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UNDER LEDELSE AF LAUGE KOCH

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# NOTES ON TRIASSIC STRATIGRAPHY AND PALEONTOLOGY OF NORTH-EASTERN JAMESON LAND (EAST GREENLAND)

BY
S. DEFRETIN-LEFRANC, K. GRASMÜCK
AND R. TRÜMPY

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BIANCO LUNOS BOGTRYKKERI A/S
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# PREFACE

In the summer of 1958, we had the privilege of being invited to join the Danish East Greenland Expedition, under the leadership of the late Dr. LAUGE KOCH. The main objective was the correlation of the Triassic formations of Jameson Land and Traill Ø (lat. 71°30'–72°30') with the classical sections on Hold with Hope (lat. 74°).

In July and early August, TRÜMPY studied the sections on Hold with Hope (Kap Stosch) and in the southern part of Traill Ø (Svinhufvuds Bjerge), while GRASMÜCK worked in the area south of Mesters Vig (Oksedal) and in northern Traill Ø (Maanedal). The results of both parties from Traill Ø are incorporated in the thesis of J. PUTALLAZ (1961).

GRASMÜCK and BOLLER were flown to the Kap Biot area in late July; they worked from base camps at the mouths of Edderfugledal and Solfaldsdal as well as from an inland camp in Henrik Møller Dal. TRÜMPY joined GRASMÜCK's party for a few days in early August and subsequently studied Wegener Halvø, from camps at the head of Fleming Fjord and at the mouth of Tvekegledal. At the close of the expedition, some sections near Mesters Vig mining village were examined.

We thus disposed only of limited time for our investigations (GRASMÜCK about 25 field days, TRÜMPY about 16), and our results must be considered as provisional. It had been planned to continue work in the Fleming Fjord area in 1959, but this was not feasible as the expedition programme was reduced in that year. Much remains to be done; especially Wegener Halvø would justify more detailed mapping, and the fossiliferous horizons in the Mount Nordenskiöld and Cape Biot formations should be exploited systematically in order to allow better dating of the Triassic redbeds. Likewise, sedimentological studies are only at their very beginning.

GRASMÜCK completed his part of the manuscript (in German) in 1960, and the long delay in publication is due to TRÜMPY, who for various reasons could only write up his at the beginning of 1967. TRÜMPY also translated GRASMÜCK's original manuscript and incorporated it into the work.

The great experience of the unforgotten Dr. LAUGE KOCH made it possible to reach good results in a short field season. To him, to his helpers and especially to the Danish Government we are thankful for a memorable Greenland summer. Miss I. BECK and the staff of the M.o.G. were very helpful during the printing, and we thank both for their patience during the long time they had to wait for completion of the manuscript. Mrs. S. DEFRETIN (Lille) determined the phyllopoda – her results form part III of this paper – Dr. H. OERTLI (Pau) the ostracoda and Dr. N. HUGHES (Cambridge, U. K.) Carboniferous plants. Talks with Dr. J. CALLOMON (London), Dr. D. T. DONOVAN (London), Dr. E. T. TOZER (Ottawa) and Dr. E. WITZIG (Schaffhausen) gave us many new insights. M. AELLEN (Berne) and J. PUTALLAZ (Geneva) readily discussed their results with us.

K. BOLLER was an agreeable companion and efficient "kitchen boy" as well as a capable co-worker to K. GRASMÜCK. R. TRÜMPY was assisted by W. MARTIN, a very energetic and conscientious young geology student from Zurich. We deeply regret that this promising and likeable man fell to his death in the Uri mountains in 1959.

I

# TRIASSIC STRATIGRAPHY AND GENERAL GEOLOGY OF THE COUNTRY AROUND FLEMING FJORD (EAST GREENLAND)

BY

K. GRASMÜCK AND R. TRÜMPY

WITH 12 FIGURES IN THE TEXT AND 4 PLATES

## Abstract

Geological description of the country to the NW of Fleming Fjord (71°45′ N, 23° W): Kap Biot and Kap Seaforth, and to the SE of the fjord: Wegener Halvø, with special emphasis on Triassic stratigraphy. The lowermost Triassic formation (Wordie Creek fm.) can be subdivided biostratigraphically into several ammonite zones. The two higher formations consist of poorly fossiliferous redbeds; the Mt. Nordenskiöld formation is understood to comprise the newly defined Paradigma member (arkose) and Solfaldsdal member (red mudstones, shales with gypsum), the Cape Biot fm. the Cape Seaforth member (variegated shales with gypsum), the Fleming Fjord member (massive red mudstones) and the Ørsted Dal member (shales and sandstones). Detritus was mainly derived from the E. The complex fault pattern of Wegener Halvø is described; a large NW-hading normal fault runs along Fleming Fjord. Broad anticlines and narrower synclines to the NE of it are probably subordinate to this fault.

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# GEOGRAPHICAL AND HISTORICAL INTRODUCTION

Fleming Fjord is the most northwesterly one of three small and not very typical fjords cutting into the northeastern part of Jameson Land. It is situated at about 71°45′N (marked by error as 71°N on the map plate 1) and 23°W. The fjord has a length of about 25 km, a breadth of 12 km at its opening into Davy Sund, but only of about 6 km in its inner reaches. It was originally forked, but the northern arm has been entirely filled by the alluvium of the great Ørsted Dal river, so that Kap Seaforth can hardly be called a cape any more. The country surrounding the fjord can be divided into three areas:

1. Kap Biot region and country to the north of Ørsted Dal. Plateau mountains of 650–800 m, rising to 1000 m further west, dissected by short valleys. We have proposed the name of Edderfugledal for the broad valley west of Kap Biot, in which large numbers of geese and ducks spend the summer, and that of Regnbuedal for the northern lateral valley to Henrik Møller Dal on account of the vivid colours of the Triassic strata which form its flanks.

2. Hills between Ørsted Dal and the inner part of Fleming Fjord, rising from Kap Seaforth towards the WSW and dropping with steep cliffs, broken only by the glacial transfluence of Solfaldsdal, into Fleming Fjord.

Areas 1) and 2) are formed by flat-lying beds of the younger Triassic formations, capped by the Rhetic-Liassic Kap Stewart formation and further inland by marine Jurassic beds.

3. Wegener Halvø, between Fleming and Nathorst Fjords, has quite a different morphological and geological character. Precambrian, Devonian, Carboniferous, Permian and Eotriassic formations, offset by faults, create a much more varied scenery. The proud landmark of Kap Brown rises to 918 m. Lower mountains, such as Paradigmabjerg (606 m) and the newly named Walter Martin Bjerg (608 m) lie in a downfaulted graben to the west of it. In the western half of the peninsula, individualized peaks, such as Ravnefjeld, "Profilbjerg"[1]) and Quensel Bjerg, again reach about 900 m.

[1]) This name was used by H. Stauber (1942), but does not have official status.

Over the short distance from Antarctics Havn to Carlsberg Fjord, there is a marked change in climate from the dry and mild foehn valleys to the sterner and more humid outer coast. This is exemplified in a striking manner by the panorama one sees from the mountains of Wegener Halvø. To the north, Svinhufvud Bjerge, on Traill Ø, is almost ice-free in spite of its over 1300 m; small glaciers are found on Wegener Halvø itself; to the southeast, the half-drowned Caledonian chain of Canning Land and Liverpool Land is draped in glaciers reaching right down into the sea.

In spite of their proximity to the bases of Scoresby Sund, Ella Ø and (in later years) Mesters Vig, the peninsulas on the northeastern border of Jameson Land have been little studied. In some summers, the sea-ice stays blocked in the fjords, making it impossible for ships to enter or even for sea-planes to water. In 1958, we could not land in Nathorst Fjord, as we had planned, and on one occasion northerly wind filled even Fleming Fjord with ice floes, making the takeoff rather adventurous. This difficulty of access may explain why Wegener Halvø, for all its fascinating geology, has been visited by relatively few scientists.

In 1900, O. Nordenskiöld and N. Hartz made the first observations in Fleming Fjord and recognized the presence of Triassic beds (Nordenskiöld, 1909). Not before 1926, when Lauge Koch passed by Wegener Halvø on his way from Scoresby Sund to the north, was the area revisited by geologists. In 1927, Lauge Koch and T. Harris made some important observations and found the first Carboniferous and Permian fossils. The first detailed studies were made by A. Noe-Nygaard in 1931 (published 1934); his work is accompanied by the first geological map of the country round Fleming Fjord and also contains a very good account of the earlier explorations, to which the reader is referred.

G. Säve-Söderbergh visited Wegener Halvø in 1934 and again, together with H. Bütler, in 1936. To these two authors we are indebted for the elucidation of the stratigraphy, especially of the Devonian, and for important contributions to the understanding of the general structure. The Triassic strata were studied in detail by H. Stauber (1942). The country north of Fleming Fjord is one of the areas for which he postulated great horizontal mass-movements, and one of the objects of our study was to control the evidence for this hypothesis. Stauber's map (1942) shows more detail than Noe-Nygaard's, but it is decidedly less objective.

# I. PRE-MESOZOIC FORMATIONS

They occur only on Wegener Halvø and were not studied in detail. We refer to the works of NOE-NYGAARD (1934), SÄVE-SÖDERBERGH (1937) and BÜTLER (1948).

## A. Precambrian

From the distance, BÜTLER (1948, p. 25) attributed the rocks forming the tip of Kap Brown to the "series of quartzitic shales" in the lower Eleonore Bay group.

## B. Devonian

The pre-Middle Devonian subvolcanic intrusions of the Cape Fletcher series (*sensu* KOCH, 1930) on the southern side of Kap Brown mountain have been described by BÜTLER (1938, p. 47). They also form dykes in the Precambrian of Kap Brown.

Devonian volcanics also occur near the mouth of Tvekegledal; from the air photographs, we gathered the impression that the volcanics were intruded into older (Precambrian?) rocks, unconformably overlain by the Devonian sediments.

The Devonian was especially studied by BÜTLER (1948) and SÄVE-SÖDERBERGH (1937). The Devonian sandstones and mudstones generally dip to the west or southwest; locally, in particular around Quensel Bjerg, they show quite pronounced folds. Their age was determined as upper Middle Devonian (Orcadian) by SÄVE-SÖDERBERGH. In the southern part of Wegener Halvø, these Orcadian beds are unconformably overlain by another formation of whitish and reddish sandstones. SÄVE-SÖDERBERGH found a scale of *Holoptychius* in the talus from these beds and considers them, with some reserves, as Upper Devonian.

## C. Carboniferous

Continental formations of Carboniferous age are restricted to the graben of central Wegener Halvø, between Tvekegle fault and Calamites fault. In 1927, Harris found *Lepidodendron*, *Calamites* and *Stigmaria ficoides* in Calamitesdal. The same rocks appear on the Fleming Fjord coast NE of the mouth of Tvekegledal.

In the course of our investigations we came across only one tiny but interesting outcrop of Carboniferous beds; only afterwards did we realize that it had already been found by Noe-Nygaard (1934, p. 27) – a remarkable feat of observation. It consists of a pingo-like tumulus in the valley east of Ravnefjeld, at about 170 m altitude, directly along the Tvekegle fault. West of this fault, no Carboniferous beds are known; they must have been eroded prior to the deposition of the Permian Domkirken and Foldvik Creek formations. This implies that an older, pre-Permian fault, also with downthrow to the east, was rejuvenated in Tertiary times (see also Bütler, 1947, p 70).

