestone and dolomite pebbles, numerous reddish granites, which have probably come from the northeast. This conglomerate, however, is separated from the older, non-crystalline, conglomerate by a tectonic disconformity. TEICHERT designated both these two conglomerates as Bjørne Ø Konglomerat. For the interpretation of the tectonics of the region the conglomerates, especially the lower one, play an important part.

III. THE DEVONIAN SANDSTONE

In the interior of the basin the conglomerates are overlain by some two or three thousand metres of varicoloured sandstone. By the aid of the red sandstone series parallelisations have been made comprising the whole Devonian area of the investigated fjord system. However, all authors were aware that an inference drawn on this basis alone was very uncertain. Upper Devonian fish remains were first found by NATHORST, afterwards by KULLING and ORVIN. It is to the great credit of SÄVE-SÖDERBERGH (18, 19, 20) that he has fixed the fossiliferous levels of the upper Devonian series. However, the levels that have been determined with certainty are limited to the northeastern part of the Devonian area, mainly to Gauss Peninsula and Mt. Celsius. The much thicker "lower sandstone complex" of SÄVE-SÖDERBERGH cannot at present be divided on the basis of palæontological viewpoints. In the subjoined table the designations used by the various authors for the individual series are correlated:

KOCH 1929	KULLING 1930	ORVIN 1930	SÄVE-SÖDERBERGH 1934
upper red series, at the base conglomerate	uppermost red series upper grey series upper red series middle grey series middle red series	upper grey series upper red series middle grey series lower red series	Upper sandstone complex Arthrodire sandstone Remigolepis series Phyllolepis series or Lower sandstone complex
grey series	lower grey series lower red series	lower grey series	

basal conglomerate

As appears already from the divisions made by KULLING, the "lower sandstone complex" is interbedded with series of red strata.

However, parts of the latter are not limited to a certain level, and may pass into grey sandstones. Hence they are not traceable throughout the region, and the succession of the grey and red series alternate from place to place. As regards the "middle red sandstone" of KULLING, the case is different. Already KOCH observed the immense conglomeratic series at the base of these red sandstones in Musk-ox Fjord and at Cape Graah, in which were embedded blocks of the underlying Devonian. ORVIN was of opinion that this red series rested disconformably on the underlying beds. It turned out that it had a very wide distribution, though of varying thickness (fig. 8). It is traceable from Traill Island into Hudson Land. In Musk-ox Fjord the basal conglomerate of this series rests disconformably on a folded (lower grey) Devonian series. To the south, however, the strata are conformable, but the conglomerates extend as far as Ymer Island. In the following this red series will be designated the Cape Graah Series¹). It has been investigated at Cape Graah by NATHORST, KOCH, KULLING, ORVIN, and SÄVE-SÖDERBERGH. This series will be of use later, when we are to place the Devonian eruptives and the foldings in the stratigraphic table.

The strong red colour of the various series in Musk-ox Fjord, on Gauss Peninsula, and on Ymer Island is partly due to the mixture with, and the disintegration of, the Devonian eruptives. Whether this material occurs farther south also will be revealed on a close examination of the samples collected. From the observations in the field it further proves that the immense red series originates from a transgression. In the interior of the basin the transgression generally commences with a grey series, but the red sandstones extend farther on to the former edge of the basin than the underlying grey beds. This applies principally to the stratigraphy on the north side of Musk-ox Fjord.

IV. THE DEVONIAN ERUPTIVE ROCKS

On his geological map KOCH (7) indicates Caledonian granite and Tertiary basalts in Musk-ox Fjord. The granite was more closely investigated by BACKLUND (2, 3), who established that beds and dikes of keratophyries, quartzporphyries, and spillite occurred in Mt. Högbom, Mt. Sederholm, Mt. Ramsay, and at Mt. la Cour, which beds did not belong to the sequence of the remaining Caledonian granitic rocks. BACKLUND determined them as pre-Cambrian and older than the Caledonian

¹) In 1929 KOCH included the whole East Greenland Devonian under the Cape Graah Formation; in the present paper this name is limited to the red series in the upper part of the Phyllolepis series.

