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LEDER: LAUGE KOCH

ON THE PALAEOZOIC STRATIGRAPHY OF
CANNING LAND, WEGENER PENINSULA,
AND DEPOT ISLAND (EAST GREENLAND)

BY

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WITH 8 FIGURES IN THE TEXT AND 2 PLATES

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CONTENTS

	Page
Preface	5
I. Introduction	7
II. Description of the investigated areas.....	8
A. Canning Land.....	8
1. Introduction.....	8
2. General structure	8
3. Horse-shoe Mountain and Southern Ridge.....	9
4. Mt. Kollen area.....	14
B. Wegener Peninsula	17
1. Introduction and general structure	17
2. Cape Brown area	18
3. Mt. Quensel area and Vimmelskafte.....	19
C. Depot Island.....	22
1. Introduction.....	22
2. General structure	24
3. Stratigraphy.....	25
III. Stratigraphical conclusions.....	28
A. Devonian.....	28
1. Local stratigraphy	28
2. Comparison with other areas.....	30
B. Carboniferous	35
C. Permian.....	35
IV. Summary.....	38
References	39

PREFACE

THE present paper is based on field-work carried out during the Danish Summer Expeditions to East Greenland in 1934 and 1936, and on subsequent work in the Swedish Riksmuseum. I wish to express my sincere thanks to Dr. LAUGE KOCH, the leader of the expeditions, and to Professor E. STENSIÖ, chief of the Palaeozoological Department of the Swedish Riksmuseum, for excellent working facilities provided in Greenland and Stockholm respectively. During the field-work in 1936 I had the great pleasure of collaborating with Dr. H. BÜTLER, who studied the same region from a tectonical point of view (cf. BÜTLER 1937), and to whom I am indebted for important information and interesting discussions. I also tender my sincere thanks for their assistance in the field to my friends Messrs. E. JARVIK (E. JOHANSSON), G. WÄNGSJÖ, B. GRANSTRÖM, S. ARNELL, A. GANNSEER, and R. MASSON, who took part in the expedition of 1934, and R. HALLIK, B. WAERN, BYGUM-NIELSEN, OLSSON, R. NIELSEN, and FREDERIKSEN, who assisted me in 1936. The long journey from Ella Island to Canning Land and various smaller excursions in 1936 were made in a motor-boat run by my friend A. DE LEMOS, who also was in wireless communication with the S/S Gustav Holm, and whose energy, helpful kindness and unfailing good temper made him an invaluable and unforgettable companion.

The fossils were determined by Professor E. STENSIÖ (*Placodermi*), Professor T. HALLE (Plants) and myself (*Crossopterygii*), and a paper on the Vertebrates by Professor STENSIÖ and myself is now in press. My best thanks are due to Professor HALLE and Professor STENSIÖ for their valuable contributions to the present work.

I. INTRODUCTION

The district studied in the present publication is very difficult of access, even in comparison with the far from easily accessible surrounding parts of East Greenland. In normal summers the ice conditions usually prevent approach by ship, and a visit is coupled with imminent risk of being shut in by the pack-ice. On the other hand, a study, even though short, of the interesting geology, and especially of the Devonian stratigraphy of the district, had long been an important desideratum in my programme of work during the East Greenland expeditions. I therefore welcomed with great interest and enjoyment two opportunities of visiting this district given me by the clever and competent arrangements of the leader of the expeditions, Dr. LAUGE KOCH; the short time offered was utilized to the utmost. The first and very brief opportunity came on July 30th and 31st, 1934, and was used for investigations on Depot Island and Mt. Quensel the 30th (from 4 a.m. to the evening) and at Vimmelskiftet on the 31st (from 2 to 8 a.m.). The exceptionally favourable ice conditions in 1936 made possible a stay of 8 days in the district, from August 30th to September 6th, of which 5 days were spent on Canning Land and 3 on Wegener Peninsula.

II. DESCRIPTION OF THE INVESTIGATED AREAS

A. Canning Land.

1. Introduction.

The geology of Canning Land has previously been studied by NORDENSKIÖLD and HARTZ (NORDENSKJÖLD 1907), KOCH (1929b), and NOE-NYGAARD (1934, 1936, 1937); the earlier observations were summarized in NOE-NYGAARD's work of 1934 (pp. 10—13). A good base for a map of the district is afforded by the carefully worked out coast lines in J. P. KOCH's map of the country (1902, pl. VIII); the topographical inland features in NOE-NYGAARD's map (1934, pl. 2) are not as accurate in regard to Canning Land. As to the geology, this is represented in radically different ways on NOE-NYGAARD's earlier and later maps (1934, pl. 2; 1936, fig. 1; 1937, fig. 2); in neither case is the conception of the stratigraphy supported by sufficient finds of determinable fossils. It may be pointed out already here, however, that the later maps (NOE-NYGAARD 1936, fig. 1; 1937, fig. 2) are much nearer the truth than the first. Thus, according to my own investigations and to information kindly supplied by Dr. BÜTLER, the E. boundary of the Devonian sediments is marked by the valleys stretching NNW. and S. from the bottom of Aalborg Fjord. The large sedimentary areas E. of these valleys, referred by NOE-NYGAARD (1934) to the Devonian and the "Upper Carboniferous-Lower Permian", are thus all pre-Caledonian (Eleonore Bay Formation), as shown in NOE-NYGAARD's later maps, and will not be dealt with in the present paper. The part of Canning Land described here is thus only approximately the westernmost $\frac{1}{4}$, extending from the lowland (Ituidlek) E. of Mt. Nordenskiöld in the W. to the valleys just said to be stretching NNW. and S. from the head of Aalborg Fjord.

2. General structure.

The topography of the district dealt with is very simple. From the head of Aalborg Fjord the large Porphyry Valley stretches NNW. to Nathorst Fjord, and the narrower Basis Valleys (the N. Basis Valley, sloping to the N., and the S. Basis Valley, sloping to the S.) extend to

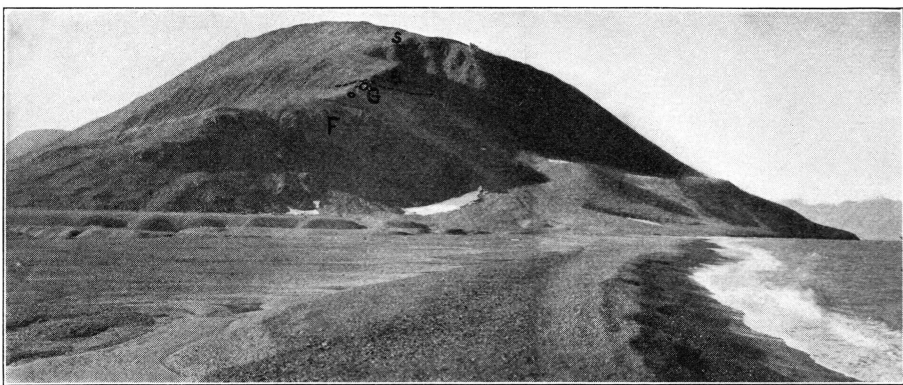
Carlsberg Fjord. On the W. side of Porphyry Valley rises the E. slope of Horse-shoe Mountain (Hesteskofjeldet), which is divided by a circus valley sloping towards Nathorst Fjord into two parts called E. Horse-shoe Mountain and W. Horse-shoe Mountain. E. Horse-shoe Mountain is continued to the S. by the Southern Ridge, which separates the Basis Valleys from a terraced landscape SSE. of W. Horse-shoe Mountain. To the W. the terraced landscape and Horse-shoe Mountain are separated from Mt. Kollen by a valley with a small lake. Mt. Kollen itself is the E. escarpment of a large terrace sloping down to the W. towards the lowland E. of Mt. Nordenskiöld (Ituidlek on NOE-NYGAARD's map 1934), which is the easiest way of communication between Nathorst Fjord and Carlsberg Fjord. On the NW. side a deep valley from the shore of Nathorst Fjord cuts into the large terrace, and forms the W. boundary of Mt. Kollen.

Despite intense partial disturbances affecting especially the Devonian sediments the main position of the strata is simply a general dip to the W. and SW. with superposition of successively younger beds towards the W. Beds of Middle Devonian age make up practically the whole Horse-shoe Mountain and the Southern Ridge, and most of Mt. Kollen. In the W. part of Mt. Kollen, however, the strongly tilted Devonian beds are disconformably overlain by slightly less steeply inclined continental Carboniferous beds, which also form the bottom of the valley W. of Mt. Kollen. The Devonian and the continental Carboniferous are again disconformably covered by marine Permian beds, also sloping to the W., though much less steeply than the older sediments. A small patch of marine Permian, resting directly on the Middle Devonian, is seen on the top of W. Horse-shoe Mountain, but a much more extensive cap of Permian deposits overlays the Middle Devonian and the continental Carboniferous in Mt. Kollen, and forms the top of this and the large terrace sloping down towards the W.

3. Horse-shoe Mountain and Southern Ridge.

A good profile through the base of the Devonian is exposed in the NE. corner of E. Horse-shoe Mountain (text-fig. 1). Climbing from the shore of Nathorst Fjord, one first encounters the substratum, brownish and greenish porphyries, and similar porphyries are found as boulders in the basal conglomerate of the Devonian, for instance at 85 m above sea-level. These porphyries (cf. NOE-NYGAARD 1936, 1937) apparently belong to the so-called Cape Fletcher Series, once wrongly dated as Permian? by NOE-NYGAARD and others, the pre-Caledonian sediments (Eleonore Bay Formation), injected by the porphyries, being misinterpreted as Permian dolomite.

The basal conglomerate of the Devonian is dark-coloured and fairly coarse, with boulders usually about one dm in diameter, chiefly of brown porphyries. This dark conglomerate has an exposed thickness of about 13 m (from 85—113 m in the slope). Its contact with the overlying strata is obscured by talus, but at 130 m solid rock is again encountered. From 130—146 m this consists of a greyish-white, conglomeratic arkose, particularly coarse at the base, and greyish-white crumbling arkose-sandstone. The light colour is due to the predominance (as boulders and arkose) of erosion débris of light-coloured crystalline rocks, but sharp-



Text-fig. 1. The NE. corner of E. Horse-shoe Mountain seen from the E. *F*, substratum of the Devonian sediments; *G*, *Heterostius* Series; *B*, *S*, Series with *Asterolepis säve-söderberghi*; *o*, fossiliferous talus; *-o-*, horizon with *Thursophyton*.

edged fragments up to a decimeter in diameter of green porphyries also occur. The exposed thickness of the greyish-white series now described is about 15 m; its dip is 20° to the NW. At 140 and 141 m it contains shaly horizons (9, pl. 2) rich in badly preserved fossil plants (*Thursophyton* sp.), and vertebrate remains were collected in local talus (9, pls. 1, 2), including a good median nuchal plate of *Homostius* and an anterior dorso-lateral and anterior lateral plate of *Heterostius* (see STRENSÖ 1938). These show the stratigraphical position of the series to be in the lower part of the Upper Middle Devonian (cf. below, pp. 30—35). The series discussed may be called the *Heterostius* Series. — A small dorsal articular plate of the pectoral fin of *Asterolepis* sp. was found in talus probably originating from the same series.