The Carboniferous rocks are grey, yellowish-weathering, medium-grained micaceous quartz sandstones and black, coal-bearing shales. From the latter a small flora was collected, which was determined by Dr. N. Hughes (Cambridge, U. K.) as containing

*Lepidophyllum* sp.
*Stigmaria ficoides* Brgt.
*Calamites* sp. (fragment)
*Sphenopteris* sp., close to *Sph. obtusiloba* Brgt.
*Lycospora* sp. (poorly preserved).

According to Dr. Hughes, this scant material would point to an age between Namurian B (?) and Westphalian C, with greatest probability for Lower Westphalian.

## D. Permian

Upper Permian rocks, especially the white, massive "reef" limestones, are widespread on Wegener Halvø. West of the Tvekegle fault, they cap some of the most conspicuous mountains (Quensel Bjerg, Ravnefjeld and Lille Ravnefjeld); in the downfaulted area between Tvekegle and Calamites fault, they are exposed along the shores on both sides of the peninsula.

The marine Upper Permian rocks can be designed as Foldvik Creek formation (Koch, 1929), but this term is far from satisfactory and has been little used. After long discussions, their Upper Permian (Penjabian) age is now well established. Massive red conglomerates and arkoses below the marine formation, unconformably overlying older rocks, have been called Domkirken formation by Witzig (1954). Most recent authors (*e.g.* Kempter, 1961) have considered the Domkirken beds as marine

Fig. 1. Vimmelskaftet valley from the Northwest.
The angular unconformity between the west-dipping Devonian strata and the flat-lying Permian is clearly visible in the foreground and on Ravnefjeld (far left). The flat summit in the right foreground is built of Wordie Creek formation; section B follows the ridge on its right. In the middle distance, right center, Lille Ravnefjeld (Permian) and immediately behind it Nordenskiöld Bjerg.

basal conglomerates of the Foldvik Creek (or Karstryggen) formation. But the two formations are quite distinct, and the marine, locally fossiliferous basal conglomerates of the Foldvik Creek formation lie often unconformably on the Domkirken conglomerates (*e.g.* on Traill Ø, see PUTALLAZ, 1961, p. 23). In the latter, the greatest axis of elongated pebbles forms mean angles of about 15° with the stratification, which is indicative of fluviatile origin.

On Wegener Halvø, the Domkirken formation is discontinuous, being represented in Calamitesdal, where it measures about 100 m, as well as in the southwestern part of the peninsula, but lacking in the central Ravnefjeld mountains. The angular unconformity at its base is very well exposed in the cliffs above Fleming Fjord (see fig. 1). In Lagunenæsset valley, at 230 m altitude, the Devonian sandstones below the flat-lying red conglomerates dip with 45° to the SSW. The conglomerates themselves are only 30–40 m thick.

The marine Foldvik Creek formation is composed of several members which are in part intertonguing and hence coeval (see Maync, 1942, 1961). The lateral replacement of the different members is probably not so extreme as upheld by Kempter (1961, fig. 15). In a general way, a lower subdivision can be distinguished, the most conspicuous term of which is the white, massive "reef" limestone; it passes laterally into gypsum and well-bedded dolomites. The upper part comprises Posidonia shales, Productus limestones, Martinia beds and their sandy to conglomeratic equivalents.

The "reef" limestones attain about 150 m on Ravnefjeld and along the Nathorst Fjord shore. They thin rapidly towards the W. In Lagunenæsset valley, their thickness is down to 15–20 m, and they are underlain by 20–25 m of yellowish-brown dolomites. It may be significant that these limestones show their greatest development along the eastern (Wegener Halvø) and western (southern Scoresby Land) margin of the basin; in its center (Traill Ø, northern Scoresby Land) they are largely replaced by dolomites, and the overall thickness of the lower part of the Foldvik Creek formation is considerably smaller. In the cliffs NE of the mouth of Tvekegledal, the top of the "reef" limestones contains malachite.

In the northern part of Wegener Halvø, the upper subdivision of the Foldvik Creek formation shows quite a straightforward succession: 20–50 m of dark, bituminous Posidonia shales, followed by up to 50 m of very fossiliferous Productus limestone. The latter forms the summit cap of Ravnefjeld (see fig. 1 and 3). The uppermost part of the Productus limestones is more or less arenaceous, as already noted by Noe-Nygaard (1934, p. 36). S of Paradigmabjerg, the coarse sandstones forming the base of the Wordie Creek formation rest directly upon thin and strongly micaceous Posidonia shales; the local absence of Productus limestones can be attributed to pre-Triassic erosion.

In the southwestern part of Wegener Halvø, the typical Productus limestones are replaced by shales, sandstones and argillaceous Martinia limestones. The section in Vimmelskaftet valley studied by Noe-Nygaard (1934, p. 34) shows the last tongues of Productus limestones. In Lagunenæsset valley, the "reef" limestones, which contain abundant productids, bryozoa and crinoids in their topmost part, are overlain by 40–45 m of dark, strongly micaceous shales with *Posidonia*, selachian spines and smooth brachiopods. One small, very badly preserved ammonite of *Cyclolobus*-like shape was also found. The shales are markedly arenaceous and contain some quartz pebbles. Intercalated thin beds of dark, fine-grained limestone show abundant sponge spicules, "calcispheres" (dm. 0.10–0.15 mm) and ostracods.

In the valley south of "Profilbjerg", the southernmost section which we studied, the top of the Foldvik Creek formation is represented by the Martinia "limestones", mainly greenish, compact marl shales. They are associated with greyish shales containing giant ellipsoidal concretions (0.5–5 m long, 0.2–0.7 m thick) of fine-grained dolomite. Lenses of calcareous sandstone with quartz pebbles also occur within the Martinia beds. The underlying Posidonia shales measure only about 5 m and are very arenaceous.

The occurrence of coarse detritus in the Martinia beds and the Posidonia shales renders probable their correlation with the lower part of the much-discussed section on Depotø, in Nathorst Fjord (see especially Säve-Söderbergh, 1937). Thus, the main part of the "Depot Island formation" may represent a marginal facies of the uppermost Permian, whereas the overlying shales, in which badly preserved ammonites resembling *Glyptophiceras* (*Hypophiceras*) *martini* sp. nov. were found by Frebold (1931), are certainly of Eotriassic age. Ice conditions made impossible our planned visit to Depotø, so that we have nothing to add to the observations of our predecessors.

# II. TRIASSIC FORMATIONS

The country around Fleming Fjord is one of the key areas for the study of Triassic formations in East Greenland. The upper part of the series forms practically all the hills to the NW of the fjord, while the lower part is exposed on Wegener Halvø.

In the lowermost formation, lithological subdivisions are rather ill-defined, whereas zonation by ammonites works comparatively well. This is the reason for our "illegal" use of zones instead of members. We propose the following terms:

A. Wordie Creek formation (Koch, 1928), Lower Eotriassic
   1.* zone of *Glyptophiceras* (*Hypophiceras*) *triviale* (absent on Wegener Halvø)
   2.* zone of *Glyptophiceras* (*H.*) *martini*
   3.* zone of *Metophiceras subdemissum* (= zone of *Otoceras boreale*)
   4. zone of *Ophiceras commune*
   5. zone of *Vishnuites* (?) *decipiens*
   6. zone of *Proptychites rosenkrantzi*
   7. *Anodontophora breviformis* beds

B. Mount Nordenskiöld formation (Koch, 1928), Upper Eotriassic and Lower Mesotriassic
   1. Rødstaken member (not present in Wegener Halvø, possibly equivalent to the *Anodontophora fassaensis* beds of the northern area)
   2.* Paradigma member
   3.* Solfaldsdal member

C. Cape Biot formation (Koch, 1928), Upper Mesotriassic? and Neotriassic.
   1.* Kap Seaforth member
   2.* Fleming Fjord member
   3.* Ørsted Dal member

D. Kap Stewart formation (Rosenkrantz, 1929), Rhetic and Lower Lias.

The units marked with an asterisk* are newly defined in this work. The composite thickness of formations A to C is of the order of 1800m.

## A. Wordie Creek Formation

The classic locality for the Wordie Creek formation is the region of Kap Stosch, on Hold with Hope, at 74° N (Koch, 1929, 1931; Nielsen, 1935; Spath, 1930, 1935). It there comprises Spath's Glyptophiceras Ophiceras, Vishnuites and Proptychites beds, of Lower Induan age, followed by the presumably Upper Induan and younger Anodontophora breviformis and Anodontophora fassaensis beds. No ammonites occur in this upper part of the formation. The ammonites permit a good correlation of the outcrops on Traill Ø, in Scoresby Land and Jameson Land with the type section (Putallaz, 1961; Trümpy, 1961; Aellen, in press), although the Vishnuites and Proptychites beds contain only few and badly preserved ammonites in this southern area.

The Wordie Creek formation of Wegener Halvø consists mainly of drab-coloured shales, with dark green and dark purple shales in its upper part, and of micaceous sandstones. Coarse to conglomeratic, often feldspathic sandstones occur near its base and form some prominent beds in its upper part, especially in the northern part of the peninsula. In Jameson Land, the thickness of the formation is considerably smaller than on Hold with Hope or on Traill Ø; it measures about 500 m in the southwestern part of Wegener Halvø and dwindles to less than 100 m in the northernmost outcrops.

### 1. Sections in Southwestern Wegener Halvø

Dark shales of the Wordie Creek formation cap the mountains east of Profilbjerg fault; because of the general plunge of the beds, they descend to sea level at the mouth of Pingel Dal, whereas they have been destroyed by erosion in the higher mountains of the Ravnefjeld group to the north. We especially studied two sections in Lagunenæsset valley, north of "Profilbjerg".

Section A (fig. 2): NNW-spur of "Profilbjerg", between the westernmost and the middle one of three small glaciers (see also fig. 8, p. 64). The section starts at 390 m, probably little above the Permian Posidonia shales.

Below: moraine.