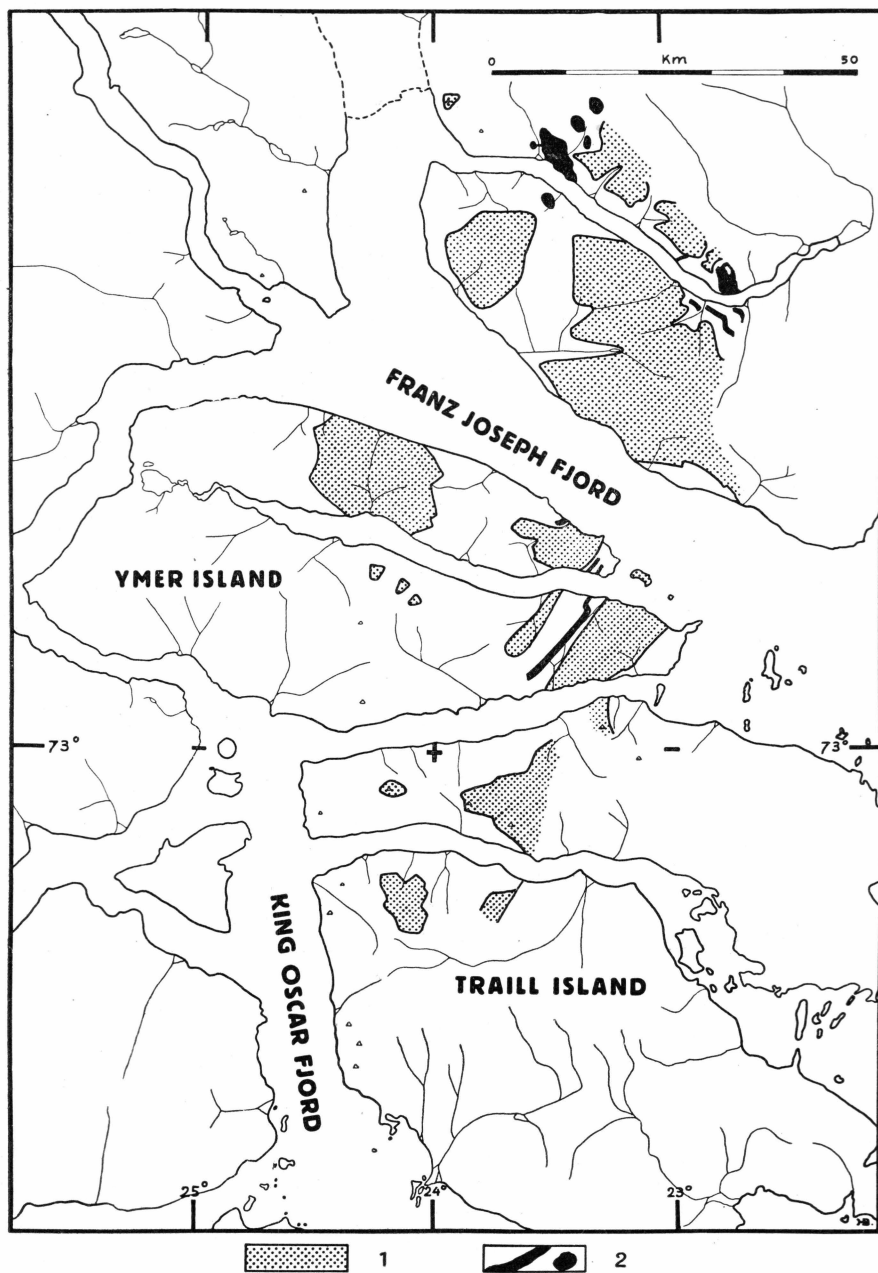


Fig. 8. Diagram of the distribution of the red Cape Graah Series and the investigated Devonian eruptive rocks.

1 = Red Cape Graah sandstones and conglomerates; 2 = Devonian eruptive rocks; intrusive bodies, vents, dykes, breccias, and tuffs.

magmatic rocks, and referred them to the Caledonian evolution phase. In the west side of Mt. Högbom dikes of this eruptive rock are cut across and overlain by a conglomerate. The conglomerate contains pebbles of keratophyries. The lower part of the conglomerate was correlated by BACKLUND with reservation with the sub-Cambrian tillites, and on this basis the pre-Cambrian age of the eruptives was inferred.

If we trace the Devonian series from the west, it appears with certainty that the conglomerate is of Devonian age and belongs to the Cape Graah Series. The sandstones in which the eruptive rocks are embedded, are also Devonian. Neither at Mt. Högbom nor at Mt. Sederholm

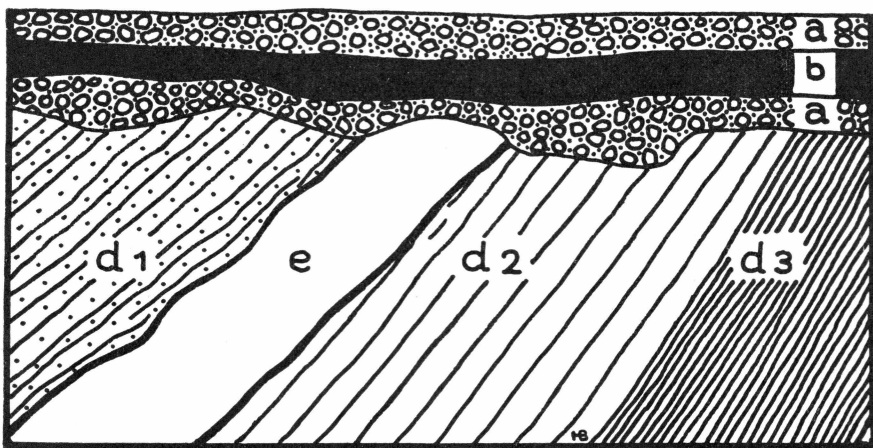


Fig. 9. Profile at the north side of Musk-ox Fjord, west of Mt. Högbom.

a = Conglomerate from the base of the Cape Graah Series; b = Younger basalt dyke;
 d₁, d₂, d₃ = red, whitish, grey-greenish sandstones of the folded lower grey Devonian series.
 e = Quarzporphyry dyke.

—Mt. Ramsay are the Eleonore Bay Formation and the tillites represented. ORVIN already assumed that part of the eruptives in Musk-ox Fjord were of Devonian age.

In Mt. Anker, however, a Caledonian granite has penetrated the quartzites of the Eleonore Bay Formation. On the slopes of Mt. la Cour conditions must be more complicated, as appears from BACKLUND's map (3). In addition to Caledonian crystalline rocks there probably occur Devonian eruptives in company with folded post-Caledonian sediments. However, I did not visit this area, and we must await SÄVE-SÖDERBERGH's publications before further conclusions can be drawn.

In the area Mt. Ramsay—Mt. Sederholm—Mt. Högbom the keratophyries and spillites are interbedded in a lower grey, folded Devonian series. Resting disconformably on this series is, to the west, the conglomerate of the Cape Graah Series. The large dikes and intrusive masses,

as far as could be observed, never penetrate the conglomerate, but are, as stated by BACKLUND, cut off by it (fig. 9). However, in Mt. Sederholm a small quartzporphyry-dike rises through the folded Cape Graah sandstone, and this is abundantly mixed with volcanic tuff material. On the east side of Mt. Högbom I observed fine-grained reddish to greyish-black tuffs deposited in water. Judging from the stratigraphical conditions and their appearance, they correspond to the base of the *Remigolepis* series. The main eruptive activity in the eastern part of Musk-ox Fjord must have taken place in the time prior to the deposition of the Cape Graah Series and may probably be connected with the folding of the lower grey series. However, volcanic eruptions also took place during and after the deposition of the red sandstone of the Cape Graah Series.

In the western part of Musk-ox Fjord TEICHERT (22) also found porphyries, volcanic breccia, and tuffs. The porphyries rise like vents through the Devonian and are, according to Teichert, post-Devonian. The tuffs, however, are embedded in the Devonian sandstone and mixed with it. The eruption of this volcano must therefore be Devonian. On the north side of the fjord a large volcano with various necks, coarse breccias, tuff beds, and effusive rocks are exposed; on the south side, however, there is only a single neck, which is overlain by younger Devonian strata. From aircraft it was further established that the volcanic zone continues farther northward, almost parallel to the crystalline zone of the inlier farther west. Here, too, it is possible to locate it in the Devonian series. However, since I only paid a short visit to this volcanic area, on a sledge journey in April, 1934, my observations are incomplete. Above a greyish-green, often almost quartzitic Devonian series there rests, in the outer part of the fjord area, a succession of several hundred metres of strongly brownish-red sandstones. They transgress to the west over the eastward sloping grey sandstones as far as the crystalline dome of the inlier. On the west side of the crystalline fold, above the Waltershausen Glacier, the red sandstones pass into grey sandstones. In the area of the volcanoes the red series is again overlain by a grey one, which, being banded with tuff, in places exhibits a green or yellowish colour. On these rest the red mural sandstones of the Cape Graah Series. The porphyries, breccias, and tuffs occur mainly below the lower red series. However, tuffs also occur at higher levels, and seen from a distance the porphyry vents and tuff-masses farther north seem to extend in below the Cape Graah sandstones. Thus the porphyries here appear to be of the same age as the keratophyries in the eastern fjord area, they belong to the grey sandstones underlying the Cape Graah Series.

