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UNDER LEDELSE AF LAUGE KOCH

STRATIGRAPHICAL OUTLINES OF
THE AREA ROUND FLEMING INLET
(EAST GREENLAND)

BY

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WITH 21 FIGURES IN THE TEXT AND 2 PLATES

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If no special information is given, the figures are photographs and sketches made by the author.

I. INTRODUCTION

During the Danish expeditions to East Greenland in 1929 and 1930 various attempts were made to visit the three outer fjords of the south coast of Davy Sound, but owing to bad ice-conditions the attempts had to be given up. The year 1931, however — the first year of the Danish three-year investigation of East Greenland 1931-1934 — at last brought success; Fleming Inlet was reached and an auxiliary station was built on the western shore of Wegener Peninsula¹).

With this station, "Vimmelskaftet", as a base the geological and other field work recorded below was carried out, partly during the fall of 1931 and partly in the spring of 1932. The actual winter months, November to March, were spent at Ella Island, the southern headquarters of the expedition.

Fleming Inlet, however, was reached late in the season, at the end of August. As the house had to be built as soon as possible, the number of working days before the new ice put an end to excursions by boat was rather limited. During the first two weeks a Canadian canoe was used for small trips along the shore of Fleming Inlet, subsequently the geological excursions were made on foot. In order to get an idea of the topographical features of the area, six trigonometric stations were measured and a great number of photographs were taken, and in the course of the winter the main lines of the map were constructed at the Ella Island station, where also the corresponding photographs were prepared. The map constructed by J. P. KOCH represents only the coast lines, and although these must be said to be fully correct, the topographical features for geological mapping purposes had to be supplemented not only along the coast, but also as far inland as possible.

As may be concluded from the above, the excursions in the autumn of 1931 were restricted to the Wegener Peninsula. As in the month of

¹) Name proposed by the present writer in honour of the late Professor ALFRED WEGENER, who died during his expedition, on the inland-ice of Greenland, in the late autumn of 1930.

September there was only very little snow, the field work was comparatively easy; but a serious obstacle was afforded by the new-ice, which was removed several times by the wind and the pack-ice, and not until the last days of October, when the length of the day was only 4—5 hours, could the journeys by sledge begin.

After wintering it was my plan to start from Ella Island about the 10th of March, but owing to fog and driving snow the departure was postponed till the 16th March. Five days later the Vimmelskafte station was reached.

The work in the spring, from the 20th March to the 1st June, was executed on sledge-journeys; the last half of April and the month of May were especially favourable for geological work. During the whole investigation I was assisted by the Greenlander JØRGEN PETERSEN, the elder of the two Greenlanders of the Ella Island station, a very skilful sledge-driver.

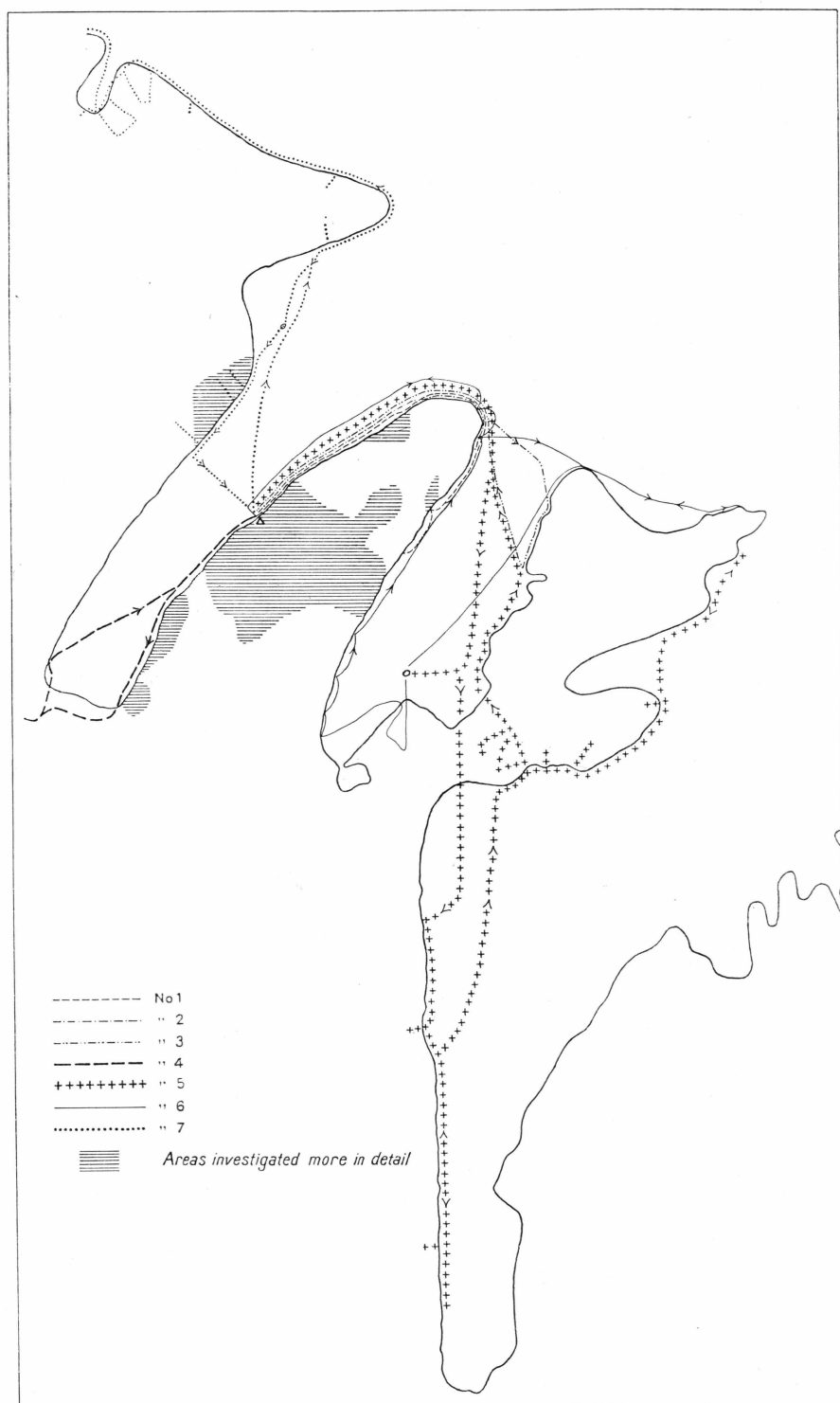
However, to give an idea of the conditions under which the work in the spring was carried out I may say a few words on the equipment, the travelling routes, and the snow conditions.

The sledge was of the common West Greenland type, and the number of dogs varied from 11 to 7. Further, Swedish hickory skis were used. A traveller's tent, cooking-equipment, provisions for men and dogs, and the geological collections were transported on the sledge, which was driven by the Greenlander, while I generally went ahead on skis.

The field work in the spring, apart from some small excursions in the neighbourhood of the station, was executed on the following eight journeys (cf. fig. 1):

- 1) 24th to 26th March: Sledge journey to Komait and Calamites River. Owing to the deep snow in these localities no reliable sections could be measured.
- 2) 28th to 31st March: Cape Brown. Here practically only the steep walls along the coast were accessible.
- 3) 1st to 5th April: *Via* Cape Brown to "Porfyrfjeldet" on the west coast of Canning Land. Because of a snowstorm lasting for three days, little more than one day could be spent in the investigation of this very interesting locality.
- 4) 6th to 20th April: Three excursions to the innermost parts of Fleming Inlet. Here two sections were measured and a visit on skis was paid to the two great valleys debouching into Fleming Inlet.
- 5) 23th April to 9th May: A journey to Scoresby Sound and back.

On the 20th of April three sledges from Scoresby Sound under the command of Mr. HØEGH, the governor of the colony, arrived at the Vimmelskafte station in order to assist in taking the collections



of samples and fossils already secured to the Scoresby Sound colony. There they might be fetched by ship if Fleming Inlet should be ice-bound during the summer of 1932. In the course of this journey investigations were made and sections were measured from Dépôt Island in Nathorst Fjord to Mt. Skansen in Klitdalen. Casual observations were made in the river bed of Ryder Elv and on the northernmost of the Fame Islands. In the colony of Scoresby-Sound a stay of almost a week for rest and completion of dogs was necessary; the collections were also packed for transport to Copenhagen. The journey back to the head of Nathorst Fjord was favoured by fine snow for sledge-driving. The 7th and 8th May were spent at Cape Fletcher and along the east coast of Canning Land. As provisions were running short, the return journey to the Vimmelskaftet had to be advanced to the 9th May; this time we drove along the west coast of Canning Land in order to get an impression of the stratification there.

- 6) 13th to 17th May: From Vimmelskaftet via Cape Brown and Cape Tyrrel¹⁾ along the north coast of Canning Land to Cape Wardlaw, and thence the same way back to Cape Tyrrel and down through Nathorst Fjord, *via* Dépôt Island to Mt. Nordenskjöld, where a section was measured. On the way back the east coast of Wegener Peninsula was examined from Mt. Quensel¹⁾ to Cape Brown.
- 7) 19th to 23th May: The area between Fleming Inlet and Antarctic Harbour and the igneous rocks at Cape Syenite²⁾.
- 8) 23th to 26th May: The west coast of Fleming Inlet and the small island in front of the Ørsteddal.

The 28th May we started for Ella Island; the rivers had now begun to flow everywhere, and large accumulations of water on the ice almost prevented further geological work. Still one section was measured, *viz.* on the east side of Antarctic Harbour.

On the 1st June we reached Ella Island.

In March and the first half of April, in particular, there were heavy snowfalls; the valleys on Wegener Peninsula and at the head of Fleming Inlet were almost filled, and it was only possible to get in touch with the backland on skies. Later on conditions considerably improved. On the whole the most unfavourable conditions were met with along the east coast of Canning Land, where the pack-ice pressed closely against the shore and all depressions and valleys were filled with deep and

¹⁾ Name proposed by the present writer.

²⁾ Name proposed by LAUGE KOCH.

powdery snow, consequently the work in these places was limited to the coast proper. On the 8th May open water was met with at Cape Wardlaw, so we had to return over the low strip of land connecting Canning Land with Jameson Land, to Nathorst Fjord.

In Carlsberg Fjord and south thereof the snow was blown hard and especially fine for sledging.

It hardly needs mention that during the melting of the snow the water on the ice impeded travelling to some extent.

In consequence of what has been said above the investigations do not claim to be very exact; as a rule only the rough features were traced; and in order to facilitate the general view of conditions, I have drawn the main lines of geology on the accompanying map (pl. 2).

The district may be divided into two rather different areas, *viz.* the northern part of Jameson Land in the south, and the two peninsulas, Canning Land and Wegener Peninsula, in the north.

Geologically the northern part of Jameson Land comprises the country extending from the head of Carlsberg Fjord northwestward to the head of the two fjords, Fleming Inlet and Nathorst Fjord, and the area west of Fleming Inlet to Antarctic Harbour.

The following chapters will furnish a description of the stratigraphical units represented within the area, beginning with the oldest and passing upwards to the youngest ones, the areal distribution of each being considered. A brief discussion of the old basement of the sedimentary formations will precede the main description.

II. PREVIOUS INVESTIGATIONS

The district treated in the following pages comprises the coast strip between Antarctic Harbour (c. 72° N. lat. 23° W. long.) and the head of Carlsberg Fjord (c. $71^{\circ}15'$ N. lat. $22^{\circ}30'$ W. long.), and forms the southern coast of Davy Sound, East Greenland.

During the last 35 years the east coast of Greenland has been visited by a number of scientific expeditions, but owing to the heavy pack-ice accumulating in the mouth of Davy Sound the visits and landings within the district in question have been short and few.

To give an impression of the general results arrived at by earlier expeditions, an outline of their investigations in chronological order will be given below.

In 1899 A. G. NATHORST, on his famous research of the Franz Joseph Fjord system, coming from the inner fjord districts arrived at Antarctic Harbour, the southeasternmost point. He did not succeed in reaching the open sea through Davy Sound, as was his plan, because the winter ice lay unbroken in the outer parts of the fjord. But here NATHORST himself made some geological observations and secured a small collection of fossils. On his geological map of East Greenland NATHORST (23, p. 274) tentatively expresses the opinion that the whole country to the west as well as to the east of Antarctic Harbour is made up of Jurassic sediments. As stated above, Fleming Inlet, Nathorst Fjord, and Carlsberg Fjord, the main subjects treated in this paper, were not visited by the Nathorst expedition.

The dotted coast line on NATHORST's map indicating the approximate position of the south coast of Davy Sound east of Antarctic Harbour was completed as early as the following summer — 1900 —, when the topographical mapping was carried out from Murray Island to Antarctic Harbour by J. P. KOCH, a member of a Danish expedition under the leadership of N. HARTZ. Together with the topographical work geological studies were made by O. NORDENSKJÖLD and N. HARTZ; the westernmost point visited by the expedition was Segelsällskapet Fjord. These

first geological field works within the district in question may be summarised as follows (cf. 25, p. 151—285).

The expedition stayed for two days in Fleming Inlet and made several landings and excursions, especially in the innermost part of the fjord — the surroundings of the entrance to Pingel Valley — and along its western shore. Short stays were also made at Cape Brown and Cape Fletcher, whereas Nathorst Fjord does not seem to have been visited (25, p. 184). In spite of the short time at the disposal of the geologists, the results arrived at were important.

Thus NORDENSKJÖLD on his geological map gives a good deal of new features in the structure of the area. Along the western side of Antarctic Harbour he marks an older series of sediments than those on the eastern side. At Cape Brown a series of sediments — “Cape Brown-Hurry Inlet series” — has been referred to the Triassic, and on Canning Land another series of sediments (and magmatites) has been designated as Palaeozoic — the “Cape Fletcher Series”.

In order to avoid confusion in the following it should be pointed out here that within the “Cape Fletcher Series” NORDENSKJÖLD comprises the Palaeozoic sediments as well as the magmatites penetrating them at Cape Fletcher, whereas later LAUGE KOCH (14, p. 119–124) speaks of the “Cape Fletcher Series” as comprising magmatites alone. Since the sediments belonging to this series have now with some degree of certainty been fixed in the stratigraphical table of East Greenland, there seems to be no reason to maintain a special term for the sediments in this area; thus the use of this term may henceforth be restricted to the magmatites, as proposed by KOCH.

Cape Fletcher, it is true, is not the locality where these rocks were first met with, but at Cape Fletcher this series was first defined stratigraphically and its members were characterized chemically.

The stratigraphic members classed by NORDENSKJÖLD and HARTZ may most conveniently be summarized in the following way:

1) Rhaeto-Jurassic formations (25, p. 185). These beds consist mainly of sandstones and subordinate schists. Limestones are of sparse occurrence, or lacking. The colour is always light, grey or yellow. Generally rich in fossils.

2) Triassic system:

A. Younger Triassic division: These beds were not examined *in situ* by NORDENSKJÖLD himself, but were met with by NATHORST (23) in Ryder Elv. Overlying a series of red, white, and green sedimentary rocks he found here a ruddy sandstone and a calcareous conglomerate, which he tentatively referred to the Keuper on account of their petrographic character and colour. The beds underlie the Rhaetic strata.

B. Older Triassic division (“Fleming Inlet series”): The petrographical description (25, p. 176) runs as follows: “The rocks themselves have, in the main, a rather young appearance. We find yellowish grey, and more or less bright red

sandstones, red, green, and black schists, and dense, hard, grey and red, also dark, limestones. "And further: — — —" at times there occur both red and green, loose, very likely calcareous, sandstone schists, which at the surface of the strata are resplendent with mica-scales."

- 3) Permian or lowermost Triassic system ("Cape Brown-Hurry Inlet series"): Of the beds from Cape Brown NORDENSKJÖLD gives the following petrographical characterisation: "There were mighty banks of red and green schists, sometimes compact and more hornstonelike, but as a rule well characterized by the plentiful presence of a micaceous mineral which gives the surface of the strata a vivid sheen." — — — "The green rock here seems to consist of angular grains of quartz, while plagioclase and other minerals are less abundant, with lamina of muscovite and green chlorite or chloritic biotite, cemented by a strongly doublerefractive carbonaceous mass."

In this locality there was further found a conglomerate containing a great variety of balls, i. a. different kinds of multicoloured porphyries and porphyrites, which NORDENSKJÖLD assumed to belong to the magmatites at Cape Fletcher.

From Hurry Inlet the above-mentioned beds underlying the Keuper and the Rhaetic as described by NATHORST are supposed to be of the same age as the beds from Cape Brown.

- 4) Palaeozoic system ("Cape Fletcher series"). The sediments here consist mainly of hard, dolomitic limestones of a grey or black colour, often with a very fine oolitic structure. Characteristic is further a coarse, light-grey dolomite breccia. Besides the limestones, coarse, red sandstones with bright spots, and fine-grained, also red, micaceous sandstones were met with. The sediments are penetrated by magmatites, presumably of Palaeozoic age ("Cape Fletcher series" in the sense of KOCH).

In the following chapters a fairly great number of references will be made to the valuable work of NORDENSKJÖLD (25), and part of his petrographical descriptions of various rock-types will be touched upon too in connection with observations made by the present writer.

It was not until the autumn of 1926 that this highly interesting area was again visited by geologists. During a sledge-journey from Scoresby Sound to Mackenzie Bay LAUGE KOCH carried out geological investigations on the east coast of Wegener Peninsula. Despite the increasing darkness and deep snow he succeeded in bringing back very valuable collections of Lower Permian age — later worked out by Professor H. FREBOLD (5) — from a locality which he named "Komait", south of Cape Brown in Nathorst Fjord.

In May, 1927, Dr. T. HARRIS, too, stayed for some days at "Calamites river" on the east coast of Wegener Peninsula north of Komait. During his stay there HARRIS discovered plant-bearing beds of Carboniferous age beneath the marine Upper Carboniferous and Lower Permian deposits (14, pp. 98—99).

Koch's great sledge-journey in the spring of 1927 and his working out of the geological map between Scoresby Sound and Danmark Havn

(14) gave the main structural features also of the district in question. As may be seen from the map (*op. cit.*), the Palaeozoic sediments and igneous rocks considered to belong to the Cape Fletcher series are restricted to the two peninsulas, Canning Land and Wegener Peninsula, while the whole hinterland together with the coastal area between Antarctic Harbour and Fleming Inlet is marked as younger.

In a summary of the Permo-Triassic beds between Hurry Inlet and Antarctic Harbour KOCH (14, p. 111) gives the following stratigraphical sequence of the sediments. To these have been added some petrographical data derived from another work of KOCH (15). Finally, a description of the Carboniferous beds will be given:

- 1) Cape Stewart formation (Rhaetic): This series includes grey, yellow and green sandstones, in the upper portion alternating with shales. Locally small quantities of limestone occur; to the south, coarse quartzitic conglomerates may be found. Cross-bedding may be met with throughout the whole series.
- 2) Klittdal formation (perhaps Keuper): These strata are described by ROSENKRANTZ (28, pp. 140—142). Red beds are predominating; at the base there is a conglomerate with pebbles possibly derived from the Cape Fletcher series. Above come clay-shales and mud-cake conglomerates with gypsum, and finally a series of purple marl beds interstratified with bands of limestone and light sandstone.
- 3) Cape Biot formation (Triassic): Very hard, strongly coloured sandstone is the main constituent of this formation.
- 4) Mt. Nordenskjöld formation (Permo-Triassic): The strata consist predominantly of grey sandstones, with two beds of strongly red-coloured sandstone.
- 5) Depot Island formation (possibly Permian): Predominating sandstone of a red colour. The series begins with a white conglomerate, containing pebbles referred to the Cape Fletcher series; interbedded in the sandstones are shaly sandstones and thin conglomeratic beds. The series terminates with grey shaly sandstone.

Then follows:

- 6) Marine Upper Carboniferous: Limestone, partly light, partly dark and bituminous. In some places the limestone has been converted into dolomite.
- 7) Continental beds of (Lower?) Carboniferous age: Light sandstones; in some places coarse conglomerates and black shales occur.

As to the age of the Cape Fletcher series, in a restricted sense, KOCH (14, p. 124) says: "In my judgement they have been ejected on the transition between Carboniferous and Permian, and have possibly been associated with faulting".

III. PRE-MESOZOIC ROCKS

1. The crystalline basement complex at Cape Wardlaw (Canning Land).

Crystalline rocks are seen to build up the coast some kilometres southwest of Cape Allén, at the mouth of the small bay — Aalborg Fjord —, which strikes SW. and debouches into Carlsberg Fjord, further Cape Allén, Cape Wardlaw, and the eastern shores of Aarhus Bay, i. e. the northeastern corner of Canning Land as well as most of the country inland (Mt. Bowen¹). The mountain-mass of Cape Wardlaw is more or less separated from the main part of the crystalline area by a rather large, glacier-filled valley.

Above the crystalline complex, partly along the north coast of Canning Land, partly in the Aalborg Fjord, a rather uniform dark-grey or reddish series of sediments can be seen, the great similarity of which to the Devonian sediments of the Wegener Peninsula (see below) and the supposed Devonian in the southern part of Canning Land is very conspicuous.

The crystalline rocks of the area are light-greyish granites, sometimes with a faint reddish or pink crust of weathering. The whole mass has a very well developed slaty structure dipping towards the north. The strike, being almost E.—W., together with the dip of the slab-planes was measured in several localities. So the dip a little to the south of C. Allén was found to be 52°—55° N.²), at the most easterly point of C. Allén 75°—80° N., and to the south of C. Wardlaw 70° N. At the northern end of the area conditions are of quite a similar character, but the strike is here N. 40° W., the dip was measured to be 70° NE. The main rock, varying but slightly from place to place, is a light-grey biotite-granite with about medium-sized grains. In the otherwise

¹) Named by the present writer in honour of Dr. N. L. BOWEN of the Geophysical Laboratory of Washington.

²) A correction for deviation of 35° W. has been used.

rather uniform main rock a number of rounded lumps rich in dark constituents were found, the diameter of which did not exceed 2—3 cm. Besides these some “foreign”, well rounded inclusions — phyllite? — up to a size of 30—40 cm were met with in the northern part of the area. At the contact with these the enclosing rock develops concentric zones, the inner zone thus being quite dense or fine-grained, the outer zones successively acquiring an almost normal grain-size. Along the northern boundary greyish white aplitic masses, very poor in biotite, were traced.

The main rock consists of *microcline*, *acid plagioclase*, *biotite*, *quartz*, and the accessories: *apatite*, *zircon*, *titanite*, and *iron ore*; further sparse *amphibole* was found in a single slide.