The greyish-white *Heterostius* Series is overlain by a series, the lower part of which consists mainly of brown and brownish-red, finely stratified sandstone, rich in mica. Subordinate banks of cross-bedded grey sandstone also occur, and at 195 m this series becomes striped, consisting of alternating grey or greenish-grey and brownish-red sandstone. The dip in the lower, brownish-red part of the series is still 20° to the NW.,

but higher up, in the striped part, it varies and is often much steeper and more to the W. The striped part of the series makes up the higher parts of the whole E. Horse-shoe Mountain. Badly preserved fossil plants (*Psilophyton* sp.) were collected on the top ridge (10, pls. 1, 2) at 365 m, and Crossopterygian scales, plates of small Arthrodiæ, and fossil plants were found further S. on the same ridge.

At the SE. corner of E. Horse-shoe Mountain the base of the Devonian is at 265 m, and is seen to dip from this point both towards the S., the N., and the W.

The profile described above largely agrees with that described by NOE-NYGAARD (1937, pp. 17—18), but NOE-NYGAARD failed to observe the dark basal conglomerate of the Devonian (his description of the Devonian strata thus begins with the greyish-white conglomeratic arkose-sandstone), nor did he find any determinable fossils.

The basal strata of the Devonian also form the E. slope of the Southern Ridge, which is a continuation to the S. of the E. Horse-shoe Mountain. A profile (profile k) was measured in the N. part of the Southern Ridge. Climbing this from the N. Basis Valley, in which large talus masses hide the basal conglomerate and its substratum, one first encounters the greyish-white, crumbling arkose-sandstone, exposed from 309—334 m (exposed thickness about 48 m), then the brownish-red and striped series, with a very thick basal, brownish-red part, from 334—454 m (thickness about 230 m), and a striped higher part (about 116 m thick) from 454 m to the crest of the ridge (514 m). The dip in profile k is 45° towards the SW. In local talus of the striped series plates of *Asterolepis säve-söderberghi* (STENSIÖ 1938) were encountered on the ridge (19, pls. 1, 2), a plate of an Antiarch, and a scale of a Crossopterygian farther down in the E. slope, and Crossopterygian scales on the W. slope (20, pls. 1, 2). In the talus in N. Basis Valley (11, pl. 2) a large block of greyish sandstone with a well preserved head and several body plates of *Asterolepis säve-söderberghi* (STENSIÖ 1938) was found. The type of the sediment shows that it originates from the upper part of the brownish-red and striped series; this series may accordingly be called the Series with *Asterolepis säve-söderberghi*. Plates of *Asterolepis säve-söderberghi* were also found in talus from this series in the S. Basis Valley (12, pls. 1, 2). At the S. side of the Southern Ridge (13, pls. 1, 2) a fragmentary inferognathal plate of *Homostius* was found, embedded in a brownish sandstone, originating from the brownish-red and striped series.

At the junction of the E. and W. parts of the Horse-shoe Mountain (in the southern wall of the circus valley separating the two parts), and in the W. side of the Southern Ridge, the brownish-red and striped series is overlain by a series consisting of greenish-grey sandstone. In the N. part of W. Horse-shoe Mountain this series is again overlain by a series of

varying rock-types, of which the most characteristic is a dark-grey to black shaly flagstone, with a yellowish-grey weathering hue, and rich in remains of *Osteolepidae* (*Canningius groenlandicus*; cf. SÄVE-SÖDERBERGH 1938). In the S. part of the W. Horse-shoe Mountain the Devonian strata are disconformably overlain by a small patch of Permian marine sediments.

A profile through the lower part of the greenish-grey series was studied in the terraces W. of the Southern Ridge. This part of the series consists of grey and greenish-grey shaly sandstone rich in mica, with badly preserved plant fossils, and was found exposed in the profile (profile j) from 84 to 179 m, at 199 m, at 200—284 m and from 344—379 m. Its contact with the brownish-red and striped Series with *Asterolepis säve-söderberghi* is obscured by talus, but the latter series occurs from 449 m upwards. The dip in the lower part of the profile is 30° towards the SW.

Two profiles were measured in the NE. slope of W. Horse-shoe Mountain, one in the southern, the other in the northern part. The first includes the upper part of the greenish-grey series, the lowermost part of the overlying Series with *Canningius groenlandicus*, and the marine Permian; the second shows a higher part of the Series with *Canningius groenlandicus*. In the first profile (profile d) the greenish-grey Devonian series was found from 206—461 m, and consists of greenish-grey sandstone with badly preserved plant fossils. The dip is a little varying (about 35—45° W.), and the exposed thickness of the greenish-grey series is about 450 m. From 461—571 m the overlying series is exposed, consisting of alternating brown and greenish shaly sandstone rich in mica, passing upwards into alternating brown and grey shaly sandstone with banks of dark grey to black bituminous flagstone. In the upper part the dip is 45° to the W. The thickness exposed of this series is about 200 m. At 571 m the Devonian strata are disconformably overlain by Permian beds, beginning with a shaly calcareous sandstone (15, pls. 1, 2) exposed from 572—576 m, with Corals in the lowermost parts, *Bryozoa*, *Productidae* etc. in the higher part. The top of the profile is formed by very hard, greyish, yellow-weathering dolomite, exposed from 576—616 m. The Permian beds have a dip of 20° to the WSW. Their exposed thickness is at least about 50 m.

The more N. profile in the W. Horse-shoe Mountain (profile c) shows strata of varying petrographical character, belonging to a higher part of the series forming the top of the Devonian in profile d (Series with *Canningius groenlandicus*). In profile c this series is exposed from 129—206 m, and includes the characteristic dark-grey to black shaly flagstone, with scales of *Osteolepidae* at 202—204 m, greyish to brownish-grey shaly sandstone, partly rich in scales of *Osteolepidae*, and a few banks of brownish-red shaly sandstone rich in mica (e. g. at 161 m). The dip in the profile is about 40° NW., and the thickness of the exposed beds



Text-fig. 2. Eastern side of the W. Horse-shoe Mountain, seen from the NE., from below E. Horse-shoe Mountain. *G*, Greenish-grey series (Middle Devonian); *C*, Series with *Canningius groenlandicus*, with -o-, fossiliferous localities at 210 and 234 m; *P*, Permian.

about 170 m. At 210 m in the ridge, WSW. of the profile, and stratigraphically about 5 m above the top of the profile (206 m) is a horizon (14, pls. 1, 2) of dark-grey to black shaly flagstone, very rich in *Osteolepidae*. The same horizon is again encountered farther S. at 234 m. The fossils from this horizon have been determined as *Canningius groenlandicus* n. g., n. sp., possibly also other *Osteolepidae*, and ?*Tristichopterus* sp. (see SÄVE-SÖDERBERGH 1938).

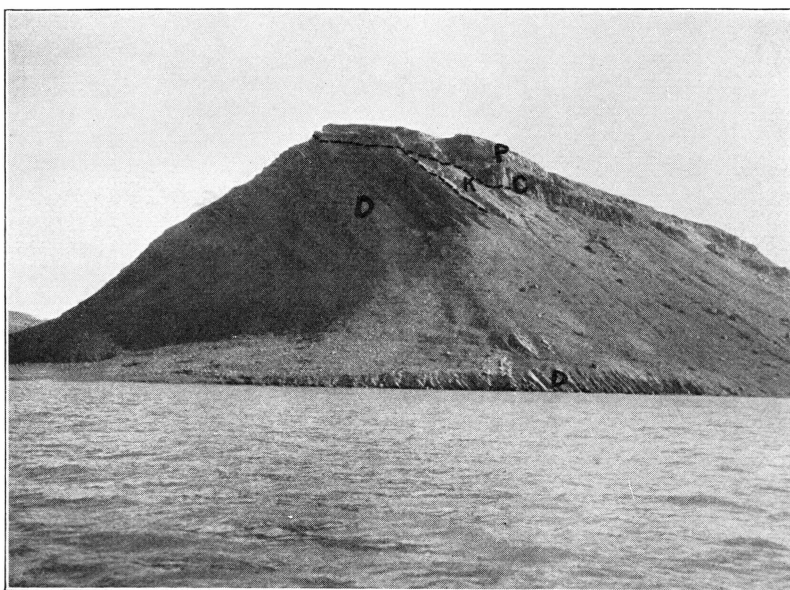
On the NW. side of W. Horse-shoe Mountain the Middle Devonian strata are overlain by a brownish-grey coarse conglomerate with boulders generally about 4—6 cm in diameter, mainly of quartz. The age of this conglomerate is of course uncertain; it may possibly be Dinantian or Upper Devonian (cf. below).

To summarize the stratigraphy in the Horse-shoe Mountain and the Southern Ridge, we here find: A) mainly arenaceous strata of Middle Devonian age, divided into four local series: 1) a basal greyish-white series, the *Heterostius* Series, with plants (*Thursophyton* sp.), *Homostius* and *Heterostius* (thickness at least about 50 m); 2) a brownish-red and striped (brownish-red and grey or greenish-grey) series, the Series with *Asterolepis säve-söderberghi*, also containing *Psilophyton*, Crossopterygian scales, *Homostius* and small Arthrodiæ (thickness at least about 350 m); 3) a greenish-grey series with badly preserved plant fossils (certainly over 500 m thick); 4) a varicoloured, but mainly greyish series, the Series with *Canningius groenlandicus*, including dark-grey to black bituminous flagstone with *Canningius groenlandicus* and ?*Tristichopterus* sp. (thickness probably more than 350 m) — the whole disconformably overlain by B) a conglomerate of uncertain age (perhaps Dinantian or Upper Devonian), and C) marine Permian beds, divided into a basal part of fossiliferous shaly calcareous sandstone (thickness about 4 m) and an upper part of hard, unfossiliferous dolomite (thickness more than 45 m).