The rocks corresponding to these eruptive rocks are also found on Ymer Island (fig. 8). On the north coast of the island, in the vicinity of Cape

Graah, the grey sandstones are interbedded with red quartzporphyries, volcanic rocks, and dyke rocks, tuffs and breccias. At some distance from the places of eruption the volcanic bombs are embedded in the sandstones. Bombs and sedimentary tuffs are also met with in Dusén Fjord. A zone of brick-red weathered porphyries, greenish tuffs, and breccias runs across the southern part of the island as far as Sofia Sound, west of the massif of Mt. Celsius. Here, too, these rocks occur below the Cape Graah Series everywhere. At the same level fine-grained tuffs probably occur, at any rate they may be met with also on the south coast of Gauss Peninsula. An examination of the rock samples will possibly show whether on Traill Island also the sands are mixed with tuff material. By later investigations in the Devonian area these tuffs will possibly permit a parallelisation of the series over greater distances.

V. TECTONICS OF THE DEVONIAN

1) General.

The stratigraphical disturbances of the Devonian hitherto described have all been ascribed to post-Devonian movements. KOCH recorded broad synclines and anticlines from Gunnar Andersson Peninsula and Gauss Peninsula and was the first to outline the folds in Røde Bjærg and in Mt. Swedenborg (7, 8, 9). The extensive troughs and arches have later been sketched by FREBOLD, who designated them folds of germano-typic type (5, p. 43). He took them to be "varistisch", whereas KULLING (13) regarded them as post-Neocomian.

The inclined conglomerate at the "inlier" of the Musk-ox Fjord was considered by WORDIE and other investigators as solidified detrital masses originating from the slopes of the crystalline fold, and their oblique bedding was regarded as primary. TEICHERT (22, p. 42) however, was of opinion that the conglomerates have been subjected to a tectonic tilting and accordingly must probably be older than the Devonian of this region.

FREBOLD and subsequently other authors, too, who have studied the tectonics of this area, have paralleled the movements with STILLE's folding phases (21). It has turned out, however, that the tectonics of the region, especially in the deeper Devonian series, are much more complicated than assumed, and that the tectonic development of East Greenland has been very different from that assumed according to STILLE's scale.

BACKLUND is quite right when he states (3, p. 40) "dass in dem Ge-

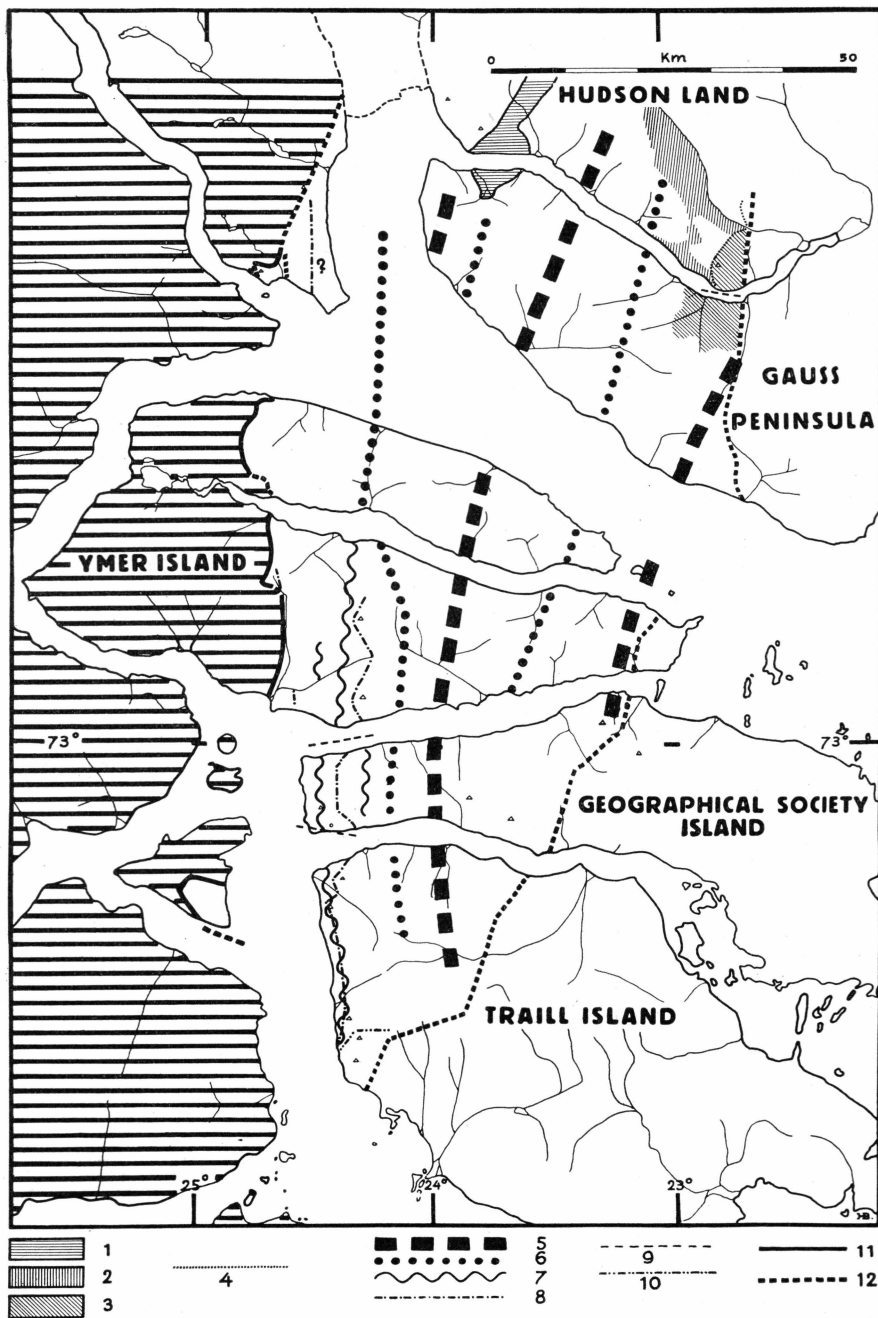


Fig. 10. Tectonic sketch map of the Devonian area between Hudson Land and King Oscar Fjord.