1. c. 15 m alternation of grey to greenish-grey micaceous silty, more or less calcareous shales, with layers (0.05–0.50 m) of coarse quartz sandstone, containing pebbles of quartzite and vein quartz. Some sandstone beds are irregularly graded and show evidence of slumping. Brachiopod shells, fragments of large crinoids and very abun-

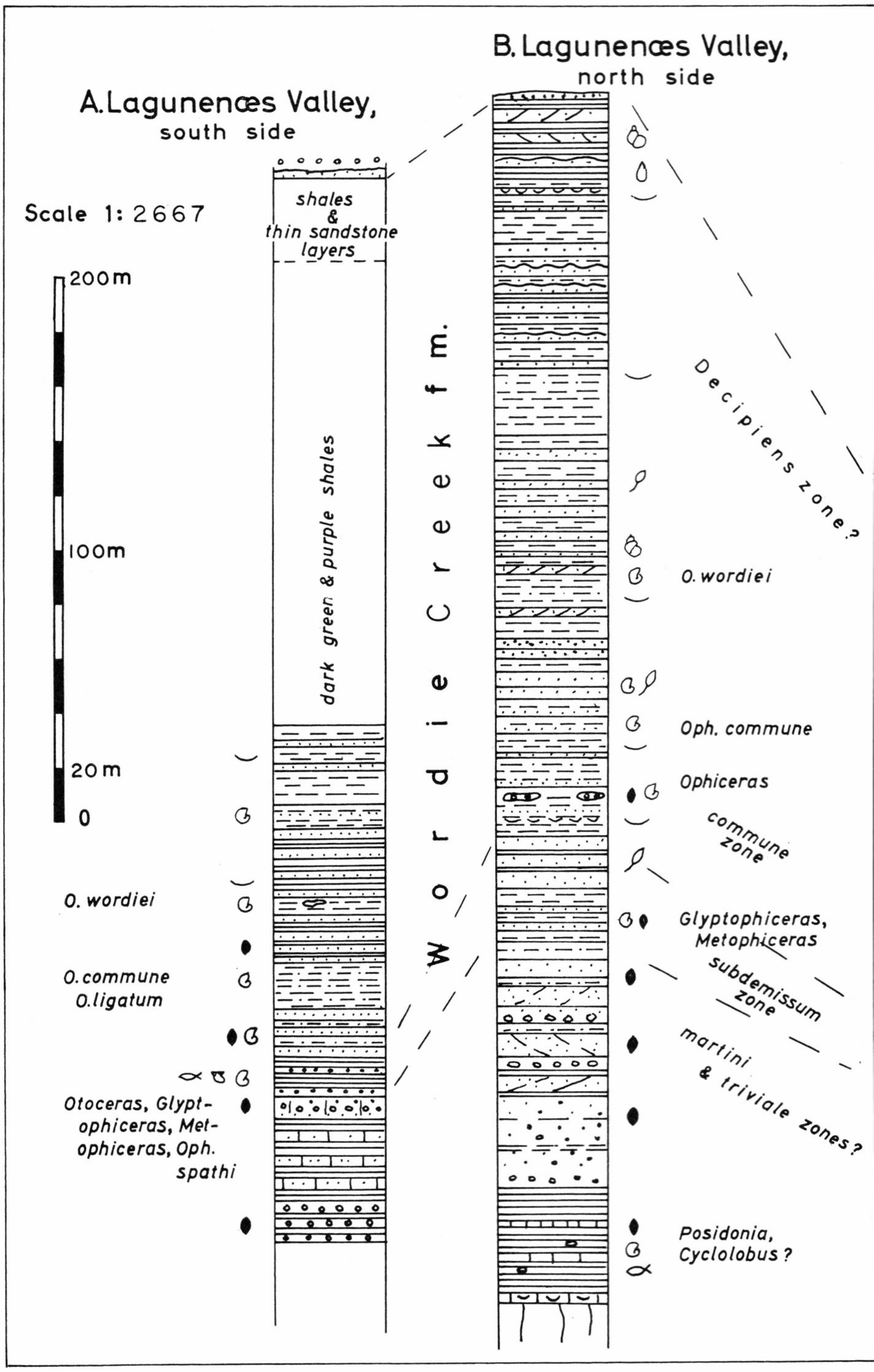
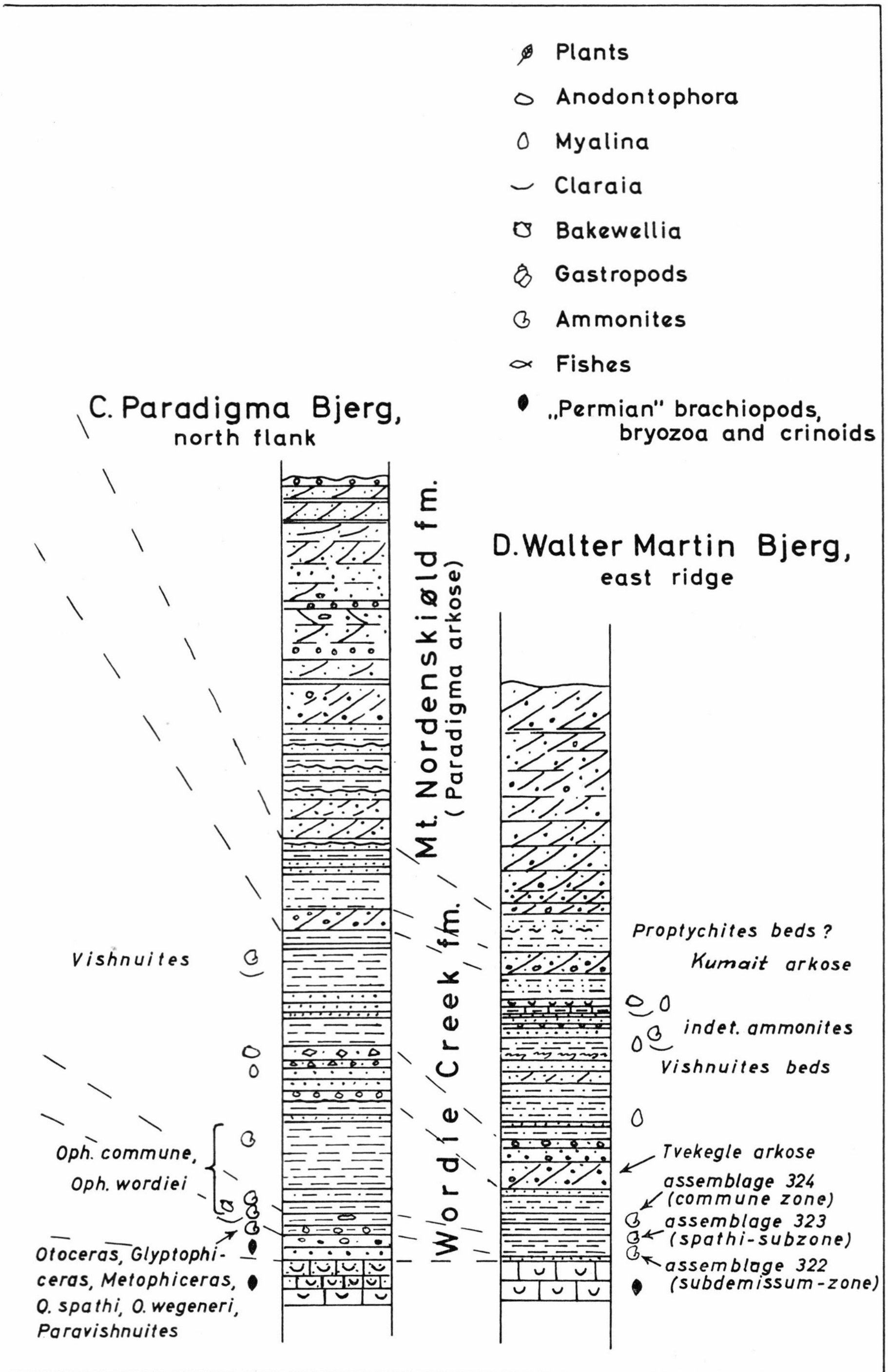



Fig. 2. Four columnar sections through the Wordie Creek formation




and lower Mt. Nordenskiöld formation on Wegener Halvø.

dant bryozoa; the delicate bryozoan colonies are not broken and appear to be preserved more or less in situ (sample T 235)[1]).

Microscopic characters:
Matrix: fine to medium-grained calcite.
Mineral components: generally angular, up to 0.7 mm. Quartz, feldspar; acc.: mica, ores, garnet, glauconite.
Lithic components: a) cataclastic, acid granite; b) medium-grained quartzite; c) andesite, much altered; d) plagioclase-rich gabbro; e) crystalline dolomite; f) phosphatic calcareous sandstone. Types d–f are rare. Organic components: bryozoa (very abundant), crinoids, brachiopods, coral fragments. Some organic remains appear to be autochthonous, others are broken and rounded; they never show adhering fragments of an original matrix.

2. c. 20 m alternation of shales and sandstones; shales dark greenish-grey, sandstones finer-grained and more calcareous than those of [1], with abundant mica flakes on the bedding planes. Some beds show grading.

3. c. 7 m coarse-grained calcareous sandstones; form a prominent, brown ledge at 440 m. They contain large chunks of shale, up to 30 cm. Some layers are conglomeratic, with mainly quartzite pebbles and several subangular boulders (up to 40 cm) of white Permian limestone. Well preserved bryozoa are abundant in the matrix (sample T 237).

4. c. 15 m dark grey to black, crumbling shales, more or less calcareous, with large limestone concretions and thin, irregularly shaped layers of medium-grained calcareous sandstones passing into ammonite coquinas.

In thin section, a calcareous sandstone is seen to be composed of 3 types of sediment:

a) coarse calcareous sandstone. c. 20 % well-sorted, subangular quartz grains, mostly 0.3–0.5 mm, maximum 0.8 mm. c. 20 % feldspar (orthoclase, perthite, sodic plagioclase).
b) fine-grained, silty, arenaceous limestone with glauconite and mica flakes. Quartz graines c. 0.1 mm.
c) micritic, brown limestone, with small quartz splinters. (b and c form in part the matrix of a).

Pelecypods, gastropods, ammonites, bryozoa, fish scales, sponge spicules.

This level (sample T 238) contains a well preserved fauna of the subdemissum zone, especially in the sandy layers:

*Otoceras boreale* SPATH
*Glyptophiceras* (*Glyptophiceras*) *gracile* SPATH

[1]) The bryozoa from this locality and other samples of "Permian" benthonic fossils from Lower Triassic beds of East Greenland are being studied by Dr. HELEN DUNCAN, Washington D.C.

*G.* (*G.*) cf. *nielseni* SPATH (?); see P. p. 91[1]).
*Metophiceras subdemissum* (SPATH)
*M. praecursor* (SPATH)
*Ophiceras* (*Lytophiceras*) *spathi* TRÜMPY (see P. p. 97, pl. 2, fig. 7).
*O.* (*L.*) *compressum* SPATH
*Bakewellia* aff. *exporrecta* (BITTN.), small *Claraia*, selachian spines, small gastropods.

5. 15–20 m greenish, strongly micaceous sandstones in thick slabs, alternating with dark grey-green, silty shales. Clay boulders are frequent in the sandstones. Some beds of coarsely arenaceous limestone to calcareous sandstone contain worn Permian fossils, mainly bryozoa and productid brachiopods, as well as a worn body chamber of *Ophiceras* sp.

6. 15–18 m greyish-green, calcareous, silty and micaceous shales. A few thin layers of calcareous sandstone are interbedded in the upper part. The base of one of these is formed by a lenticular coquina, only 1–2 cm thick, with beautifully preserved ammonites (sample T 240):

   *Ophiceras* (*Lytophiceras*) *commune* SPATH (abundant)
   *O.* (*L.*) *ligatum* SPATH (see P. p. 101, pl. 2, fig. 4, 5)
   *O.* (*L.*) sp., similar to *O. spathi* (one specimen)
   *Claraia stachei* (BITTNER)
   Fish and stegocephalian remains.