4. Mt. Kollen area.

Except for its Permian capping and the westernmost part, where this is underlain by probably Dinantian strata, the whole of Mt. Kollen is made up of Middle Devonian strata, evidently belonging mainly to the uppermost of the four local series in the Horse-shoe Mountain, characterized by the presence of dark-grey to black shaly flagstone with *Canningius groenlandicus* and ?*Tristichopterus* sp. A profile (profile e) was measured in the NE. side of Mt. Kollen, and shows a basal part (86—121 m), which is only exposed in the north-easternmost part of the slope, made up of greenish-grey, well stratified sandstones, rich in mica, and probably corresponding to the uppermost part of the greenish-grey (third) local series in the Horse-shoe Mountain. The dip is here 38° towards the WSW., and the exposed thickness is about 64 m. Above

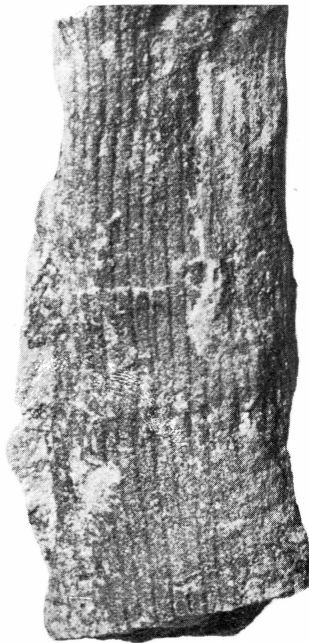
121 m there are sediments of varying types, including brownish-red, brownish-grey, and greenish-grey shaly sandstone, rich in mica (at 121—156 m), white and light brownish-grey hard fine-grained sandstone (e. g. at 134 and at 188 m), and the characteristic dark-grey to black shaly, partly bituminous, yellow-weathering flagstone with *Osteolepidae* and ?*Tristichopterus* sp., and badly preserved plant fossils (e. g. at 186 m). The thickness of this series exposed in profile e is about 275 m. The top



Text-fig. 3. Mt. Kollen seen from the W. *D*, Middle Devonian; *K*, continental Carboniferous; *C*, Permian conglomerate; *P*, Permian dolomite.

of the Devonian is marked by a terrace at 271 m. From this the uneven sub-Permian surface slopes to the W., overlain by a coarse grey or brownish, partly reddish-weathering conglomerate with boulders generally a few cm in diameter, chiefly composed of quartz, brown porphyries, and various light-coloured crystalline rocks. The thickness of the conglomerate increases strongly to the W.; on the NE. side of Mt. Kollen it is about 8 m, but at least 20 m on the NW. side, where the boulders are up to $\frac{1}{2}$ m in diameter. The conglomerate is conformably overlain by hard greyish yellow-weathering dolomite (from 268—286 m at the top of Mt. Kollen). At the base of the dolomite is a strongly fossiliferous layer (2—3 m thick; 17, pls. 1, 2), which has been weathered away SE. of the top, leaving abundant fossils lying loose over a large area. The fossils found here include Brachiopods, Bryozoa, and a spine of an Elasmobranch. The dip of the Permian strata is 25° to the W.; its exposed thickness is about 16 m.

In talus, chiefly of dark grey to black, partly bituminous shaly flagstone from the Middle Devonian strata above 134 m in the N. slope of Mt. Kollen (16, pls. 1, 2) a number of Osteolepid remains were collected including bones of *Canningius groenlandicus* (SÄVE-SÖDERBERGH 1938), and also a scale of a type, similar to that called *Glyptolepis baltica* by GROSS (1933a, pl. VI, figs. 20, 21, 24).



Text-fig. 4. *Asterocalamites scrobiculatus*, from the continental Carboniferous near the delta in the valley W. of Mt. Kollen. Natural size.

The bottom of the valley W. of Mt. Kollen is made up, at least largely, by a series of strata consisting of pure white or yellowish-white, loose, coarse sandstone and black shale with plant fossils. This series is exposed in small patches, especially in the river sections. Most of the plant fossils are very badly preserved and indeterminable, but in a section near the delta (18, pls. 1, 2) we succeeded in finding two determinable specimens of *Asterocalamites scrobiculatus* (text-fig. 4), which fixes the age of the series as Carboniferous, most probably Dinantian (or possibly lowermost Namurian).

At the NW. corner of Mt. Kollen (text-fig. 3), the Middle Devonian immediately below the Permian conglomerate dips 45° to the S. 35° W., and is overlain disconformably by a coarse white conglomerate (boulders about 1—5 cm in diameter, chiefly consisting of quartz) dipping 40° to the W. 20° S., and accordingly itself overlain with strong angular discon-

formity by the Permian conglomerate (dipping 25° to the W.). The white conglomerate is conformably overlain by a pure white sandstone, identical with that of the continental Carboniferous series just described from the bottom of the valley W. of Mt. Kollen.

In the innermost part of the valley W. of Mt. Kollen the Permian conglomerate overlies at 113 m a yellow, coarse talus conglomerate, with angular boulders of light-coloured crystalline rocks; the contact is an uneven, eroded surface, and there is a very slight angular disconformity. The yellow conglomerate is at least about 10 m thick, and itself seems to overlie with slight angular disconformity another, reddish brown talus conglomerate. In the upper of the two conglomerates a large angular boulder of the white continental Carboniferous sandstone was found. The age of the conglomerates is of course, uncertain, but one or both may perhaps correspond to the Namurian continental deposits farther N. in East Greenland (cf. HALLE 1931; MALMQUIST 1932; SÄVE-SÖDERBERGH 1934, Appendix).

B. Wegener Peninsula.

1. Introduction and general structure.

A summary of earlier studies of the geology of Wegener Peninsula, including NORDENSKIÖLD's (1907), KOCH's and HARRIS' (KOCH 1929b) will be found in NOE-NYGAARD's work (1934, pp. 10—13). The distribution of the different geological formations on Wegener Peninsula is in the main correctly shown on NOE-NYGAARD's map (1934, pl. 2). As will be seen from this map, very large parts of the peninsula are built up by Palaeozoic sediments. The short time at my disposal, however, only permitted a rapid investigation from the SE. coast of two important areas — the Cape Brown area and the Mt. Quensel area —, and a short visit in the Vimmelskaftet valley on the NW. coast of Wegener Peninsula. The Cape Brown area includes the steep and beautiful Cape Brown promontory (Cape Brown Mountain), the valley W. of this (which has no such large glacier as shown in NOE-NYGAARD's map), and the low ridge separating that valley from the Calamites River valley. The parts investigated in the Mt. Quensel area include the N. slope of Mt. Quensel, the large valley N. of Mt. Quensel, the SW. corner of the mountain (called by us Eastern Mountain) N. of the large valley, the Little Circus Mountain, forming the W. side of the valley before this bends W. of Mt. Quensel, and two small hills between Little Circus Mountain and Eastern Mountain.

In general structure, the E. part of Wegener Peninsula corresponds to the W. part of Canning Land described above. The oldest strata are found to the E., and the general dip is to the W. or SW. At Cape Brown

igneous rocks ("Cape Fletcher Series") form the substratum of the basal formations of strongly tilted Middle Devonian sediments, just as in E. Horse-shoe Mountain on Canning Land. At Calamites River HARRIS found continental Carboniferous beds (KOCH 1929b, p. 99) comparable to the continental Carboniferous beds in the valley W. of Mt. Kollen; and the older Palaeozoic sediments are disconformably overlain by less steeply inclined marine Permian beds, dipping to the W. and overlain by Triassic formations, just like the Permian beds exposed in Mt. Kollen, Depot Island, and at the foot of Mt. Nordenskiöld dip in beneath the huge pile of Triassic sediments exposed in the higher parts of Mt. Nordenskiöld.

An important fault-line separates the E. part of Wegener Peninsula now discussed from its W. part; the E. part is lowered in relation to the W. part. The succession of strata in the Mt. Quensel area, W. of the fault-line, differs somewhat from that in the E. part of Wegener Peninsula and includes: a) very strongly disturbed Middle Devonian strata, probably disconformably overlain by b) Upper Devonian beds, themselves disconformably overlain by c) marine Permian and d) Triassic formations.

2. Cape Brown area.

The basal parts of the Devonian sediments were studied on the S. side of the Cape Brown Mountain (profile i) during a climb to the top from the mouth of the valley W. of the mountain. The dark porphyry forming the substratum of the sediments was found farthest S. in this profile, where it forms a terrace at about 181 m. Overlying this (from 186 to 196 m) a light grey arkose was found, similar to the greyish-white basal arkose (*Heterostius* Series) found in E. Horse-shoe Mountain though more fine-grained and a little reddish. Its contact with the substratum is here obscured by talus but a coarse conglomerate, probably forming the basis of the light grey series and equivalent to the coarse basal conglomerate in E. Horse-shoe Mountain, was found in this neighbourhood by O. NORDENSKJÖLD (1907, pp. 178—179). The dip of the light grey arkose is 30° to the W. 15° N., and the exposed thickness is about 23 m. The light grey arkose is overlain by alternating light grey arkose and brownish-red shaly sandstone rich in mica.

The strata are well exposed in a ridge from 301 m up to the top of the mountain at 965 m. The lowermost strata exposed here consist of alternating light grey arkose and brownish-red shaly sandstone rich in mica, with a bank of richly fossiliferous greenish sandstone at 304 m (1, pl. 1). The fossils in this are mostly broken fragments but also include plates of *Asterolepis* sp. and *Homostius* sp., teeth of *Crossopterygii*, and scales of *Osteolepidae* and other *Crossopterygii*.

In the higher parts of the ridge, up to the top at 956 m, brownish-red and greenish-grey sandstones rich in mica alternate, forming a striped series similar to that in the E. Horse-shoe Mountain and the Southern Ridge on Canning Land. The dip varies, in parts indicating strong disturbances, as shown by BÜTLER (1937). Only indeterminable fragments of fossils were found here, but Crossopterygian scales were collected in talus on the slope.

The ridge on the other side of the valley W. of Cape Brown Mountain consists of alternating brownish-red and greenish beds in the S. part, but farther N. there are strata including beds of dark-grey to black bituminous flagstone with *Osteolepidae*. In talus (2, pl. 1) of this type were collected several bones of *Osteolepidae*, including a fronto-ethmoidal shield referable to *Canningius groenlandicus* (SÄVE-SÖDERBERGH 1938).

The Middle Devonian sequence of strata observed in the Cape Brown area may be summarized as follows: a basal series of light grey arkose (more than 23 m thick) and a striped series of alternating brownish-red and greenish-grey sandstone with *Asterolepis* sp. and *Homostius* sp. similar to those on Canning Land are encountered, but no definite brownish-red part of the higher series; this agrees with the fact that on Canning Land there is a very much thicker brownish-red part in the S. (230 m in the Southern Ridge) than in the N. (24 m at the NE. corner of the E. Horse-shoe Mountain). The Series with *Canningius groenlandicus*, containing the characteristic dark-grey to black bituminous flagstone with *Osteolepidae* is also present in the Cape Brown area, but its relations to the underlying series cannot be determined here with certainty. It seems probable, however, that it directly overlies the striped series with *Asterolepis*, whose uppermost part would then probably correspond to the greenish-grey (third) series on Canning Land.

3. Mt. Quensel area and Vimmelskaftet.

Strongly disturbed Middle Devonian beds, apparently corresponding to the three uppermost series (the second, third and fourth) on Canning Land, are widely distributed in the northern part of the Mt. Quensel area, building up Eastern Mountain and the small hills between it and Little Circus Mountain. These beds are also exposed in the river sections in the large valley between Eastern Mountain and Mt. Quensel, and on the N. slope of Mt. Quensel. The Series with *Canningius groenlandicus* with its characteristic dark-grey to black, partly bituminous shaly flagstones with *Osteolepidae* was found at the SW. corner of Eastern Mountain (4, pl. 1), and in the small hills (5, pl. 1) between it and Little Circus Mountain, and probably makes up most of Eastern Mountain. In local talus were collected: at the SW. corner of Eastern Mountain, and in the northeastern of the

two small hills bones of *Osteolepidae* (?*Canningius groenlandicus*); in the southwestern of the small hills: Osteolepid bones, including a good fronto-ethmoidal shield of *Canningius groenlandicus* (SÄVE-SÖDERBERGH 1938).