- | | | |
|--|--|--|
| 1 = Crystalline fold of the Musk-ox Fjord inlier. | | |
| 2 = Folded lower grey Devonian series, folding older than the Cape Graah conglomerate. | | |
| 3 = The folded Devonian series of Mt. Sederholm and Mt. Ramsay and the upthrust series of Mt. Högbon. Folding older than the Remigolepis series. | | } Devonian foldings. |
| 4 = Thrust-plane at Mt. Högbon. | | |
| 5 = Broad anticlines. | | |
| 6 = Flat synclines. | | |
| 7 = Folded lower Devonian series. | } Late Devonian or early Carboniferous foldings. | 10 = Young, probably Tertiary upthrust at Kongeborgen. |
| 8 = Thrust-plane. | | 11 = Devonian boundary. |
| 9 = Tear-faults (décrochements). | | 12 = Fault. |

biete des Moschusochsefjordes unerwartete Komplikationen vorliegen, die in Aussicht stellen, aus ihrer Lösung weitgehende Schlüsse zu ziehen". In the following some of these complications will be discussed.

In the Devonian area three different forms of folds can be distinguished. The most conspicuous, because at the coast they are coloured by the red sandstones, are the simple, widely distributed throughs and arches, which are traceable throughout the whole area (fig. 10). However, also sliding series of strata, which are folded or thrust into narrow longitudinal zones, are met with. As the third kind of folds may be mentioned the archings of the Caledonian substratum. An apparently simple crystalline arch appears below the Devonian of Musk-ox Fjord. However, from the stratigraphy of the lowermost sediments at the western side of the folds it can be inferred that we are concerned with a crystalline mass which is upturned to the west, but of which only the uppermost part is visible in the fjord.

The three types mentioned above represent, on account of a special kind of movement, various deeply eroded folding levels. The extensive undulations bear evidence of the effect of the movement on the superficial sediments, the folded and sheared off series show the local complications in the lower zones, the crystalline arch indicates the starting point of the movements. The three different fold levels, however, are not of the same age. They owe their origin to different though similar movements. Only at the oldest fold does the denudation within the Devonian area extend to the substratum. The other folds are younger and in the large synclinal throughs to the northeast the youngest Devonian beds have been included in the folding. That the movements are of varying age is also clearly evidenced by the stratigraphic disconformities and the varying axial directions of the folds (fig. 10).

2) The Musk-ox Fjord Inlier.

The gneiss dome in the western part of Musk-ox Fjord was discovered by WORDIE. He took the gneisses to be Archæan, whereas KOCH and BACKLUND regarded them as the products of a Caledonian metamorphosis. The gneiss dome extending northward from Gauss Peninsula in below the Devonian was designated as an inlier. According to the views set forth so far, the mountainous sub-Devonian topography within the Devonian area is exposed here. On the west side of the fold PARKINSON and WHITTARD (17) found mylonitised gneisses and deformed limestones with fossil remains. Their peculiar mutual position was explained as the result of faulting, and BACKLUND (2, p. 255) assumed that the gneisses represented metamorphosed portions of the middle and upper Eleonore Bay Formation. TEICHERT observed on the south side of the fjord that

the lowermost conglomerates were conformable with the limestones, that they were tilted with them to a fairly vertical position, and that they were disconformably overlain by the Devonian (22, p. 40). From this he inferred that the conglomerate was not the Devonian basal conglomerate proper, but must be older. He proposed the peculiar designation Bjørne Ø conglomerate, however, without attempting a closer determination of its age.

From the observations in the field it is clearly evidenced that the conglomerates have been somewhat dislocated and disrupted. The same is the case with the limestone and in part the gneisses. On the north side of the fjord, still in the western limb of the anticlinal fold, there

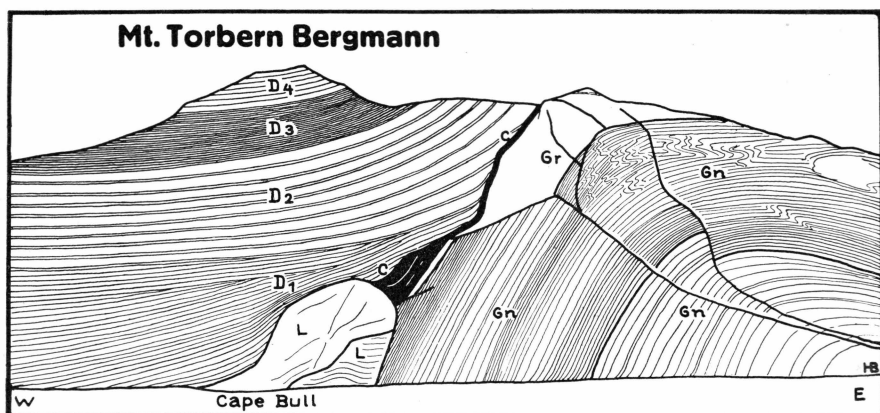


Fig. 11. Diagrammatic section from the western side of the Musk-ox Fjord inlier, northern bank.

D ₁ = Grey Devonian sandstones.	} Lower grey series	G _n ² = Caledonian gneisses.	} Folded in Caledonian time	} Folded in Devonian time
D ₂ = Grey and brown Devonian sandstones.		G _r = Caledonian granites.		
D ₃ = Red Devonian sandstones.		L = Cambrian or Silurian limestone.		
D ₄ = Grey Devonian sandstones.		C = Calcareous conglomerate from base of Devonian.		

extends right to the top of the slope, beginning above the limestone of the bank, a band, several metres thick, of conglomerates and limestones compressed by each other, which have together been squeezed out and laminated (fig. 11). This band runs along a steep "couloir", east of which a highly transformed grey granite occurs. (In fig. 16 of TEICHERT's paper this granite is indicated as Devonian sandstone). However, according to the composition and the stratigraphy of the rocks, the lowermost conglomerate represents the base of the Devonian. The folding at the inlier must be younger than the Devonian basal conglomerate and older than the upper transgressing Devonian series. In the interior of the Devonian basin a small fold of the basement has formed (Pli de fond in the sense of Argand in the terminology of 1, s. 215), rising by steps. Various disconformable and transgressive conglomeratic levels point towards

several erosion cycles. The "pre-Devonian faults" of TEICHERT are Devonian movement planes, which can be located in the folding system. The merely sporadic occurrence of the limestone is thereby also accounted for, being portions of a much eroded and subsequently refolded mountain mass. At the bottom the arching fold has been separated along a thrust plane and has advanced to the west. The crystalline zone of the "inlier", in disagreement with the present maps, continues towards the north. Since it rises axially in this direction, a detailed investigation in the interior of Hudson Land might bring to light interesting results.