7. c. 15 m greenish sandstones and silty shales, like [5]. Some beds of microconglomeratic sandstones, weathering to a yellowish-brown colour, contain bryozoa and crinoids of "Permian" type; this is the youngest horizon in which these fossils were found.

8. 6 m dark green, silty shales with limonitic layers of fine-grained sandstones. Concretions contain (sample T 241):
   *Ophiceras* (*Lytophiceras*) *wordiei* SPATH (abundant)
   *Glyptophiceras* (*Gl.*) sp. (rare)
   *Claraia stachei* (BITTNER).

9. 25–30 m medium- to coarse-grained micaceous sandstones, dull green, with clay galls and oscillation ripple marks, alternating with thicker units of green, silty shales.

10. c. 10 m calcareous, silty, micaceous shales, generally dull green, some purple horizons. Thin beds of fine-grained, micaceous, cross-

[1]) Page and figure references marked P refer to the paleontological part of this paper: R. TRÜMPY (1969): Notes on Lower Triassic Ammonites from Jameson Land, East Greenland. M.o.G. vol. 168, nr. 2 II.

bedded sandstone. Concretions in the lower part furnished (sample T 242):

*Ophiceras* (*Lytophiceras*) *wordiei* SPATH, and passage form to *O. subkyokticum* SPATH.
*Claraia stachei* (BITTN.)

11. c. 30 m green, silty shales with 4 sandstone beds. Badly preserved *Claraia*.

Here, we had to return because of a minor accident and could not study the rest of the section. The higher part of the crest is formed by 250–300 m of dark green, occasionally purple to brownish shales with few sandstones beds, representing probably the upper part of the commune zone and the Vishnuites beds. Green and purple sandstones become again more abundant in the topmost part, and a yellow sandstone ledge – probably an equivalent to the Tvekegle arkose of northern Wegener Halvø (see p. 27) – stands out near the summit of "Profilbjerg" (compare fig. 8, p. 64).

Section B (fig. 2): Ridge limiting Lagunenæsset valley to the north. Section begins at 410 m (see fig. 1).

Below: Posidonia shales of Foldvik Creek formation (Upper Permian), see p. 14.

Sharp boundary against

1. 35 m very coarse to conglomeratic sandstones, with indistinct stratifications; forming a whitish-brown ledge. The sandstones are polygenic, with limonite specks and generally carbonatic cement, which may be concentrated in spherical concretions. Bryozoa, spiriferid and productid brachiopods (some complete valves).
2. 45–50 m sandstones, darker (greenish-brown) and more regularly bedded than [1]. Cross-bedding frequent. Carbonate content increases towards the top. Conglomeratic layers, mainly with well rounded quartzite pebbles (reworked from Domkirken conglomerates?). Few intercalations of greenish, silty and calcareous shales, breaking into boardlike fragments.
   Abundant fauna of "Permian" benthonic elements: brachiopods, bryozoa, crinoids (sample T 263). These fossils occur especially in coarse sandstones, but also in finer-grained and even shaly beds. Many of them are worn, but others, including delicate bryozoan colonies, are quite fresh and do not appear to be derived.
3. 5–7 m green sandstones and dark green, micaceous shales.
4. c. 20 m green, micaceous, silty shales with sandstone layers (0.1–0.5 m). In the lower part, the sandstones are mainly coarse and

calcareous, in the upper one more quartzitic and micaceous. Poorly preserved fauna (subdemissum zone):
*Glyptophiceras (Glyptophiceras) gracile* Spath (?)
*Metophiceras* sp.
*Claraia* sp., Bryozoa.

5. c. 20 m medium-grained micaceous sandstones, with greenish-brown and reddish-brown patina, in thick slabs with shale intercalations. Ripple marks, clay galls, plant fragments.

6. c. 30 m hard, dull green and purple shales. Thin beds of micaceous sandstone, with clay galls and gas bubbles, and chunks of very coarse sandstone with bryozoa and crinoids. Coquinas of broken *Claraia* shells. A few badly preserved *Ophiceras (Lytophiceras)* sp. in the lower part.

7. 0.35 m hard, quartzo-feldspathic sandstone.

8. 20 m silty and sandy shales similar to [6], but without sandstone chunks. Nests of badly preserved, large *Ophiceras (Lytophiceras)* cf. *commune* in the lower part.

9. 10 m green, well-bedded, micaceous sandstones. Carbonaceous plant fragments abundant, very badly preserved ammonite casts, clay galls.

10. 5 m dull green shales and micaceous sandstones.

11. 7 m hard, medium-grained, quartzo-feldspathic sandstone, breaking into thick slabs. This bed forms a conspicuous, yellowish-brown horizon within the dull-coloured shale succession; it crosses the ridge just below the little summit at 650 m.

12. c. 35 m mainly dull purplish-brown, occasionally green, silty shales with thin layers of micaceous, laminated, current-bedded sandstones. Red sandstone nodules in the upper part. Bellerophontids, *Claraia*, one large but very poor *Ophiceras* sp.

    In thin section, the laminae (1–5 mm) of a micaceous siltstone to sandstone show graded bedding, but with decrease of grain size indiscriminately towards top or bottom. Quartz (0.01–0.06 mm), c. 60 %; sericite, chlorite, ore, carbonate in patches; acc. zircon, tourmaline, apatite.

13. c. 40 m sandstones in irregular alternation with purplish-brown, silty shales. The sandstones are micaceous, with mica flakes parallel to bedding in the finer-grained beds, more or less randomly oriented in the coarser ones, and show oscillation ripples, mud galls as well as abundant vegetal fragments.

14. c. 20 m hard, dull greenish-grey, micaceous, silty shales. Thin dull green or brown sandstone layers are intercalated in the upper part;

they show oscillation ripples, flow marks and semicylindrical flow rolls. The shales contain large, well preserved *Claraia stachei* (BITTNER) and *Spirorbis* sp.

15. 30 m micaceous sandstones and silty shales, like [13]. Sandstones with symmetrical ripple marks, drag marks, load casts, flow rolls.

16. c. 25 m green and reddish-brown, silty shales with sandstone layers. At 810 m, slabs with *Myalina schamarae* BITTNER, *Claraia stachei* (BITTNER), *Naticopsis* sp.

17. c. 25 m similar to [16], but with thicker sandstone beds, which make up 1/3 of the unit. Sandstones fine-grained, hard, micaceous; generally laminated, with cross-bedding and ripple-marks.

18. 2 m light yellowish and greenish, massive, coarse- to medium-grained arkose.

    Microscopic character:

    58 % fresh feldspar, mainly sodic plagioclase, max. 0.5 mm; grains are often subidiomorphic.
    24 % quartz, of irregular grainshape, max. 0.3 mm. Quartz and feldspar grains are well sorted, most of them measuring about 0.2 mm.
    17 % calcite, in irregular patches.
    Acc. biotite, less muscovite, chlorite, glauconite (?), ore, garnet, zircon, epidote.

    Bed [18] forms the summit of the pyramid-shaped mountain (850 m) NE of Lagunenæsset valley. On "Profilbjerg", the corresponding arkose beds would come in little below the yellow sandstone horizon which we tentatively correlate to the Tvekegle arkose (see p. 22).

Only a few observations were made on the Wordie Creek formation of the southernmost part of Wegener Halvø.

The lowest righthand lateral valley to Pingel Dal, which comes from a low col leading into Jameson Dal, forms a little gorge, at 30–60 m above sea-level, before joining Pingel Dal. An interesting section, cut by a dolerite dyke, is exposed in this gorge:

1. 8 + x m hard, black argillaceous shales with flat concretions. *Claraia* sp.

2. 2 m greenish, medium-grained, well bedded sandstone.

3. 6 m hard, finely arenaceous, dark grey or rusty, rarely greenish shales with thin beds of laminated micaceous sandstone (sample T 198).
   *Glyptophiceras* (*Hypophiceras*) *martini* TRÜMPY
   *Claraia stachei* BITTNER (very abundant)
   *Enantiostreon* sp., *Anomia* (?) sp., *Bakewellia* sp., plant fragments.

4. 3 m green, coarse-grained, very micaceous sandstone, with clay galls, cross-bedding and some slump structures.

5. 5–6 m greenish-grey argillaceous conglomerate. Silty to argillaceous matrix, massive in the lower part, schistose in the upper one, contains disseminated, rounded pebbles of pea- to walnut-size and quartz grains. Badly preserved *Glyptophiceras* (*Hypophiceras*) sp. and *Claraia* sp. Large chunks of coarse sandstone with remarkably fresh feldspar grains occur in the upper part. As a whole, the bed has the character of a pseudo-tillite (slump breccia, submarine mudflow deposit) and also resembles certain types of wildflysch.

   In thin section, the matrix is seen to be argillaceous, almost isotropic, with small quartz splinters (0.05 mm), unoriented mica flakes, some feldspar, chlorite, ore and carbonate. Components measure up to 5 mm, are very badly sorted, some of them rounded, some angular, and consist of quartz, feldspar (intermediate plagioclase, perthitic potash feldspar), microgranite and an ultrabasic rock with augite phenocrysts and chloritic pseudomorphs after olivine.

6. 2 + x m sandstone, covered by fluviatile gravels.

The Permian does not reach the surface at the outlet of the lateral valley, but the occurrence of *Glyptophiceras martini* in unit [3] proves the presence of the martini zone. The remarkable pseudotillite of unit [5] compares closely with the "mélange" we found in beds of the same age at the foot of Svinhufvud Bjerge, on Traill Ø (TRÜMPY *in* PUTALLAZ, 1961, p. 39).

The lowermost Triassic zones wedge out rapidly towards the East. The Permian Martinia shales, with dolomite lenses and coarse sandstones, dipping with 15° to WNW, appear at the altitude of 200 m in the bottom of the above-mentioned lowest lateral valley of Pingel Dal (see p. 15). They are overlain by 0.5–2 m of extremely coarse to conglomeratic sandstone, with worn bryozoa and crinoids, containing "white blocks", large boulders of Permian "reef"-limestone. In black to dark greenish-grey shales with concretions, at about 12 m above the basal sandstone, we collected a beautiful assemblage of large *Ophiceras* (*Lytophiceras*) *wordiei* SPATH, including the variety with falcate ribs (P. pl. 6, fig. 1) and forms transitional to *O. compressum* SPATH, together with numerous *Claraia stachei* (BITTNER) (samples T 202 and T 203). *Ophiceras* (*Lytophiceras*) *commune* SPATH, *Claraia* and *Bakewellia* occur in concretions 10 m higher up. The martini beds are absent from this place, but a little to the West, lower down the valley, they are seen to lie below the "basal" conglomeratic sandstone. This observation implies that beds of subdemissum or even commune age are transgressive towards the East.

The rest of the Wordie Creek formation is a monotonous succession of greenish, hard shales with intercalated beds of micaceous sandstone; *Claraia* and badly preserved *Lytophiceras* are found up to 250 m above the base. In the uppermost part of the succession, dark purple shales predominate. A conspicuous band of yellow sandstone near the top may represent either the Tvekegle or the Kumait arkose. We have not studied the upper part of the formation in this area.