A preliminary examination of a few slides gives allowance for presenting a few data concerning the minerals characteristic of the rocks in question:

Microcline: Often large patches of irregular outlines and rather highly decomposed; smaller grains are fresher, and perthitic structure is here generally well developed. *Plagioclase*: The generally idiomorphic crystals are to a great extent converted into sericite, especially in the central core. Zoning is of common occurrence. The composition has been measured in five slides (in sections $\perp$ PM) to 28—35 % An. Plenty of myrmekite along the contact with the potash-felspar. *Biotite*: Big, sharply pleochroic (reddish-brown to light-yellow), often irregular flakes, somewhat altered into chlorite, dominate. The flakes are often somewhat bent at their ends; along the cleavages and at the ends there are a great number of small titanite-grains. As inclusions apatite, zircon (without pleochroic haloes), and iron-ore are of common occurrence. *Quartz*: Generally irregular and dissected grains with undulatory extinction and sometimes with mortar-structure. Further, small grains of vermicular quartz are met with in the potash-felspar. *Amphibole*: Only met with in a single slide. Light-green to colourless, partly occurring as nearly idiomorphic crystals surrounded by biotite, sometimes with multiple twins (100), partly as small grains sparsely scattered all over the slide. *Apatite*: Small idiomorphic crystals abundant. *Titanite*: As mentioned above mostly occurring along the ends of the biotite flakes, pinkish pleochroism very weak or absent. *Zircon*: Small grains without pleochroic haloes. *Iron ore*: Especially in the biotite flakes.

Darker grey, mottled rocks of this series containing considerable quantities of mafic constituents, especially a common hornblende (cf. above), are poorer in potash-felspar and approach diorites.

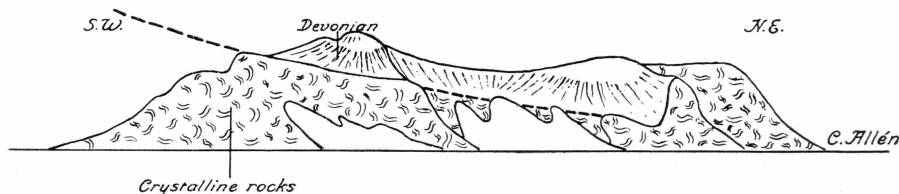


Fig. 2. North coast of Aalborg Fjord, Canning Land, seen from the south.

The boundary between the crystalline complex and the superposed sediments is seen along the north coast of Aalborg Fjord. It seems to be a plain, sloping gently towards the northeast, with a somewhat steeper dip at its eastern end, cf. fig. 2.

On the north coast of Canning Land, in Aarhus Bay, the depression marking the boundary between the crystalline basement and the sediments along the coast is occupied by a small glacier and therefore not accessible.

The fairly uniform rocks of this small area, which may most conveniently be termed the "Cape Wardlaw Complex", seem to be of quite another type than those of the previously known Cape Fletcher series (BÄCKSTRÖM (23), NORDENSKJÖLD (25), CALLISEN (14)). Among boulders collected in the talus at Cape Wardlaw some other types of rocks were observed; they are, however, reminiscent of some magmatites of the crystalline area of Liverpool Land, reconnoitred in the course of the geological work during the summer of 1933.

The boundary between the crystalline rocks and the sediments conveys the impression of a regular superposition. Hence the present writer concludes that the rocks of Cape Wardlaw belong to the unit of crystalline rocks of Liverpool Land; in other words, the Cape Wardlaw Complex may be interpreted as a northerly prolongation or outlier of the great crystalline area building up this part of the coast zone of East Greenland, which LAUGE KOCH has classed as belonging to the Caledonides. This area, at any rate, constitutes the basement of the Devonian.

A further study of the contacts and of the lower part of the Palaeozoic sediments probably of Devonian age on Canning Land is certainly needed in order to confirm the real superposition.

2. Devonian.

The main distribution of Devonian sediments in Old-Red facies development in East Greenland was already indicated by NATHORST on his geological map (23).

Later more detailed (or local) studies were published by L. KOCH (14), KULLING (18), ORVIN (26), SÄVE-SÖDERBERGH (31).

On the geological map of KOCH (14) the southernmost locality marked as Devonian represents the area between Mästers Vik and Syltoppene, along the north coast of Scoresby Land. Farther southeastward, as for instance in the district now under consideration, no Devonian sediments have been previously recorded.

A. General:

Within the present district strata referred to the Devonian occur in three distinctly different areas, *viz.* a) The central and southeastern part of Wegener Peninsula, b) Cape Brown, and c) Canning Land.

The formation is chiefly made up of red and greenish-grey sandstone layers. The sandstones may be coarse and arkose-like, or they may be fine-grained, thin-bedded sandstone-schists; the red as well as the grey, or greyish-green, ones are very rich in mica, lending to the bedding-planes a conspicuous lustre (cf. 25, p. 178). Intraformational conglomerates as well as conglomerates notably with pebbles of various types of quartzite, are common. Well preserved fossil rain-prints, sun-cracks, ripple-marks of varying amplitude, and portions with well defined cross-bedding may be met with throughout the series, especially in the fine-grained red sandstones. Under the microscope the grains prove to be sharp-edged; only very few rounded grains are seen. The main and dominant constituent is quartz; between the quartz grains large, somewhat bent, flakes of muscovite occur together with some plagioclase. Occasional grains of zircon and some iron-ore were also noticed. The cement is mainly carbonaceous and limonitic. Calcite also penetrates the rock in thin veins and occasionally forms secretions in large cavities between the other mineral grains. Plant remains are often met with in the grey sandstone-schists, but generally they are too strongly carbonized and consequently indeterminable. A fossil fauna (vertebrates) has only been met with at Vimmelskaflet, so the description of its mode of occurrence and state of preservation may be postponed till the special discussion of this locality.

a) The central and southeastern part of Wegener Peninsula.

The first impression of this area, seen from the sea, is that of a uniform red series; but embarking upon a detailed study, it soon becomes clear that the sediments are of a very variegated character. The upper steep mountain slopes along the coast are composed of red and grey, or greyish-green, sandstones in horizontal beds of greatly varying thickness. They alternate with black shales (cf. fig. 4), which on weathering assume a somewhat rusty colour. The shales are fossiliferous almost everywhere (see later); fossils are, however, also met with in some intraformational conglomerates of a greyish-green colour. Plant remains are only preserved in the grey members of the series. The lower parts of the sections consist of a uniform grey sandstone series, which crops out along the coast round Vimmelskaflet and southeast of this point. Subordinate conglomerate beds are met with in this lower grey series. Southwestward from Vimmelskaflet, as far as survey has been undertaken, similar

strata have been traced; their sections correspond broadly to those measured at the "Ravnefjeld"¹⁾-area in the vicinity of the station; the same seems to be the case with the strata of Mt. Quensel.

b) The Cape Brown area.

This area comprises the main part of the cape itself together with a small ridge southwest thereof striking northwest-southeast. Its southern boundary is well marked by the transverse valley of Calamites River. The upper half of the mountain consists of an alternating series of red and light-grey sandstone beds; towards the east and northeast the basal part of the mountain consists of magmatites with but few and rather strongly contact-metamorphosed remnants of sediments. On the west side, towards Fleming Inlet, the lower horizons are exposed right down to the sea; they consist of a series of alternating, coarse, grey sandstones and conglomerates, and resemble the lower part of the outcrops at Vimmelskaftet mentioned above. The pebbles of the conglomerates, with a maximum size of 35—40 cm, consist mainly of quartzites of varying colour, but also pebbles of granite and gneiss and of various limestones and dolomites were met with. Special attention was paid to boulders of a grey limestone with white calcite-veins, and of a yellow dolomite, highly reminiscent of some rocks of the upper portion of the Eleonore Bay formation occurring in the stratigraphical vicinity of the tillite. The nearest outcrops of these rocks were met with (1933) at Syltoppene, at the mouth of Segelsällskapet Fjord.

The small ridge to the south of Cape Brown, also referred to this area, consists to the west of grey sandstones and sandstone-schists with a single horizon observed to carry green clay-balls. In the talus red sandstone also occurs.

Nowhere within the Cape Brown area were fossils met with; yet the general character of its sediments and their great petrographical similarity to those of the former area suggest relationship in the very sedimentation act and broad identity in age.

c) The Canning Land area.

Investigations of sediments which may be parallelized with those of the former two areas have been carried out, especially in two places, *viz.* in the mountain Kollen at the base of the peninsula and at Cape Tyrrel at its northwestern corner. In Kollen two sections were measured, one at the south end and one at the north end. At the first-mentioned locality the mountain consists, from sea-level to about 130 m, of a grey sandstone, alternating with sandstone-schists of the same colour; above

¹⁾ Name proposed by the present writer.

follow red sandstones interbedded with the grey one; the upper portion of the mountain — to about 275 m — consists of a coarse, red sandstone with ripple-marks. In the sandstone-schists carbonized plant remains were of common occurrence, but no determinable fossils were met with.

The mountain to the east of Kollen, Hestekofjeldet, consists mainly of red sandstones interbedded with red sandstone-schists and thin bands of shale of a greyish-green colour.

At Cape Tyrrel there is a series of alternating red and light-grey sandstones, disconformably underlying marine Upper Carboniferous limestones (see below). Even if this series possibly pertains to the continental beds of Carboniferous age to which it shows a very similar habitus and colour elsewhere, it has been included on the map (plate 2) with the above-mentioned sediments, because strata similar to those were recognized in localities nearby, and because the Car-

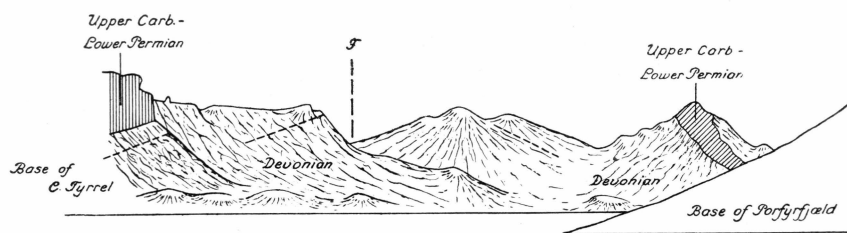


Fig. 3. Geological conditions at Snevigen, northwestern corner of Canning Land.

boniferous (see below) sandstones at Calamites River are quite different. The strata at C. Tyrrel are very fine-bedded and contain plenty of mica, exactly as the previously described types. No fossils were met with here.

As to the other parts of Canning Land only scattered observations are at hand.

Thus at the southernmost part of the east coast — Cape Fletcher itself — sedimentary rocks of the type hitherto described crop out below a limestone referred to the marine Upper Carboniferous (see below). These sediments have suffered a great deal from the igneous intrusion pertaining to the Cape Fletcher series (see later), i. e., they are intersected by an actual net-work of various dykes. The sediments in question are dark-green sandstones and sandstone-schists, generally rich in calcite- and quartz-veins; sometimes they are brecciated throughout. Nevertheless some primary features, such as ripple-marks, are easily recognizable.

The same beds seem to constitute the base of the mountains along the south coast of Aalborg Fjord; their upper boundary with the above-mentioned limestones (of Upper Carboniferous age) is very irregular, cf. fig. 8.

The mountains encircling the head of the fjord and bordering the north coast seem to consist of sediments belonging to the same series. Some kilometres to the southwest of C. Allén the supposed crystalline basement, i. e. rocks of the Cape Wardlaw Complex, disappears below the coast line.

Along the north coast of Canning Land, in Aarhus Bay, the same types of sediments as in Aalborg Fjord are met with. Here, too, calcite- and quartz-veins intersect the sediments. The same dark, greenish colour predominates along the coast, while more reddish tints seem to prevail in the backland.

As a little appendix to the first area there are three minor outcrops on the northern side of Tvekegle Valley, to the north of Ravnefjeld. Their strata are very similar to the upper parts of Ravnefjeld, i. e. alternating red and grey, micaceous sandstones; the shales mentioned at the former locality seem, however, to be lacking. These sediments are directly superposed by marine Upper Carboniferous and Lower Permian, and the geological position is therefore likely to be parallelized with conditions in Ravnefjeld, since everywhere within the area between Calamites River in the east and the high central parts of Wegener Peninsula in the west marine Upper Carboniferous beds otherwise rest directly upon strata belonging to the continental beds of Carboniferous age. No fossils were found in these localities.

B. Geological position:

The greatest altitude — 700 m — is attained by the strata investigated in Ravnefjeld; from here their surface slopes downwards towards the southwest. In the creek midway between Lagunenæsset and the entrance to Pingel Valley the Palaeozoic strata are bounded by a fault. At this southernmost locality the altitude of the upper surface of the red sandstones is estimated at 200 to 300 m.

In the part of Ravnefjeld facing Fleming Inlet between Vimmelskiftet and Tvekegle Valley a local disturbance occurs, produced by magmatic intrusion. Near the coast the strata dip 52° towards the SSE., in the middle of the valley 30° towards the SSE., and at the head of the valley, where the section given in p. 22 was measured, the strata are nearly horizontal.

The area between Vimmelskiftet and Lagunenæsset shows a gentle folding. An anticline is seen in the coast immediately to the south of Vimmelskiftet; the axial strike is SE.—NW., seemingly with a slight dip towards the SE. The northern limb of this anticline may be seen

along the south side of Vimmelskafte dipping towards the NE., the southern limb is seen along the coast between the creek to the south of Vimmelskafte and Lagunenæsset, dipping towards the SW.

In the Mt. Quensel area no strike nor dip have been measured.

At C. Brown — in its western side — the dip measured in the lower grey series amounts to 40° N. 20° W.; in the small ridge to the south thereof the dip was only 15° NW. This area is bounded by a fault marked by the Calamites River depression.

On Canning Land, at Mt. Kollen, a dip of 26° S. 20° W. was found; it increases perhaps somewhat southwards at the coast of Carlsberg Fjord. On the southern slope of Hesteskofjeldet the dip is somewhat greater, namely 54° .

The east coast of Cape Fletcher is rather much affected by magmatic intrusions of the Cape Fletcher series, so no dip nor strike were measured.

At Cape Tyrrel nearly the same conditions seem to prevail as at Cape Brown, the dip being 15° — 20° NNW.; possibly the small bay between Porfyrfjeldet and C. Tyrrel — Snevigen — marks either a flexure or a fault (cf. fig. 3) since the dip of the red and grey sediments south hereof, behind Porfyrfjeldet, is a southerly (southwesterly?) one.

The general impression of the dip of the strata is that of a gentle semi-radial sloping away from a point in the east, which nearly coincides with the Cape Wardlaw Complex, the supposed basement of the strata. As this sloping cannot have been a primary one and as the sedimentation transport, as has been especially emphasized for the C. Brown area, has most likely taken place from the west, the dip seems to be due to a secondary threshold, which came into action after the deposition of these sediments. Further, local disturbances seem to have affected the strata and caused their present dip and strike.

C. Special description:

Determinable fossils having only been met with in the first-mentioned of the three areas discussed above, the following description is restricted to this. As already mentioned, the section begins with a grey sandstone series, followed by alternating red and grey sandstones interbedded with shales.

A section through this upper portion was measured in Ravnefjeld above the glacier in the Vimmelskafte valley, where the strata are almost horizontal. The following figures were obtained:

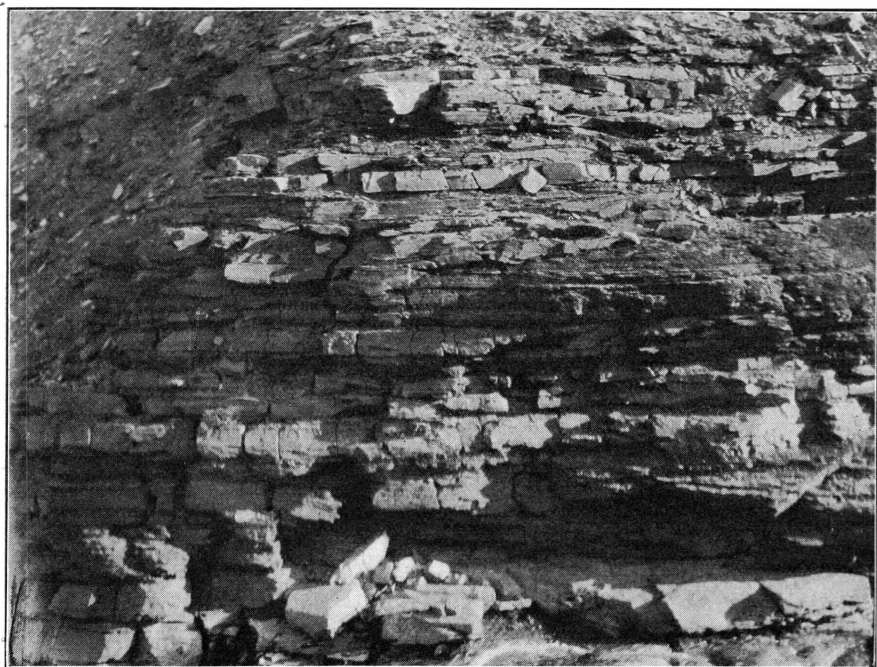


Fig. 4. Ravnefjeld. Detail picture of the Devonian — alternating sandstone and fossiliferous shale (Sept. 1931).

- 683¹⁾ m. Summit (cairn).
 681—683 m. Hard, grey, coarse, micaceous sandstone with calcite-veins.
 524—681 m. Alternating red and grey sandstone-layers with interbedded thin strata of black, arenaceous shale, with a brown or yellow weathering crust.
 522—524 m. Hard, red, coarse, micaceous sandstone.
 482—522 m. Talus-covered slope.
 442—482 m. Alternating red and grey sandstone beds, interstratified with thin mud-cake conglomerates and black shale.
 427—442 m. Coarse red sandstone with ripple-marks and sun-cracks.
 366—427 m. Alternating red and grey sandstones interstratified with black shale.
 355—366 m. Alternating, hard, red and grey sandstones.
 0—355 m. Modern delta-deposits, moraine, and glacier.

The fossils were especially found in the black shale at the following altitudes: 366 m, 396 m, 408 m, 442—482 m, 524—681 m. The material collected was handed over to Mr. SÄVE-SÖDERBERGH, Stockholm, to whom the following statement is due (cf. 32, pp. 103—107):

“Among the material collected by Mr. A. NOE-NYGAARD at the Nathorst Fjord and Fleming Inlet during the first wintering of the

¹⁾ All the altitudes given have been measured by means of two small altimeters, system *Paulin*.

Danish Three-Year Expedition to East Greenland (Leader: Dr. LAUGE KOCH) there are Devonian fossiliferous rocks both of the same facial type as in the northern district (Ymer Island and Gauss Peninsula, cf. SÄVE-SÖDERBERGH 1932a, 1933) and of a new type, not previously recorded from Greenland. The fossils in the rocks of the new type are scales and other remains of Osteolepid Crossopterygians. They are embedded in dark sandy shales, with a light brownish hue of weathering. So far only one specimen is generically determinable, but this single specimen is of great interest, both from a palaeontological and from a stratigraphical point of view. It consists of the nearly complete frontoethmoidal shield of an Osteolepid (pl. 14, fig. 3), and is strikingly similar to the corresponding part of the cranial roof of *Diplopterax agassizi* TRAILL, as figured by MILLER (1841) and JAEKEL (1901, 1911). The similarity between the Scotch *Diplopterax* and the East Greenland form seems to me so great that it justifies a determination of the latter as *Diplopterax* sp. It should be added that the specimen from East Greenland shows an exactly similar mode of preservation to the material examined of *Osteolepis* and *Diplopterax* from the Orkneys. In both species the bony substance is black and apparently bituminous. Also the matrix rock is of a rather similar type, indicating a similar facies of the deposits in both cases.

In consideration of what has been said above, it seems justifiable to draw a parallel, at least provisionally, between the new type of Devonian strata from East Greenland and the Scotch "Orcadian" or "Middle Old Red" (see EVANS 1917). The Orcadian, according to EVANS and FLETT (1898), is included between the strata with the *Asterolepis*-fauna, which is of Middle Devonian age (cf. OBRUTSCHEW 1930, SÄVE-SÖDERBERGH 1932a, GROSS 1932), and the Lower Devonian strata with Pteraspids, more abundant Cephalaspids etc. The groups of the Orcadian, containing *Diplopterax* or closely related to strata containing fishes of this genus, and thus especially suited for comparison with the new East Greenland Devonian, seem to be the Stromness flags of the Orkneys, the nearly related Achanarras horizon in Caithness, and the localities of the Moray Firth — Cromarty, Lethen, Tynet Burn and Gamrie —, between which and the Achanarras horizon EVANS (1917) draws a parallel. Of *Diplopterax* there have been found no certain remains in other countries than Scotland and East Greenland".

D. Determination of age:

As may be seen from the above, SÄVE-SÖDERBERGH has succeeded in giving an exact determination of the age of these new Devonian strata: They are of Orcadian, i. e. of lower Upper Middle Devonian, age.

For further particulars the reader is referred to the stratigraphical table (32, p. 107).

The fish-remains from rocks of the same facial type as the Upper Devonian farther north mentioned by SÄVE-SÖDERBERGH, however, have proved to be indeterminable; as moreover they originate from erratics, their stratigraphical value is very limited. The only conclusion that can be drawn is that younger strata are possibly present somewhere within the district.

The collection of plant remains was handed over to and examined by Prof. HALLE, Stockholm; unfortunately the state of preservation was too bad to allow of a more accurate determination. His information (by letter) runs as follows (in translation): "Among the plant-remains from the localities of Devonian strata (i. e. Ravnefjeldet)¹⁾ some species are found which may perhaps be designated cf. *Psilophyton* sp., which seems to agree with the supposed Devonian age".

Although no further statements could be made, it seems to be of a certain interest that plant fossils — unfortunately more or less indeterminable — were met with within the same strata that carry vertebrate fossils of a Middle Devonian age.

As previously stated, no fossils were found at C. Brown, and only indeterminable carbonized plants were met with in Mt. Kollen, Canning Land. Consequently no exact determination of the age, based on organic remains, has been possible with regard to these strata, by the present writer grouped together with the series of Ravnefjeld. The age determination within the two other areas is thus based on the similarity of facial development, on the geological position, on the petrographical data, and on the colour. The facial development within the three areas seems to be that of the typical Old-Red.

E. Concluding remarks:

If the sediments described from Canning Land really belong to the Devonian, a new and interesting feature in the geology of East Greenland has been traced, since nowhere in the northern part of the east coast of Greenland do Devonian strata rest directly upon crystalline basement rocks. Either beds of continental Carboniferous or of marine Upper Carboniferous age (20, 24, 3 (cf. map)) are superimposed on the crystalline basal complexes. The only suggestion of a parallel hitherto found is a series of sediments met with during the geological work in the summer of 1933 on the east coast of Hurry Inlet opposite Fame Islands. Here an arkose rests disconformably on the old crystalline rocks of Liverpool Land. At this locality also no exact determination of age

¹⁾ Added by the present writer.

could be made; if, however, the sediments of Canning Land are of Devonian age, it seems probable that the arkose, too, might be referred to this period.

If, in accordance with what has been the case with the Upper Devonian strata (Cape Graah Formation, NATHORST 1899 (23, p. 242)), a new formation name based on the Middle Devonian fossils found in the Fleming Inlet district should be introduced, it seems natural to propose Ravnefjeld Formation, since at this locality the strata are best exposed, and here the only determinable fossils within the area have been found. Even if the sediments of Cape Brown and Canning Land belong to the Devonian, they may as well represent other horizons than those encountered in the Ravnefjeld.