The same series was investigated in 1934 in Vimmelskaftet, in the profile (3, pl. 1) described by NOE-NYGAARD (1934, pp. 21—22) and in which he found a fossil, determined by myself (1933b, pp. 103—107) as the fronto-ethmoidal shield of *Diplopterax* sp., of Upper Middle Devonian age. Already during my visit in 1934 I noted that the facies here is more markedly different from that in the northern Devonian districts of East Greenland (cf. for instance SÄVE-SÖDERBERGH 1932, 1933a, 1934) than appears from NOE-NYGAARD's description. The predominant and most characteristic sediment is a dark grey to black bituminous flagstone with *Osteolepidae*, a type of sediment not met with in the northern Devonian district, but characteristic, as we now know (cf. above), of the uppermost (fourth) local series of Middle Devonian strata on Canning Land. Fossils were collected in 1934 from local talus including a lower jaw and an opercular of an Osteolepid (cf. *Canningius groenlandicus*), and the fronto-ethmoidal shield, collected by NOE-NYGAARD may now be determined as belonging to a large specimen of *Canningius groenlandicus* (SÄVE-SÖDERBERGH 1938).

On the N. slope of Mt. Quensel the strata are well exposed in parts. In the lower part of the slope, up to a terrace at 307 m, there are strongly disturbed (partly vertical) beds of alternating brownish-red and greenish-grey hard, well stratified sandstone. In talus (6, pl. 1), probably from these beds, was found a median nuchal plate of *Homostius*. Above the terrace at 307 m the profile is obscured by talus up to 389 m; from 389 to 422 m there follows a greyish-white conglomerate with well rounded boulders, dipping 15—20° SW. The conglomerate is followed by a greyish-white arkose, exposed from 447 to 469 m, in which was found the badly preserved posterior median dorsal plate of an *Antiarch*. The thickness of the greyish-white conglomerate and arkose is about 110 m. The greyish-white arkose is overlain by a series of brownish-red to brownish-grey, coarse, partly conglomeratic and cross-bedded arkose-sandstone, dipping 15° SW. and exposed from 512 to 567 m (thickness exposed about 75 m) in profile g. In local talus from this series (7, pl. 1) an interesting specimen was collected in 1934, viz. a well preserved impression of a scale (text-fig. 5) of the type generally called *Holoptychius nobilissimus* AG. Though not determinable as to species until a revision has been undertaken of the family *Holoptychiidae*, this scale type is known to be very characteristic of the Upper Devonian in East Greenland (cf. STENSIÖ 1931; SÄVE-SÖDERBERGH 1932, 1933a, 1934) and elsewhere, and is thus important from a stratigraphical point of view. With a certain reservation due to the very scanty material, this find allows us to refer the series discussed to the Upper Devonian.

The brownish-red and brownish-grey Upper Devonian beds are disconformably overlain by Permian marine formations, partly beginning with a yellowish white talus conglomerate (at 568 m in profile g), partly with a hard grey dolomite resting directly on the Devonian strata (e. g. at 602 m, NW. of profile g). The dolomite itself is overlain by a dark, bituminous limestone with small Corals.

Beds similar to those in the N. slope of Mt. Quensel, referred with reservation to the Upper Devonian, were also studied in a profile (profile h) in the W. part of Little Circus Mountain. Here a coarse light-



Text-fig. 5. Impression of a scale of the type, called *Holoptychius nobilissimus*, from the N. slope of Mt. Quensel. Natural size.

coloured conglomerate with well rounded quartz boulders was noted from 161 to 171 m, overlain by a partly conglomeratic white arkose, exposed from 184 to 186 m. At 186 m a small fault cuts the profile, raising the beds exposed in the higher parts of the profile, so that the boundary between the conglomerate and the arkose occurs again at 196 m. The dip is here about 45° WSW., but higher up it becomes less steep — about 40° — and more towards the S. The arkose becomes more brownish-grey up to 291 m, where it is very similar to the brownish-grey arkose in Mt. Quensel. Higher up the strata again become more greyish-white, and the arkose is found exposed up to 341 m. Above this, very large talus masses of white arkose obscure the profile up to 441 m. Some indeterminable Vertebrate bones were found in the talus. At 441 m a white arkose-sandstone with red bands forms the solid rock; then from 442 to 480 m the slope is covered by talus of a loose, well stratified red sandstone and coarse brownish-red arkose. A large scale of a Crossopterygian was collected in the talus. At 481 m a white arkose is again met, at 482 m a red loose shaly sandstone, then from 483 to 489 m a coarse, brownish-red arkose-conglomerate. This is overlain by brown sandy shales, occurring from 489 to 492 m, above which talus

obscures the contact with the overlying Permian dolomite exposed from 497 m upwards in a steep wall.

The fossils found do not suffice for determining the age of the strata described above; owing to the short time at our disposal a fuller investigation had to be left to later students. On the map the strata exposed in the lower part of the profile are provisionally marked as Upper Devonian.

The cursory investigation of the Mt. Quensel area and Vimmelskiftet shows that the Middle Devonian Series with *Canningius groenlandicus* with its characteristic dark-grey to black bituminous flagstones with *Osteolepidae* is widely distributed on the Wegener Peninsula, that these beds are here much disturbed, and that in the W. part of the Peninsula there is a series of Devonian sediments, different from those on Canning Land, and most probably of Upper Devonian age.

C. Depot Island.

1. Introduction.

Depot Island is a small flat island with a maximum diameter of only about half a kilometer, situated in the inner part of Nathorst Fjord. Despite its small size, this island has played a prominent rôle in the extensive discussions on the younger Palaeozoic and Triassic strata in East Greenland. It was first visited by L. KOCH (1929 a, b) who camped on Depot Island in the winter of 1926, and discovered fossiliferous beds there. KOCH's first collection comprised mussels, determined by ROSENKRANTZ as *Pleurophorus* sp. (KOCH 1929b, p. 106). The island was next visited by HARRIS and KOCH in the spring of 1927. HARRIS measured a section along the north coast, quoted by KOCH in 1929 (1929b, p. 106)¹).

According to HARRIS the section comprises 40 m of grey, unfossiliferous limestone, overlain by half a meter of white conglomerate containing rolled Brachiopods, 5 m of white sandstone, 3 m of pink sandstone with bands of pebbles and various fossils; an undetermined thickness of pink, unfossiliferous sandstone; and finally at the top about 10 m of grey shaly sandstone with badly preserved Cephalopods?, molluscs, and plant remains.

The rolled Brachiopods collected by HARRIS in the conglomerate were determined by ROSENKRANTZ (1929a) as *Spirifer*; ROSENKRANTZ determined the fossils from the pink sandstone as "*Grammysia*? sp., probably not belonging to the genus *Grammysia*, but closely related to

¹) Probably by a lapsus the section, though beginning with the oldest strata, is said to run from W. to E. The real dip is towards the SSW., the oldest beds thus occurring in the NNE.

Grammysia? carbonaria from the Permian of the United States, if not specifically identical with the said species", *Leda* sp., other Lamelli-branches, and living-chambers of a Nautiloid. According to KOCH (1929b, p. 107) the last-mentioned fossils have some resemblance to certain Cephalopods of the Russian Arta-beds.

The age of the strata was by ROSENKRANTZ (1929a, b) and KOCH (1929b, pp. 106—107; 1929a, pp. 246—247) regarded as not definitely determinable, but probably Permian, possibly Artinskian. The name Depot Island Formation was introduced by KOCH for the conglomerate, the white and pink sandstone, and the grey shaly sandstone. This locality now became of great interest, being possibly the only occurrence of Lower Permian in East Greenland.

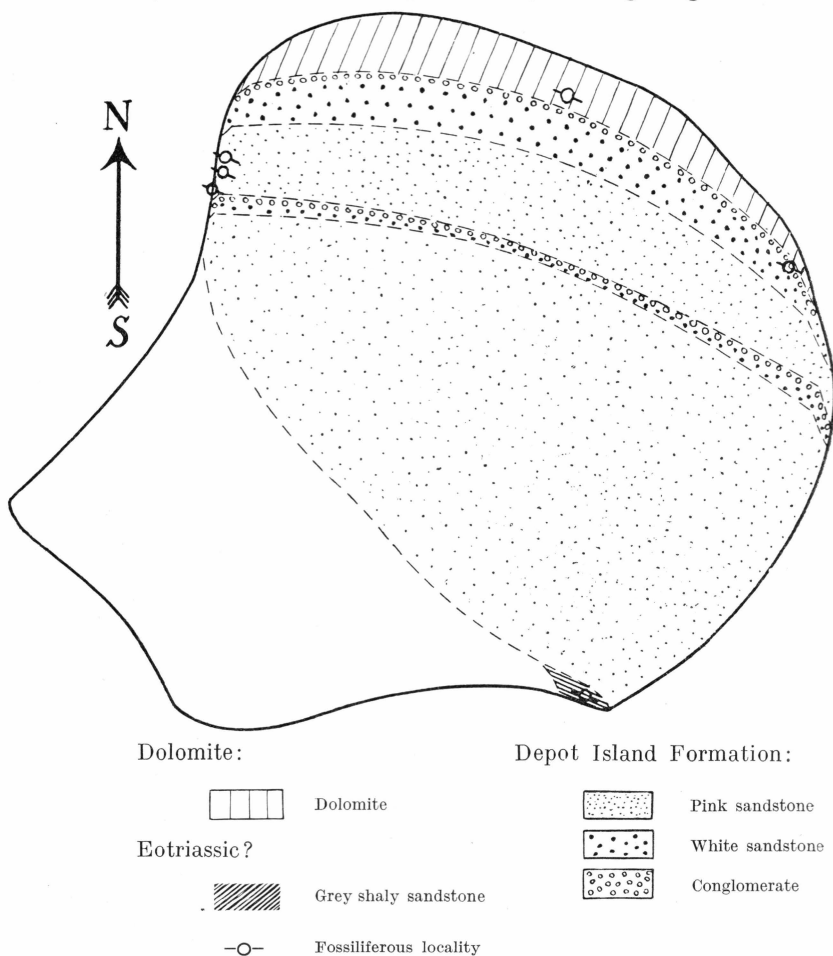
A different opinion was advanced in 1931 by FREBOLD (1931a, c) who determined the badly preserved Cephalopods from the uppermost, grey shaly sandstone as *Ophiceras* sp. cf. *O. aff. demissum* (OPPEL) SPATH and *Glyptophiceras minor* SPATH. Hence FREBOLD concluded that this uppermost grey shaly sandstone was of Eotriassic age. — The *Spirifer* in the basal conglomerate was by FREBOLD referred to *S. cameratus* MORTON.

In the meantime the series of Palaeozoic and Eotriassic strata at Cape Stosch and at Mt. Brinkley (cf. KOCH 1931, NIELSEN 1935) had been discovered. Here Palaeozoic layers of limestone with Brachiopods were found to be overlain by sandy layers of Eotriassic age. Now FREBOLD emphasized the similarity in petrographical sequence between the profiles of Cape Stosch and Mt. Brinkley, on one hand, and that of Depot Island on the other, and concluded that the whole of the Depot Island Formation was probably of Eotriassic age. The conglomerate he interpreted as an indication of an orogenic movement corresponding to the "Pfälzische Phase" of STILLE.