## 2. Sections in Central Wegener Halvø

Eotriassic shales and sandstones of moderate thickness are preserved in the downfaulted block of central Wegener Halvø, between Tvekegle fault and Calamites fault. As the blocks are tilted towards the West, conditions for observation are particularly good on the Nathorst Fjord side.

Section C: Paradigmabjerg (fig. 2).

Lower units on northeastern slope, higher ones on the north ridge. This section was also studied by NOE-NYGAARD (1934, p. 50) and reproduced by STAUBER (1942, p. 228).

The Wordie Creek formation lies with a sharp contact on the very fossiliferous Productus limestones of the Permian Foldvik Creek formation, which contain sandy intercalations towards the top.

1. 9–10 m coarse, unevenly bedded, calcareous sandstones, weathering with buff to dirty yellowish colour. Rounded pebbles up to 3 cm, mainly of quartz, but also some of porphyry, are scattered throughout the middle and upper part of these "basal" sandstones.

2. 2.5 m brownish, soft, conglomeratic sandstones. Abundant fragments and some complete shells of "Permian" brachiopods.

3. c. 5 m greenish-grey calcareous shales with limestone concretions; thin intercalations of incompletely cemented conglomerate and of quartzitic sandstones.
   This level is poorly exposed, but very fossiliferous. A rich fauna was collected on the terrace SE of the low col north of Paradigmabjerg (sample T 300). To judge by the kind of preservation, fossils from two levels have been mixed up by solifluction (corresponding to units 2–3 and to unit 4 of section D, see p. 30):

   3a. Preservation in black, sparry calcite, inside laminated, brownish-grey carbonate concretions:
   *Otoceras boreale* SPATH (also 1 good specimen on the NW-side of the col)
   *Metophiceras praecursor* (SPATH)
   *Ophiceras* (*Lytophiceras*) *spathi* TRÜMPY
   *Ophiceras* (*Acanthophiceras*) cf. *poulseni* SPATH
   *Paravishnuites paradigma* TRÜMPY (holotype P. pl. 2, fig. 7)
   Fishes, *Myalina schamarae* BITTNER, *Claraia* sp., *Naticopsis* sp.

3b. Preservation as casts of greenish-grey calcareous siltstone, inside concretions of the same colour:
*Ophiceras* (*Lytophiceras*) *commune* SPATH (abundant)
*O.* (*L.*) *subsakuntala* SPATH
*O.* (*L.*) *wordiei* SPATH

4. c. 45 m greenish-grey, silty to finely sandy and micaceous, more or less calcareous shales, with thin beds of calcareous sandstone and some levels with concretions. *Ophiceras commune* occurs both at the base (together with *O. wordiei*) and near the top of these shales. About 200 m N 15°W of the col north of Paradigmabjerg (locality T 295), the topmost part of these shales contain:
*Ophiceras* (*Lytophiceras*) *commune* SPATH, very abundant casts of large specimens with complete body-chambers; including originals of text-figure P. 9a and 9b.
*O.* (*L.*) *commune* var. *aperta* SPATH
*Claraia* sp., *Spirorbis* sp.
Sharp, uneven contact (disconformity) against

5. c. 20 m coarse arkose sandstone, weathering to a characteristic light yellow colour. A conglomerate bed at the base contains mainly granite and quartzite pebbles, few porphyries. Large shale and sandstone balls, some of them with abundant *Myalina schamarae* and *Anodontophora* cf. *breviformis*.
On the north ridge, this light yellow arkose (Tvekegle arkose, see section D, units 8–10) crops out near the col at 320 m above sea-level.

6. c. 10 m green, sandy shales, like [4].

7. c. 10 m dark brown and green, thin-bedded micaceous sandstones, of fine to medium grain, with clay balls.

8. c. 20 m green, silty and sandy shales with thin layers of rust-coloured fine-grained micaceous sandstones, with *Claraia stachei*. On the north ridge (340–360 m), these shales are largely covered by scree. *Claraia* and crushed Ophiceratids were also found in this horizon N of Paradigma col, on the east slope of the mountain between Tvekegle and Kumait fault. The ammonites from this locality (T 294) show a sharpened venter and recall *Vishnuites* of the *decipiens* group, but we were not quite able to decide whether this character was a primary one or only due to the diagenetic flattening of the sandstone casts.

9. 8 m coarse, cross-bedded arkose, with abundant pink orthoclase. Scattered pebbles, up to the size of a fist, of red Cape Fletcher porphyry. This unit, which we may call Kumait arkose, weathers

with a characteristic, warm yellow colour (darker than the Tvekegle arkose of unit 5).

10. 7 m dull green and dark purplish-brown, hard, sandy and micaceous shales alternating with evenly bedded, slightly calcareous sandstones which show symmetrical ripple-marks.

11. 15 m rather friable, coarse to medium-grained, beautifully pink to salmon-coloured arkose, with porphyry pebbles. Coarser layers are slightly calcareous. Indistinct cross-bedding.

    In thin section, a medium-grained variety is seen to contain 38 % quartz, 56 % fresh feldspar (microcline, perthitic orthoclase and sodic plagioclase, in decreasing order; often ± idiomorphic), 2 % mica and 3 % carbonate.
    Accessories: ore, zircon, apatite.
    Lithic components: rhyolite, fine-grained sandstone.

12. 15 m silty shales and dark reddish-brown, evenly bedded micaceous, often feldspathic sandstones, similar to [10], breaking into large boardlike slabs. Ripple-marks (some of them truncated), flow rolls, rill marks.
    Top at 435 m. The following pink arkoses are attributed to the Paradigma member of Mount Nordenskiöld formation (see p. 41); perhaps units 11–12 should also be considered as base of the higher formation, but the dark-coloured, thin-bedded sandstones of units 10 and 12 are elsewhere characteristic of the Proptychites to breviformis beds of the Wordie Creek formation.

The lower part of the Wordie Creek formation also crops out in the low country south of Paradigmabjerg, above Nathorst Fjord, but the beds are much disturbed by solifluction. The coarse "basal" sandstones (C 1–2) have swollen to 26 m; they contain mainly quartzite pebbles, but no fragments of Permian fossils were seen. From overlying dark shales with concretions (locality T 343, corresponding to section C, unit 3 a) we collected:

*Otoceras boreale* Spath (large body-chamber fragments)
*Ophiceras* (*Lytophiceras*) *spathi* Trümpy
*Ophiceras* (*L.*) *compressum* Spath
*Ophiceras* (*Ophiceras*) *transitorium* Spath (see P. p. 96, text-figure 5)
*Claraia* sp.

These shales of subdemissum age are followed by 20 m green, micaceous shales with abundant, but badly preserved *Ophiceras commune* Spath and one specimen of *O. kilenense* Spath (?). The overlying light yellow (Tvekegle) arkose is considerable thicker than the corresponding unit (C 5) north of Paradigmabjerg.

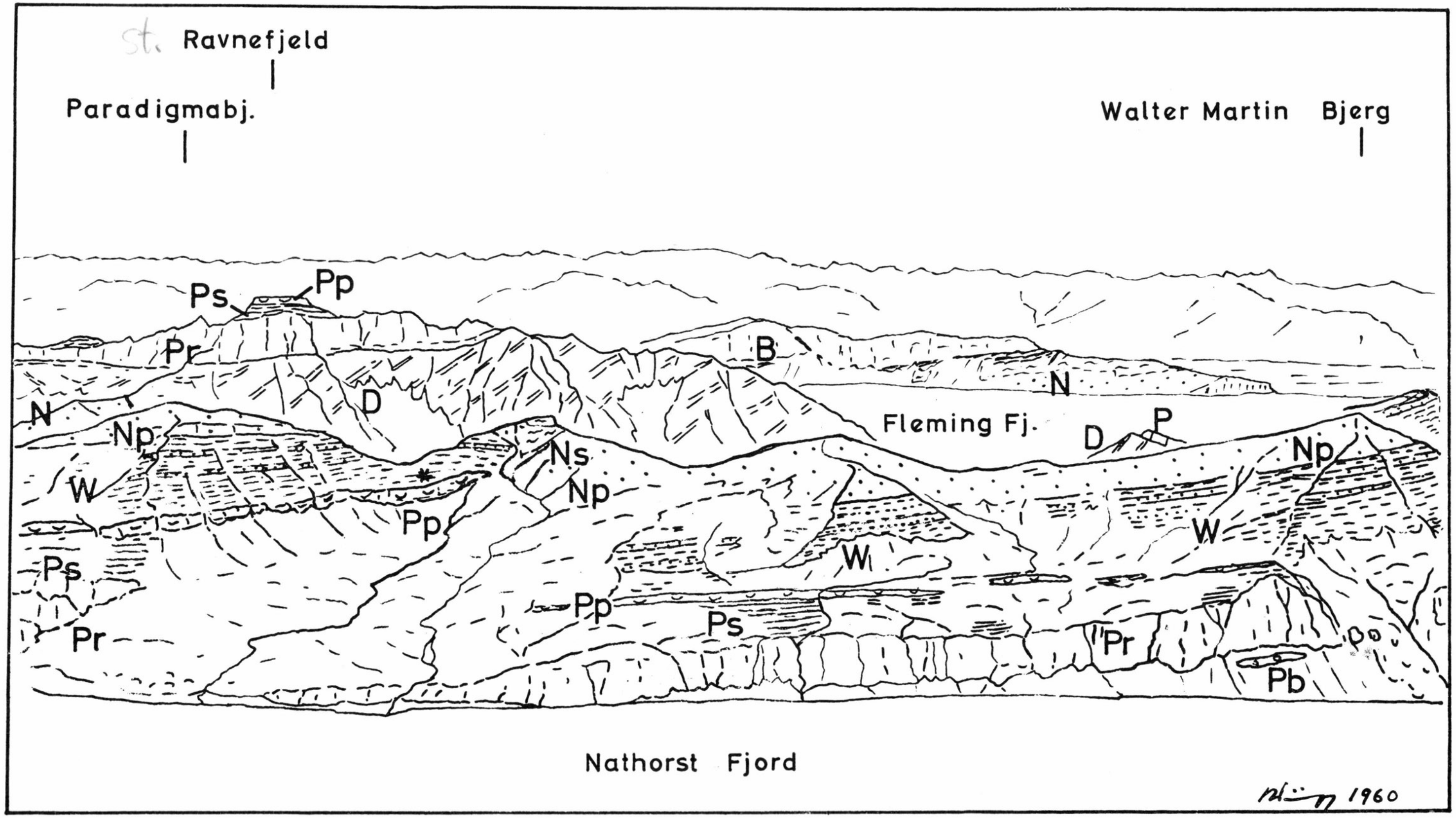



Fig. 3. The central, downfaulted block of Wegener Halvø, seen from the southeast.
D = Devonian; P = Permian; Pb = basal conglomerates (Domkirken fm.?); Pr = "reef" limestones; Ps = Posidonia shales; Pp = Productus limestone; W = Wordie Creek fm.; N = Mt. Nordenskiöld fm.; Np = Paradigma member; Ns = Solfaldsdal member; B = Cape Biot fm.