3. Continental Carboniferous Beds.

(Mt. Pictet Formation).

The existence of Palaeozoic beds younger than Devonian on the south coast of Traill Island along King Oscar Fjord and Davy Sound was already supposed by NATHORST (23). The investigations of KOCH in 1926—27 (14) confirmed this suggestion; to these post-Devonian strata (Mt. Pictet Formation) he also referred a series of preferably light grey sandstones which crops out along the coast between Antarctic Harbour and Mästers Vik, and which by NATHORST (23) was referred with reservation to the Jurassic.

On the whole, the age of the corresponding strata of various parts of East Greenland seems to range from perhaps the lowermost Dinantian to Namurian, as borne out by plant fossils (HALLE). The dominating rocks are light grey, red or pink, and dark grey sandstones with subordinate beds of black shales and coal; also conglomeratic portions are common: Plant-remains, generally in a bad state of preservation, occur scattered throughout the whole formation.

After KOCH's investigations in 1927, beds belonging to the continental series of Carboniferous age have been studied in various parts of East Greenland by several geologists of the Danish expeditions 1929—33 [BACKLUND (1), KULLING (19), ROSENKRANTZ (30), MALMQUIST (20)].

A. General.

On the Wegener Peninsula strata belonging to this series were first met with by HARRIS in the spring of 1927 in the bed of Calamites River to the south of C. Brown. The following description of this locality gives

a rather good impression of the stratigraphical conditions (cf. 14, p. 99): — — — “in a valley extending south of a small mountain behind Cape Brown he (i. e. HARRIS) found coal-bearing shales at a height of 100 m, subjacent to grey limestone with Upper Carboniferous brachiopods¹). The shale was not seen fixed and seemed to originate from a coal bed only a few centimeters thick. The black shale contained the following plant fossils: *Lepidodendron* (badly preserved), *Stigmaria ficoides*, *Calamites* sp. pith cast, *Calamites* sp. external cast”.

B. Description of localities:

During the present investigation Carboniferous strata of continental character, besides in Calamites River, have only been met with in three exceedingly small localities on the Wegener Peninsula. The possibility that beds belonging to this series exist on Canning Land has been touched upon in the preceding chapter. As no direct connection between these areas was found, a separate description of each locality and its peculiar conditions may best serve the purpose.

The country to the south of Calamites River and the depression marking its topographical continuation is due to a fault, which separates the central part of Wegener Peninsula from the Devonian of C. Brown already described. On the southern bank of this river, in the lower half of the mountain slopes, the continental series of the Carboniferous of HARRIS is exposed. The beds are continuous from the coast of Nathorst Fjord to the head of the river. The plant-bearing horizon of HARRIS was not found again, yet a study was made of the various types of sedimentary rocks occurring here.

These mainly consist of coarse-grained, pink arkose sandstones with abundant big and sharp-edged, red (microcline) felspar grains. Through the whole series subordinate conglomerate-beds are met with, chiefly containing small quartzitic pebbles; also within the sandstone itself scattered pebbles are met with. Although these pebbles are mainly quartzitic and varying in colour, crystalline rocks are also represented, chiefly a grey, rather fine-grained gneiss. No plant fossils were observed in these coarse beds. The age is, however, indicated to a certain degree by the superincumbent marine Upper Carboniferous-lowermost Permian and by the determination of the plant-remains by HARRIS, who (14, p. 99) states: — — — “that this little flora is obviously Carboniferous, but cannot be more closely classed”.

A small outcrop of a pinkish sandstone at the northern base of Mt. Paradigma along the shore of Nathorst Fjord belongs to the same area. It was not closely examined, but it seems to belong to the same

¹) The fossils have later turned out to be of Lower Permian age.

type as the sediments in Calamites River. The reappearance of the beds, which soon disappear below sea-level, about midway between this river and Mt. Paradigma is due to a small fault with an apparent uplift of the southern limb (cf. map, plate 2).

Along the shore of Fleming Inlet between Tvekegle Valley and the creek immediately south of the small ridge of the Devonian area of C. Brown another Carboniferous area was met with. It probably forms a continuation of the Calamites River area, its sediments being highly reminiscent of, and presumably corresponding to, those of the latter area. Here, too, the marine Upper Carboniferous and lowermost Permian are superincumbent.

The sediments of the outcrops along the northwestern coast are coarser than those along the southeastern coast. Thus conglomerates with intercalated pinkish-red sandstone beds are dominating along Fleming Inlet. Two points were visited. The northern point shows conglomerate-cobbles of a greater size than the southern one (max. 45 and 15 cm resp.); crystalline rocks as well as limestones and dolomites were met with among the cobbles besides the dominating quartzitic ones. The height of the outcrop varies; its maximum elevation above sea-level, to the base of marine Upper Carboniferous, is about 120 m.

The third small area of the continental Carboniferous is met with in the upper part of Tvekegle Valley, in its southeastern corner, exactly upon the fault-line running along the Devonian ridge (cf. map, pl. 2) and separating Mt. Paradigma from Ravnefjeld. Topographically the outcrop forms a hillock not exceeding 50 sq.m. within a rivulet-bed which debouches in the southeastern corner of Tvekegle Valley, its height above the talus along the river-bed being only 8—10 m (height above sea-level 183 m).

The hillock consists of a coarse-grained, micaceous, light-grey sandstone, interstratified with thin seams of shaly coal. One of these coal-seams has a thickness of 45 cm, and contains two sandstone bands only a few centimetres thick. Owing to the rapid weathering of the coal, the slopes are almost black. Real solid rock is nowhere exposed, so the dip and strike could not be measured. In the coal-seams some fossil plants were found, about which Prof. HALLE says that their state of preservation may promise finds of possibly determinable plants in the future.

C. Geological position:

The strata of the northern and the southern localities dip, broadly speaking, WSW, with a somewhat varying dip-angle. At the localities of Fleming Inlet 15° and 20° W. respectively were measured, with the greater dip-angle at the northern point, however, owing to the existence of two downward slips the dip-angle given is perhaps a little too high. Conse-

quently two conclusions may be drawn: 1) If the sediments are contemporaneous, the coarseness of the material of the northern localities indicates a sediment transport from the west, a direction already indicated by the carbonaceous pebbles; 2) The conglomeratic members in the north, in consequence of the common dip, may be a little younger than the beds below the marine Upper Carboniferous at Calamites River.

Evidently there is a disconformity between the continental and the marine strata of the Carboniferous; conditions are very similar to those of Cape Stosch (19, 17) and of the south coast of Traill Island — Mt. Svinhufvud — reconnoitred during the summer of 1933.

As to the substratum of the plant-bearing beds of the third locality



Fig. 5. West coast of Antarctic Harbour — continental Carboniferous strata (Mt. Pictet area).

nothing can be said with certainty. In the rivulet below the hillock a red sandstone crops out; but whether it belongs to the red strata of the continental Carboniferous or of the Old-Red, it is difficult to decide.

The beds belonging to the continental Carboniferous along the west coast of Antarctic Harbour, penetrated at C. Syenit by igneous rocks, are almost horizontal (cf. fig. 5). The south coast of King Oscar Fjord from Syltoppene to Antarctic Harbour too, as proved during the field work in the summer of 1933, is composed of horizontal strata belonging to this series, with occasional local disturbances.

Looking westward along "Quôrok" from the lower parts of the Desert Mountains at the head of Fleming Inlet, high mountains are observed at some distance to the west of Ørsted Valley; they exhibit quite a different morphology from the younger strata in front of them. Probably these mountains belong to a southerly continuation of the area to the west of Antarctic Harbour.

4. Marine Upper Carboniferous-Lower Permian.

Deposits of marine strata belonging to this series of sediments in East Greenland were first discovered by the Danmark Expedition 1906—08 in the area between 80°—81° N. lat. (Mallekufjeld). The

fossils were examined by K. A. GRÖNWALL (9). The next occurrence was met with by L. KOCH in 1921 on Herlufsholms Strand in the eastern part of Peary Land. During the sledge-journey of KOCH in 1926—27 localities were found at several points between Danmarks Havn and Scoresby Sound; the southernmost of these was in Nathorst Fjord, within the district of the present investigation. Preliminary reports on occurrences of marine Upper Carboniferous¹⁾ between 72° and 75° N. lat. have been furnished by KOCH (14, 17), BACKLUND (1), KULLING (19), and ROSENKRANTZ (30). A more detailed description based on the palaeontological data was delivered by FREBOLD in 1931 (5).

A. General Description:

KOCH examined the marine beds of this series in Nathorst Fjord, in two localities on the east coast of Wegener Peninsula. The rocks of the southern locality were dolomitic, without fossils; the northern locality — Komait — to the south of Calamites River turned out to be very rich in fossils.

During the spring of 1927 HARRIS too made a collection of fossils from the marine strata, but evidently not from exactly the same locality as KOCH. But in both cases the same horizon is represented, as indicated by the determinations of FREBOLD (5, p. 11).

As will be seen, observations of these marine beds and their position are restricted to the east coast of Wegener Peninsula. When nevertheless KOCH marks them as rather extensive on his geological map (14), it is because they are very conspicuous in the topography, forming steep rock walls, and hence are easily recognizable from great distances.

As may be seen from the geological map (pl. 2), these marine deposits, with the exception of the north-eastern end, are represented all over Wegener Peninsula; further it will be seen that the formation occurs at two different altitudes above sea-level, *viz.* in a southern area including Mt. Quensel at a high position and in a northern area at a lower level (limited by faults). Erratics found in the river-bed in Pingel Valley, containing Lower Permian brachiopods, seem to indicate an extension of the marine Upper Carboniferous-Lower Permian beds southward behind Wegener Peninsula.

Turning to the east from Wegener Peninsula, we encounter the marine beds at the base of Dépôt Island in Nathorst Fjord, along its north shore.

On Canning Land the strata occur along the south coast of Aalborg Fjord, on the Cape Fletcher peninsula; two isolated smaller areas inland

¹⁾ According to fresh finds of fossils belonging to lowermost Permian (see below).

are situated to the north of Aalborg Fjord. At C. Tyrrel (see photograph, fig. 18 in 25) they constitute the upper half of the cape and part of the mountain behind Porfyrfjeldet, to the south of which they descend to sea-level.

B. Lithological Characteristics:

Broadly speaking the strata may be divided into three more or less sharply defined members: 1) a more or less dolomitic limestone with weak or absent bedding, 2) a series of black, limy, bituminous shales interstratified with thin bands of a black limestone, 3) a series of black, often shaly, limestones passing upwards into a limy sandstone with lenses of dolomitic limestone.

Fossils are especially found in the limestone bands of 2) and in the limestone strata of 3).

As these three members, though with local variations, have been traced everywhere within the district where a closer examination of the strata has been undertaken, it seems natural to keep them distinct in the following description.

1) Lower dolomitic limestone: The rocks, local differences caused by magmatic action disregarded, are very uniformly developed throughout the district. The main rock appears to be a light-grey, hard, dolomitic limestone, generally penetrated by white calcite veins; stylonitic structures are of common occurrence. Brecciated portions, generally of a yellow dolomite, may be met with in several places (cf. also 25, p. 184). The weathering colour is, as a rule, yellow or rusty-red; often the exposed surface is covered with corrosion pits. In Ravnefjeld, at an altitude of about 700 m, the lower part of this member has undergone a high degree of dissolution; great sinks and caverns of several metres' length are common. The rock is very coherent everywhere, and often forms over-hanging rock-walls. At lower levels they often moulder into small parallelepipedal pieces. Fossils were found in a single place only.

Near the contacts with magmatites the limestone is usually converted into marble and is brecciated throughout.

In cracks and fissures there occur in places well developed calcite crystals — mostly scalenohedra. Further, occasional crusts of malachite and azurite have been found.

2) Shales interstratified with limestone: This part of the formation, hitherto unknown from the Nathorst Fjord area, consists of a dark, almost black series of shales. The shales are highly bituminous and contain scattered crusts of pyrite. Further they moulder very fast, so that outcrops of solid rock are seldom encountered; generally the

slopes are covered with a thick talus of small pieces of shale. The shales are interstratified with a dark-grey or black limestone; the limestone-bands vary in thickness from a few centimetres to half a metre, and are, as a rule, highly fossiliferous. In Mt. Paradigma a band of yellow dolomite-lenses — more than two metres long, and up to 75 cm thick — is found within the shale-beds.

In some localities the shale series seems to replace the lower dolomitic limestone to a certain degree. In the section given below ("Southwest Section") the shale series attains a thickness of about 100 m just to the south of Vimmelskafte; at the southernmost locality of Palaeozoic strata in Fleming Inlet their thickness increases, while here the lower dolomitic limestone thins out.

3) Upper limestone-series: The boundary between the lower shale series and the upper limestone is nowhere sharp; the transition is marked by an alternation of shale and limestone. The limestone itself is black and very rich in fossils. There seems to exist a slight facial difference between the western and the eastern areas, especially in what belongs to the upper part of the series. Thus in Mt. Paradigma, the upper part of the strata is made up of a limy sandstone, plenty of arenaceous matter having entered into the composition of the rocks, while in the "Southwest Section" the lower part of the limestone series consists of a very fine-bedded calcareous shale and the uppermost portion of a compact limestone without fossils, perhaps representing a hardening horizon.

Broadly speaking, conditions are very similar to those of the northern localities in East Greenland: C. Stosch, C. Franklin, and Clavering Island. There are, however, two remarkable differences, namely: the absence of the gypsiferous bed in association with the lower dolomitic limestone and, to the south, the appearance of terrigenous matter within the top layers, both probably being of local importance only.

C. Geological Position:

The mean thickness of the whole formation between the floor and the capping younger sediments may be estimated at 250—300 m.

Wegener Peninsula, central and southeastern parts: The formation rests directly upon the (Middle) Devonian. At Ravnefjeld, the northernmost occurrence within this area, its base lies at a level of 700 metres. The strata dip gently towards the southwest, in accordance with the sloping upper surface of the Devonian, the dip angle varying from 4° to 7°. The outcrop ends at the same fault which cuts across the Devonian (cf. above, p. 20, cf. also fig. 15).

No section was measured at Mt. Quensel, but at its top, also at

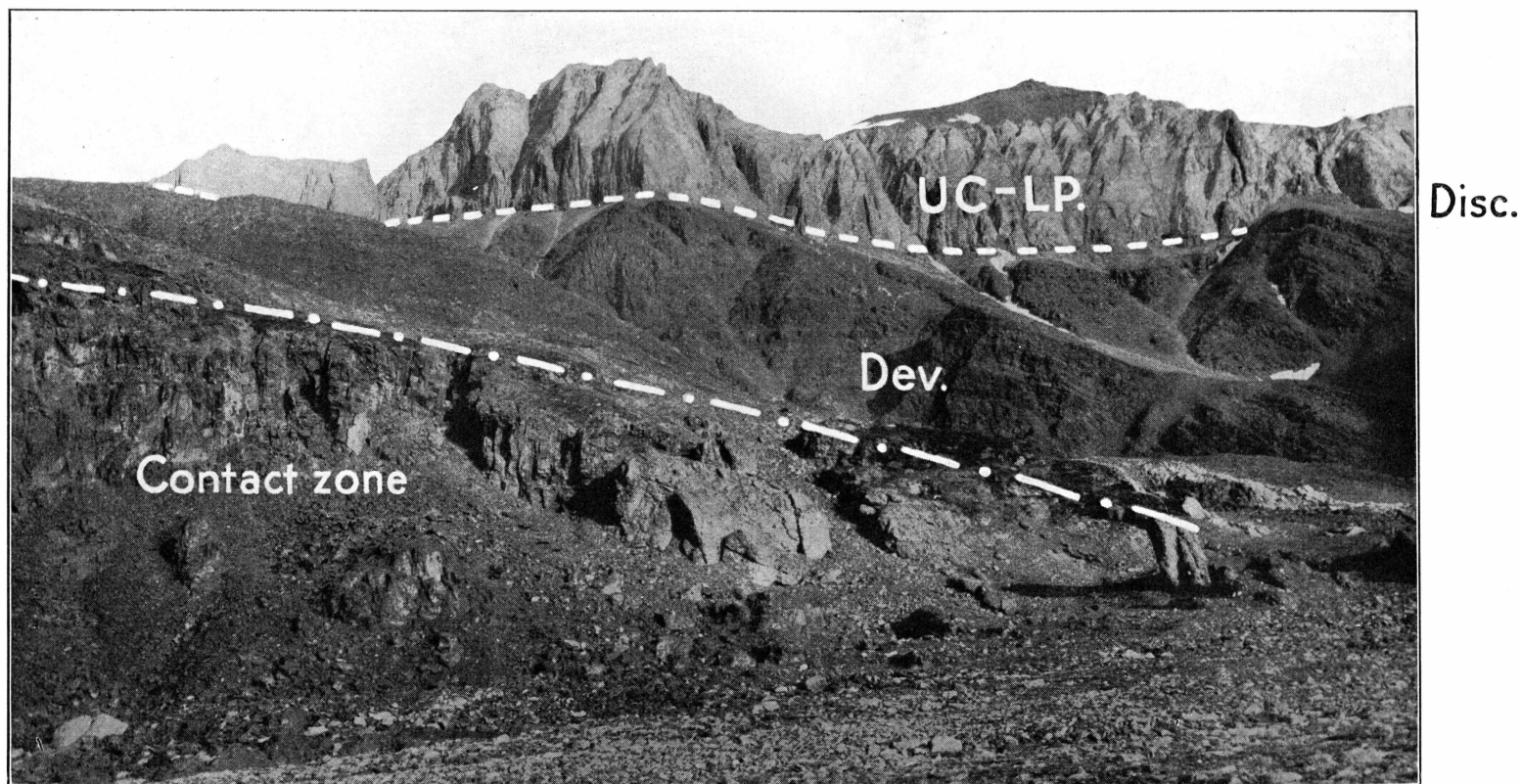


Fig. 6. Ravnefjeldet, seen from the station Vimmelskiftet (Sept. 1931).

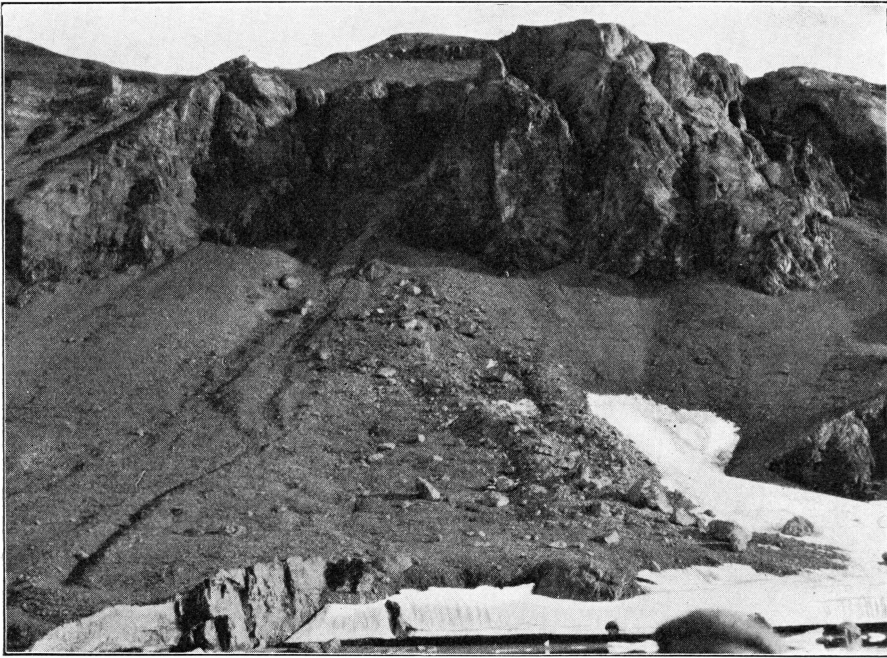


Fig. 7. West coast of Wegener Peninsula between Tvekegle Valley and the valley behind C. Brown. Continental Carboniferous, at sea level, covered by Upper Carboniferous-Lower Permian and, at the top, Eotriassic (Sept. 1931).

an altitude of about 700 m, steep erosion-remnants, in ruined castle style, of a coherent limestone-dolomite are exposed; these strata dip towards the southwest, and farther south they are overlain by other sediments, probably pertaining to the shale and the upper limestone horizons.

The area between Ravnefjeld-Mt. Quensel and Calamites River: The formation rests directly upon continental beds of Carboniferous age. Its strata are here exposed along Fleming Inlet as well as along Nathorst Fjord; further a fine outcrop is represented in Mt. Paradigma. The base of the strata attains its maximum altitude at Calamites River — about 250 m; some distance south of Komait the strata descend to sea-level. After a repeated outcrop in Mt. Paradigma (cf. above p. 26), they disappear below sea-level in the northern part

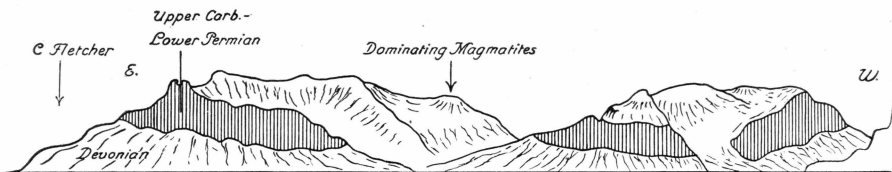


Fig. 8. The C. Fletcher peninsula, seen from the north.

of the valley which marks the mouth of Jameson River in Nathorst Fjord. Along Fleming Inlet their height above the sea varies from 0 to 120 m. Taken as a whole the dip is here also a gentle southwesterly one; in Mt. Paradigma, for instance, a dip angle of 5° SW. was measured.

Depôt Island: According to HARRIS (14, p. 106) 40 m of a light-grey limestone with calcite veins crop out along the northern shore of the island. The dip is a southwesterly one. The substratum of the limestone is not known.

Canning Land: At C. Tyrrel the limestone is seen to rest directly upon the strata described as Devonian, the dip is 15° — 20° NW. Behind Porfyrfjeldet the strata have a different dip, but to the southwest, where they descend to sea-level, a northwesterly dip of 20° was again measured.

As to the strata along the north coast of the C. Fletcher peninsula no closer observations were made, moreover nothing can be said with certainty owing to local disturbances caused by magmatic activity. The two small areas to the north of Aalborg Fjord seem to have a southwesterly dip.

D. Special Description:

Sections through the marine strata in question have been obtained in several localities on Wegener Peninsula. As, however, conditions differ somewhat within the various parts, two sections will be given, one of the central and southeastern part, the other of the northern, down-faulted, part of Wegener Peninsula.

The "Southwest Section", running from the south side of Vimmel-skaffet to the mountain marked 709 m on the map (pl. 2); the section embraces three parts. The uppermost 20 m pertain to the Eotrias.