During the winter 1931—1932 the area round Fleming Inlet and Nathorst Fjord was investigated by NOE-NYGAARD (1934), who did not, however, revisit Depot Island. In his publication NOE-NYGAARD (1934, pp. 42—44) discusses the red sandstone series of Depot Island, and cites the opinion expressed by Dr. SPATH that some fossils collected by NOE-NYGAARD from the apparently corresponding strata discovered by KOCH (1929b, p. 104; cf. NOE-NYGAARD 1934, p. 50) at the base of Mt. Norden-skiöld might be of Palaeozoic age. NOE-NYGAARD also, though with reservation, paralleled with the Depot Island Formation some newly discovered strata in Mt. Kollen on Canning Land, subsequently found to be simply a transgression conglomerate of the marine Permian (cf. NOE-NYGAARD 1937, pp. 20—22, and above, p. 15). The whole Depot Island Formation was by NOE-NYGAARD (1934) referred to as Upper Permian(?).

As will be seen from the above account, the only two visits previously paid to the actual type locality were made by KOCH and HARRIS in the winter 1926—27.

On both occasions large parts of the island were apparently covered with snow, which prevented a complete study of its geological structure.



Text-fig. 6. Geological sketch map of Depot Island. Scale 1:5000.

A renewed investigation was thus highly desirable. For that purpose a party under my leadership was landed on the island at 4 a.m. on July 30th, 1934, and spent a few hours there.

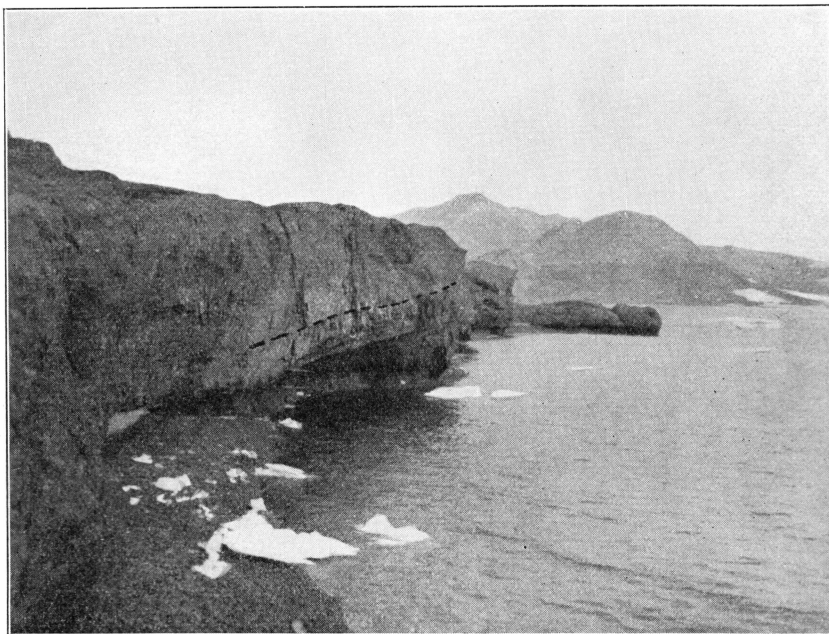
2. General structure.

In the summer, when most of the covering snow has melted, the main structure of Depot Island is very clearly shown (text-figs. 6, 8). It consists of a series of sedimentary strata, mainly dipping 20° towards the SSW.

The SW. part of the island is covered by quaternary sand and gravel; but its by far greatest part is made up of solid rock terraces that follow the general dip towards the SSW. The highest point is about 26 m above sea level. At the shore there is usually a steep cliff section, some 2 to 10 meters in height.

3. Stratigraphy.

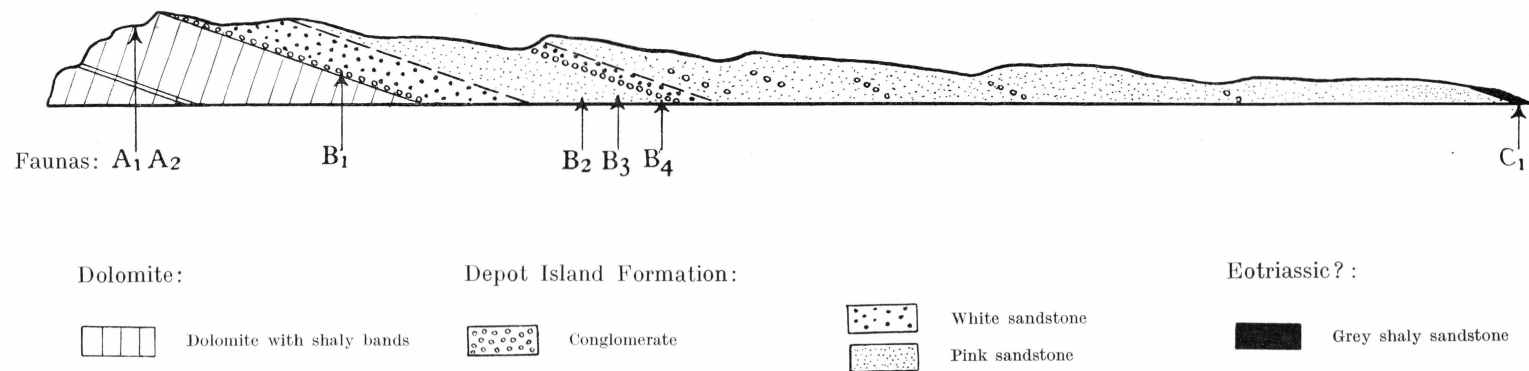
Dolomite. The lowermost strata are exposed in the NNE. part of the island, and consist of a series of grey, thin-bedded very hard dolomite,



Text-fig. 7. The contact between dolomite and basal sandstone of the Depot Island Formation on the E. shore of Depot Island.

weathering, as well described by HARRIS (KOCH 1929b, p. 106), into a very rough surface "resembling the broken surface of bubbly slag". The thickness exposed I estimated to be about 35 m (40 m according to HARRIS). Two bands of black bituminous shale, mentioned by HARRIS, were found in the lowermost part of the dolomite. Two fossiliferous banks were encountered a little higher up in the dolomite series both containing Brachiopods (faunas A_1 and A_2), at present not determined. A small basalt dyke was noticed near the E. shore of the island, in the highest part of the dolomite.

Depot Island Formation. The upper boundary of the dolomite is very well exposed in the cliff section on the E. side of the island (text-fig. 7), whereas at the corresponding locality on the W. side the section was unfortunately still hidden by snow at the time of our visit. The



Text-fig. 8. Diagrammatic profile of Depot Island. Scale 1:2000.

section on the E. side shows the dolomite to be overlain concordantly by a series of white sandstone with two conglomeratic bands at its base. The conditions at the contact show that fine-grained white sandstone has filled out cracks up to 2 m in depth in the surface of the dolomite. The conglomeratic bands contain well rounded quartz pebbles, 1—5 cm in diameter, and some fossils, possibly rolled (fauna B₁), including the *Spirifer* referred by FREBOLD to *S. cameratus* MORTON.

Above the conglomeratic bands the sandstone is white, medium-grained. The thickness of the white sandstone was estimated to be here (on the E. shore) about 10 m. It is possibly less on the W. shore, where at the time of our visit it was entirely covered by snow.

The white sandstone is, again concordantly, overlain by a series of mainly pink sandstone, conglomeratic in parts. This pink series was more closely investigated in the cliff section along the W. shore. Its base was here hidden by snow. The lowest accessible parts consisted of a pink sandstone with scattered conglomeratic parts. In this sandstone fossils occur mainly in two horizons (faunas B₂, B₃), both yielding abundant big specimens of *Grammysia* and numerous smaller Lamellibranchs. No Cephalopods were found in 1934, but the living-chambers collected in 1927 probably originate from one of these two horizons. All the fossils are preserved as impressions only.

A little above the horizon containing fauna B₃, the pink sandstone is succeeded by a bank of more calcareous sandstone. This bank yielded the interesting fauna B₄, including i. a. *Productidae* very similar to *Juresania juresanensis*, as figured by TSCHERNYSCHEW (1902, pl. XLVII, figs. 1, 2)¹). These fossils are partly preserved as shells, not only as impressions. Above the fossiliferous bank with fauna B₄ follows a conglomerate, about 1½ meter thick.

The conglomerate is again succeeded by a thin-bedded, strongly cross-bedded, grey, medium-grained sandstone. Its thickness is about 2 m. Above this grey sandstone there is again a pink sandstone, coarse, and strongly cross-bedded. This pink sandstone makes up a very considerable part of the island, and is really its most typical sediment. It seems to be entirely devoid of fossils.

Eotriassic(?). In the southeasternmost part of Depot Island the coarse pink sandstone described above, is overlain by about 1 m of fine-grained dark greyish-green shaly sandstone. This is the locality and horizon from which originate the Ammonites, determined by FREBOLD as Eotriassic Ophiceratids. No new material was found here in 1934.

¹) When the manuscript was already finished I got an opportunity of submitting these fossils to Dr. DUNBAR, who very kindly examined them and stated that they actually do belong to the genus *Juresania*.

III. STRATIGRAPHICAL CONCLUSIONS

A. Devonian.

1. Local stratigraphy.

The local stratigraphy of the Middle Devonian is very clear on Canning Land, where four series of different petrographical composition and fossil contents can be distinguished. On Wegener Peninsula the sequence is not so clear, and the different series found here can only with some reservation be correlated with those of Canning Land.

In both areas the sequence begins with a coarse conglomerate and a broadly equivalent series of greyish-white or light grey arkose containing remains of *Thursophyton* sp., *Homostius* and *Heterostius* on Canning Land. This series may be called the *Heterostius* Series.

Immediately above this is the Series with *Asterolepis säve-söderberghi*, beginning on Canning Land with a brownish-red part of very varying thickness, increasing to the S., succeeded by a thick striped part, consisting of alternating brownish-red and greenish-grey sandstone. On Wegener Peninsula there is no brownish-red basal part; a striped series of brownish-red and greenish-grey sandstone here follows immediately above the light grey basal series. The fossil contents of the brownish-red and striped series on Canning Land include *Psilophyton* sp., *Asterolepis säve-söderberghi* STENSIÖ (1938), small *Arthrodires*, and scales of *Crossopterygii*, while in the similar series on Wegener Peninsula are found: *Asterolepis* sp., *Homostius* sp., *Osteolepidae*, and other *Crossopterygii*.

Two plates of *Homostius* have been found in talus from this series — possibly from its lower part —, one on Canning Land, the other on Wegener Peninsula.

On Canning Land the brownish-red and striped Series with *Asterolepis säve-söderberghi* is succeeded by a series of greenish-grey sandstone with badly preserved plant fossils. No similar series has been found on Wegener Peninsula, but the uppermost part of the striped series there may possibly also include the equivalent of the greenish-grey series on Canning Land.