One of the best, though stratigraphically reduced sections was studied on the east crest of Walter Martin Bjerg. This pyramid-shaped mountain of 608 m stands in the ESE corner of the Tvekegledal cirque and dominates the lower reaches of Calamitesdal (see also fig. 3). We named it in memory of our field assistant during the summer of 1958, who fell to his death the year afterwards.

Section D: East ridge of Walter Martin Bjerg (fig. 2).

Begins at 450 m with sharp boundary above very fossiliferous Productus limestone of Foldvik Creek formation.

1. 0.4 m brownish-grey, calcareous sandstone of fine to medium grain, with few quartz pebbles up to 2 cm and abundant fragments of Permian brachiopods and mollusca. Apparently reduced equivalent of the "basal" conglomerate (C 1–2).
2. 2–3 m grey, argillaceous to silty shales with large, ellipsoidal concretions of silty limestone, weathering to a dark buff colour. Rich fauna of subdemissum zone (sample T 322):
   Fishes (*Bobasatrania* sp. and others)
   *Otoceras boreale* Spath
   *Glyptophiceras* (*Hypophiceras*) *minor* Spath
   *Metophiceras subdemissum* (Spath)
   *Metophiceras wegeneri* Trümpy (holotype, P. pl. 1, fig. 6, text fig. 4 a–b; also pl. 1, fig. 4–5, text fig. 3 c)
   *Ophiceras* (*Lytophiceras*) *spathi* Trümpy (rare)
   *Ophiceras* (*L.*) cf. *subakuntala* Spath (one specimen, perhaps not in place)
   *Ophiceras* (*L.*) *commune* Spath (different preservation, probably slipped down from bed 3 or 4)
   *Claraia* sp., *Bakewellia* sp.
3. 7 m greenish-grey silty shales, poor in carbonate, with laminated, brownish-grey concretions of silty limestone; fossils preserved in black, sparry calcite (spathi subzone of subdemissum zone, sample T 323):
   *Glyptophiceras* (*Glyptophiceras*) aff. *pascoei* Spath
   *Glyptophiceras* (*G.*) sp., close to *G. gracile* Spath
   *Ophiceras* (*Lytophiceras*) *spathi* Trümpy, very abundant (P., text fig. 6 c)
   *Ophiceras* (*L.*) *commune* Spath (rare)
   *Paravishnuites paradigma* Trümpy (?)
   *Claraia*, *Bakewellia*, *Anomia*, small *Nucula*-shaped pelecypods.
4. 5 m harder, more micaceous, greenish shales, with thin layers of slightly calcareous, reddish-weathering sandstone.

*Ophiceras* (*Lytophiceras*) *commune* SPATH (very abundant, sample T 324)

5. 5 m greenish, more argillaceous shales.
6. 7 m green, hard, silty and micaceous shales with thin layers (1–5 cm) of fine-grained, green sandstones, with abundant mica flakes on the bedding planes, weathering to a rusty colour. Passage to
7. 3,5 m light green sandstones of medium to coarse grain, with pink feldspar and large muscovite flakes. Current bedding and slump structures. Forms a bastion at 485 m.
8. c. 10 m coarse arkose, weathering to a light yellow or cream colour (Tvekegle arkose = section C, unit 5). The sandstones contain abundant grains of pink feldspar and limonite specks; they break into uneven slabs of 5–10 cm. Few partings of green shale; pebbles are scattered throughout the middle part of the unit and form a conglomerate bed of 1 m near the top. The components are badly sorted, but generally well rounded, mainly porphyry and quartzite, less granite. Large, angular boulders of grey, crystalline dolomite with orange patina, containing brachiopod shells (Permian), are also present.
9. c. 5 m coarse arkose sandstone with large pink feldspar grains, weathering to a dark green colour. Abundant clay balls, some intercalations of finer-grained, flaggy sandstones.
10. 2 m light yellow arkose with pebbles of pink porphyry and of rhyolite; most pebbles are smaller than 5 cm but some measure up to 20 cm.
11. 5 m green and dark purplish-brown sandy shales with thin beds of brown, fine-grained, micaceous sandstone.
12. 1 m brown, micaceous sandstone.
13. 9 m shales like [11]; dark brown to purplish colours predominate. Sandstone beds with wavy top surfaces and some flow structures. Few pelecypods (*Myalina*).
14. 5 m alternation of dark brown silty shales and micaceous sandstones, rich in *Myalina*.
15. 3.5 m hard, dull white to greenish, medium-grained feldspathic sandstone, thick-bedded, with current-bedding and ripple marks.
16. 4 m wine-red silty shales with layers (up to 50 cm) of brown, micaceous sandstones. The upper surface of one sandstone bed is covered with large *Myalina*.
17. 3 m well-bedded, fine to medium-grained micaceous sandstones, weathering to a dull greenish-brown colour. One bed with ellipsoidal

flow-rolls of 20–40 cm thickness, often truncated by penecontemporaneous erosion, similar to those in the Proptychites beds of Traill Ø (PUTALLAZ, 1961, p. 36).

18. 8 m purplish-brown to wine-red, more rarely dull green silty shales with thin, nodular layers of fine-grained sandstone; limonitic crusts. *Myalina*, *Claraia*, one large, very badly preserved ammonite (*Lytophiceras* or *Vishnuites*??).

19. 0.6 m green, microconglomeratic arkose, with subangular grains of fresh pink feldspar up to 8 mm and large chunks of shale and micaceous sandstone.

20. 1.7 m massive, hard, coarse to medium-grained arkose with light green patina. Top layer microconglomeratic (like 19).

21. 2 m brick- to wine-red, medium-grained, flaggy, micaceous sandstone, with clay galls.

22. 1.5 m green and purple, silty shales, alternating with yellowish-green calcareous shales which contain *Myalina* and *Claraia*.

23. 2 m purple and green, fissile, marly silt shales; pelecypods (*Claraia*, *Myalina*, *Anodontophora*) in limonitic layers.

24. 9.5 m variegated silty shales; beds of fine to medium-grained flaggy sandstone, with much mica on the bedding-planes, are most prominent in the upper third. Oscillation ripples, cross-bedding, small flow rolls; isolated lenses of coarse arkose. Micaceous sandstones near the top contain *Anodontophora* cf. *breviformis* and small *Myalina*. Sharp boundary, at 500 m, against

25. 8.5 m coarse, pinkish-white arkose, weathering to a rich yellow colour (darker than D 8). Layers of conglomerate with well-rounded pebbles of rhyolite, granitic to granosyenitic porphyry, gneiss, amphibolite, rarely quartzite. Very well developed current-bedding, the laminae of which are uniformly inclined to the West. This is the "Upper yellow arkose" or Kumait arkose (equal to unit 9 of section C).

26. 15–18 m hard, dark greyish-green and purplish-brown siltstones, alternating with fine to medium-grained micaceous sandstones; beds of purple arkose, very rich in biotite, in the lower part. The sandstones show well-developed flow-rolls, truncated by erosion surfaces. This unit forms a dark, well stratified cliff between the yellow Kumait arkose and the pink Paradigma arkose. Its upper boundary, at 525 m above sea-level, it not particularly sharp.

The broad, flat bottom of eastern Tvekegledal is formed by shales and sandstones of the Wordie Creek formation, but conditions for study are bad because of the plunge of the beds, tectonic complications along faults and extensive solifluction. The contact with Permian limestone east of the two Coni is not a stratigraphic unconformity (NOE-NYGAARD, 1934, p. 52), but it is formed by the eastern branch of the Tvekegle fault, which dips with 55° to the ESE. South of the southern Conus, just east of the fault, the base of the formation is exposed in a stream-bed; it consists of grey, micaceous marl shales with concretions, from which we collected *Ophiceras* (*Lytophiceras*) *spathi* TRÜMPY and *Glyptophiceras* (*Glyptophiceras*) cf. *pascoei* SPATH (sample T 282). This shows that here also the lowermost Triassic beds belong to the subdemissum zone. The light yellow Tvekegle arkose forms much of the valley bottom. The conglomerates in its upper part vary considerably in composition, granites and quartzites being predominant in one place, pink porphyries in another.

In the chain of small mountains north of Walter Martin Bjerg, between Tvekegledal and Calamitesdal, green calcareous shales and siltstones, corresponding probably to units 22 and 23 of section D, contain abundant *Myalina*, *Claraia*, *Anodontophora* and *Naticopsis*. About 15 m above this level we found micaceous sandstones with small, reef-like bodies (about 15 × 5 cm) of light greenish-grey, stromatolitic (algal?) limestone, very similar to the Naticopsis limestone which constitutes a marker horizon in the Proptychites beds of Traill Ø (TRÜMPY *in* PUTALLAZ, 1961, p. 38 and p. 41). Overlying purple and dull reen sandstones and siltstones show the same sedimentary structures as [D 24]; they are capped by the dark yellow Kumait arkose, which forms a summit (582 m) 1 km to the north of Walter Martin Bjerg.

In the cliffs above Fleming Fjord, 2 km to the NE of the mouth of Tvekegledal, the base of the Triassic succession was also studied, but the section is partly obscured by scree and by minor faults. The "reef" limestones of the Foldvik Creek formation are overlain by 5 m of fine to medium-grained, calcareous sandstone, with some quartz pebbles and limestone fragments; comminuted brachiopod shells are very abundant. In the field we considered this sandstone as basal unit of the Wordie Creek formation, but bituminous, platy limestones with sponge spicules and radiolaria in the upper part of the sandstone are very similar to those of Lagunenæsset valley (p. 14) and thus probably still of Permian age. In overlying dark shales we found *Paravishnuites paradigma* TRÜMPY and *Glyptophiceras* (*Glyptophiceras*) sp., indicating the subdemissum zone, together with beautifully preserved fenestellid bryozoa in concretions (sample T 314 and 315). The Tvekegle arkose measures almost 30 m, and its base lies 100 m above the Permian, as compared to 30 m on Walter Martin Bjerg; this illustrates the westward thickening of the entire Wordie Creek formation.

### 3. Correlations and Comparisons

The lowermost Triassic zone, characterized by *Glyptophiceras (Hypophiceras) triviale* SPATH and by abundant, apparently autochtonous benthonic fossils of "Permian" type, is not known from Wegener Halvø. Its southernmost outcrop found so far lies at the foot of Svinhufvud Bjerge on Traill Ø (PUTALLAZ, 1961, p. 36). We would expect to find thin, bituminous shales of triviale age underneath the central and northerly part of the Jameson Land basin.

Shales with *Glyptophiceras (Hypophiceras) martini*, representing the second-lowest zone, occur at the mouth of Pingel Dal, near the head of Fleming Fjord. They are overlain by a polygenic slump conglomerate (p. 25). Little further to the east, the "basal" conglomerate transgresses onto the Permian and is directly overlain by shales of subdemissum and commune age. Conglomerates and sandstones frequently lie at the base of the Wordie Creek formation; in Lagunenæsset (section A, 1–3, section B, 1–2), they measure almost 100 m and contain abundant "Permian" brachiopods and bryozoa, whereas they are down to 5 m or less in central Wegener Halvø. However, this "basal conglomerate" does not represent the oldest Triassic beds, as at the mouth of Pingel Dal and especially in Schuchert Dal (AELLEN *in* TRÜMPY, 1961, p. 252) it is seen to overlie shales of the martini zone. It marks a period of coarsely detrital sedimentation at the end of martini and beginning of subdemissum chronozone, and may be correlated with the thick, massive "*Glyptophiceras*" sandstones of Traill Ø.