- 689 m. Base of Eotriassic basal conglomerate, containing rolled Lower Permian fossils, e. g. brachiopods, crinoid-stems, and bryozoans.
- 679—689 m. Thin-bedded, black, hard limestone (hardening-horizon?) without fossils.
- 673—679 m. Light-grey, limy shale with ophiomorphs.
- 673 m. Thin shale-bed with fish-remains.
- 656—673 m. Argillaceous shale alternating with thin sandstone-bands.
- 655—656 m. Coherent, black, shaly limestone.
- 627—655 m. More or less arenaceous shale alternating with limy sandstone. No fossils.
- 622—627 m. Conglomeratic limy sandstone containing somewhat rounded dolomite and limestone pebbles of the size of a fist. The limestones contain fossils (*Martinia* sp.).
- 590—622 m. Black shale with a rather yellow weathering. The upper part is somewhat arenaceous. No fossils.
- [600—603 m. Limy shale with dolomite-lenses containing crinoids and brachiopods (*Productus porrectus* KUT¹⁾).]

¹⁾ All the determinations of fossils are due to Prof. FREBOLD in Greifswald.

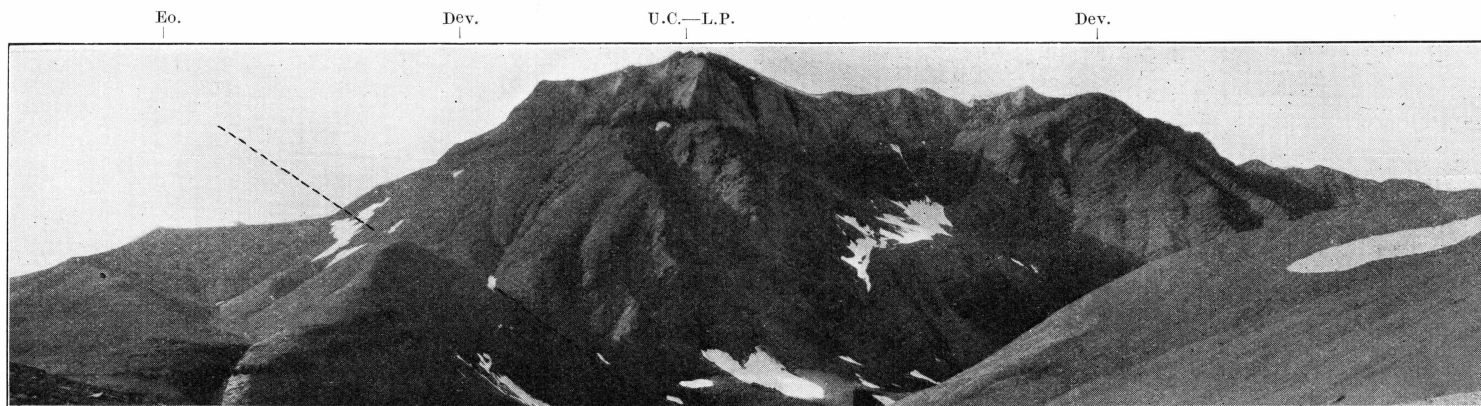


Fig. 9. Central part of Wegener Peninsula; Ravnefjeldet, seen from the NE. (Sept. 1931). Dev. = Devonian;
UC—LP = Upper Carboniferous-Lower Permian; Eo = Eotriassic.

- 581—590 m. Black, mouldering shale with a few hard limestone-beds or lenses. In the shale was found a seemingly very scarce mussel (*Posidonomya* sp.).
- 570—581 m. Black shale apparently without fossils, yet containing beds of a dark limestone with crinoid-stems and bryozoans.
- 476—570 m. Light-grey, dolomitic limestone, with calcite veins — often of a pink colour. No fossils found.
- 0—476 m. Devonian strata. Alternating red and grey sandstones, interstratified with black shales in the upper portion.

The "Mt. Paradigma Section": The section was measured in the northern side of the mountain. The upper 350 m of the mountain consist of Mesozoic strata.

- 266 m. Base of Eotriassic basal conglomerate, containing rolled brachiopods and crinoid-stems from the substratum; the cement of the conglomerate is rich in lime.
- 259—266 m. The upper part consists of a limy sandstone with large lenses — of several meters' length — of a light, extremely hard dolomite with a characteristic brown weathering. In the sandstone vertical worm-tubes (?) of 35 cm length. Passes downwards without sharp limits into a light, somewhat dolomitic limestone, with calcite veins and rich in fossils (*Productus* aff. *timanicus* STUCK. *Linoproductus* of the *cancrini-cancriniformis* group).
- 257—259 m. A very coherent limestone-bed containing corals and bryozoans.
- 257 m. A thin coherent limestone-bed with indeterminable brachiopods.
- 245—257 m. Somewhat dolomitic limestone (without arenaceous elements) with indeterminable brachiopods, bryozoans, and corals.
- 165—245 m. Dark-grey to black, limy, bituminous shale with corals and brachiopods (*Derbyae* sp. indet., *Productus porrectus* KUT, *Spirifer* sp. indet., *Spiriferella* aff. *keilhavii* v. БУСН). The upper part of this shale series contain a few, rather badly preserved, fish-remains.
- At 235 m altitude a band of highly fossiliferous dolomite-lenses; the hard rock, however, prevented collecting.
- 140—165 m. Light-grey, hard, dolomitic limestone with calcitic secretions and veins. In a single place badly preserved brachiopods were found (cf. *Rhynchopora* sp.).

Along the coast of Nathorst Fjord this lower limestone series is seen to rest on the continental beds of Carboniferous age cropping out here.

- 0—140 m. Dèbris and modern river deposits.

Two new features of this marine series from the Nathorst Fjord district were traced, namely: The existence of the "Posidonomya-shale" and the "Martinia-rocks", not previously known from this area.

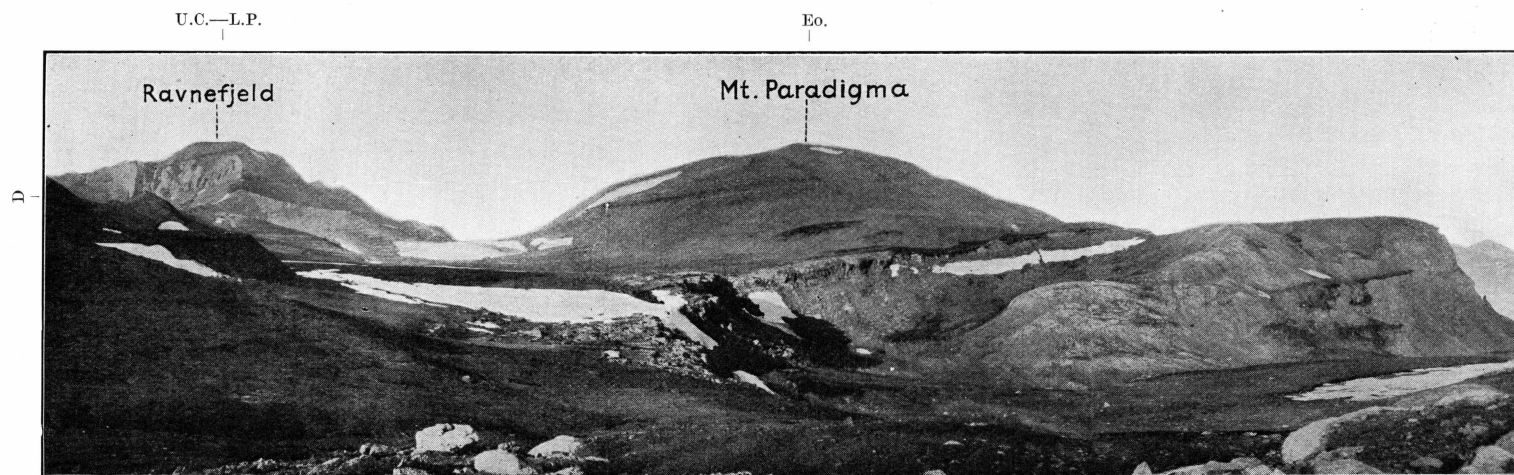


Fig. 10. Central part of Wegener Peninsula; Ravnefjeldet, seen from the SE. (Sept. 1931).

D = Devonian; UC—LP = Upper Carboniferous-Lower Permian; Eo = Eotriassic.

E. Determination of Age:

Considering that the three members of this formation pass gradually into one another, as stated above, they are very likely to be parallelized with conditions from the northern areas of East Greenland, for instance Cape Stosch. Consequently we have (cf. table p. 54 in 5):

Brachiopod-limestone.

Posidonomya-shale.

Dolomitic limestone.

As to the age of the strata FREBOLD (5, p. 58) says: — — — “Wenn wir also den Schluss ziehen, dass die bisher bekannt gewordenen marinen Oberkarbonablagerungen Ostgrönlands dem Schwagerinenkalk entsprechen, so gilt das als bewiesen für die Fauna des Brachiopodenkalkes des Cape Stosch sowohl für die des Nathorstfjordes¹⁾ und des Wollaston Forelandes — — —”.

As a fourth member of the series may be mentioned the so-called “Martinia rocks”, occurring i. a. in the “Southwest Section” above 622 m. FREBOLD writes of the sedimentary rocks belonging to this part of the series from the northern areas (7, pp. 32—33):

“Im nördlichen Teil von Ostgrönland und zwar zwischen dem Cap Franklin und der Clavering Insel treten meist grünlich-graue, teils aber auch rötliche Gesteine auf, die im wesentlichen Martinien und Choneten, nun aber auch einige Ammoniten geliefert haben. Diese Martinien-gesteine sind teils etwas jünger als der “obercarbone” Brachiopodenkalk, teils müssen sie als eine besondere Fazies dieses Horizontes aufgefasst werden. Unter den hier gefundenen Ammoniten, von denen nur zwei begutachtet werden konnten, ist eine grosse *Medlicottia*, die als *M. malmquisti* sp. nov. beschrieben wird. — — — Nach ganz allgemein üblichen Auffassung gilt *Medlicottia* als eine typische permische Gattung. Aus den stratigraphischen Verhältnissen (teilweise Übergang in den “obercarbonen” Brachiopodenkalk, teilweise nur wenig jünger) sowie aus der Organisationshöhe der Ammoniten ergibt sich, dass es sich um älteres Unterperm handelt, das somit einwandfrei in Ostgrönland nachgewiesen ist”.

No ammonites were found on Wegener Peninsula, but FREBOLD writes (in a letter) of the “Southwest Section”: “Aus diesen Profil ergibt sich, dass generell eine ähnliche Faziesfolge wie im nördlichen Teil von Ostgrönland vorliegt. Es ist jedoch zu beachten, dass die Gesteine nicht

¹⁾ Spaced by the present writer.

vollkommen übereinstimmen, wie das auch kaum zu erwarten ist” — — — “Neu ist somit der Nachweis von Martiniengesteinen, das bisher im Bereich des Nathorstfjordes noch nicht bekannt war. Dies Martinien-gestein gehört sicher ins Unterperm”.

Concerning the Martinia-rocks in the “Soutwest Section” it should be noted that these seemingly occur as pebbles in a conglomerate containing rolled material of rocks belonging to the series. That no concretions or lenses of fossiliferous type, but real balls, occur here may i. a. be concluded from the fact that fossiliferous limestones as well as non-fossiliferous yellow dolomites are found in the same bed. Most probably, however, this conglomeratic horizon is only of local importance.

At a geological colloquium held by Dr. LAUGE KOCH in Copenhagen on the 11th and the 12th January, 1934, a revision of the question of the limit between marine Upper Carboniferous and Lower Permian in East Greenland was discussed, and the result given below was arrived at. (Present at the meeting were: Dr. L. KOCH, Prof. H. G. BACKLUND, Prof. H. FREBOLD, Dr. C. E. WEGMANN, Dr. E. H. KRANCK, Dr. D. MALMQUIST, and the present writer).

The sediments in question, on the map accompanying the present paper given in the same colour, were formerly considered to represent mainly the uppermost part of the marine Upper Carboniferous. Since, however, the three members, *Posidonomya* shale, *Brachiopod* limestone and *Martinia* rock, may substitute one another and are considered to be more or less contemporaneous facial developments of the same series, and since two of them contain the Permian ammonite *Medlicottia*, they must all of them be referred to the lowermost Permian, in a marine facies.

The lowermost members of the series (cf. above, p. 30), the dolomitic limestone and the gypsum (cf. below) occurring locally, cannot be precisely determined as to age.

Since, however, a more or less continuous passing into one another is observable everywhere, no great break seems to exist. In the northern locality — Mallemukfjeld — fossils belonging to horizons older than the Schwagerina horizon are found, so it seems possible that the dolomitic limestone in the southern localities underlying the *Posidonomya* shale may be synchronous with these.

Consequently a continuous series of marine sediments, embracing the uppermost Carboniferous (the dolomitic limestone and locally gypsum) and the lowermost Permian (*Posidonomya* shale, *Brachiopod* limestone, and *Martinia* rock), may be represented here.

5. Young-Palaeozoic Igneous Rocks.

Rocks presumably belonging to this epoch of magmatic activity were found by NATHORST at C. Parry on the east coast of Traill Island. The rocks collected were examined by Dr. H. BÄCKSTRÖM, who determined an aegirite-quartz-syenite and an associated tinguaitite-like rock (23).

Further, an erratic from the Fame Islands in Hurry Inlet, described by BÄCKSTRÖM as a monchiquite, is referred with reservation to the same cycle of magmatic activity.

The next observations were made by NORDENSKJÖLD (25) at C. Fletcher. From this locality he records four different types of rock: 1) coarse syenite-like rocks, 2) acid orthoclase-bearing porphyries, 3) basic rocks of lamprophyric type, 4) dike rocks of nepheline-tephritic type.

As to the age NORDENSKJÖLD mentions that in conglomerates found near C. Brown (see below), pebbles occur — — “which seem to correspond to the medium acid forms — —”.

During his investigation in 1926—27 L. KOCH succeeded in tracing igneous rocks, which he classed with the rocks described by BÄCKSTRÖM and NORDENSKJÖLD, along Davy Sound. The basic sills occurring to the north of Antarctic Harbour, which KOCH also considered as belonging to the Cape Fletcher series, have, however, proved to be of Tertiary age.

During the present investigation the following localities were visited: C. Fletcher and Porfyrkjeldet on Canning Land; Mt. Quensel, C. Brown, and Ravnefjeld on Wegener Peninsula, and C. Syenite just northwest of Antarctic Harbour.

At C. Fletcher and Porfyrkjeldet these igneous rocks penetrate beds of continental Devonian as well as marine Upper Carboniferous-Lower Permian; in Ravnefjeld the intrusion has taken place in the (Middle) Devonian strata, but seems also to have caused a local uplift of the marine Upper Carboniferous superincumbent to these; at C. Brown only Devonian strata have been influenced by the magmatic activity; in Mt. Quensel no close examination was undertaken. At Antarctic Harbour the series intruded by the magmatites belong to the continental beds of Carboniferous age.

Altogether three series of different Palaeozoic sediments exhibit a hot contact with these igneous rocks, whereby their lower limit is determined. They are younger than marine Upper Carboniferous-Lower Permian.

The rocks show a very variegated series of types, but on the map (pl. 2) they have been given the same colour; however, whether they all belong to the same period of igneous activity has not yet been definitely proved. In a special publication to be published later I hope to deal with these rocks and their petrological position.

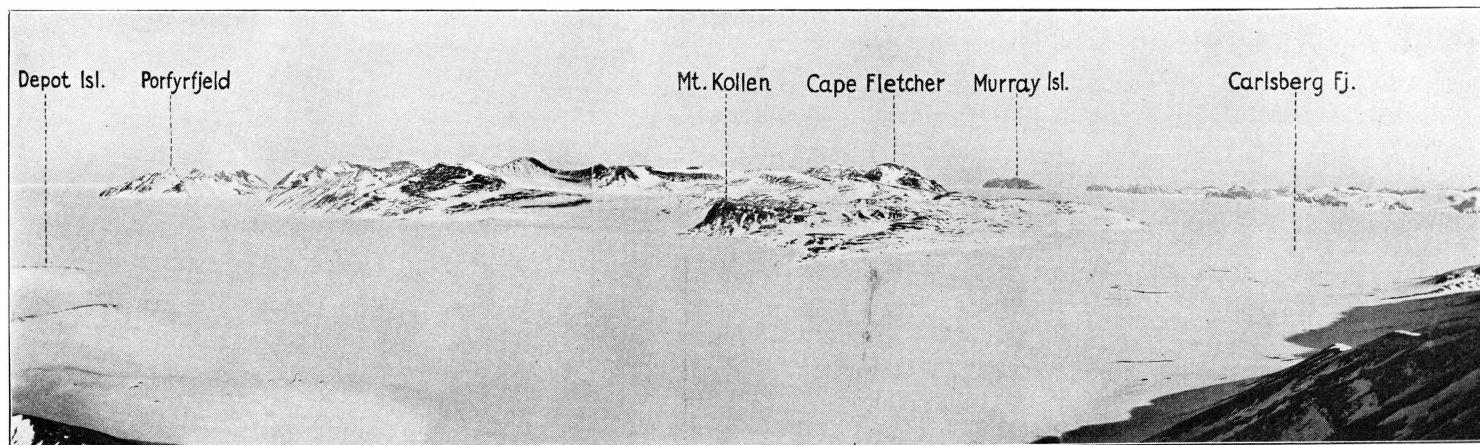


Fig. 11. Total view of Canning Land from the top of Mt. Nordenskjöld (May 1932).

The sediments referred to the Devonian along the north side of the Cape Fletcher peninsula and the north coast of Aalborg Fjord as well as in Aarhus Bay along the north coast of Canning Land seem to have been somewhat contact-metamorphosed. Their colour is generally a dark greenish or reddish; and they are filled with veins of calcite and quartz. Possibly this may be due to a greater distribution of the magmatites of the Cape Fletcher series inland. This supposition is supported i. a. by the fact that a new locality evidently belonging to this group of igneous rocks — Porfyrfjeldet — was found during the present investigation in the northern part of Canning Land. As mentioned above (p. 19), ripple-marks were found at C. Fletcher in sediments of this type. The sediments, including the Devonian, at Cape Brown and Ravnefjeldet near the magmatites show a very similar appearance to those at C. Fletcher.

6. Upper Permian (?).

(Depôt Island Formation, KOCH 1926).

On Depôt Island in Nathorst Fjord and at the base of Mt. Norden-skjöld KOCH encountered some sediments which he classed as a special formation ("Depot Island Formation"). Further, an erratic boulder found by HARRIS at Calamites River and some boulders, also erratics, found by the present writer on the eastern side of Wegener Peninsula, as also a conglomerate encountered on the top of Mt. Kollen, Canning Land, are referred with some reservation to that formation.

The material collected by KOCH and HARRIS on Depot Island was examined by ROSENKRANTZ, who writes (29, p. 287): "At the base, grey limestone (Uppermost Carboniferous) overlain disconformably by a conglomerate, half a meter thick, containing well rolled shells of a *Spirifer*. The conglomerate is overlain by 5 m of white, non-fossiliferous sandstone, and this again by pink sandstone in a thickness of 3 m carrying a marine fauna, generally badly preserved, comprising indeterminable brachiopods and a number of big mussels, which I provisionally term *Grammysia*? sp., since, owing to their peculiar structure, they recall *Grammysia carbonaria* known from the Permian of the United States. In addition to this *Grammysia* the pink sandstone contains a number of indeterminable lamellibranchs (*Leda* sp., *Astartidae*? and others) and further, moulds of body-chambers of highly compressed *Nautiloideae* with a pentagonal cross-section. The pink sandstone is overlain by 10 m of dark green, shaly sandstone carrying compressed, undeterminable cephalopods? and lamellibranchiates, among which *Pleurophorus* is of most frequent occurrence".

The same material has later been reexamined by FREBOLD (6), who

confirms the determinations of ROSENKRANTZ. Further he gives an approximative determination of a cephalopod, namely *Ophiceras* sp., cf. *Ophiceras* aff. *demissum* (OPPEL) SPATH and *Glyptophiceras* SPATH; on this basis he writes (6, p. 26): "Da die Depot Island Formation in ihren oberen Teilen bestimmt, in ihren unteren Teilen wahrscheinlich, der Wordie Creek Formation entspricht, also ebenfalls der Eotrias angehört, kennen wir bisher auch im Gebiet des Nathorstfjordes weder anstehendes Unter- noch Oberperm. Die Trias transgrediert hier vielmehr ebenfalls über marinem Obercarbon".

Since on Wegener Peninsula decidedly younger strata are met with everywhere reposing directly on the marine Lower Permian, while nowhere within this area an evolution of the boundary sediments between Lower Permian and the superincumbent strata similar to the conditions on Dépôt Island — with for instance *Grammysia* — was found, the present writer considers it best to keep these sediments apart until a renewed investigation has been carried out, instead of placing the whole series with the younger cappings, based only on a perhaps not fully reliable determination, in the Eotriassic.

Dr. SPATH, to whom a couple of fossils derived from the very base of Mt. Nordenskjöld were sent, expresses the opinion that they are of Palaeozoic age.

The erratic of HARRIS from Calamites River, which contains a *Bakewellia antiqua* MNSTR., together with some sandstone-boulders found by the present writer in the valley to the south of Mt. Paradigma and containing some mussels, are probably derived from the basal conglomerate of the covering younger formation (see below); these boulders may possibly originate from a series of sediments which may be grouped together with the sediments in question of the Dépôt Island.

On top of Mt. Kollen, Canning Land, above the strata previously described as Devonian, a conglomerate was met with of quite a similar habitus to those on Dépôt Island; but it bears also resemblance to those at the base of decidedly younger strata. This conglomerate rests, with a very marked angular unconformity, on the substratum and dips 3°—5° SW. The dip-angle shows that the low passage, Ituidlek, does not seemingly mark any fault, but that the conglomerate on top of Mt. Kollen seems to continue below Mt. Nordenskjöld. No fossiliferous beds were found at Mt. Kollen, so it cannot be ascertained whether these capping sediments are of Permian or of later age (Eotriassic?). It is, however, very obvious that the conglomerate carries an extremely great quantity of balls, which seem to originate from, and therefore to be later than, the *mise-en-place* of the Cape Fletcher series. This should determine the upper age limit of these as older than Uppermost Permian.

Further this conglomerate carries boulders of red and grey sandstone (Devonian?) — up to half a meter in length —, of limestones (Carboniferous) and pebbles of various quartzites.

From the above the following partial reconstruction may perhaps be possible: On Dépôt Island and at the country just to the south thereof sediments in a perhaps originally basin-shaped area were superimposed on, and partly derived from, the Uppermost Carboniferous-Lowermost Permian and from the igneous Cape Fletcher series already exposed. Not long afterwards they were strongly eroded, their remnants being covered by, and redeposited as, a later formation.

The conglomerate on Mt. Kollen, which has dip and strike in common with the Mesozoic series of Mt. Nordenskjöld, belongs either to the beds of Dépôt Island and the base of this mountain — Upper Permian — or constitutes the basal conglomerate of a later formation (Eotrias).