The movements came to an end during the deposition of the lower grey Devonian series. The eruption of the quartzporphyries did not take place until the end of the main movements in this region. The range of volcanoes in the western Musk-ox Fjord is situated along the crest of this basement fold and runs almost parallel to its strike.

3) Mt. Högbom, Mt. Sederholm, and Mt. Ramsay.

Between Mt. Högbom and Mt. Sederholm the Musk-ox Fjord cuts across a folding zone striking in a north-and-south direction. In ORVIN's section (16) Mt. Högbom may be interpreted as a pre-Devonian series elevated to the west, though this interpretation is nowhere clearly expressed in the text.

The tilted series of strata at Mt. Högbom is actually a mass of sandstone that has been thrust up from the east, but is of Devonian age. On BACKLUND's map it is indicated as Eleonore Bay Formation, and the same is the case with the folded series at the western base of the mountain, which is situated below the tilted beds. In order to explain the stratigraphy on either side of the fjord BACKLUND had to assume the presence of several faults. However, in this part of the fjord the Eleonore Bay Formation is nowhere exposed. It is not till farther eastward, beyond the large longitudinal faults, in Mt. Anker, that the quartzites of the Eleonore Bay Formation are met with.

On the western side of Mt. Högbom above the fjord a shaly, folded sandstone series crops out, striking nearly in a north-and-south direction and dipping 30° to 50° to the west (fig. 9). At an altitude of about 450 m it is overlain disconformably by a reddish conglomerate, which rests upon an abrasion plane dipping slightly to the south. The grey mountains north of Anker Valley possibly correspond to this lower folded Devonian series. On the south side of the fjord, at the base of Mt. Sederholm, the conglomerate occurs only slightly above sea-level. It forms the base of the Cape Graah Series. Accordingly the folding of the lower grey sandstone series is older than the Cape Graah conglomerate, but younger than the origin of the crystalline fold of the "inlier" to the west. However,

the available information about Musk-ox Fjord is too scanty to allow of further inferences. The folding, which is of a considerable extent, should be investigated in greater detail in Anker Valley and Granite Valley. South of Musk-ox Fjord, however, the Cape Graah Series seems to rest conformably on the lower beds.

The sandstone series of Mt. Högbom has been thrust steeply from the east over the conglomerates (fig. 12). This series consists of grey

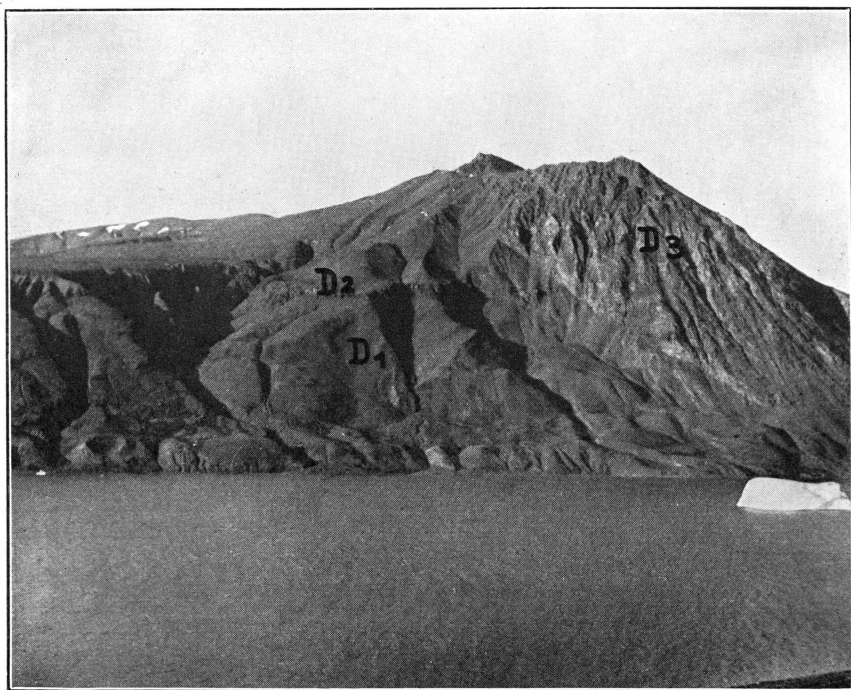


Fig. 12. The upthrust at Mt. Högbom, seen from the southwest.

D₃ = Lower grey, upthrust sandstone series of Mt. Högbom.

D₂ = Conglomerate from the base of the Cape Graah Series.

D₁ = Folded lower grey Devonian sandstone.

Devonian sandstones and is penetrated by dislocated diabases and granophyries as also by undisturbed younger basalts. On the eastern side of the mountain a remnant of *Remigolepis* beds rests disconformably on the thrust series dissected by faults. This upward thrust of Mt. Högbom is younger than the Cape Graah conglomerate but older than the *Remigolepis* series.

On the other side of the fjord, at Mt. Sederholm, the conglomerate rises vertically to the east. It is capped by a small doublefold of compressed red Cape Graah sandstones. Thus the red sandstones are here included in the folding. Opposite Mt. Högbom this southern folded area is displaced towards the west. The bend of the fjord possibly coincides

with a transverse displacement of the fold. The unequal development on either side of the fjord has some connection with the axial rise towards the north as well as with the stiffening resistance offered by the "inlier" in the northern part.

The continuation of the fold in the northeastern end of Mt. Sederholm is visible below the *Remigolepis* series in Mt. Circus. So far nothing is known about the further course of the fold either to the south or the north. At about 1200 m altitude at Mt. Sederholm the tilted beds of the Cape Graah Series are covered by horizontal grey sandstones. It is the light grey beds below the *Remigolepis* Series which together with a basal conglomerate have transgressed across a partially denuded fold. The time of the folding can thus be fixed even more precisely than at Mt. Högbom, viz. it has taken place between the deposition of the red Cape Graah Series and the middle grey series of KULLING.