In a general way, the martini zone is restricted to the westernmost exposures studied. Towards the east, beds of subdemissum or commune age are transgressive. However, this rule suffers exceptions, as the uppermost beds of the Depotø succession (FREBOLD, 1931; SÄVE-SÖDERBERGH, 1937) are apparently a relic of martini zone, spared by the pre-subdemissum erosion.

The zone of *Metophiceras subdemissum* has furnished the richest ammonite faunas. In the southern part of Wegener Halvø, it is fairly thick (20–30 m) and contains sandstone beds, but in the northern area it is condensed and only represented by a few meters of dark grey shale with concretions. Where outcrop conditions are exceptionally good, an older and a younger horizon ("spathi subzone") can be distinguished, but this may be a local feature. In the whole of the southern Triassic area of East Greenland, the zone is represented by a thin unit of very fossiliferous shales (Schuchert Flod: collections by P. AELLEN, Oksedal near Mesters Vig: collections by K. GRASMÜCK, Traill Ø: PUTALLAZ, 1961). On a short excursion to Domkirken (Korsbjerg), near the mining village of Blyklippen, we collected *Otoceras boreale* SPATH, *Glyptophiceras*

(*Hypophiceras*) *minor* Spath (numerous specimens, including P. pl. 2, fig. 3 and text-fig. 2), *Gl.* (*Gl.*) *gracile* Spath and *Gl.* (*Gl.*) *modestum* Spath, from shales 5 to 6 m above the thin "basal" conglomerate. The subdemissum chronozone is probably the time when the most normally marine conditions prevailed in the southern part of the East Greenland trough, with quiet, at times poorly oxygenated water of normal salinity.

Life conditions for cephalopods apparently deteriorated during the time of the *Ophiceras commune* zone. At its base we still find very rich but practically monospecific assemblages, and locally also other ammonites like *Ophiceras ligatum*, *O. wordiei* and *Paravishnuites oxynotus* Spath (the latter on Domkirken); but soon ammonites become rare, while few species of pelecypods flourish. Stronger agitation and probably also shallowing of the water is shown by the numerous intercalations of micaceous sandstones (especially in the NE), with ripple-marks, clay galls and plant fragments. Colours gradually and with many reversals change from grey over green into dirty purplish-brown, indicating succeedingly better oxygenation. On the whole, sedimentation was much more rapid than during subdemissum time, but there are great lateral variations. Thus the reduced and sandstone-rich sequence in northern Wegener Halvø (c. 45 m on Paradigmabjerg, c. 20 m on Walter Martin Bjerg) contrasts with several hundred meters of monotonous silty shales in the southwestern part of Wegener Halvø, which are rather reminiscent of the basin facies of Svinhufvud Bjerge, though less fossiliferous. On the other (western) side of the basin, the thickness is again much reduced, and on Domkirken the entire Wordie Creek formation, including the Proptychites beds which form the summit of this mountain, measures only 120 m.

Scarcity of ammonites prevents the drawning of a boundary between the commune zone and the decipiens zone. "*Vishnuites*" of the decipiens group were found on Traill Ø (Trümpy *in* Putallaz, 1961, p. 38), on Domkirken and in dubious specimens on Wegener Halvø (p. 27), but the delimitation of the zone is quite uncertain. The type of sedimentation is similar to that of the upper half of the commune zone; sandstones occupy a larger part of the section. A conspicuous marker horizon is formed by the light yellow, often conglomeratic Tvekegle arkose of northern Wegener Halvø (C 5, D 8–10). Its pebbles are mainly white granite and quartzite, but locally pink porphyries may predominate; uniform westerly inclination of the current-bedding laminae indicates transport from an eastern source area, from Canning Land or from the northern prolongation of the Liverpool Land block. The probable equivalent of this arkose in southwestern Wegener Halvø (p. 22) is considerably thinner and lacks pebbles. On the other hand, the Tvekegle arkose is strikingly similar to the Svinhufvud arkose in the decipiens zone of southern Traill Ø. In our preliminary paper (Trümpy, 1961, p. 251) we correlated the two arkose units, but this was perhaps somewhat rash, as different tongues of yellow conglomeratic arkoses might occur. All these arkoses are derived from the east, and in the Domkirken section, near the western margin of the basin, the decipiens zone is represented by uniform grey shales, in which we collected "*Vishnuites*" sp.

Only on the basis of lithological similarity can the uppermost part of the Wordie Creek formation on Wegener Halvø be compared to the Proptychites beds or rosenkrantzi zone (and Anodontophora breviformis beds?), but no *Proptychites* were found south of Maanedal, on northern Traill Ø (Grasmück *in* Putallaz, 1961). In this part of the formation, variegated but generally dull coloured, silty shales alternate with siltstones and micaceous sandstones. Evidence of penecontemporaneous slumping is widespread; we found it in southern Wegener Halvø (B 14–15), in northern Wegener Halvø (C 12, D 24 and 26), on southern Traill Ø (Trümpy *in* Putallaz, 1961, p. 12 and p. 42) as well as on the summit of Domkirken near Blyklippen mining village. On Hold with Hope as well as on Traill Ø (Maanedal and Svinhufvud Bjerge) a thin bed of a peculiar concretionary limestone with *Naticopsis* seems to constitute a marker horizon within the rosenkrantzi zone. Indistinct traces of this limestone also occur in the northern part of Wegener Halvø (p. 33).

On the eastern margin of the Jameson Land basin, the "normal" sediments – shales and micaceous sandstones – of the upper Wordie Creek formation alternate with coarse arkoses, again derived from an easterly source area (current-bedding laminae inclined to the W, frequency of pink porphyry pebbles from the Devonian Kap Fletcher series). A lower arkose tongue, weathering to a characteristic orange-yellow colour, is a local guide horizon in northern Wegener Halvø (Kumait arkose, C 9–D 25). Higher in the section, the arkoses become pink and undistinguishable from the raspberry-coloured arkoses of the Paradigma member of Mount Nordenskiöld formation; on Paradigmabjerg, the boundary between the two formations is indeed rather arbitrary. We drew it above the last intercalation of dark shales, siltstones and micaceous sandstones of Wordie Creek type.

Section C and D show this gradual encroaching of the pink Paradigma arkoses, which we consider as lower member of the Mount Nordenskiöld formation, on the "normal" basin sediments. This implies that the base of the Mount Nordenskiöld formation is heterochronous, and that the lower part of the Paradigma member is coeval to the upper part of the Wordie Creek formation (breviformis and fassaensis beds, perhaps also part of the Proptychites beds). Further basinwards, on Traill Ø, the fassaensis beds are still present in their characteristic silty marine

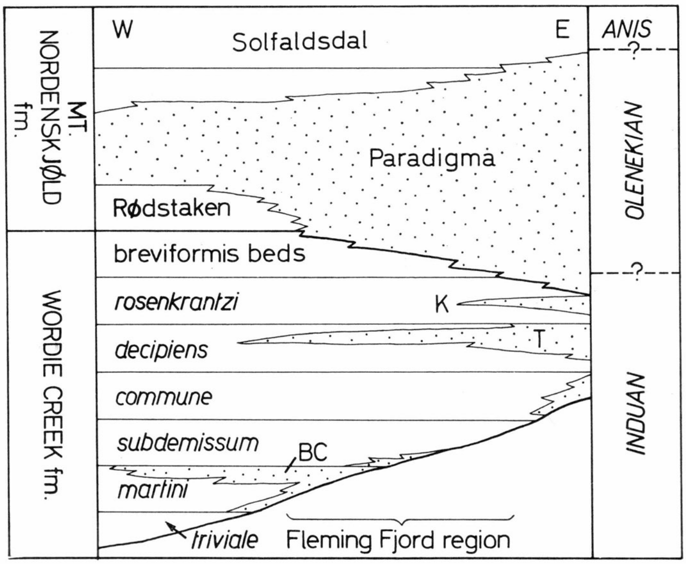



Fig. 4. Diagrammatic representation of the relations between Wordie Creek and Mount Nordenskiöld formations. – Stippled: coarse arkoses (BC: "basal" conglomerate, T: Tvekegle arkose and Svinhufvud arkose, K: Kumait arkose).

redbed development, as on Hold with Hope (Putallaz, 1961). The Rødstaken member of Schuchert Dal (M. Aellen, in prep.) might be an equivalent of the fassaensis beds, but we shall have to await publication of Aellen's results before judging the case. Aellen considers the Rødstaken beds as lower member of the Mount Nordenskiöld formation, and this is indeed a plausible assumption. Its consequence might eventually be to remove the fassaensis beds from the Wordie Creek formation, from the rest of which they differ considerably in sedimentological and also faunal character. The table fig. 4 illustrates our present concept on the relationship of Wordie Creek and Mount Nordenskiöld formations.

On the eastern margin of the basin, the pink Klitdal (= Paradigma) arkoses rest directly on the crystalline substratum of Liverpool Land (Rosenkrantz, 1929, Bütler, 1957). Bütler (1957, p. 62) described 400 m of dark, micaceous shales, intercalated between two arkose units, from the eastern shore of Hurry Inlet (Hurry Inlet formation, Backlund, 1932) and attributed them to the marine Eotriassic (= Wordie Creek formation); however, the complete absence of fossils renders this interpretation subject to caution.

We have already (Trümpy, 1961) drawn attention to the point that some of Stauber's (1942) correlations must be revised. Stauber, who studied the Triassic of the southern outcrop area with admirable energy and in a completely independent manner, was hampered by his lack of knowledge of the type sections on Hold with Hope. His "Bunte Serie" is essentially the Cape Biot formation; but he confounded beds belonging to the upper part of the Wordie Creek formation (on Traill Ø and probably on Geographical Society Ø) or to the Solfaldsdal member of Mount Nordenskiöld formation ("autochthone Bunte Serie" of the Fleming Fjord region) with the typical "Bunte Serie" ("Bunte Serie der Gleitdecke") or Cape Biot formation. On Traill Ø, he mistook the Svinhufvud arkose, in the decipiens zone, for the "Kontinentale Serie" (= essentially Paradigma arkose member of Mount Nordenskiöld formation). These wrong identifications led him to put forth his interesting but certainly erroneous hypothesis of great gravity sheets lubricated by Tertiary basalts (Stauber, 1940, 1942; compare also p. 69). His "Gleitfaltenlagen", interpreted as a sort of mylonites marking the thrust-planes, show flow-rolls truncated by penecontemporaneous erosion surfaces, which demonstrate that the gliding took place during deposition of the Triassic formations. Other "Gleitfaltenlagen" are stromatolites, due to algae growth or to diagenetic swelling of dolomite beds (see p. 50).