IV. MESOZOIC ROCKS

1. Eotriassic.

A. General:

With the exception of the conditions on Dépôt Island discussed in the preceding chapter, several hundred metres of younger sediments rest directly upon the marine Lower Permian (or in the special case mentioned above on Uppermost Permian?), wherever sections were measured within the district.

From these series NORDENSKJÖLD and HARTZ brought back some fossils derived from localities in the innermost parts of Fleming Inlet; these were examined by ROSENKRANTZ (30), who writes: "In 1900 HARTZ and NORDENSKJÖLD collected a great number of fragments of *Pseudomonotis* shells from beds in Fleming Inlet, a form which, with some doubt, was referred to the *Ochotica* group. However, the new and complete material from the north coast of Hold-with-hope admits of an identification of these shells as belonging to the same subgenus (*Claraia*) and species. Consequently there is every reason to refer the *Pseudomonotis*-bearing beds in Fleming Inlet to the Lower Triassic". These fossils were the only ones known from the series in question prior to the present investigation.

The strata have been described by KOCH — as "Mt. Nordenskjöld Formation" — and by ROSENKRANTZ — as the two lower members of his "Klitdal Formation". The description of KOCH (op. cit.) gives the impression that two different series overlies one another. Some attention will therefore be paid to these previous observations in order to contribute to the solution of the existing confusion.

ROSENKRANTZ's investigations were restricted to Hurry Inlet and Klitdalen, while KOCH's observations were made at Mt. Nordenskjöld and Cape Biot; the intervening stretch, i. e. the area round the head and the southern part of Carlsberg Fjord, was never closely investigated, because KOCH on his return journey from Danmark Havn on account of snow-melting in Klitdalen was forced to pass along the

Liverpool Coast to Scoresby Sound. Observations in two widely distant localities explain the different divisions arrived at by the two explorers.

The observations of KOCH have been summarised above (Chapter II), while the investigations carried out by ROSENKRANTZ in the more southerly areas may be summarized as follows (cf. 28, pp. 140—142):

The basal part of the Rhaeto-Liassic sediments in Hurry Inlet and Klitdalen rests directly upon a series of sediments named "Klitdal Formation", which consists of three members, *viz.*: 1) The arkose member, 2) The gypsum member and 3) The red marl member. In this connection only the two first-mentioned are of interest.

1) Arkose member: "The lower beds consist of very coarse conglomerates with pebbles up to the size of a head — — — The arkose beds become increasingly fine-grained towards the top. The conglomerates are overlain by arkose sandstone in which occur scattered pebbles. — — — This series, which in the southern portion of Klitdalen is estimated at about 60 m, increases in thickness towards the north". — — —

2) Gypsum member: "The red sandstone of the Arkose member is overlain by a series of mud-cake conglomerates which contain limestone and dolomite. These beds pass upwards into ferruginous clay-slates, at several levels containing lumps of gypsum up to the size of a head — — — The thickness is at least 60 metres". — — —

During the present investigation it has been possible to trace these series continuously from Hurry Inlet to Antarctic Harbour.

B. Lithological description:

Where the whole formation is present within the district, its thickness may be estimated at about 500 m; southwards along the eastern side of Jameson Land the thickness as well as the altitude above sea-level decrease (cf. ROSENKRANTZ *loc. cit.*).

The base of the formation is characterized by a conglomerate of varying thickness (in Wegener Peninsula ranging from about 3 m to about 10 m). The boulders of this conglomerate are quartzites, sandstones, limestones, and dolomites together with rolled fossils from the Lower Permian. The cement of the conglomerate is limy. Interbedded in the conglomerate there may occur irregular beds of an arkose sandstone. The colour is generally rusty. The size of the balls¹⁾ in this conglomerate ranges from that of a hazelnut to that of a head, varying in different localities.

¹⁾ In the following the conglomerate-balls of different sizes are termed according to TWENHOFEL: *Treatise on Sedimentation*. 1926.

Besides this basal conglomerate several others occur throughout the formation; they are generally interstratified with arkose sandstones. These conglomerates attain a maximum thickness of 5 m, the general thickness being from about half a metre to one and a half metres. The ball material deviates from that of the basal parts, as will be discussed below; their size may be up to 40 cm.

The bulk of the formation, however, consists of arkose sandstones of varying colour interstratified with the above-mentioned conglomerates, and sandstone-schists. Arenaceous shales and sandstone-schists of varying colour — red, green, yellow and grey — in certain layers containing lumps of gypsum, further play a great rôle in the composition of the strata.

Fossils are met with in three horizons within the series of strata. In the lowermost horizon they are found in an arenaceous shale of a greenish-grey colour carrying limonitic concretions. At the middle horizon they are found in a light sandstone, while the uppermost fossiliferous strata are red sandstone-schists.

C. Geological Distribution:

The areas occupied by this formation within the district may most conveniently be divided into the following five units: 1) The west coast of Carlsberg Fjord from Klitdalen to Mt. Nordenskjöld. 2) The area between Calamites River and Ravnefjeld. 3) The highest summits of the southern half of Wegener Peninsula. 4) The southeastern corner of Fleming Inlet. 5) The area between Fleming Inlet and Antarctic Harbour:

1) The southernmost point of observation within this area lies about 10 km to the north of the head of the fjord. Here the basal parts of the mountains up to about 200 m consist of a red arkose sandstone with conglomerate beds, overlain by gypsiferous beds, followed at the top by continental beds of another formation.

The same succession of strata was traced and examined northwards along the western side of Carlsberg Fjord. In Mt. Nordenskjöld the top of the gypsum-shale series lies at an altitude of 520 m above sea-level.

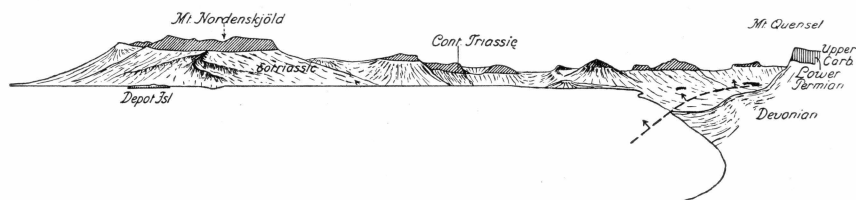


Fig. 12. Head of Nathorst Fjord.

The same conditions may be seen at the head and along the eastern side of the valley extending between this mountain and Mt. Quensel (cf. fig. 12).

2) The strata, here resting upon the marine Lower Permian, constitute the upper half of the mountains. Along Nathorst Fjord they are seen i. a. at Komait and on top of Mt. Paradigma. Along Fleming Inlet between Tvekegle Valley and the valley to the south of the Devonian at Cape Brown they form continuous exposures. At the northernmost end of this area, where the marine Lower Permian descends to sea-level, their basal-conglomerate lies close to the shore; this must be the locality where NORDENSKJÖLD (25) encountered the conglomerates containing pebbles of the Cape Fletcher series.

3) The strata in question are met with at an altitude of 690 m, here, too, resting directly upon marine Lower Permian. Only 20 m of the formation are left on the mountain top 709 m high. Farther southward a somewhat greater portion of the formation is still found.

4) Around the entrance to Pingel Valley (cf. fig. 13) the lowermost fossiliferous strata of the formation crop out along the coast and at the very base of the mountains; they are overlain by the other members including the gypsiferous beds; these again are covered by younger sediments.

5) Between Cape Seaford and Solfald Valley the lowermost strata exposed belong to the alternating arkose sandstone and conglomerate series. These are followed by the gypsiferous shale series, and the uppermost portion of the ridge, from about 450 m altitude and upwards, belongs to the covering younger strata. Along the west side of Ørsted Valley also the upper part of the series just mentioned is exposed. Farther on the gypsiferous beds are seen at the mouth of the three great valleys debouching into Fleming Inlet from the west-northwest.

D. Geological Position:

In Klitdalen the gneiss of Liverpool Land forms the substratum of this formation. If the conglomerate of Mt. Kollen in Canning Land, already described as Upper Permian, actually belongs to the present

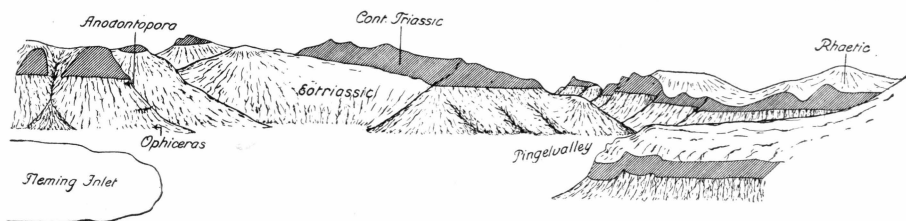


Fig. 13. Entrance to Pingel Valley, head of Fleming Inlet.

formation, its substratum is here Devonian, whereas on Wegener Peninsula the marine Lower Permian serves as substratum everywhere.

Broadly speaking, the formation occurs at three very different altitudes above sea-level, *viz.*: at about sea-level, at about 300 m, and at about 700 m altitude.

At sea-level its basal strata are found in the northern Carlsberg Fjord and around Mt. Nordenskjöld, further, behind Wegener Peninsula at the entrance to Pingel Valley in the southeastern corner of Fleming Inlet (cf. fig. 13). The strata descend slightly below sea-level along the west coast of this fjord. In other words, in the localities belonging to Jameson Land, in a geological sense, the formation is exposed almost at sea-level. At about 300 m altitude they are found on Mt. Paradigma; at Calamites River the base of the formation lies a little higher; to the west of both localities the strata approach lower levels. At about 700 m the strata are found at the 709 m mountain and the high-lying area south thereof.

However, even though the strata at the present day are met with at very different altitudes, their general gentle southwestward dip, is nevertheless but slightly affected by later tectonical disturbances. On Mt. Paradigma a dip-angle of 5° SW., on the 709 m mountain only of 3° SW., was measured; however, near later fault lines the dip is probably somewhat greater.

E. Special Description:

As the formation is somewhat differently developed within the five areas, sections from each of them will be given. One of these (the uppermost part of the Mt. Paradigma section) will be rather detailed in order to give an impression of the very sedimentation-act and of the rich occurrence of conglomerates carrying red porphyries referred to the Cape Fletcher series. The other sections are somewhat rougher. They will be given in the same order in which they are mentioned above (C).

1) Mt. Nordenskjöld. The section extends from sea-level just behind Depôt Island to 520 m altitude. No fossiliferous horizons were encountered:

- 520 m. Base of the younger covering strata.
- 495—520 m. Alternating fine-bedded layers of a hard dolomitic limestone and an arenaceous shale of a reddish colour.
- 470—495 m. Mouldering, greyish-green shale interstratified with beds carrying lumps of gypsum.
- 431—470 m. Hard arkose sandstone and fine-bedded shale of a red and green colour, carrying lumps of gypsum.
- 379—431 m. Grey or greyish-green sandstone with irregular spots of a red colour, and scattered pebbles on the bedding-planes.

- 325—379 m. Grey, coarse sandstone with scattered cobbles of red porphyries of the size of a fist.
- 225—325 m. Light, reddish, coarse arkose sandstone, clearly cross-bedded, with numerous conglomerate-beds up to one and a half metres in thickness. The pebble-material, with few exceptions, is a red porphyry.
- 233 m. A rather conspicuous conglomerate-bed carrying almost exclusively one type of porphyries.
- 165—225 m. Coarse, red arkose sandstone with cross-bedding and white, circular dots. Unfossiliferous concretions of a red sandstone are common. Scattered pebbles throughout the whole sandstone bed.
- 10—165 m. Talus.
- 0—10 m. Coast cliffs with the same strata exposed as described from Dépôt Island (with *Grammysia* and *Astarte*).

The total thickness of the strata does not exceed 510 m.

2) Mt. Paradigma. This section is an upward continuation of that of marine Lower Permian given in p. 36, and ranges from 266 to 606 m above sea-level:

- 548—606 m. Uniform, red, mouldering sandstone with conspicuous cross-bedding. Thin beds with mud-cake conglomerates are of common occurrence. In the lower part circular white dots were noticed.
- 547—548 m. Conglomerate. The cobbles, consisting of red porphyries only, attain a size of 10—15 cm in diameter.
- 522—547 m. Red sandstone with an intraformational conglomerate at the base.
- 512—522 m. Coarse, reddish-grey sandstone.
- 512 m. A conglomerate half a metre thick with a cobble-size of up to 20 cm; red porphyries are dominating.
- 506—512 m. Coarse, light-grey sandstone.
- 456—506 m. Uniform, light-coloured sandstone with scattered pebbles, up to 3 cm, through the whole series. The pebbles consist partly of quartzites partly of porphyries.
- 455—456 m. Conglomerate, with cobbles up to a fist's size, consisting of quartzites and red porphyries.
- 440—455 m. Coarse, light sandstone, thoroughly cross-bedded: compound foreset-bedding¹⁾ (cf. fig. 14). A single bed with clay-balls. Small pebbles of red porphyries are found through the whole series.
- 435—440 m. Fine-grained, reddish sandstone; in the lower part with circular, white dots.
- 424—435 m. Alternating argillaceous sandstone and arenaceous shale of a light colour.
- 416—424 m. Grey, arenaceous shale, rich in muscovite, with ripple-marks and a rusty hue of weathering.
- 398—416 m. Alternating very coarse arkose sandstone and conglomerate beds. The cobbles are only now and then larger than an egg. They consist of but slightly rolled, varying types of old crystalline rocks. The whole series is cross-bedded.
- 384—398 m. Hard beds of sandstone, interstratified with loose, mouldering shales of a greenish-grey colour. Worm-tubes?

¹⁾ Cf. LAHEE: Field Geology. New York 1923 (pp. 77—85).

- 372—384 m. Fine-grained, argillaceous sandstone, rich in muscovite.
- 368—372 m. Cross-bedded sandstone alternating with conglomerate beds. The conglomerate-cobbles, consisting of various crystalline rocks and quartzites, are of the size of an egg.
- 360—368 m. Conglomeratic very loose arkose sandstone with cross-bedding. The cobbles, attaining a size of 10 cm in diameter, consist of older crystalline rocks and quartzites.
- 340—360 m. Fine-bedded, reddish sandstone, rich in muscovite, alternating with thin layers of a light-coloured shale.
- 324—340 m. Thin-bedded, light-grey sandstone.
- 280—324 m. Fossiliferous Eotriassic strata. The lowermost five metres consist of an arenaceous, greyish-green shale; this shale is followed by an easily mouldering grey shale, rich in muscovite, with limonite-concretions rich in fossils (*Ophiceras* and *Pseudomonotis*). The upper part is rich in mussels, but no ammonites were found; further the concretions were missing in the upper strata.
- 266—280 m. Basal-conglomerate with pebbles generally not bigger than a hazelnut, mostly consisting of quartz and small pieces of dolomite; further, rolled fossils of Lower Permian age are common.

The total thickness of the strata must be less than 340 m.

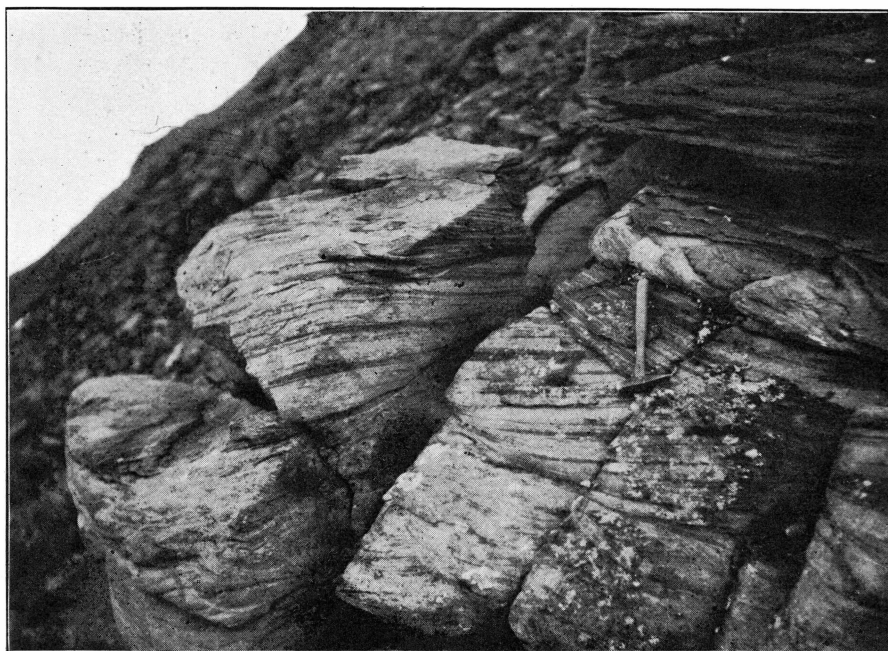


Fig. 14. Cross-bedded Eotriassic sandstone; Mt. Paradigma, upper part (Sept. 1931).

2 a) A section in the river-bed between Cone 1 and Cone 2 on the northern side of Tvekegle Valley. The section runs from the bottom of the valley, at 31 m, to 145 m above sea-level:

- 145 m. Light-grey cross-bedded sandstone.
 139—145 m. Coarse conglomerate; the boulders, which attain a size of 30—40 cm in diameter, consist almost exclusively of red porphyries.
 135—139 m. Light, greenish-grey sandstone.
 119—135 m. Greenish-grey shale; fossiliferous horizon (*Ophiceras* and *Pseudomonotis*), the upper part only with mussels (*Pseud.*).
 Angular disconformity.
 103—119 m. Limestone, in the upper part carrying Lower Permian fossils.
 Angular disconformity.
 31—103 m. Red and grey Devonian sandstone.

Only the lowermost strata of the formation are represented here:
 26 m.

3) Uppermost part of the "Southwest Section" (cf. p. 34) running from 689 to 709 m above sea-level:

- 705—709 m. Grey, micaceous sandstone with grey mud-cakes of a length of 10—15 cm. No fossils met with.
 704—705 m. Grey, easily splitting, micaceous, arenaceous shale with a few indeterminate plants.
 702—704 m. Greyish green, arenaceous shale with a rusty weathering, containing numerous dolomitic concretions without fossils. The shale crowded with ammonites and mussels (*Ophiceras* and *Pseudomonotis*, further some other, badly preserved, mussels).
 695—702 m. Arenaceous shale, finer-grained than the overlying beds. (*Ophiceras* and *Pseudomonotis*).
 694—695 m. Light, fine-grained conglomerate with small, white, quartzitic pebbles; the conglomerate is rich in mica.
 692—694 m. Red, coarse sandstone.
 689—692 m. Conglomerate with pebbles of white and grey quartzites, of the size of a hazel-nut, and rolled brachiopods and crinoid-stems from the Lower Permian substratum. The weathering-colour is reddish. Occasional cavities in the rock are filled with calcite.
 Angular disconformity.
 689 m. Top of marine Lower Permian.

Here, too, only the very lowermost part of the formation is present: 20 m.

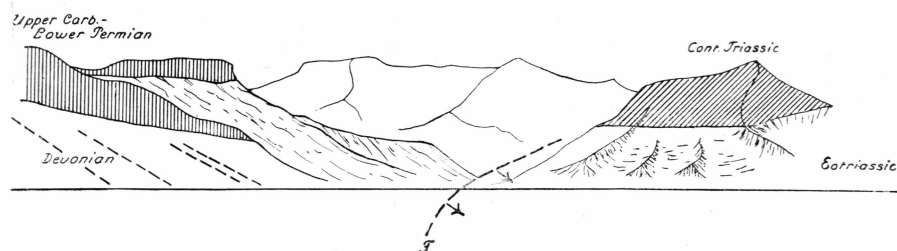


Fig. 15. Wegener Peninsula, southern fault-line in Fleming Inlet.

4) As no continuous section was measured in the neighbourhood of the entrance to Pingel Valley, only the main lines will be given here:

Younger covering strata (about 500 m above sea-level).

Shale and dolomitic limestone series (in erratics: *Anodontopora*).

Shale-gypsum series.

Alternating series of arkose sandstone and conglomerates. (In the talus the following conglomerate-balls were observed: grey gneiss, quartzites, red granite, dark limestone, and numerous red porphyries. Cobbles up to 20 cm in diameter).

Fossiliferous beds of greenish shales (*Ophiceras* and *Pseudomonotis*). The collections of fossils made by HARTZ and NORDENSKJÖLD are probably derived from these beds.

5) The section at the most westerly locality was measured 2—3 km to the south of Cape Seaford in the narrow ridge separating Fleming Inlet from Ørsted Valley, and is given in fairly great detail because two fossiliferous horizons were met with:

450 m. Covering younger strata.

425—450 m. Fine-bedded, grey and yellow shales, rich in lime. Thin bands of yellow dolomitic limestone are intercalated in the upper portion. In a subordinate thin sandstone-schist badly preserved plant-remains were met with. At the very top — at the transition to the covering strata — red sandstone-schists containing a small lamellibranch (*Anodontopora*) were found.

390—425 m. Talus.

315—390 m. Alternating series of greenish and reddish, somewhat arenaceous, shales, strongly weathering. In these, bands and lumps of gypsum up to a size of 15 cm in diameter, generally white, but also now and then pink or pale-red. Sun-cracks and ripple-marks are well developed on the bedding-planes. Also cross-bedding was noticed. In a massive bank pseudomorphs of NaCl were observed.

230—315 m. Alternating reddish sandstone-schists and light-green shales with ophiomorphs. In cracks and fissures gypsum.

200—230 m. A fine-bedded, light sandstone alternating with a dark, bituminous, limy shale containing mussels, often crushed, and a small gastropod.

160—200 m. Grey sandstone with irregular bedding, beginning with a greenish mud-cake conglomerate, passing upwards into an alternation of grey and yellow sandstone-beds. At the top a 40 cm thick limestone band without fossils.

144—160 m. Red sandstone alternating with grey shales.

112—144 m. Red, cross-bedded arkose sandstone. 10—20 cm thick sandstone-schists alternate with hard sandstone-beds 1—2 m thick. A single thin shale-bed in the middle of the series.

0—112 m. Talus.

Here the thickness of the formation does not exceed 450 m.

Considering the rough features of all these sections, it will be noticed that conditions are of a general character, though varying strongly from place to place.

In Mt. Nordenskjöld the very base of the strata here referred to this formation, if we disregard Depot Island, is not known; the accessible part of the section no doubt begins somewhere at the alternating sandstone-conglomerate series. The three sections from Wegener Peninsula comprise the basal strata, the *Ophiceras*-horizon and greater or smaller parts of the alternating sandstone-conglomerate series. At the entrance to Pingel Valley the whole series from the *Ophiceras*-horizon to the very top of the formation seems to be exposed (in the talus there were also found boulders carrying fossils similar to those found at C. Seaford between 200 and 230 m altitude). At C. Seaford the section begins with strata somewhat above the *Ophiceras*-horizon and terminates with a fossiliferous bed at the very top (*Anodontophora*).