Towards the lower parts of Karin and Parallel Valleys the folded beds of Mt. Sederholm dip towards a syncline, to rise again into an arch in Mt. Ramsay. On the north side of Mt. Ramsay the lower Devonian series with their conglomerates and eruptives crop out again, though the Eleonore Bay Formation and the sub-Cambrian tillites are nowhere exposed.

From Mt. Sederholm in the southern part of Long Mountain (see map 20) feeble foldings can be observed in the *Remigolepis* beds. The movements that have folded the various Devonian series in the Musk-ox Fjord area seem to have continued to the close of Devonian times. Since in this region the age of the folds decreases in the direction from west to east, the stronger Carboniferous movements must be looked for farther east.

On the east side of Mt. Högbom and Mt. Ramsay a fault zone extends at acute angles to the folds. It was assumed by ORVIN, but ascertained with certainty by BACKLUND. According to BACKLUND's map, Devonian and Carboniferous beds have subsided into through faults. On the east side, in Mt. Anker, quartzites of the Eleonore Bay Formation with Caledonian granites and migmatites crop out. According to BACKLUND's map this zone of Caledonian rocks continues into Mt. la Cour. Conditions are, however, possibly rather complicated (3, p. 54). The sliding and folding of the Devonian series of Mt. Ramsay and Mt. Sederholm has no doubt some connection with the movements of these crystalline areas. Probably here too, in the eastern part of Gauss Peninsula, a basement fold thrust towards the west will appear. This has repeatedly been elevated, eroded, and again covered with sediments. The axial upheaval at Mt. la Cour is possibly greater than at the fold of the inlier in the western part of the fjord. Here, in the eastern part of the fjord, the intricate tectonics of the lower levels are exposed, and the

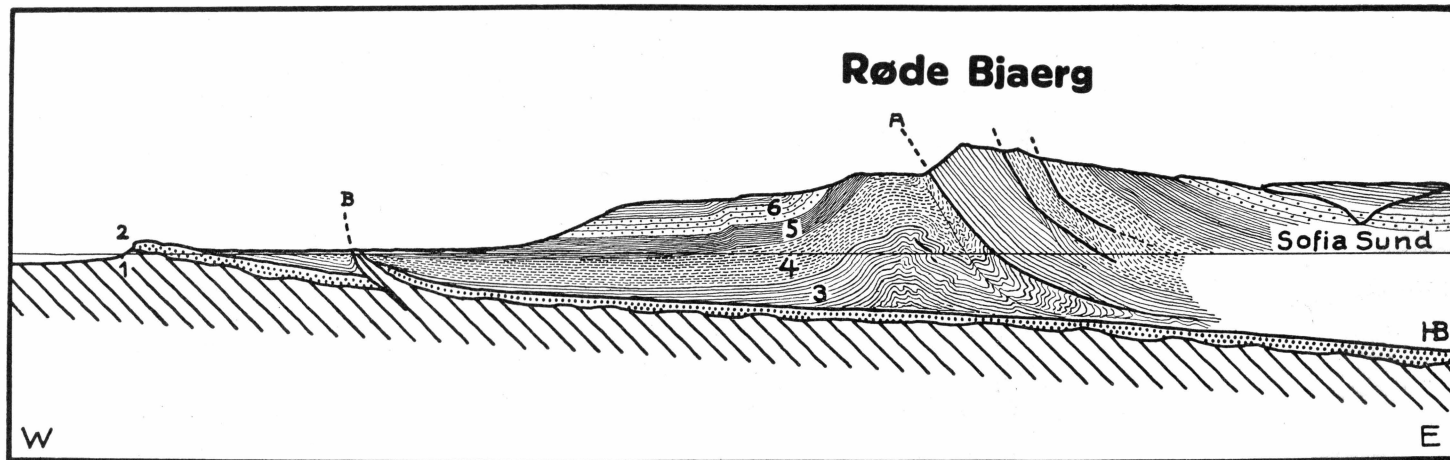


Fig. 13. Cross-section of Røde Bjærg.

- 1 = Caledonian folded substratum of the Devonian.
2 = Devonian basal conglomerate.

- 3 = Shaly grey sandstones.
4 = Brown banded sandstones.
5 = Red sandstones.
6 = Whitish sandstones.

} Lower grey and
Lower red sand-
stone series.

- A = Main thrust plane.
B = Limestone slice of the upper Eleonore Bay Formation.

investigations by SÄVE-SÖDERBERGH are therefore tectonically of very great importance.

4) The folding zone between Dusén Fjord and Kongeborgen.

A narrow folding zone about 75 km long extends from Dusén Fjord through Mt. Angelin, Mt. Røde Bjærg, Swedenborg, and Kongeborgen (fig. 10). Its position in the vicinity of the western edge of the Devonian area is probably due to the resistance which the edge of the Caledonian

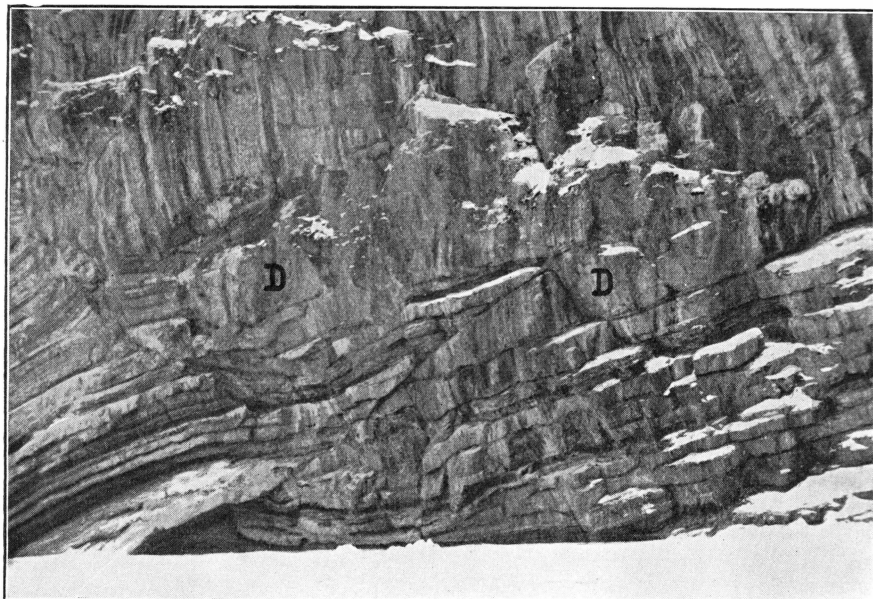


Fig. 14. Small wedges in the Devonian substratum (Dolomite Point Formation) and in the Devonian basal conglomerate, formed by the late-Devonian or early Carboniferous folding activities, at the western edge of the Devonian basins. North coast of Gunnar Andersson Peninsula.