The uppermost part of the Middle Devonian on Canning Land, the Series with *Canningius groenlandicus*, is a series of sandstones of varying types, greyish and reddish, including a very characteristic dark grey to

black, partly bituminous flagstone with *Osteolepidae*. Similar sediments, with similar fossil contents, are found in various places on Wegener Peninsula, including NOE-NYGAARD's type profile at Vimmelskaflet. The fauna of this series (cf. SÄVE-SÖDERBERGH 1938) includes: *Canningius groenlandicus* n. sp., possibly other *Osteolepidae*, ?*Tristichopterus* sp., and scales of larger *Crossopterygii*.

The strata on Canning Land and on Wegener Peninsula may thus, with some reservation, be correlated as follows:

Canning Land		Wegener Peninsula
4. Series with <i>Canningius groenlandicus</i> : greyish and reddish sandstones and dark-grey to black partly bituminous shaly flagstones with <i>Canningius groenlandicus</i> , ? <i>Tristichopterus</i> sp., and other <i>Crossopterygii</i> .		3. Series with <i>Canningius groenlandicus</i> : greyish and reddish sandstones and dark-grey to black partly bituminous shaly flagstones with <i>Canningius groenlandicus</i> .
3. Greenish-grey sandstone series (with badly preserved plant fossils).		
2. Series with <i>Asterolepis säve-söderberghi</i>	Upper part: alternating brownish-red and greenish-grey sandstone with <i>Ast. säve-söderberghi</i> , <i>Crossopterygii</i> , and <i>Psilophyton</i> sp.	2. Alternating brownish-red and grey or greenish-grey sandstone, with <i>Asterolepis</i> sp., <i>Homostius</i> sp., <i>Osteolepidae</i> , and other <i>Crossopterygii</i> .
	Lower part: brownish-red sandstone.	
1. <i>Heterostius</i> Series: basal conglomerate and greyish white arkose with <i>Heterostius</i> sp., <i>Homostius</i> sp., <i>Thursophyton</i> sp.		1. Basal conglomerate and light grey arkose.

Summarizing the common features and the evidence of the fossil contents, the stratigraphical sequence of the Middle Devonian on Canning Land and Wegener Peninsula may be given as follows:

3. Series with *Canningius groenlandicus*: reddish and greyish sandstones, and dark-grey to black partly bituminous flagstones with *C. groenlandicus* and ? *Tristichopterus* sp.
2. Series with *Asterolepis säve-söderberghi*: brownish-red and greenish-grey sandstone with *A. säve-söderberghi*, small Arthrodiros, *Crossopterygii*, and *Psilophyton*, also with *Homostius*, possibly only in the lower part.
1. *Heterostius* Series: basal conglomerates and greyish-white arkose with *Homostius*, *Heterostius* and *Thursophyton*, probably also *Asterolepis* sp.

The Series with *Asterolepis säve-söderbergi* (2) here provisionally includes also the third (greenish-grey) local series of Canning Land, which has not yet yielded any determinable fossils.

The stratigraphy of the beds on Wegener Peninsula referred (with some reservation) to the Upper Devonian is not sufficiently known to be further discussed here.

2. Comparison with other areas.

Of the fossils found in the Middle Devonian beds on Canning Land and Wegener Peninsula, *Homostius*, *Heterostius* and *Asterolepis* are of great stratigraphical importance.

In the Baltic States and NW. Russia (cf. GROSS 1933a; OBRUTSCHEW 1930, 1933; HECKER, PHILIPPOVA, BARKHATOVA 1932; JARVIK 1937, pp. 120—122), *Homostius* and *Heterostius* are characteristic fossils of an important division (Dm₃; Luga Beds in Russia) of the Middle Devonian Old Red Sandstone above the basal division with *Pterichthyodes* (Dm₁, Dm₂; Narowa Beds in Russia), and below two divisions (Dm₄, Dm₅; Oredesch Beds and Subsnetnaia Beds in Russia) characterized by the two species of *Asterolepis*, *A. ornata* and *A. radiata*. — In Russia a third species of *Asterolepis*, *A. cristata* occurs in the Oredesch Beds together with *A. ornata*.

In Scotland (cf. EVANS 1929; WATSON 1935; WESTOLL 1937) *Heterostius* is absent, but *Homostius* occurs in the Stromness Beds of the Orcadian series, where it is found together with *Pterichthyodes*, and in the lower and main part of the Rousay Beds. Here, too, *Asterolepis* is characteristic of higher beds than *Homostius* (and *Pterichthyodes*), and occurs in the highest part of the Orcadian Rousay Beds (*A. orcadensis*), in certain Beds in Shetland (*A. thule*; cf. below), and in the Nairn Beds (*A. maxima*).

A large species of *Asterolepis*, *A. scabra* (A. S. WOODWARD 1891), is found in the Wijde Bay Series in Spitsbergen, which was earlier referred to the Upper Devonian (KIAER 1916; STENSIÖ 1918; NATHORST 1920; also HEINTZ 1935), but should now rather be included in the Upper Middle Devonian (SÄVE-SÖDERBERGH 1932, pp. 32—33, 37)¹. — *Heterostius* is also found in the lower part of the Upper Middle Devonian (Lower *Stringocephalus* Beds) of Sötenich, Rheinland (GROSS 1933b, p. 38; 1937, p. 34).

The more accurate knowledge of the Devonian stratigraphy of the Orkneys now available (WILSON and others 1935; WATSON 1935) allows a closer comparison and a more exact correlation with other areas than that proposed in my earlier works (1933b, 1934) and followed by WESTOLL (1937). In 1933 and 1934 I included the whole of the Orcadian in my "*Pterichthyodes* Beds" excepting only the Eday Sandstone, which was placed at the boundary to the *Asterolepis* Beds. In the "*Pterichthyodes*

¹) Cf. Addendum, p. 37.

Beds" I also included with hesitation the Baltic division Dm₃, with *Heterostius* and *Homostius*. Since, however, *Pterichthyodes* is only found in the lower part of the Orcadian (Stromness Beds) and in divisions Dm₁₋₂ in the Baltics, it seems more appropriate to restrict the use of the name *Pterichthyodes* Beds to these strata and their equivalents, and to use the name *Heterostius* Beds for the strata situated between them and the *Asterolepis* Beds, and characterized in the Baltics by the genera *Homostius* and *Heterostius*. *Homostius* seems to have a wider range than *Heterostius*, and occurs in the Orkneys both with *Pterichthyodes*, in the Stromness Beds, and above this, in the lower part of the Rousay Flags, together with i. a. *Thursius pholidotus* and *Coccosteus minor*. This lower part of the Rousay Flags is probably broadly equivalent to the division Dm₃ in the Baltics.

Already in 1934 (p. 50) I expressed some doubt concerning the position of the uppermost part of the Rousay Flags. This part is now known (WATSON 1935, p. 167) to form a separate zone, characterized by the species *Asterolepis orcadensis* (WATSON 1932), while the lower and main part of the Rousay Flags forms the zone of *Thursius pholidotus*, which also contains *Coccosteus minor* and *Homostius*. The presence of *Asterolepis* in the uppermost part of the Rousay Flags and *Homostius* in the lower part, indicates that the uppermost part should be paralleled with the lowermost part of the *Asterolepis* Beds (Dm_{4,5}) in the Baltics, and the lower part with the *Homostius-Heterostius* Beds (Dm₃). The overlying Eday Beds (characterized by the three genera *Microbrachius*, *Tristichopterus*, and *Pentlandia*) would then also correspond to part of the *Asterolepis* Beds, and this is strongly supported by the fact that WESTOLL (1937, p. 37) reports the find of *Asterolepis thule* (WATSON 1932) together with *Microbrachius* in the Brindister Beds in Shetland.

The new correlation of the Scottish and Baltic Middle Devonian is shown in the following table.

Old Red Sequence	Baltic States	Scotland (especially Orkneys)	
<i>Asterolepis</i> Beds	Dm ₅ : <i>Aster. radiata</i>	Nairn Beds: <i>Aster. maxima</i>	
	Dm ₄ : <i>Aster. ornata</i>	Eday Sandstone, John o'Groats Sandstone, Brindister Beds: <i>Microbrachius</i> , <i>Tristichopterus</i> , <i>Pentlandia</i> , <i>Aster. thule</i>	
		Zone w. <i>Coccosteus fletti</i>	
<i>Heterostius</i> Beds	Dm ₃ : <i>Homostius</i> , <i>Heterostius</i>	Rousay	Zone w. <i>Aster. orcadensis</i>
		Beds	Zone w. <i>Thursius pholidotus</i> , <i>Homostius</i> , <i>Coccosteus minor</i>
<i>Pterichthyodes</i> Beds	Dm ₁₋₂ : <i>Pterichthyodes</i>	Stromness Beds: <i>Pterichthyodes</i> , <i>Homostius</i> etc.	

For the correlation with the marine Devonian sequence (cf. GROSS 1933b; SÄVE-SÖDERBERGH 1933b, 1934), it is important to note that the upper boundary of the *Asterolepis* Beds in NW. Russia and the Baltic States lies — at least approximately — at the boundary between the Middle and Upper Devonian; and the find of *Pterichthyodes* in the lower part of the marine Upper Middle Devonian (*Stringocephalus* Beds) of Eifel and Lüdenscheld, Westphalen (GROSS 1933b) indicates the position of the Orcadian Stromness Beds and the broadly equivalent division with *Pterichthyodes* (Dm₁, Dm₂) in the Baltic States and NW. Russia. This division of the Old Red sequence — the *Pterichthyodes* Beds — thus evidently belongs to a lower part of the Upper Middle Devonian, the *Heterostius* Beds of the Baltic States and their Scottish equivalents belong to a middle part of the Upper Middle Devonian, and the *Asterolepis* Beds belong to the upper part of the Upper Middle Devonian. The occurrence of *Heterostius* in the Lower *Stringocephalus* Beds of Germany (cf. above) indicates that the *Pterichthyodes* Beds and the *Heterostius* Beds are together broadly equivalent to the Lower *Stringocephalus* Beds (lower part of marine Upper Middle Devonian), whereas the *Asterolepis* Beds are broadly equivalent to the Upper *Stringocephalus* Beds (upper part of the Upper Middle Devonian).