Within the sediments here referred to the same strata — Eotriassic — local differences are met with all over the district, as may be evident from the above; but nowhere within the strata has a general alternation of the sedimentation-set been traced. Consequently no division of these beds, as was previously made by ROSENKRANTZ, has been made, on the contrary the whole series is considered as a unit, the lower limit of which is clear and the upper limit of which is marked by the alternation of sedimentation characterizing the covering, younger series.

The following main features of the general habitus seem to be of particular interest:

A decreasing coarseness in the material from east to west; in this connection it should also be noted that no fossils were met with in the easternmost localities: Carlsberg Fjord, Mt. Nordenskjöld, and Klitdalen (ROSENKRANTZ); they may have been dissolved by percolating water or have been crushed and disintegrated during the very in-bedding in the strata, if the facial development was not of such a nature that conditions for organic life did not exist.

A better developed gypsum-horizon at C. Seaford, in the west, than in Mt. Nordenskjöld, in the east.

The torrential occurrence of red porphyries on Wegener Peninsula; here occurring above the *Ophiceras*-horizon.

A. Determination of Age:

The fossils collected were all handed over to Dr. SPATH in London, to whom the determinations are due.

A little above the base of the formation *Ophiceras* and *Pseudomonotis* occur; they determine together its age as Eotriassic (SPATH). From C. Seaford — 200—230 m altitude — fossils were collected, which, however, proved to be indeterminable. At the top of the section at C. Seaford a great number of an *Anodontophora* was found. Comparing these finds with the stratigraphical conditions within the northern areas, they are most likely to be parallelized with the Eotriassic strata of C. Stosch (17, 33); however, the facial development of the sediments in the north is to a great extent different.

The very clear and well-defined alternation of the sedimentation above the *Anodontophora*-bearing horizon warrants the drawing above it of a limit between the sediments referred to the Eotriassic and the sediments referred to the covering, younger formation. In C. Stosch also the uppermost fossiliferous horizon belonging to the Eotriassic carries *Anodontophora* (17).

None of the plant fossils observed were determinable.

2. Triassic-Continental Beds.

These strata, referred by NATHORST with reservation to the Keuper, correspond to the "Cape Biot Formation" of KOCH and the "Red Marl Member" in the "Klitdal Formation" of ROSENKRANTZ.

The observations made by ROSENKRANTZ (28) in Klitdalen (where the strata repose on the "Gypsum member") may be given as follows: "It is made up of purple marl beds, frequently interstratified with bands of limestone. In the upper portion the red marl beds alternate with beds of white kaolin sandstone with red felspar grains. — — —

— — — In the southern part of Klitdalen the series attains a thickness of about 225 metres".

The observations on which the description given by KOCH (15) is based, have most likely been made in a subordinate sandstone-bed within the series, since nowhere within the district does a sandstone play the greatest part in the composition of the beds.

The cementation of the strata, however, seems to be more perfect in the northern areas, i. e. within the district in question, than in the south. Thus the outcrops of the formation along Fleming Inlet and along the northern end of Carlsberg Fjord are steep and cliff-forming, while in Klitdalen gentle slopes are seen within the same strata. The cliff-forming habit within the present district makes the formation easily recognizable over great distances, (cf. fig. 13 and 16).

The thickness, estimated by KOCH at 150—200 m, is very constant.

ROSENKRANTZ states 225 m, and the same thickness was observed by the present writer at the northern end of Carlsberg Fjord and near C. Biot.

During the present investigation these strata have been traced from the head of Hurry Inlet to Mt. Nordenskjöld; at the former locality they repose near sea-level, while at the latter their base rises to an altitude of 520 m. From here they have been traced behind the Wegener Peninsula to the southeast corner of the head of Fleming Inlet; their base



Fig. 16. C. Biot, seen from the east. Fine-bedded continental Triassic strata (May 1932).

is here at an altitude of 3—400 m. Further they can be traced along the western shore of Fleming Inlet and the western slope of Ørsted Valley. Somewhat to the north of C. Biot the strata descend to sea-level. In the valley connecting the outer part of Flemming Inlet with Antarctic Harbour the strata are seen to constitute the base of the mountains in the east to about midway up the valley.

With the exception of local disturbances the strata exhibit the same gentle southwesterly dip as was found in the Eotriassic series.

Seen from a distance the rocks are of a very uniform appearance, but on closer examination they prove to consist of rather thin beds of varying colour and varying material. Owing to the action of surface water and of snow the whole series has obtained a uniform red colour.

The formation consists of alternating fine-bedded, red, limy, argillaceous shales and thin beds of marl; further, thin, micaceous sandstone-schists and thin, generally yellow, limestone-bands. Now and then there occur irregular lumps or concretions of a grey, hard, dolomitic limestone with concentric linings. On the bedding-planes sun-cracks and ripple-marks are common. Subordinate mud-cake conglomerates are also commonly met with at various levels. The white, gritty sandstone mentioned by ROSENKRANTZ from the upper portion of the series is also met with within the district in question.

No fossils were met with in these beds, however, worm-tracks and various problematica were noticed. Common are also large irregular spots of a yellow or green colour within the red strata. Under the microscope some small, often lenticular, cavities, now filled with calcite and quartz, are seen; possibly there have here been traces of organic life now totally destroyed.

All over the district where these strata have been traced they are seen to repose on, or pass continuously into, the upper part of the Eotriassic strata just described. Further they are without interruption overlain by the following formation. Consequently these strata are no doubt of Triassic age, most probably embracing a somewhat greater period of time than suggested by NATHORST (Keuper).

3. Rhaeto-Liassic-Continental Beds.

A. General:

This formation — "Cape Stewart Formation" (HARTZ) KOCH — was first met with by SCORESBY at C. Stewart on the southeast corner of Jameson Land. He collected some plant fossils, which were originally determined as Carboniferous. Later — in 1891—92 — the strata were investigated by HARTZ. After a re-examination of the material of HARTZ these beds were examined by T. HARRIS in 1926—27 (11, 12). Also some more casual observations made by ROSENKRANTZ within these strata deserve mention (28).

ROSENKRANTZ (op. cit. p. 143) gives the following description of the rocks: "The series includes grey, yellow, and green sandstones, often cross-bedded and alternating with shales in the upper portion. To the south coarse quartzitic conglomerates enter as constituents of the series. Petrified wood is often found embedded in the lower portion of the formation, which has a thickness of about 175 metres, while the upper portion, which is interbedded with more or less arenaceous clay shales, contains the plant fossils described by HARTZ and HARRIS".

Based on these plants HARRIS (11) writes: "The plant-bearing beds

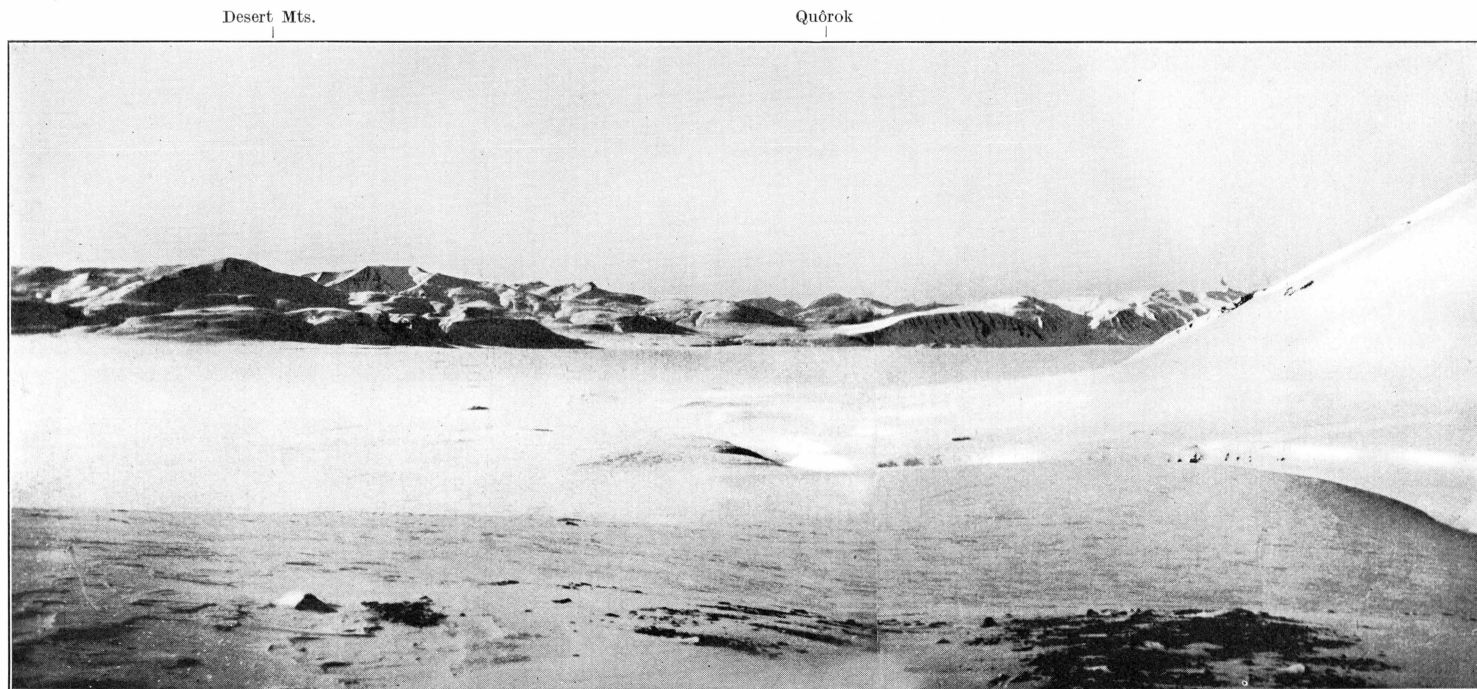


Fig. 17. Southwestern corner of Fleming Inlet. Lower part of the mountains in the background continental Triassic, upper part Rhaeto-Liassic (April 1932).

are 90 metres thick, the upper 30 metres is characterized by one set of species and are termed the zone of *Thautamopteris schenki*; and the lower 60 metres have another set of species and are termed the zone of *Lepidopteris ottonis*".

In areas farther north, within the present district, observations of these strata have been made by NATHORST and KOCH.

NATHORST climbed the mountain to the east of Antarctic Harbour, where he found the following rocks: Grey, greenish, and yellow sandstones rich in muscovite; at a greater altitude he found a dark, bituminous shale containing badly preserved plant-remains, which did not allow of a certain determination.

Shales with plant-remains were also found by KOCH in 1926—27 at Antarctic Harbour, slightly above sea-level.

B. Geographical Distribution:

The strata belonging to this formation occur only within the geological unit of Jameson Land.

Most naturally the occurrences may be divided into two areas, namely: 1) The coast stretch along Carlsberg Fjord, being a direct continuation of the area investigated by HARRIS and ROSENKRANTZ. 2) The country around the innermost parts of Fleming Inlet — Desert Mountains — and the whole area between this fjord and Antarctic Harbour.

1) In the northern part of Klitdalen this formation is seen to constitute the lower and essential part of the mountains; at the head of Carlsberg Fjord they are seen to repose on the continental strata of Triassic age, further, as a glimpse through the great valleys debouching into Carlsberg Fjord, they are seen to constitute a great part of the backland. Somewhat past the middle of the fjord they disappear from the coast-cliffs, but may still be seen farther inland. Southward behind the valley between Mt. Nordenskjöld and Mt. Quensel they also seem to occur, reposing on the continental Triassic (cf. pl. 6 in 14, here only erroneously designated as "Klital Formation"), this occurrence has not been represented in the map, pl. 2.

2) In the inner parts of Fleming Inlet the sediments play a great rôle, thus Desert Mountains are mainly built up of them, perhaps covered by still younger strata. Further they occur above the continental beds of the Triassic on the mountain-ridge between Fleming Inlet and Ørsted Valley. To the west of this valley they increase in thickness westwards, to constitute at Antarctic Harbour nearly the whole of the mountains from sea-level to the very top. Along Davy Sound their base descends to sea-level between C. Biot and Antarctic Harbour.

C. Lithological Characters:

In reality the description of the sediments of this formation in the south given by ROSENKRANTZ is valid also for the north.

Dominating are coarse, often gritty, grey and yellow sandstones, in places rich in muscovite. Interbedded with them are subordinate shaly beds carrying badly preserved plants. Thin conglomerates carrying quartzitic pebbles also occur; further, thin, red mud-cake conglomerates are found. Ripple-marks and cross-bedding are common. Perhaps the sediments are somewhat coarser in the north than in the south.

D. Geological Position:

The formation, the lower part of which according to ROSENKRANTZ (loc. cit.) attains a thickness of 175 m, seemingly grows much thicker to the north. At Antarctic Harbour the greater part of the mountain to the east — 855 m — seems to consist of strata belonging to this formation. In Desert Mountains the thickness of the strata is difficult to estimate owing to the presence of sills of Tertiary basalts.

All over the district in the Carlsberg Fjord-Klitdalen as well as the area around the head of Fleming Inlet and west hereof these sediments repose on, and form a conformable continuation of, the underlying continental beds of Triassic age. The dip is everywhere a gentle south-westerly one. In places these beds too have been affected by local disturbances.

E. Special Description:

One section (1) was measured in a valley running westward from Klitdalen; another (2) was measured in Desert Mountains, and two were secured in the neighbourhood of Antarctic Harbour, only one of which is given below (3). Further, observations were made at several other places, i. a. at C. Seaford between Fleming Inlet and Ørsted Valley. In order to establish a connection with the areas already investigated, the southernmost section from a mountain to the north of Mt. Skansen will be given first. The section ranges from the bottom of the valley, about 100 metres above sea-level, to the summit of the mountain, at 631 m.

434—631 m. Younger marine strata.

300—434 m. Fine-grained, light sandstone and sandstone-schists, with a few badly preserved plant-remains.

100—300 m. Grey and yellow, coarse, often arkose-like sandstones with a rusty weathering-surface. Interbedded in these there are arenaceous shales and thin, strongly mouldering coal-seams; further, thin beds of a fine-grained greenish shale occur. In the sandstones numerous, but extremely badly preserved plant remains are found; in the arkose-portions only carbonized wood is met with.

2) This section was measured some kilometres inland, on the east side of the great mountain complex, belonging to Desert Mountains, which bounds the eastern of the two main valleys debouching into Fleming Inlet (cf. pl. 2):

- 575 m. Summit (separated from the main mass of the mountain by a narrow ridge).
- 515—575 m. Grey and yellow sandstone and argillaceous shale, rich in muscovite. Occasional indeterminable plant-remains.
- 450—515 m. Fine-bedded, grey, micaceous shale, rather arenaceous. In the upper portion some rather coherent beds of sandstone containing carbonized wood and lenticular mud-cakes. In the lowermost part ripple-marks occur.
- 415—450 m. Yellowish grey sandstone, alternating coarser and finer beds, the coarser ones dominating upwards.
- 425 m. A clay-ball conglomerate.
- 415 m. Numerous trails (Crustaceans?) in the sandstone.
- 380—415 m. Grey, mouldering shale, containing flat, lenticular, limonitic concretions. A portion of 4—5 m exhibits very pronounced cross-bedding, and ripple-marks on the bedding-planes. Thin sandstone-beds alternate with the shale in the uppermost 10 m. In this series some plant-remains were found. (They were examined by T. HARRIS, who states (by letter): "impressions of Equisetaceous stems, *Neocalamites* (?) , in micaceous sandstone" — —).
- 320—380 m. Alternating, coarse, greyish-yellow sandstone, in the lower parts interstratified with black and reddish shales, in the upper part with grey shales. In the sandstone some few indeterminable plant-remains were noticed. (According to HARRIS an erratic from the talus contained a *Neocalamites*?).
- 145—320 m. Basic sills and contact-metamorphosed shale and sandstone.
- 0—145 m. Talus.

3) This section was measured in the southern part of the mountain on the east side of Antarctic Harbour. No determinable fossils were found, but the section is recorded here to give an impression of its lithological characters:

- 855 m. Summit (old cairn).
- about 800—855 m. Light, strongly mouldering sandstone, with conspicuous cross-bedding, and containing carbonized wood.
- 765—about 800 m. White, coarse sandstone (two very problematic ammonites?).
- 705—765 m. Light, greyish sandstone with carbonized wood.
- 345—705 m. Talus.
- 295—345 m. Talus with occasional outcrops of coarse sandstone; (also shales were met with).
- 175—295 m. Light, coarse sandstone with a rusty weathering. In the lower part sandstone-concretions up to 20—25 cm in diameter occur, increasing in size upwards.
- 0—175 m. Talus.

The other section from this area shows quite similar conditions.

The conditions at C. Seaford (cf. 25, fig. 17) are rather intricate owing to two minor faults (cf. fig. 19) and require some words of explanation. The red strata belonging to the continental Triassic have here slid down in relation to the southern part of the ridge, together with which they seem to constitute a continuation of one of the red members of the Eotriassic strata. As a consequence of this movement the covering strata have also been lowered and now constitute the northern end of the ridge; the very northernmost point of the cape has by another fault been lowered considerably in relation to the portion just discussed, for which reason the light, presumably Rhaeto-Liassic, series of sediments is found at sea-level. Here the following conditions were met with:

- 58—78 m. Light, grey sandstone with limonite-concretions.
 - 42—58 m. Light greenish shale alternating with light grey sandstone; in the sandstone concretions of the size of a fist, in the shale carbonized plant-remains.
 - 26—42 m. The lower part consists of coarse, grey, conglomeratic sandstone with several carbonized stems (up to 16 cm in breadth) and other plant-remains. The upper part is more fine-grained, micaceous. A single stem was determinable: "internal cast of large stem of *Neocalamites*, like *N. carcinoides*" (HARRIS).
 - 0—26 m. Grey sandstone, with a single red bed, interstratified with thin shaly bands.
-

F. Determination of Age:

As will be seen from the above, only a very scarce determinable material has been secured. A more detailed stratigraphy cannot be made on the basis of it. Since, however, the formation, as previously mentioned, passes downwards into the preceding formation and can be traced continuously from C. Stewart to C. Biot, there can be no doubt that it is an equivalent to the formation represented along Klittdalen and Hurry Inlet, and consequently of Rhaeto-Liassic age in general (cf. HARRIS).

That these strata possibly include still younger strata in a continental evolution, is indicated by the seemingly much greater thickness in the north than in the south; but at present nothing can be stated with certainty.

The lowermost strata encountered at Antarctic Harbour by PARKINSON and WHITTARD (36) contained, according to HARRIS, a *Neocalamites*, which does not allow of a more exact determination of age. It is most probable that the section given above represents to a rather great extent strata of a younger age than the Rhaeto-Liassic, the sediments, however, resemble each other very much throughout the whole mountain.

4. Jurassic-Marine Deposits.

Within the present district, especially at Antarctic Harbour, vestiges of marine strata superincumbent on the continental beds just described are present, consequently a few words may be devoted to the covering strata met with in the southern and considerably better known areas.

In Klittdalen the present writer measured a single section through these beds, representing the upward continuation of section No. 1 of the preceding chapter. The locality — at Skansen — lies to the south of the southern limit of the map represented in pl. 2. The following conditions were found:

586—631 m. Yellow, coherent sandstone.

531—586 m. Grey shale, with limonitic concretions. At the base they may be one metre in diameter, upwards their size decreases to that of an egg.

531 m. Plateau. The whole surface is strewn with fossils, especially mussels (internal moulds).

434—531 m. Alternating arenaceous shale and sandstone.

434 m. Plateau, strewn with fossils: mussels and belemnites.

100—434 m. Above-described plant-bearing continental beds.

According to ROSENKRANTZ, who has made observations in the areas immediately south and west of this locality, the strata belong to the marine Upper Liassic.

In localities in the neighbourhood of Mt. Skansen he records ammonites together with a fauna similar to the fauna encountered by the present writer. ROSENKRANTZ kindly informs me that this part of the series may be referred to the Lower Toarcian (Whitbian) bifrons-zone.

The original description (28, pp. 143—44) refers the beds in question to the "Oyster bank series" of the "Neills Cliff formation". The two lower horizons of this formation, viz. "The Pecten limestone series" and "the Gervilleia horizon", were not met with by ROSENKRANTZ to the north of Mt. Skansen and Vardekløft respectively. The absence of these two horizons in the present section is therefore in accordance with the observations of this writer.

NATHORST as well as KOCH recorded badly preserved fossils from Antarctic Harbour, presumably of "younger Mesozoic character". In the section — No. 3 of the preceding chapter — two doubtful ammonites were found; further, in a section facing Davy Sound in the same locality on the top of the mountain, very badly preserved mussels were encountered.

No determination of the fossils found by the present writer at

Antarctic Harbour has been possible. The only conclusion that can be drawn is that the continental plant-bearing beds are covered by strata carrying marine fossils.

During the Cambridge Expedition (Leader J. M. Wordie) in 1929 fossiliferous Jurassic strata were found by PARKINSON and WHITTARD on the south-east side of Antarctic Harbour (36). A section is given (op. cit. p. 653) which exhibits almost the same characters of the rocks as does the section given by the present writer in the preceding chapter; the English geologists, however, succeeded in making a more detailed division of the strata (survey during the summer). The fossils collected (zone VI in the succession p. 653) were examined by L. F. SPATH (33 a), who (p. 136) gives a list of species. He, too, points out the strange scarceness of fossiliferous horizons in this enormous series of beds, assigned to the Jurassic. Owing to the presence of *Cranocephalites* cf. *pompeckji* (MADSEN) the beds may be referred to the Upper Bathonian (cf. p. 145, op. cit.): "they may be of slightly earlier date than the *pompeckji* fauna of Cathedral and Ammonite Mountains" (p. 137).

With some reservation the area to the east of Antarctic Harbour as well as an area farther inland have been indicated as Jurassic on the map. Since an erratic containing a piece of an ammonite, (which may have been transported by water or ice from a southern locality) was found at sea-level on the western side of Antarctic Harbour, it might seem probable that marine Jurassic strata are present farther inland here along the northwestern boundary of Jameson Land.

Observations made from airplane by L. KOCH (1933) show that light (Jurassic?) erosion-remnants are found, covering Triassic strata in the inner parts of the north of Jameson Land (oral communication).

It will be easily seen from the above that our knowledge of the strata described in this chapter is still too insufficient to warrant a division of the beds or continuous correlations as to the position of various strata in various parts of the district (i. e. the northern parts of Jameson Land). Consequently the fossiliferous strata from Klittdalen (Upper Liassic) and the beds from Antarctic Harbour (Upper Bathonian) have been designated as Jurassic in general.

V. TERTIARY

(BASIC IGNEOUS ROCKS)

The "common" fine-grained basalts, *viz.* dolerites and a special type of basic igneous rocks, generally named the "Fame Islands Porphyrites" (14), belong to this series. About their mutual relations NORDENSKJÖLD (25) writes: "Whether the sheets of porphyrites from Fame I. and Fleming Inlet can be really classed among this series (i. e. common Tertiary basalts), is a question that cannot be answered at the moment". Since, however, both groups cut through, and consequently are younger than, the Jurassic, the suggestion set forth by KOCH (14, pp. 199—200) is the only natural one: "It seems most probable that we have here a special development of the Tertiary basalt, which is of most frequent occurrence between the northernmost locality of the southern basalt area and the most southerly locality for the basalts of the northern area".