D = Devonian basal conglomerate.

basin has offered to the Devonian top series that has been forced towards the west. The continuation of the crystalline arch from the Musk-ox Fjord inlier towards the south must here occur at a very low level or have been flattened out. Otherwise the resistance in the deep would have been reflected in the later shearing of the beds.

The sandstones of this southern folding zone are all older than the Cape Graah Series. On the basal conglomerate rests a greyish-greenish, often shaly and very micaceous sandstone series. To the east, in the interior of the basin, it attains a considerable thickness. It is overlain by red and brown banded sandstone of varying intensity of colour. This red series builds up Mt. Røde Bjærg, Mt. Swedenborg, and the upper

part of the rock wall of Kongeborgen. It attains its greatest thickness in Mt. Swedenborg; to the north, east, and south it passes gradually into a grey sandstone. East of the folding zone red sandstones are again met with in flat synclinal troughs at higher levels; only these correspond to the Cape Graah Series.

The lower red sandstones in Mt. Røde Bjærg, on the northern bank of Sofia Sound, form an anticlinal fold, the core of which consists of much compressed grey sandstones and shales of the lowermost grey series (fig. 13). The slide of the series took place in these grey shales, as also observed by WEGMANN. However, thrust planes occur also at the higher

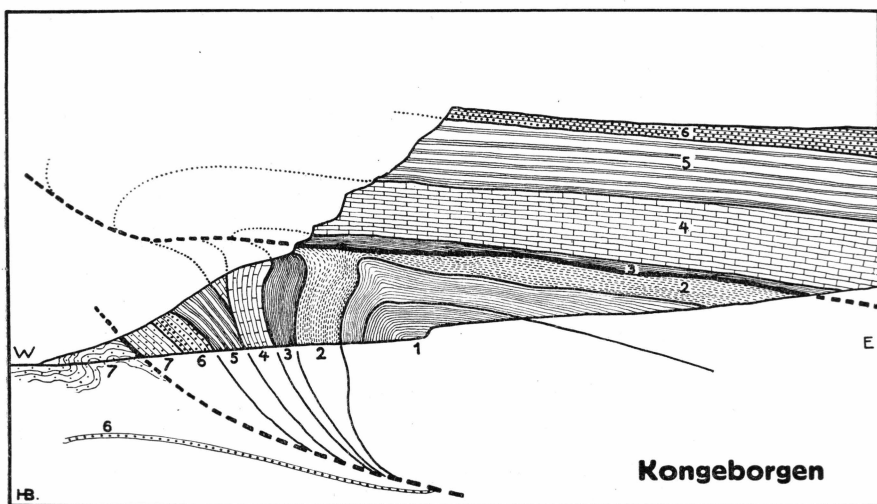


Fig. 15. Cross-section through the middle part of Kongeborgen.

1—7 = Varicoloured sandstones of the lower grey and the lower red Devonian series.

levels. The fold has been covered from the east by the disrupted and steeply tilted red and brown banded series. Here a similar picture is displayed as at Mt. Högbom: The fold of Mt. Røde Bjærg runs across the southern part of Ymer Island as far as Dusén Fjord, whereas the overthrust disappears north of Mt. Angelin.

KOCH observed that the folding zone on the south side of Sofia Sound is broader and more complicated than on the north side. It is possible here to draw some parallels with Musk-ox Fjord. In both places the movement on the north side of the fjord manifested itself in the elevation of a huge Devonian series of strata. On the south side, however, several folds developed, which extend farther westward than the overthrust. In both fjords a horizontal displacement, striking approximately east-and-west, must be found. The folding zone consists to the south of Sofia Sound of several anticlines incumbent to the west. The series

affected from the east moved across several thrust planes and were subsequently folded up. In this way the structure of the folding became somewhat complicated. At the south end of the steep wall of Mt. Swedenborg a small tear-fault can be observed, the southern limb of which has again been thrust forward.

In Kongeborgen, above the level of the fjord, only a single anticlinal fold overfolded to the west can be ascertained. The normal limb of the fold has been cut off and forced towards the west (fig. 15). The thrust-plane is traceable from Vega Sound through the whole northern half of the wall of Kongeborgen (fig. 16). To the south the axis of the fold strikes into Kong Oscar Fjord, and the disturbances of the beds cannot therefore be traced farther.

The continuation of Narhval Sound corresponds to a pronounced axial depression in the Kongeborgen fold. In the southern part of the rock wall of Kongeborgen the Devonian crops out, and the lower, very micaceous grey sandstone series appears below the large talus cone at sea-level. In the southern part of the coast it is intricately folded, while the high wall above exhibits a very simple bedding. Probably the lower levels which were succeeded by the shearing of the Devonian overthrust beds appear at sea-level. The measurements in the folding zone, however, furnish distinct evidence of two almost opposite directions of pressure, one of which has acted approximately in a north-and-south, the other in an east-and-west direction.

The high southern wall of the Kongeborgen is dissected by large parallel ravines. These have developed on planes of cleavage, which strike in a nearly south-southeast direction and dip 40° towards the south (fig. 17). On closer examination the northernmost of these ravines turns out to be a thrust-plane. The southern part of the sandstone series has been thrust obliquely upwards some 300 to 400 m. The thrust is further indicated by a basalt bed extending through the whole rock wall, which is disrupted at the thrust-plane, but appears again some hundred metres higher up the wall, whence it continues undisturbed towards the south. The greatest upheavals in Kongeborgen occur in this southern upthrust part.