The dark-grey to black bituminous flagstone with *Osteolepidae*, characteristic of the uppermost Middle Devonian series met with in East Greenland (Series with *Canningius groenlandicus*), is of a type strikingly similar to that commonly met with in the Scottish Orcadian series, and to the fossiliferous Devonian sediments in W. Norway. From a determination as *Diplopterax* sp. of a specimen collected by NOE-NYGAARD at Vimmelskafte, I concluded (1933, pp. 103—107) that the Middle Devonian of East Greenland should be provisionally paralleled with the Orcadian series in Scotland. The richer collections of fossils now available allow a closer comparison with the sequence in other areas and a more accurate determination of the age of the strata. The presence of *Homostius* and *Heterostius* in the basal, greyish-white *Heterostius* Series in Greenland shows this series to be broadly equivalent to the division Dm₃ in the Baltic States, and to the lower, main part of the Rousay Beds in Scotland. The occurrence of *Asterolepis* sp. in talus probably from the *Heterostius* Series indicates that this series probably corresponds to the uppermost part of the division Dm₃ in the Baltic States. The brownish-red and striped Series with *Asterolepis säve-söderberghi* evidently belongs to a part of the stratigraphical division (*Asterolepis* Beds) represented in the Baltic States by Dm₄ and Dm₅, and in Scotland by the uppermost part of the Rousay Beds, the Eday Beds, and the Nairn Beds. The finds of *Homostius* plates in

Age (marine sequence)		Old Red sequence	Baltic States	Scotland (especially Orkneys)		East Greenland (especially Canning Land)
Upper Middle Devonian	Upper part	<i>Asterolepis</i> Beds	Dm ₅ : <i>Aster. radiata</i>	Nairn beds: <i>Aster. maxima</i>		3. Series with <i>Canningius groenlandicus</i> , ? <i>Tristichopterus</i> sp.
			Dm ₄ : <i>Aster. ornata</i>	Eday Sandstone, John o'Groats Sandstone Group, Brindister Beds: <i>Microbrachius</i> , <i>Tristichopterus</i> , <i>Pentlandia</i> , <i>Aster. thule</i>		
				Zone w. <i>Coccosteus fletti</i>		
	Lower part	<i>Heterostius</i> Beds	Dm ₃ : <i>Heterostius</i> , <i>Homostius</i>	Rousay Beds	Zone w. <i>Aster. orcadensis</i>	2. Series with <i>Asterolepis säve-söderberghi</i> : brownish-red and striped sandstone with <i>Aster. säve-söderberghi</i> , <i>Homostius</i> , and <i>Crossopterygii</i>
					Zone w. <i>Thursius pholidotus</i> , <i>Coccosteus minor</i> , <i>Homostius</i>	
	<i>Pterichthyodes</i> Beds	Dm _{1,2} : <i>Pterichthyodes</i>	Stromness Beds: <i>Pterichthyodes</i> , <i>Homostius</i>		1. <i>Heterostius</i> Series: greyish-white arkose with <i>Heterostius</i> , <i>Homostius</i> Basal conglomerate	

Age (marine sequence)		Old Red sequence	Baltic States (and NW. Russia)		Scotland	East Greenland	Other areas
Upper Devonian		<i>Grönlandaspis</i> Beds				Arthrodire Sandstone Series	
		<i>Remigolepis</i> Beds				<i>Remigolepis</i> Series	Victoria, New South Wales, Australia
		<i>Phyllolepis</i> Beds	Do ₁₋₄		Rosebrae Beds, Dura Den	<i>Phyllolepis</i> Series	Bristol District; Chemung, Catskill, U.S.A.; Bear Island; Beds of Evieux, Belgium
		<i>Bothriolepis</i> Beds			Alves and Scaat Craig Beds		Various localities in England; Senecan, U.S.A.; Scaumenac Bay, Canada
			<i>Bothriol. cell. Marl</i>	Subsnetnaia Beds: <i>Bothr. cellulosa</i> , <i>Aster. radiata</i>	Whitemire		Ellesmere Land; Nov. Zemlya; Timan
Upper Middle Devonian	Upper part	<i>Asterolepis</i> Beds	Dm ₅ : <i>Aster. radiata</i>		Nairn Beds: <i>Aster. maxima</i>	Series w. <i>Canningius groenlandicus</i> , also with ? <i>Tristichopterus</i> sp.	Wijde Bay Series, Spitsbergen: upper part
			Dm ₄ (Oredesch Beds): <i>Aster. ornata</i>		Eday Sandstone, John o'Groats Sandstone Group, Brindister Beds: <i>Microbrachius</i> , <i>Tristichopterus</i> , <i>Pentlandia</i> , <i>Aster. thule</i>		
	Lower part	<i>Heterostius</i> Beds			Zone w. <i>Coccosteus fletti</i>	Series w. <i>Aster. säve-söderberghi</i> , also with <i>Homostius</i> , and <i>Crossopterygii</i>	Wijde Bay Series, Spitsbergen: lower part
			Dm ₃ (Luga Beds): <i>Heterostius</i> , <i>Homostius</i>		Rousay Beds	<i>Heterostius</i> Series: <i>Heterostius</i> , <i>Homostius</i>	
Lower Middle Devonian		<i>Pterichthyodes</i> Beds	Dm ₁₋₂ (Narowa Beds): <i>Pterichthyodes</i>		Stromness Beds: <i>Pterichthyodes</i> , <i>Homostius</i>		

talus from the brownish-red and striped Series with *Asterolepis säve-söderberghi* indicate that this series corresponds to the lowermost part of the *Asterolepis* Beds. The parallelisation with the lowermost part of the *Asterolepis* Beds (Zone w. *Asterolepis orcadensis* in the Orkneys) is strongly supported by the markedly close relationship between *Asterolepis säve-söderberghi* and *A. orcadensis* (cf. STENSIÖ 1938). The position of the Series with *Canningius groenlandicus* is not definitely clear, but the similarity of the Greenland Osteolepid to certain Orcadian *Osteolepidae*, and the possible presence of *Tristichopterus* in this series in Greenland, indicate that the Series with *Canningius groenlandicus* should also be placed in the Upper Middle Devonian and may be provisionally parallelized with the Orcadian Eday Beds and their equivalents in other parts of Scotland.

The correlation arrived at is expressed in the table p. 33.

The whole Upper and Middle Devonian sequence in East Greenland and certain other areas may now be given as shown in the table p. 34.

As regards the distribution in other areas of the Upper Devonian scale-type called *Holoptychius nobilissimus* Ag., the reader is referred to my earlier work (1932).

B. Carboniferous.

The find of beds containing *Asterocalamites scrobiculatus* in the valley W. of Mt. Kollen proves that KOCH (1929a, p. 99, pl. II; 1929b, p. 245; 1935, p. 62) is right, in so far that continental Carboniferous beds are present on Canning Land, and his critics (BØGGILD and others 1935, p. 504) are wrong in their somewhat naive assertion that there is no continental Carboniferous on Canning Land because one of them (NOE-NYGAARD) failed to find it. The present find also allows a closer determination of the age (Dinantian, or possibly lowermost Namurian) than has so far been possible of continental Carboniferous beds in the district discussed here (cf. KOCH 1929, p. 99; 1935).

C. Permian.

The profiles through the marine Permian beds described above and in NOE-NYGAARD's papers (1934, 1936, 1937) show a very variable composition of the sediments. In some places a thick conglomerate is found at the base, in others dolomite or calcareous sandstone rests directly on the underlying Devonian strata. The very strongly increasing thickness to the W. of the Permian conglomerate in Mt. Kollen is also noteworthy in this connection.

The Permian beds include several localities rich in well preserved Invertebrate fossils, Corals, Brachiopods, Bryozoa etc. Unfortunately, these fossils are not yet determined; and even if they were, it might be difficult to state the exact age of the beds, in view of the present confusion regarding Permian (and "Permo-carboniferous") stratigraphy. Provisionally, following ALDINGER (1935), the whole is referred to as Permian, and supposed to belong to the Middle or Upper part of this formation. At any rate, ALDINGER's arguments from the composition of the fish-fauna in the more N. part of East Greenland (Cape Stosch etc.) cannot be so easily disposed of as attempted by FREBOLD (1936, 1937).

The dolomite that forms the top of the profiles in W. Horse-shoe Mountain and Mt. Kollen and the basal layers on Depot Island is exactly similar to that usually found in the younger Palaeozoic of East Greenland, for instance at Cape Stosch, at Mt. Brinkley and in the NE. part of Clavering Island, in Margrethe Valley, on Wollaston Foreland, and on Wegener Peninsula (cf. KOCH 1931, NIELSEN 1935, NOE-NYGAARD and SÄVE-SÖDERBERGH 1932, FREBOLD 1931b).

The character of the dolomite on Depot Island may be discussed on the basis of the conditions at its upper boundary. The overlying sandstone deposited here has filled out very deep cracks in the dolomite. This indicates that at the time of the sedimentation of the sandstone the dolomite was already solid, and cracked, which may be explained in two ways. Either the dolomite had solidified, and then been exposed to weathering — a break in the sedimentation must then be supposed —, or the dolomite must be of organic origin (possibly a reef).

The conglomerates and white and pink sandstones, following above the dolomite on Depot Island, form the Depot Island Formation. For the present it seems best to define this formation to include the sediments between the dolomite and the sandy shales with Ammonites, thus excluding the latter strata, which are possibly of Eotriassic age¹).

The lower part of the Depot Island Formation shows a tendency to rhythmical sedimentation, beginning with a conglomerate, which is then overlain by white sandstone, in its turn followed by pink sandstones. The latter are coarse and partly conglomeratic, and appear to be pronounced shallow water deposits.

The age of the Depot Island Formation has, as emphasized above, been a matter of dispute. ROSENKRANTZ and KOCH were inclined to assume a Permian age of the formation, whereas FREBOLD for petrographical reasons seems to have felt fairly certain that the whole for-

¹) It will be clear without comment to any reasonable and competent reader (though apparently not to BÖGGILD and others 1935) that this is the sense in which the name Depot Island Formation is used by KOCH (1935).

mation ought to be referred to the Eotriassic. Our find of *Productidae* (*Juresania*), in the highest fossiliferous horizon of the Depot Island Formation (as defined above) settles the problem, and proves that at least the lower parts, and most probably the whole of the Depot Island Formation, is of Younger Palaeozoic, Carboniferous or Permian age. Until the much disputed age of the other, more richly fossiliferous Carboniferous or Permian deposits of East Greenland has been definitely settled, it hardly seems justifiable to attempt a closer determination of the age of the Depot Island Formation. Suffice it to note that if ALDINGER (1935) is right in referring the fish-bearing *Posidonomya*-shales in the more northern localities to the Middle or Upper Permian, the Depot Island Formation may probably also be of Upper or Middle Permian age. Facially, it seems fairly comparable to the red arenaceous series on Wollaston Foreland described by FREBOLD (1932a, pp. 15—20; 1932b).

The settling of the age of the Depot Island Formation as late Palaeozoic, probably Permian, also naturally proves the *Grammysiae*, found in beds below the horizon containing Productids, to be of late Palaeozoic, probably Permian age. It also shows the great danger of such long-distance correlations on petrographical grounds as attempted by FREBOLD, even in cases of marine deposits.

Since no new fossils were found in the thin bed of greyish shaly sandstone overlying the Depot Island Formation as here defined, little can be said of the age of the shaly sandstone. Also, the Ammonites determined by FREBOLD as Eotriassic Ophiceratids are very badly preserved, perhaps hardly determinable. If, after all, the shaly sandstone should turn out not to be of Eotriassic age, it may be better to include also that type of beds in the Depot Island Formation. At present, however, this does not seem justifiable.