The late Cretaceous or early Tertiary age of the basalts, determined at Cape Dalton for the southern area (27) and at Sabine Island for the northern one (21), has been discussed elsewhere. Whether the basalts of the present area belong to the earlier or to one of the later magmatic stages (cf. 3), cannot be decided without detailed petrographic studies, which are not the object of this description.

Of the porphyrites, dikes as well as sills are known from Klitdalen and along Hurry Inlet (25, see also pl. 14); further, erratics of these rocks were encountered by NORDENSKJÖLD in Fleming Inlet, whereas dikes were found by KOCH between C. Biot and Antarctic Harbour.

Even this distribution suggests that there is no real hiatus between the northern and the southern basalt areas (cf. *op. cit.*).

At the northern end of Klitdalen immediately south of the head of Carlsberg Fjord two dikes, dipping towards the south, are seen; another

dike is seen in the mountain to the south of Mt. Nordenskjöld. Judging from erratics these dikes seem to be developed as porphyritic rocks.

In Canning Land basaltic rocks were met with at C. Fletcher by NORDENSKJÖLD. They were found in the form of erratics by the present writer in Aalborg Fjord and in Snevigen, between C. Tyrrel and Porfyr-fjeldet. On the north coast, within the crystalline complex of Cape Wardlaw, four narrow dikes of a fine-grained basalt with a columnar structure were encountered; the strike is nearly N.—S.

On Wegener Peninsula a single basic dike is seen in Ravnefjeldet some hundred metres to the northeast of the station; the rock is a fine-grained basaltic one.

At the head of Fleming Inlet a great number of sills were met with, partly intruded into the Triassic continental beds, partly into the base of the covering Rhaeto-Liassic strata. These rocks belong to the porphyrites.

Along the west coast of Fleming Inlet two sills of about 3 m thickness are seen together with a dike of a N.—S. strike and 2 m thickness. The small island in the outer part of Fleming Inlet — Kekertak — consists mainly of a basic sill with columnar structure. All these rocks belong to the porphyritic group, but they are somewhat more fine-grained than the rocks at the head of Fleming Inlet.

At the entrance to Fleming Inlet, on the south side of C. Biot, a narrow dense dike cuts through the Triassic beds and develops as an inconspicuous sill at the base of the Rhaetic; whether the rocks belong to the porphyrites or to the simple basalts, cannot be decided.

Between C. Biot and Antarctic Harbour three small dikes about 2 m thick are seen in the coast cliffs. At the eastern side of Antarctic Harbour a vertical dike with a NW.—SE. strike is found at 700 m altitude. All these dikes belong to the porphyritic group, which, judging from the numerous erratics, seem to have a great distribution in the Mesozoic sediments of this area.

These additional observations on basic outcrops confirm those recorded above: that there is no substantial nor geographical hiatus between the northern and southern basalt areas.

At the minor sills and dikes the contact-metamorphism produced by these Tertiary basic rocks is very inconsiderable. In one place only i. e. at the large intrusive sheets in Desert Mountains, at the boundary between the Continental Triassic and the Rhaeto-Liassic, a conspicuous action of heat is traceable. The sandstone is red-burnt and the shaly series, originally red, now grey or yellow, are mouldering into small

parallelepipedonal pieces; at the very contact the rich representation of a light brown garnet testifies to the contact-metamorphism produced by the intruding igneous rocks.

As the underlying as well as the covering strata have been affected, a proof of the intrusion of the basic magmatites in the form of a sill has been delivered.

VI. THE GEOLOGICAL EVOLUTION OF THE AREA.

1. Faulting and Folding.

As already suggested by KOCH the tectonics of Canning Land and Wegener Peninsula are of a rather complex and intricate nature. The lack of a topographical substratum, however, did not permit him to insert any observations on the tectonics in the map. He is of opinion that faults synchronous with the intrusion of the Cape Fletcher series are predominating, and writes as follows about their age (14, p. 99): "— — these are probably younger than upper Carboniferous, but older than Permo-Triassic". He is also aware of the possible existence of Tertiary faults.

In fact the tectonic activity, as will be shown below, should be divided into two groups, *viz.* Late Palaeozoic and Tertiary disturbances.

A. Pre-Mesozoic Diastrophism.

The supposed oldest movements within the district are met with in the (Middle) Devonian just to the south of Vimmelskaftet, where, as stated above (p. 20), a slight folding has taken place prior to the deposition of the marine Upper Carboniferous-Lower Permian. Since, on Wegener Peninsula, no similar folding seems to have affected the continental beds of Carboniferous age older than the said marine Carboniferous, there seems to be a possibility that this folding has taken place after the deposition of the Continental (Middle and Upper?) Devonian, but before the Continental Carboniferous beds were laid down.

To the west of the district in question, at the eastern slope of Syltoppene in front of Menander Islands, movements have evidently taken place during this time (1933). Rising their edge above the level of erosion, the Devonian sediments already deposited were removed before the deposition of the Continental Carboniferous began upon its basement, i. e. on the older sediments of the Caledonides. Only remnants of Devonian, deposited within post-Caledonian erosional tracts at the very

edge of the folding range, have escaped the post-Devonian — pre-Carboniferous erosional activity.

Prior to the deposition of marine strata of the Upper Carboniferous — Lower Permian and after the deposition of Continental Carboniferous strata, tectonical disturbances reappeared, the marine beds in the close neighbourhood reposing partly on Devonian and partly on Continental Carboniferous beds. A fault belonging to this time of tectonical activity cuts the coast just to the north of Tvekegle Valley, whence, covered by talus and Mesozoic sediments, it runs southwards, to the northeast of Cone 1 and Cone 2. Most probably its continuation coincides with the depression between Ravnefjeld and Mt. Paradigma, i. e. with the large fault which was revived later by Tertiary action and which continues along the eastern base of Mt. Quensel.

The development of the fault-line, which runs northwestward through Calamites River, and the depression to the northwest thereof, in the northern part of Wegener Peninsula, may also date back to this time.

The slightly pronounced, yet visible facial variations of the fossiliferous marine Lower Permian in the various parts of the district are perhaps due to outstanding erosion remnants of these blocks of vertical movement, producing different depths within the transgressional area.

The angular unconformity observed between Continental beds and marine Carboniferous and Permian at Mt. Svinhufvud on Traill Island (1933) furthermore marks the tectonical movements of this time. A similar age may perhaps also be presumed of the slightly undulating position of the Lower Carboniferous along the coast between Syltoppene and Antarctic Harbour (1933).

The marine transgression, which includes the marine Upper Carboniferous and Lower Permian, was followed by the main activity of the Cape Fletcher magmatites. They ascend to the dolomites and limestones and intrude into them, causing a regional upheaval of them and of their base above sea-level and exposing them to erosional action.

The following sediments — Upper Permian? — already at their base carry balls of hypabyssal porphyries of the Cape Fletcher type; accordingly these were laid bare by erosion. Further they carry balls of Devonian (red and greyish sandstones) and Carboniferous (limestones and dolomites); consequently these formations were also exposed to erosion. Thus prior to the supposed Upper Permian transgression tectonic block-movements, probably coupled with the *mise-en-place* of the magmatites of the Cape Fletcher series, were in action.

No faults exclusively restricted to these movements were observed in the field; whether the movement was a flexural one, or was marked by an incipient fault running northwest between Hestekofjeldet and Mt. Kollen and later revived, it is difficult to decide.

Prior to the Eotriassic transgression a differential upheaval in the east seems to have again taken place; fresh portions of older formations were exposed by erosion. In the Eotriassic deposits plenty of coarse conglomerates with balls of the Crystalline Basement, of Devonian, Upper Carboniferous-Lower Permian (also rolled fossils) and porphyries represent their indicators. The Eotriassic series reposes alternately on members of Crystalline rocks (to the south), Lower Permian and Upper Permian (?).

All these tectonical movements can be classed as Late-Palaeozoic, and are well defined together as Hercynian in contrast to the Caledonian ones. They were followed by a period of quiet sedimentation during the Mesozoic period, as far as is indicated by the sediments later than Eotriassic. They must be termed "Germanotypic" block-movements, without intense folding. Four sets or phases of movements were distinguished; if, however, the supposed Upper Permian (?) cannot be maintained as an independent formation within the area, the two last-mentioned movements may perhaps be regarded as two different sub-phases of one phase; the difference in the ball material of the conglomerates at the base and higher up in the Upper Permian-Eotriassic strata justifies such a separation, as does also the two distinctly different plutono-magmatic phases in the development of the Cape Fletcher series, as traced in 1933 on the southeastern Traill Island.

A slight ground for parallelizing the late-Palaeozoic diastrophisms of the present area with more or less synchronous tectonical activity in other parts of the earth with the subdivisions of STILLE (34) of the Hercynian disturbances (op. cit. pp. 80—131) is delivered by the following computation.

The supposed faulting with downthrow and gentle folding of the Devonian, prior to the sedimentation of Continental Carboniferous, may very likely be parallelized with the "Bretonic (or "Sudetic") phase" of movements.

The more conspicuous activity after Continental Carboniferous, prior to the marine Upper Carboniferous-Lower Permian transgression (cf. above, p. 69), might belong to the "Asturic phase", since nowhere in East Greenland are there any proofs of a "Sudetic" movement, although indications exist.

As to the following movements conditions are less clear. Here two alternatives exist. If the conglomerate in Mt. Kollen really belongs to the Upper Permian, the coming into existence of the main mass of the Cape Fletcher series and the faulting which has laid them bare to erosion before the transgression, must have taken place before the supervention of marine, supposed Upper Permian (it seems probable that the *Bakewellia antiqua* belongs here). The main eruption of the igneous rocks

and the associated faulting might then belong to a period corresponding to the "Saalic phase"?

If, however, the conglomerate in question is of Eotriassic age, this faulting-epoch may possibly be grouped together with the following pre- (or more or less syn-) Eotriassic movements; and they must be interpreted as two subphases of the "Palatinat (pfälzish) phase" of faulting activity. Reasons for keeping the two phases apart have been given above.

Considering these phases of orogeny, we might perhaps compare them to the phases described by VAN WATERSCHOOT VAN DER GRACHT (35) from North America (op. cit. pp. 138—41). The Bretonic phase should then be compared to the "Acadian Orogeny", the Asturic phase to the "Arbuckle Orogeny", and the last late-Permian-Eotriassic-period of orogenetic movement to the "Appalachian orogeny".

It seems evident that such parallelizations as sketched out here cannot be taken as proved. They are only given here to render clear the main lines of possible relations to other areas, if such a parallelization can on the whole be undertaken.

B. Post-Mesozoic Movements.

The Tertiary tectonical activity partly takes advantage of older, i. e. Hercynian, disjunctive lines, partly are renegant. From the northern sedimentary areas of East Greenland, Clavering Island, Wollaston Foreland etc. (1, 8), faults partly older partly younger than the basaltic activity are reported. It seems possible that both kinds of faults may also occur within the present district, although no direct observations as to this distinction have been made.

Among the Tertiary disjunctive lines, marked on the map (pl. 2), there is a set running in NW, with local deviations to nearly north; another set runs in NNE. with a deviation to NE. Some of these have been subjected to closer observation, others are extrapolated from observations on the position, at different altitudes, of the base of the Mesozoic strata present in the district; to the latter group pertain i. a. the faults supposed to run in a NNE. direction within the fjords.

NW-faults: The southernmost one is observed on the eastern shore of Fleming Inlet, about midway between Lagunenæsset and the head of the fjord (cf. fig. 15). On the northern wall the base of the Eotriassic lies at about 500 m, whereas south of the fault it descends to, or slightly below, sea-level. The throw to the south consequently exceeds 500 m. On the dip slip no observations could be made. The northwestern continuation of this fault is unknown, because the Mesozoic sediments in the continuation of the strike, on the western shore of

Fleming Inlet, seem to be undisturbed. Southeastward the fault seems to run south of Mt. Quensel, where conditions are similar to those on the shore of Fleming Inlet, the Devonian slopes of Mt. Quensel contrast with the Mesozoic strata at equal altitudes in the south. No observations were made on the throw in this part of the fault. Farther southeastward no continuation is seen; along the west coast of Carlsberg Fjord no faults were observed. No observations deciding the pre-basaltic or post-basaltic age of this fault could be made.

The medial fault of Wegener Peninsula partly disposes of older disjunctions. Perhaps its deviation to the north is due to this disposition. In the north it begins at the mouth of Tvekegle Valley about 1—1,5 km to the south of the above-mentioned Palaeozoic fault (cf. p. 69), thence it runs, gently curved, along the eastern slope of Ravnefjeld, and reaches the coast of Nathorst Fjord at the eastern foot of Mt. Quensel; in the southern part it seems to coincide in broad features with the older one. The throw is to the northeast. On the western wall at the top of the mountain 886 m, the base of the Mesozoic strata reposes at about 750 m, on the eastern wall in the north it lies at about 120 m, perhaps descending a little to the south; thus the throw to the north amounts to at least 630 m, perhaps increasing southwards to about 700 m; as no Mesozoic strata were seen with certainty to cover Mt. Quensel or its southern continuation, the latter figure cannot be given more exactly. As regards dip slip and relations to the basalts, here, too, no observations are at hand. The northern continuation of this fault may perhaps be identified with dislocations immediately to the southwest of Cape Seaford, on the western side of Fleming Inlet. The top of the ridge about 500 m high — the northern end of which has been marked 450 m — north of Solfald Valley, made up of Eotriassic strata, is crowned by Continental Triassic with a small remnant of Rhaetic on the very top. The base of the Continental Triassic is to be met with on the northern end of the mountain at 450 metres altitude. A little to the north of the middle of the ridge the Continental Triassic descends abruptly to, and below, sea-level along a seemingly vertical fault, which, striking NW., produces a repetition of the Rhaetic at lower levels in the northern third of the ridge. The throw to the northeast amounts to about 450 m. At the northern end, behind Cape Seaford proper, the Rhaetic, once at about 500 m on top of the central mountain, forms the immediate shore, past a fault striking NNW. The downthrow in the northeast amounts to at least 150 m. Thus the total downthrow of these step-faults amounts to about 600 m, or very nearly that of the fault on Wegener Peninsula near the mouth of Tvekegle Valley. Even if no direct connection of these two fault-sets can be made, there seems to be a certain relation between them. To the south, at Mt. Nordenskjöld, no southeastern continuation

of the fault is seen. However, in the southeastward strike of it a small basalt dike is met with on the western shore of Carlsberg Fjord in the mountain to the south of Mt. Nordenskjöld; although this dike is rather inconsiderable, it may indicate the presence of a zone of weakness occurring in the continuation of the fault just described.

To the group of medial NW. faults may still be reckoned a small vertical fault immediately to the south of Vimmelskaftet. Its throw to the southwest is about 100 m. Its possible continuation on the south-eastside of the whole mountain-complex, in the valley of Jameson River, has not been examined. To the north it points directly at the southernmost of the C. Seaford group, with which it seems more easily connected than the main medial fault (cf. above).

Further a NW.-fault may exist in the valley to the north of Mt. Paradigma; here Continental Carboniferous strata, after descending below sea-level to the south of Komait (cf. p. 27), rise again a little above sea-level; the height of the exposure was not measured, but does not exceed 50 m. A gentle upheaval of the southeastern wall has taken place. The exact strike of this fault is difficult to determine, since the valley is filled with river deposits covered by vegetation, and the Mesozoic strata in the middle of the peninsula are strongly covered by talus. Very probably, however, there is a certain relation between this fault and the late-Palaeozoic fault which cuts through the coast to the north of Tvekegle Valley; for the last-mentioned fault shows a small movement in post-Mesozoic (Tertiary) time. The marine Upper Carboniferous-Lower Permian, the base of which descends to the very shore just to the north of this fault, and its covering Eotriassic strata have suddenly been bent upwards, which brought about a northerly dip of the first-mentioned marine strata, on the northern corner of the entrance to Tvekegle Valley along Fleming Inlet. No actual throw is seen, only a different dip of both sides of this line marks its late activity. Because of lack of observations inland, as stated above, the two lines of disturbance cannot yet be connected on the map.

These minor NW.-faults must be interpreted as distortions caused by, and a splitting up of, the great medial fault-line.

The third, northernmost fault-line in Wegener Peninsula runs northwestward from Calamites River across the peninsula, through a rather marked depression. The southwestern wall of this fault has been thrust down in relation to the northeastern one. On the Nathorst Fjord side the base of the southern wall consists of Continental Carboniferous; on the Fleming Inlet side the base of the Upper Carboniferous-Lower Permian descends to sea-level just to the south of the fault-line. Supposing that at least the Upper Carboniferous-Lower Permian marine beds have once covered the Devonian strata of the C. Brown area, the

downthrow may be estimated at at least 900 m but is probably still greater. This fault-line, too, as mentioned above, has presumably originated in late-Palaeozoic time. No continuation of it is found in the region of C. Biot, where a gentle folding occurs (see later); the fault between C. Biot and the mountains southwest thereof, as assumed by KOCH (14), could not be identified. However, along the coast of Davy Sound to the southeast of Antarctic Harbour a number of small Tertiary dikes occur; they may possibly mark a zone of weakness disposed approximately in the (strike-) continuation of the fault now discussed. To the south the fault running between Mt. Kollen and Hestekofjeldet at the base of Canning Land seems to represent a direct continuation of the fault of the northern part of Wegener Peninsula. To the southwest Upper Permian (?) or Eotriassic strata repose directly on the Devonian, whereas to the northeast the whole mountain is built up of Devonian, so the height of the (SW.) throw cannot be given.

If movements have occurred between Mt. Nordenskjöld and Mt. Kollen in Tertiary time, they must have been very weak, since the dip of the strata on top of Mt. Kollen agrees with the dip at the base of Mt. Nordenskjöld.

NNE.-faults: To these faults are to be referred those postulated to run along Nathorst Fjord and Fleming Inlet, further a fault marking Antarctic Harbour and two minor faults in the northwestern Canning Land, developed with a more easterly strike.

At the head of Nathorst Fjord, between Mt. Quensel and Mt. Nordenskjöld, and the mountains to the south of it, there runs a very conspicuous fault (cf. fig. 12). At Mt. Nordenskjöld, which is more than 600 m high and consists chiefly of Eotriassic strata covered by beds of Continental Triassic, the base of the Eotriassic formation does not probably occur more than 50 m above sea-level, probably still lower; no exact figure can be given. On top of Mt. Quensel, which is about 700 m high and consisting of Devonian strata, marine Upper Carboniferous-Lower Permian occur; whether erosion-remnants of Eotriassic may be met with to the south on the top of the mountain is unknown. No exact figure of the downthrow to the southeast can be given, but it doubtless exceeds 650 m. This fault is supposed to continue along Nathorst Fjord, partly because different formations are exposed in its opposite shores, partly because formations occurring on both sides are found at different levels.

The fault-line postulated along Fleming Inlet is drawn parallel to that of Nathorst Fjord. No sure traces of it are observable; at the head of the fjord the Mesozoic strata repose undisturbed. Yet its existence is evidenced by the pronounced stratigraphical inequality of the opposite

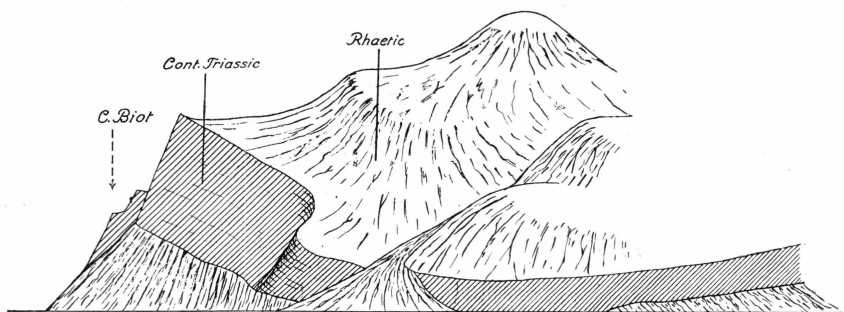


Fig. 18. C. Biot, seen from the north. Folded Mesozoic strata.

shores of the fjord; a postulated and probable downthrow of the north-western wall of several hundred metres must be reckoned with.

These two faults are alike in that they intersect the set of the three NW. ones of the Wegener Peninsula; as stated above, the latter do not continue either to the northwest or to the southeast. From this it may be concluded that the second set of faults is the latest. Still for the medial fault or its connected southern minor fault a northwestward continuation of different magnitude was supposed (C. Seaford group). Two differential phases of movements were supposed for one of these continuations. Perhaps we have a somewhat greater pre-basaltic fault and a smaller post-basaltic one. (?)

The fault-line which runs through Antarctic Harbour and probably continues farther inland, is also indicated by the inequality of the opposite shores. The throw to the southeast, being of considerable magnitude, cannot be given exactly. To the southeast the Rhaeto-Liassic comprises the whole mountain plateau, while to the northwest the whole area consists of Continental Carboniferous (cf. fig. 5), possibly in the backland with erosion-remnants of marine Upper Carboniferous-Lower Permian.

Older forerunners of these three faults are unknown, but probable.

Of the two minor faults in the northern Canning Land the northernmost is exposed at the head of Snevigen (cf. fig. 3), and its continuation cuts the coast in Aarhus Bay to the east of C. Tyrrel. Its character is that of a flexure with a break exposing bilateral drag. The downthrow, not of greater dimensions, is to the northwest.

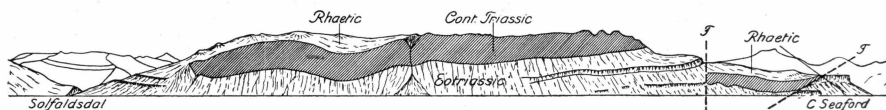


Fig. 19. West coast of Fleming Inlet. Gently folded Mesozoic strata.

The southern one is a regular fault. In the area to the north of it, just to the south of Porfyrfjeldet, the marine Upper Carboniferous-Lower Permian descends to sea-level. The southern side of the mountain-mass consists of strata referred to the Devonian. As in Aalborg Fjord, two erosion-remnants of marine Upper Carboniferous-Lower Permian are seen to rest on these Devonian strata at about 500 m altitude. A downthrow of the northern area in relation to the southern one is conspicuous, the magnitude may be about 400 m, since these Carboniferous-Permian beds seemingly dip towards the southwest.

Besides this faulting also real Tertiary folding has been ascertained. Thus the west coast of Fleming Inlet (cf. fig. 19) exhibits a gentle folding with a rather flat anticline around Solfald Valley and another, a step farther to the west, just to the south of C. Biot. To the northwest of this cape, facing Davy Sound, traces of this fold are also seen (cf. fig. 18). The axes of the folds seem to strike NNW.