The age of the various movements within the area in question alone cannot be more precisely fixed, since the upper Devonian series is lacking. The folding and thrusting traceable from Ymer Island to Kongeborgen have resulted from the westward directed pressure, which has folded the Devonian area into broad troughs and arches. Thus the folding is entirely late-Devonian or early Carboniferous. The transverse fold in the southern part of Kongeborgen, however, must be much younger. The not brecciated basalts within the Devonian area have hitherto been referred to the Tertiary. The vertical dyke from which issues the flat

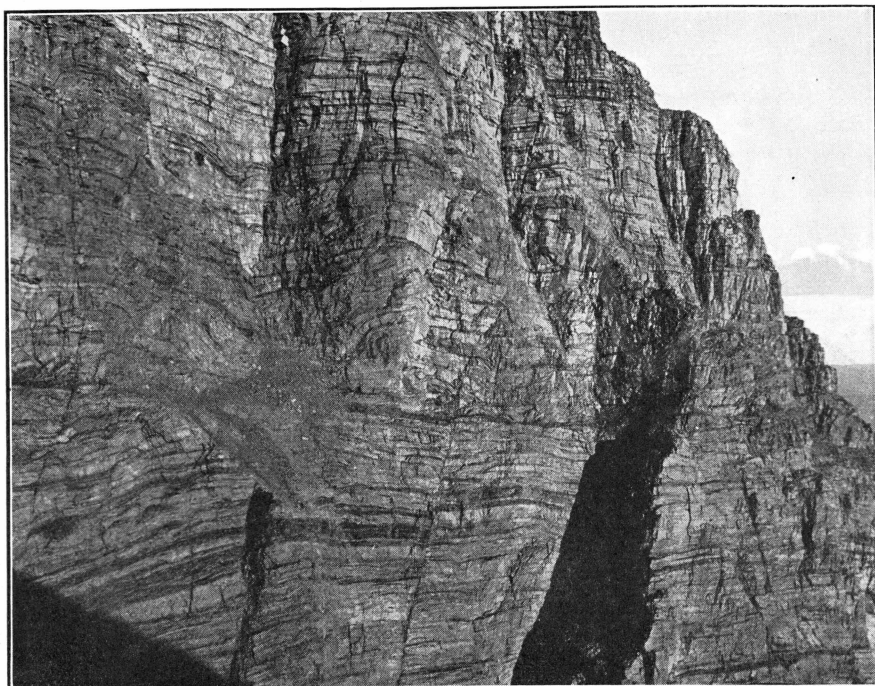


Fig. 16. The thrust-plane in the northern part of the rock-wall of Kongeborgen.

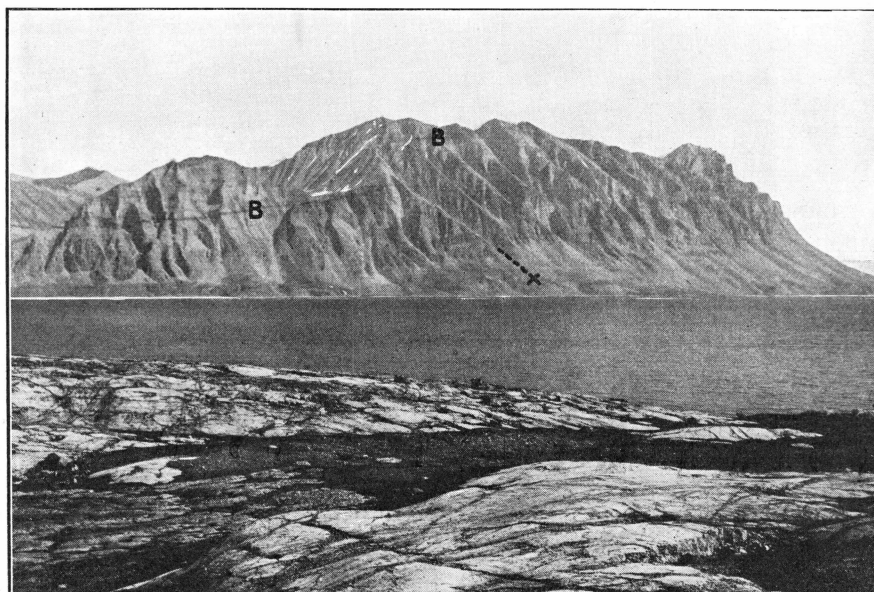


Fig. 17. The large ravines and the upthrust in the southern part of Kongeborgen.

B = Basalt dyke; +---- Thrust-plane.

sill at Kongeborgen, follows a broadened cleft-direction within the area. The origin of these clefts must also have connection with a movement. The observed overthrust is younger than the basalt, but older than the faults which cut off the Devonian beds at the south end of Kongeborgen.

VI. CONCLUDING REMARKS

Koch (6, p. 289) rightly compared the sediments of the East Greenland Devonian with the Alpine Molasse. It will be obvious from the above that the Old Red of East Greenland is an orogenic sediment. The movements acting in the direction east-west within the eroded Caledonian Folding system repeatedly elevated, folded, and disrupted the Devonian sandstones during deposition. The oldest movements in Musk-ox Fjord took place during the deposition of the lower grey series, and the same applies to the main eruption of the quartz-porphyrries. The position of this series within the Devonian has not yet been established with certainty. It has been attempted to draw parallels with the Wegener Peninsula, where according to the most recent results of NOE-NYGAARD and EKLUND the porphyries of the Cape Fletcher Series are also Devonian and apparently belong to the folded upper Middle Devonian. Contrary to this view, however, it is held by SÄVE-SÖDERBERGH that all the sandstones in the northern area are Upper Devonian (20, p. 48). The younger folding activities at Mt. Högbom—Mt. Sederholm are doubtless Upper Devonian, since the age of the Cape Graah and the *Remigolepis* series has been unanimously fixed. These late-Caledonian folding movements in Devonian times continued through part of Carboniferous times. At the end of the Devonian or at the beginning of Carboniferous times the sandstones south of Musk-ox Fjord were folded into broad arches and troughs. Towards the western edge of the basin there developed as a consequence a number of unsymmetrical folds and overthrusts in the slided sandstone series. Because the folding of the southern area is younger, the considerable stratigraphical disconformities within the Devonian series disappear southward from Gauss Peninsula. The movements seem to have originated in the crystalline area, at present partially subsided and covered by younger sediments, at the outer coast. FREBOLD was the first to suggest that the covering of this eastern area with younger sediments must have preceded an upheaval with subsequent erosion. The mechanics of the movement, however, are of an essentially different kind from those stated by FREBOLD (5, pp. 84, 90). Also as regards time the movement should

be given another place than that assigned to it by FREBOLD on the basis of STILLE's folding phases.

Through KOLDERUP's investigations (10,11) tectonic complications within the Devonian are also recorded from the west coast of Norway, where KOLDERUP found the Devonian beds to be penetrated by keratophyries, and overthrust of Caledonian gabbro masses, the thrusting of which he regards as late-Caledonian. Possibly the conditions in the East Greenland Devonian may furnish a clue to the origin of the overthrusts in the Devonian of Norway.

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