Finally it may be mentioned that an important fault apparently occurs between Depot Island and Mt. Nordenskiöld, since the pink sandstones with *Grammysia* are according to NOE-NYGAARD found also in the base of that mountain.

Addendum. According to HEINTZ (Skrifter om Svalbard og Ishavet, Nr. 72, 1937; arrived when my manuscript was already sent to the press), the so called Wijde Bay Series in Spitsbergen includes a lower part (Wijde Bay Series s. str.) with *Heterostius* and *Homostius* (new finds) and an upper part with the well-known Fish Cleft Fauna with *Asterolepis*. Concerning the age of the latter, HEINTZ (p. 19) now turns to the view expressed by myself already in 1932 (pp. 32—33, 37; also 1934, p. 50; 1937: Fortschr. der Paläontologie, I, p. 257). — The new results have been inserted in the table, p. 34.

IV. SUMMARY

The Palaeozoic sedimentary series on Canning Land, Depot Island, and certain parts of Wegener Peninsula are described. These sedimentary series include Middle Devonian and Upper Devonian beds of Old Red Sandstone facies, continental Carboniferous beds, with *Asterocalamites scrobiculatus* on Canning Land, and marine late Palaeozoic, probably Permian formations.

The Middle Devonian includes three series with determinable fossils: 1) The *Heterostius* Series, mainly greyish-white arkose with *Heterostius*, *Homostius*, and *Thursophyton*, 2) The Series with *Asterolepis säve-söderberghi*, brownish-red and greenish-grey sandstone with *A. säve-söderberghi*, *Homostius*, *Crossopterygii*, and *Psilophyton*, 3) The Series with *Canningius groenlandicus*, various sandstones with *C. groenlandicus*, ?*Tristichopterus* sp., and other *Crossopterygii*. The two first-mentioned series correspond to the uppermost part of the *Heterostius* Beds in other areas (lower part of the Rousay Beds in Scotland; division Dm₃ in the Baltic States) and the lowest part of the *Asterolepis* Beds (Zone with *A. orcadensis* in Scotland; lower part of the division Dm₄ in the Baltic States). The third series probably corresponds to a higher part of the *Asterolepis* Beds (Eday Beds etc. in Scotland and corresponding beds in the Baltic States). The stratigraphy of the Middle Devonian beds in this district and of comparable formations in other areas is summarized in the tables on pp. 33—34 and a new correlation is proposed (pp. 30—31) of the beds in Scotland and the Baltic States. — The marine late Palaeozoic, probably Permian, formations of the district definitely include the much discussed Depot Island Formation.

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Færdig fra Trykkeriet den 28. December 1937.

PLATES

Plate 1.

Map showing the distribution of Palaeozoic sediments on Canning Land and Wegener Peninsula (East Greenland). Compiled from own and earlier observations.

The numbered fossiliferous localities are:

1. Horizon at 304 m in the Series with *Asterolepis säve-söderberghi* in profile i, Cape Brown Mountain.
2. Fossiliferous talus of the Series with *Canningius groenlandicus* on the E. slope of the ridge W. of Cape Brown Mountain.
3. Fossiliferous talus of the Series with *Canningius groenlandicus* in NOE-NYGAARD's type profile, Vimmelskæftet.
4. Fossiliferous talus of the Series with *Canningius groenlandicus* at the SW. corner of Eastern Mountain.
5. Fossiliferous talus of the Series with *Canningius groenlandicus* in two small hills between Eastern Mountain and Little Circus Mountain.
6. Loose plate of *Homostius*, found below Mt. Quensel and probably originating from the Series with *Asterolepis säve-söderberghi*.
7. Scale of the type called *Holoptychius nobilissimus* AG. in talus from the Upper Devonian on the N. slope of Mt. Quensel.
8. Various fossiliferous horizons on Depot Island (Permian and ?Eotriassic).
9. Fossiliferous talus of the *Heterostius* Series in profile a, NE. corner of E. Horse-shoe Mountain.
10. Fossiliferous talus of the Series with *Asterolepis säve-söderberghi* in the top ridge of E. Horse-shoe Mountain.
11. (Not numbered; cf. pl. 2). Fossiliferous talus from the Series with *Asterolepis säve-söderberghi* in the N. Basis Valley.
12. Fossiliferous talus in the S. Basis Valley.
13. Loose plate of *Homostius* in talus from the Series with *Asterolepis säve-söderberghi* on the S. side of the Southern Ridge.
14. Fossiliferous horizon at 210—234 m in the Series with *Canningius groenlandicus* in the N. part of W. Horse-shoe Mountain (near profile c).
15. Fossiliferous horizon at 572—576 m in the basal part of the marine Permian in profile d, W. Horse-shoe Mountain.
16. Fossiliferous talus of the Series with *Canningius groenlandicus* on the N. slope of Mt. Kollen.
17. Fossiliferous horizon in the Permian near the top of Mt. Kollen.
18. Locality with *Asterocalamites scrobiculatus* in the continental Carboniferous near the delta in the valley W. of Mt. Kollen.
19. Fossiliferous talus of the Series with *Asterolepis säve-söderberghi* on top of the Southern Ridge.
20. Fossiliferous talus of the Series with *Asterolepis säve-söderberghi* on the W. slope of the Southern Ridge.

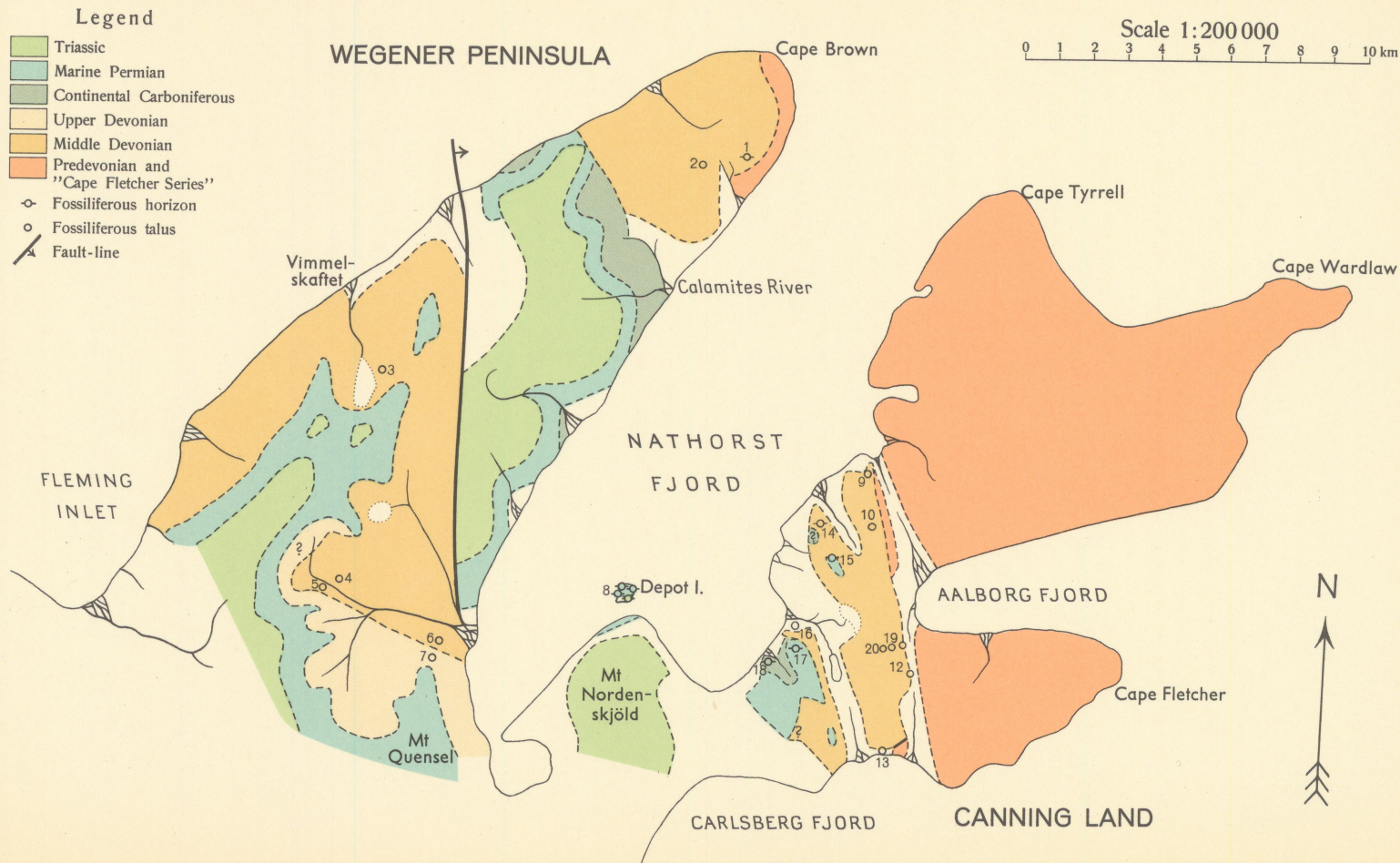


Plate 2.

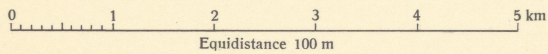
Geological sketch-map of the W. part of Canning Land.

The numbered fossiliferous localities are:

9. Fossiliferous talus of the *Heterostius* Series and horizon with *Thursophyton* sp. in profile a, NE. corner of E. Horse-shoe Mountain.
10. Fossiliferous talus of the Series with *Asterolepis säve-söderberghi* in the top ridge of E. Horse-shoe Mountain.
11. Fossiliferous talus from the Series with *Asterolepis säve-söderberghi* in the N. Basis Valley.
12. Fossiliferous talus in the S. Basis Valley.
13. Loose plate of *Homostius* in talus from the Series with *Asterolepis säve-söderberghi* on the S. side of the Southern Ridge.
14. Fossiliferous horizon at 210—234 m in the Series with *Canningius groenlandicus* in the N. part of W. Horse-shoe Mountain (near profile c).
15. Fossiliferous horizon at 572—576 m in the basal part of the marine Permian in profile d, W. Horse-shoe Mountain.
16. Fossiliferous talus of the Series with *Canningius groenlandicus* on the N. slope of Mt. Kollen.
17. Fossiliferous horizon in the Permian near the top of Mt. Kollen.
18. Locality with *Asterocalamites scrobiculatus* in the continental Carboniferous near the delta in the valley W. of Mt. Kollen.
19. Fossiliferous talus of the Series with *Asterolepis säve-söderberghi* on top of the Southern Ridge.
20. Fossiliferous talus of the Series with *Asterolepis säve-söderberghi* on the W. slope of the Southern Ridge.

Geological sketch-map of the
Western part of Canning Land

Scale 1:75 000



Legend

- Marine Permian
- Continental Carboniferous
- Middle Devonian:
4. Series w. *Canningius groenlandicus*
- Middle Devonian:
3. Greenish grey series
- Middle Devonian:
2. Series w. *Asterolepis säve-söderberghi*
- Middle Devonian:
1. *Heterostius* Series
- Predevonian and
"Cape Fletcher Series"
- Fossiliferous horizon
- Fossiliferous talus