The combination of a comparatively strong faulting with a gentle folding in Tertiary time points towards block-movements of a similar character as those of late-Palaeozoic time (cf. above, p. 70). The disturbances are of the Saxonian (Germanotypic) type (cf. 34).

2. Course of Sedimentation. Regressions and Transgressions.

As stated above (Chapter III,2, and III,3), the material constituting the continental beds of Devonian and Carboniferous age has been transported from the west towards the east. The existence of Middle Devonian strata in the east, while such have not hitherto been recognized in the west, finds its natural explanation in the fact that at the beginning of the Devonian time the area of the folded Caledonides was much broader than is the visible chain of to-day. The folding-range was affected by erosion at the beginning of its block-rise on its outer portions to the east. The coarse *débris* material was laid down immediately to the east of the erosion area as a mighty "molasse". The strong backward erosion, probably accompanied by a continued rise in the west, rapidly narrowed the area of the Caledonides in a direction perpendicular to its general strike. The "molasse" deposition followed the tracks of erosion westward, so that constantly younger sediments were laid down on the now planed basement in the east, exactly like roof tiles (cf. fig. 20 a), with the youngest (uppermost) deposits to the west. A disagreement between rate of erosion and rate of upheaval

produced a change in the coarseness of sediments, from conglomerates via sandstones to shales, and *vice versa*. The dominating strongly red colour of the Devonian seems to point towards continental (oxydizing) climatic conditions of sedimentation above or at groundwater- (or sea-) level. The more or less regular intervention of grey and greenish-grey beds without facial change seems to point to (rhythmical) subsidences, at intervals, of the sedimentation area slightly below water-level. Nevertheless the Devonian within the present district, being down-faulted erosion-remnants, points towards a considerable thickness of "molasse-deposition" — about 1000 m, perhaps even more.

With regard to one peculiarity the areas south of Davy Sound seem to differ conspicuously from the region between Musk-ox Fjord in the north and Kongeborgen in the south. The deposition of Devonian was followed by complete erosion to the very basement of this mighty formation, in other words, a marked hiatus of erosion followed upon the Devonian prior to the sedimentation of the beds, also of continental character, of Carboniferous age. In respect to this evolution the present district behaves, broadly speaking, as the area around and north of Gael Hamkes Bay (FREBOLD: 8). Considering the strong erosion and practically total removal of the Devonian south of Menander Islands (1933), it seems probable that the Devonian, still present on Wegener Peninsula and Canning Land, was protected by a downthrow fault in the west (cf. fig. 20 b).

The sediments constituting the Continental Carboniferous may have been derived partly from the eroded and removed Devonian, partly from the Caledonides of its basement and in the west. Along the very eastern limit of the folding range Continental Carboniferous beds, as mentioned above, rest directly upon folded strata (1933); only in old pre-Carboniferous valleys within the very folding chain Devonian erosion-remnants are still seen (cf. KOCH (14), BACKLUND (1)). If a more pronounced uplift of the area has taken place during the Carboniferous time, it seems strange that these remnants should still be found.

Amongst the ball-material of the Carboniferous conglomerates the quartzitic rocks in particular may have been partially washed out of the preceding formation and re-deposited; it seems impossible, however, that the abundant coarse material, especially the limestone-dolomite balls (for instance in the conglomerates of Fleming Inlet), should have been derived from such secondary deposits; no doubt they were principally transported either directly from the folded strata in the west or from the Devonian basement deformed anew by Bretonic movements (cf. above). The ball-constituents of the Continental Carboniferous are also in general of a somewhat smaller size than are the Devonian. The "molasse character" of the Devonian sediments decreases distinctly in

the Carboniferous; the material seems on the whole to have been better washed, perhaps on account of a longer (watery) route of transport.

The colour of the strata is bright compared with the dull colour of the Devonian, generally light greyish-white or (upwards) slightly pinkish. The cement of the dominating sandstones is rather scarce, upwards somewhat limy; the sandstones proper are rich in decomposed feldspars (white kaolin) and the finer-grained beds contain plenty of mica. The sedimentation is indicative of somewhat different conditions from those prevailing during the Devonian; the predominant light colour seems to be due to (reductional) continental conditions near sea- or groundwater-level; the reduction is caused by an abundant organic (plant) life, traces of which are seen in occasional thin coal-seams in series of gritty sandstones with a bright grey weathering crust, yet on fresh fracture nearly black, from abundant powdery carbonaceous cement and crowded tracks of different organic life in general (plants?). Higher up in the Carboniferous — near the top of the exposed strata to the south of Davy Sound (in Mt. Pictet for instance, 1933) — a series of alternating conspicuous brick-red or darker red and light-grey sandstones suggest conditions of sedimentation reminiscent of those of the Devonian. However, here the light beds alternating with the red ones have a somewhat different appearance from the grey and greyish-green sandstone layers alternating with the red Devonian ones, their colour being brighter, often almost white and strongly contrasting with the red layers. At the very top gypsum too may occur. Seen from a distance, however, they are difficult to distinguish from the Devonian strata. The Continental Carboniferous of the Wegener Peninsula belongs to the upper, partly red, portion of the series and thus indicates a considerable thickness of its strata beneath the outcrops; it is bounded on all sides by faults (cf. above, p. 27), as regards thickness this is seemingly the only possible form of preservation.

The deposits of Continental Carboniferous did not remain undisturbed very long. They were soon completely removed by strong erosion caused by their uplift above the denudation-base, probably as a consequence of the Asturic phase of movements. The down-faulted area of Wegener Peninsula, another evidence of these disturbances, is its only remnant met with, eroded, as it is, on a level with the Devonian strata of its own basement (cf. fig. 20 c). In this respect the district in question exhibits some analogies to the eastern median half of Clavering Island, where also the Continental Carboniferous was completely removed (cf. 1, 8) prior to the deposition of the next group. There are, however, various points of difference.

This next group is the first real marine transgression after Caledonian

time, marking the beginning of the marine Upper Carboniferous-Lower Permian and reposing on varying basements. Although this formation consists of typical marine limestone beds, the sea in which they were deposited was no doubt shallow. Facial changes and the entering of terrigenous components into its upper part (cf. Wegener Peninsula, p. 36) are caused both by the proximity of shore-lines and by inequalities of depth; all that points towards an incomplete planation of the basement during the preceding erosion period. The almost mass-like dolomites without bedding and the local abundance of corals seem to indicate the presence of reefs (cf. 5 and 24). The transgression is that of a typical shelf near land. The occurrence of gypsum (Mt. Svinhufvud 1933) further points towards protracted and sudden negative shore displacements within certain parts of the transgressed area.

How far towards the west, south of King Oscar Fjord, this marine transgression has spread, is not known; there are, however, indications that areas west of Antarctic Harbour were encroached. L. KOCH believes to have seen, from airplane, light cliff-forming sediments possibly belonging to this series, to the south of Mästers Vik, in the interior of Scoresby Land (oral statement). A similar observation by BACKLUND (1933) from mountains west of Mästers Vik points in the same direction. On the south coast of Traill Island the marine Carboniferous-Permian is found in the western slopes of Mt. Svinhufvud (1933).

A definite regression marks the hiatus between the marine Upper Carboniferous-Lower Permian and the following transgression of the Upper Permian (Depot Island formation). It was accompanied, perhaps even caused, by two very pronounced and closely connected new events in the general evolution of the area (cf. fig. 21 a), viz., the intrusion of the Cape Fletcher series, and block-faulting owing to which partial erosion could develop. The Permian transgression upon varying basements, then, could already dispose i. a. of the juvenil Cape Fletcher series partly left as a sign of erosion (fig. 21 a, in a section behind). The crystalline basement (of the Devonian) rose to higher levels. The Upper Permian, which, as far as observed, is conglomeratic throughout, was doubtless laid down very near land or even within the littoral zone; the shore line was probably very complicated. The westward extension of the transgression is so far unknown, but no doubt narrower than the marine Upper Carboniferous-Lower Permian one, and surely of shorter duration.

Subsequently the events again developed as regressions and as last-movements of the late-Palaeozoic time (cf. fig. 21 b). The Crystalline Basement in the east and south was raised definitely above sea- and erosion-level, as well as Devonian (?), Carboniferous-Permian, and once

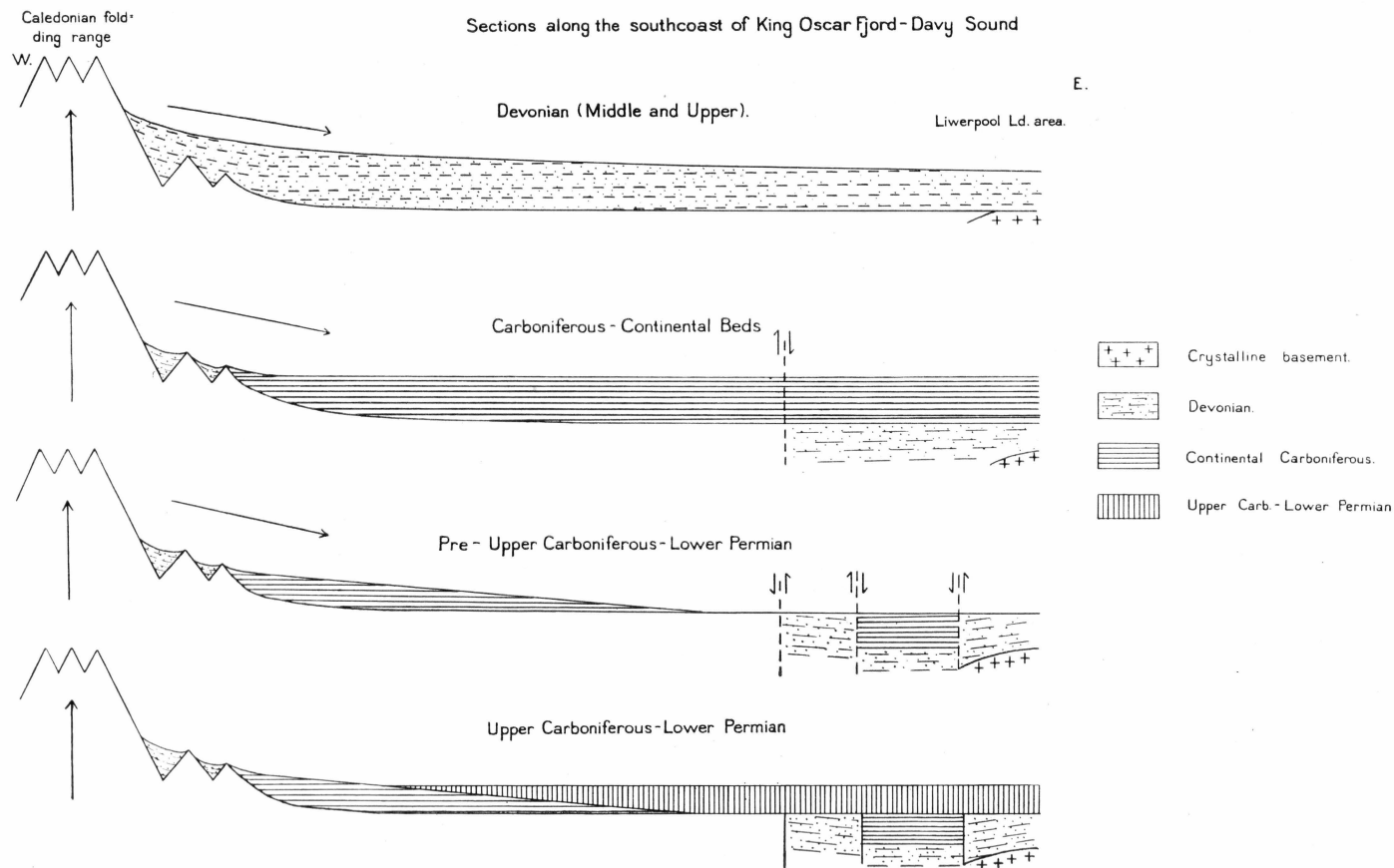


Fig. 20. (a—d).

Diagrams representing the eastern fourth of the preceding sections (another scale has been used)

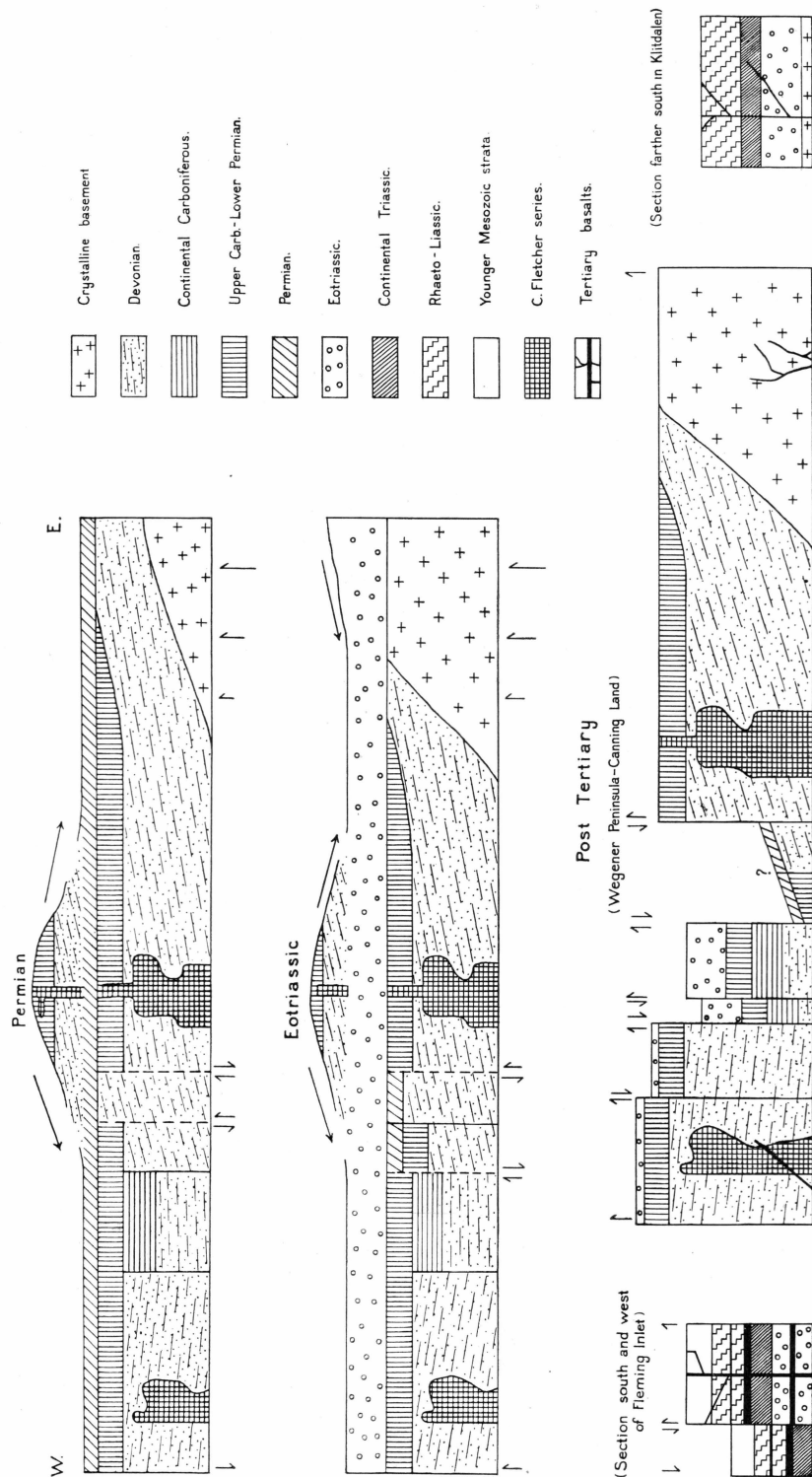


Fig. 21 (a-c).

again the Cape Fletcher series. The variegated ground, partly complicated by further faulting and roughly planed, served as substratum for the next — the Eotriassic — transgression.

The coarse detrital material of this formation was doubtless widely distributed; the assortment points towards a transport of the débris, just as in the Upper Permian (?) from the east, i. e. from an opposite direction to that of the Devonian and the Carboniferous. In other words, there were still tendencies of rising to the east during the Upper Permian and the Eotriassic: a borderland came into existence. The sedimentation is of a littoral, often perhaps of an estuarine, character; strongly conglomeratic development, dominating arkose sandstones outside the conglomeratic beds, delta cross-bedding and compound foreset bedding, badly preserved fossil plants indicate the proximity of land. The frequent occurrence of gypsiferous beds, and the existence of pseudomorphs of NaCl in the upper part of the series show that the shallow water conditions were at times interrupted by definite negative shore-line displacements. The very big conglomerate-balls and the abundant occurrence of feldspars within the Eotriassic sediments are indicative of short distances of transport.

The gypsiferous strata of the Upper Eotriassic without doubt indicate a beginning regression; the continuous stratigraphical transition upwards, though with a rather abrupt change of conditions, points towards such a development. The superimposed Triassic beds, of an intense red colour, seem to indicate continental and oxydizing climatic conditions. The constant thickness of predominant fine-grained material throughout the district renders it difficult to decide whence the material was derived; the existence of a borderland in the east is no necessity, the material may as well have been carried from western denudation-areas.

The Rhaeto-Liassic may perhaps be interpreted as mighty delta deposits (cf. a. o. ROSENKRANTZ: 28) or as an out-filling of a now no longer overflowed depression, perhaps deposited during a much more accentuated humid climate compared with the preceding formation. The dominant colours point to reductional conditions below or at sea-level (or groundwater-level). The sediments are distinctly more thoroughly washed than e. g. the sediments of the two preceding formations, perhaps an indication of a long transport — gritty sandstones, and quartzitic balls in the conglomerates. In the north (cf. chapter IV, 3) the formation seems to increase in thickness, and the material seems to become coarser, possibly indicative of a transport from the west towards the east, with decreasing distance in the north from the western erosional districts. No borderland has necessarily existed, as was not seemingly the case in the Continental Triassic either. Structure-forms such as clay-

balls, mud-cakes, various types of cross-bedding etc., indicate a delta deposition origin, as do also the fossil plants.

The quiet sedimentation without disturbances of episodic character during this part of the Mesozoic time seems to have been controlled only by epeirogenetic movements, variations in the position of the coast line, and climatic changes.

The youngest sediments recorded from the present area again indicate marine conditions, i. e. a fresh transgression of the sea. It marks a regular partial subsidence of parts of the marginal zone of East Greenland. The invading sea was very shallow; no important changes in climate are reported from neighbouring continental areas. The quiet sedimentation persists.

The Tertiary period seems to be characterised by basaltic intrusions only, under strongly erosional conditions, re-sharpened by faulting (cf. fig. 21 c). It institutes a long period of regression, which continues up to the present day (3 a, 24 a, 26 a) and seems to culminate in an essential uplift of the NE. of the district the geological history of which has been traced in the present investigation.

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SUMMARY

- 1) Crystalline rocks, considered as a northern outlier of the crystalline area of Liverpool Land, constitute the basement of the sedimentary strata.
- 2) A continental series, about 1000 m thick, of alternating red and grey sandstones, supposed to repose on the crystalline rocks, is referred to the Devonian. Fossils indicating Middle Old-Red were found.
- 3) A series of light sandstones carrying fossil plants of Carboniferous age constitute the following sediments. About 300 m are exposed. They "transgress" upon down-faulted erosion-remnants of the preceding formation.
- 4) 250—300 m of dolomites (Upper Carboniferous) and limestones carrying marine fossils indicating the Schwagerina-zone (Lower Permian). The formation transgresses upon remnants of (2) and (3).
- 5) A conglomeratic series, carrying badly preserved marine fossils, may be referred with some doubt to the Upper Permian? It transgresses upon remnants of (2) and (4).
- 6) An alternating series of dominating conglomerates and arkose sandstones with gypsiferous beds at the top; it carries marine Eotriassic fossils. The thickness is about 500 m. The transgressional character continues; here resting upon (1), (2)?, and (3).
- 7) A series, 250 m thick, of red beds, alternating shales and marl with thin limy bands, is referred to the Continental Triassic. Conformity with (6). No considerable break occurs between these two formations.
- 8) An extremely thick series of predominantly light sandstones carrying plant fossils belongs to the Rhaeto-Liassic. Behaves as (7).
- 9) Marine beds with Upper Liassic fossils constitute the youngest sediments recorded from the district by the present writer. Conformity with (8) probable, though not directly observed.
- 9a) Marine beds from Antarctic Harbour carrying Upper Bathonian ammonites (SPATH).

Magmatic activity has taken place in two different periods, *viz.* in the late-Palaeozoic (between (4) and (5)): Cape Fletcher series; and after the deposition of the youngest sedimentary rocks (9a): Tertiary basalts.

Tectonic disturbances occur in two groups, *viz.* late-Palaeozoic movements, divided into four phases; and Tertiary movements, possibly comprising two phases.

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Abbreviations:

M. o. G. = Meddelelser om Grønland. (Købh.).

G. F. F. = Geologiska Föreningens Förhandlingar (Stockh.).

D. G. F. = Meddelelser fra dansk geologisk Forening (Købh.).

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EXPLANATION OF PLATES

Plate 1.

Plate 1. High central part of Wegener Peninsula. View towards the NE.-E.-SE. from mountain 709 m (cf. map pl. 2). The glacier in the foreground descends into the Vimmelskaft Valley (Sept. 1931). Dev = Devonian; UC—LP = Upper Carboniferous-Lower Permian; Eo = Eotriassic.

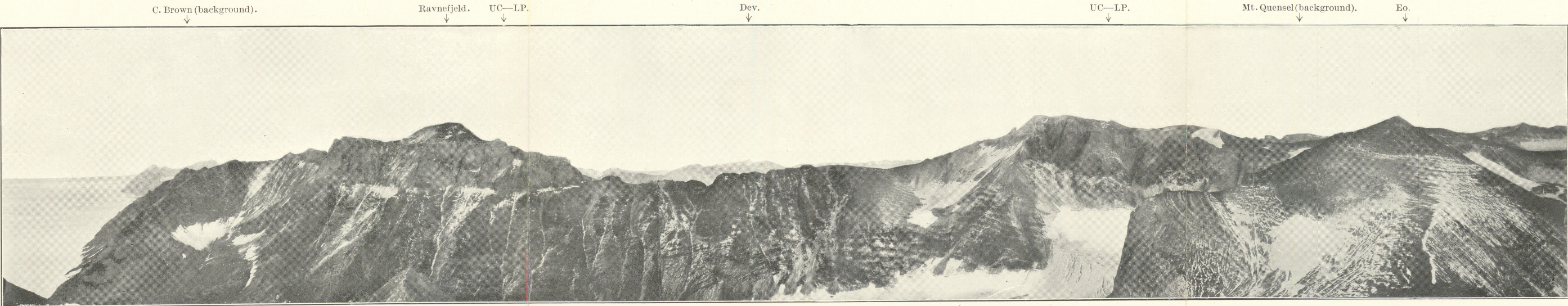


Plate 2.