By its fauna and lithological character, the Wordie Creek formation of East Greenland can be correlated with part of the Blind Fjord formation of Arctic Canada (Tozer, 1961, 1963), the Vardebukta formation, especially its Selmaneset member, of Svalbard (see Buchan *et al.*, 1965) and the Induan of Eastern Siberia (summary in Sachs and Strelkov, 1961). Apparently, a large Arctic sea persisted from Late Permian into Early Triassic times. The lowermost, triviale zone of the East Greenland Triassic seems to be only locally present, in the *Otoceras concavum* zone of the Canadian Arctic (Tozer, 1965) and possibly in Siberia. The "Permian" benthonic fossils encountered in the martini and subdemissum zones of Wegener Halvø might be regarded as derived, though this interpretation seems dubious for entire productid shells and for very delicate, unbroken bryozoan colonies (*e.g.* unit B 2, p. 22) or for fenestellid bryozoa occurring in concretions (p. 33). At any rate, we feel quite certain that productids and "Permian" bryozoa occur in primary association with several species of *Glyptophiceras* (*Hypophiceras*) and with true *Otoceras* in the triviale zone of Kap Stosch (Spath, 1935; Trümpy, 1960). Since this paper was written, Grønlands Geologiske Undersøgelse made it possible for B. Kummel, C. Teichert and R. Trümpy to investigate the critical lowland sections around Kap Stosch; results of this 1967 expedition are not yet published.

It is certainly significant that the coarse detritus of the Tvekegle, Kumait and Paradigma arkoses is derived from an easterly landmass, and that the ammonite fauna of the middle and upper part of the Wordie Creek formation becomes impoverished towards the south. We must figure the Jameson Land basin as a blind alley, connected with the open Arctic sea to the north. There is no direct evidence for the existence of a North Atlantic Ocean in late Paleozoic and early Mesozoic times.

## B. Mount Nordenskiöld Formation

### 1. Introduction; key to sections of Mount Nordenskiöld and Cape Biot formations

With the second Triassic formation, named by L. Koch (1928, 1929) after Nordenskiöld Bjerg between Nathorst Fjord and Carlsberg Fjord, continental to paramarine redbeds make their appearance, the marine fauna becomes extremely scarce and correlations hazardous. No complete and undisturbed section through the formation is exposed in the area studied, so that we must abstain from defining a type section; likely places for such a profile would be either Nordenskiöld Bjerg itself or the mountain east of the lower part of Pingel Dal. The base of the formation and the lower part of the Paradigma member (mainly pink arkoses) were examined on Wegener Halvø. On the downfaulted, northwestern side of Fleming Fjord, only the uppermost part of the Paradigma member reaches the surface, but the overlying Solfaldsdal member – gypsum-bearing, variegated shales, red mudstones and a limestone band with marine pelecypods – is exposed in the sea-cliffs west of Kap Biot, and again between Kap Seaforth and Solfaldsdal.

A number of profiles through the Cape Biot formation and the upper part of the Mount Nordenskiöld formation were measured by K. Grasmück with K. Boller; they are reproduced, in a somewhat simplified manner, on pl. 2. The sections were taken at the following localities:

Section a: "Profilbjerg", east of the southern end of Fleming Fjord. Composite section, cursorily examined by R. Trümpy.
Comprises the upper part of the Paradigma member and the badly exposed, but fossiliferous Solfaldsdal member as well as the almost complete Cape Biot formation.

Section b: Cliffs 5 km to the SW of Solfaldsdal, dominating the inner reaches of Fleming Fjord.
Only Cape Biot formation: upper part of Kap Seaforth member, Fleming Fjord member and Ørsted Dal member. The latter is exceptionally well exposed in these reaches, which may be taken as type section of the Ørsted Dal member; further north, the unit is generally covered by scree from the overlying Kap Stewart formation.

Section c: 2 sections. The lower one was taken in the cliffs NE of the mouth of Solfaldsdal. Here the upper part of the Mount Nordenskiöld formation (Solfaldsdal member) appears at the surface and furnished a relatively rich fauna (pelecypods, gastropods and phyllopods).
The section continues north of a flat-lying fault. The upper part shows the uppermost unit (Ørsted Dal member) of the Cape Biot formation and the base of the Kap Stewart formation (exposed near Pt. 610).

Section d: Cliffs on the coast of Fleming Fjord, halfway between Solfaldsdal and Kap Seaforth. Here, the upper part of the Mount Nordenskiöld formation (top of Paradigma member, Solfaldsdal member) and the lower part of Kap Biot formation reappear. The section ends against the steep, inaccessible mountain (Pt. 476), forming the corner between the inner Fleming Fjord and Ørsted Dal, SW of a fault.

Section e: On the prong-shaped mountain advancing into the coastal plain between Henrik Møller Dal and Regnbuedal.
This profile is characteristic for the outcrops north of the lower Ørsted Dal. Exposed are the main part of Cape Biot formation and the lower part of Kap Stewart formation (Rhetic), the base of which furnished ostracods.

Section f: East ridge of the mountain west of Edderfugle delta, between Edderfugledal and the outer part of Fleming Fjord.
This is the most complete section for the lower units: top of Paradigma member and Solfaldsdal member of Mount Nordenskiöld formation, Kap Seaforth member of Cape Biot formation. The type sections for both Solfaldsdal and Kap Seaforth member can be chosen here. The section ends against the inaccessible ridge formed by the mudstones of the Fleming Fjord member. Phyllopods permit a rough dating of the base of the latter.

Section g: Mountain forming the bastion on the coast east of Edderfugledal.
Typical for the Kap Biot area. The Mount Nordenskiöld formation as well as the Ørsted Dal member in the upper Cape Biot formation are badly exposed, but the rest of the Cape Biot formation is easily accessible and was measured in detail. Type locality for Fleming Fjord member.

## 2. Paradigma Member

### a) Outcrops on Wegener Halvø

The Paradigma member consists mainly of pink (raspberry- to salmon-coloured) arkoses, which measure up to 450 m. They laterally replace the Rødstaken beds of Schuchert valley and the fassaensis beds of Traill Ø, probably also part of the breviformis and Proptychites beds (see p. 37). Their age is presumably still (Middle and Upper?) Eotriassic.

On the north crest of Paradigmabjerg itself (in continuation of section C, p. 28) the base of the formation was taken at 435 m above sealevel (compare Noe-Nygaard, 1934, p. 50). It begins with 15 m of compact, cross-bedded, coarse pink arkoses with porphyry pebbles. Then follows an alternation (ca. 60 m) of coarse, pink-coloured with medium-grained, brick-red arkoses, which show desiccation cracks and symmetrical ripple-marks. Most of the arkose layers are crossbedded, the direction of the foreset laminae, which are often disturbed by incipient slumping, always indicating transport from the east. Several conglomerate levels, with porphyry pebbles up to 20 cm, occur; there are also a few small and disconnected intercalations of viciously green, soft shales. The highest exposed beds, forming the summit cap of Paradigmabjerg from 510 to 606 m, consist of monotonous pink arkoses with a few conglomeratic and a few argillaceous intercalations. The top surfaces of some arkose beds show a pavement of pea-sized pebbles, indicative of winnowing by wind or running water. Cementation of the arkoses is often incomplete. – Quite a similar succession is exposed on Walter Martin Bjerg, in continuation of section D.

The upper part of the Paradigma arkoses was studied on the western slope of "Profilbjerg", in southwestern Wegener Halvø, but the section is covered by scree and disturbed by land-sliding. The total thickness of the member is here of the order of 400 m; it consists almost entirely of pink, rarely yellow, coarse-grained arkoses; pebbles of rhyolite, porphyry, quartzite and green gneiss are either scattered or concentrated in lenses. A typical sample, 100 m below the top, contains 40 % quartz, 49 % feldspar (potassium feldspar more abundant than plagioclase), 8 % calcite, 2 % ankerite or siderite in sharp rhombohedra, and as accessories rutile, muscovite and apatite. Especially in the upper part of the member, the arkoses are often badly cemented and show cavities, which may have been originally filled with gypsum. The arkoses pass into about 20 m of dark red to cocoa-brown siltstones, with grains (up to 1 mm) of clear rhyolite quartz, and micaceous sandstones. These topmost, finer-grained and darker red layers of the Paradigma member are thus considerably thinner than the corresponding beds on the other (NW) side of Fleming Fjord; they seem to represent the "normal" basin deposits outside the reach of the coarse detritus tongues. Arkose sedimentation apparently continued longer on the southeastern than on the northwestern shore of Fleming Fjord. On "Profilbjerg", the limit between Paradigma and Solfaldsdal members is not very sharp.

### b) Outcrops Northwest of Fleming Fjord

Only the uppermost part of the Paradigma member, in which the characteristic reddish-brown or pink arkoses are lacking, appears at the surface on the northwestern shore of Fleming Fjord. Because of the general northwesterly dip of the beds, the outcrops are found on the southeastern border of the studied area, especially near the mouth of Edderfugledal and Solfaldsdal, as well as in the region of Kap Seaforth. The oldest beds are exposed at the last-named locality, where a thickness of 60 meters can be observed; of course this represents only a small part of the total thickness. STAUBER (1942) already distinguished these beds as part of his "Kontinentale Serie".

The rocks are mainly reddish-brown, fine-grained micaceous sandstones to sandy siltstones, which are interbedded with sandy and silty, carbonate-bearing shales of the same colour. In general aspect, the sequence already shows analogies to stratigraphically higher Triassic units (*e.g.* upper part of Solfaldsdal member, or part of Fleming Fjord member in Cape Biot formation). Typical arkoses are absent. We consider these beds as part of the Paradigma member on account of their stratigraphic position, below the softer shales of the Solfaldsdal member.

A typical sample from section g) shows the following characters:

**Macroscopic:** fine-grained, reddish-brown sandstone, with small-scale cross-bedding.

**Microscopic:** Small (mean 0.05 mm), well-sorted, angular grains, predominantly quartz, c. 10 % feldspar (plagioclase, micropegmatitic orthoclase), some detrital sericite, little autigenic dolomite. Matrix very fine-grained, silty and strongly pigmented by hematitic matter. The lamination is produced by a concentration of the pigment in certain layers.

Intercalations of conglomerates to breccias are characteristic for these beds; some of these layers may be due to reworking of semiconsolidated sediments, others are intraformational. The sample described below comes from the creek bed east of section f) (Edderfugledal):

**Macroscopic:** Reddish-brown siltstone with indistinctly conglomeratic structure. Components relatively small (diameter up to 3 mm).

**Microscopic:** The components are mainly reddish-brown, strongly pigmented, more or less sandy siltstones of the same character as in the surrounding beds. The ferruginous pigment is enriched in concentric rings, conferring an "oolitic" structure to the components. Their outermost layer is bleached. A few components show microconglomeratic structure. Rolled siltstone shards are also present. The matrix is formed by clear, secondary calcite, in places it is also silty and strongly pigmented (see pl. 3, fig. 1).

In the field, the sandstones of the Paradigma member form a lowermost cliff (*e.g.* in section f), and it is easy to draw their limit against the overlying, softer beds of the Solfaldsdal member. The top of the member is furthermore marked by several beds of greenish-grey, silty arenaceous limestone, with shale partings of the same colour. The limestone contains a few microfossils (ostracods, echinoderms, questionable foraminifera), implying marine origin.

### 3. Solfaldsdal Member

The term was chosen for the complete and fossiliferous development of these beds in Solfaldsdal, on the northwestern shore of the inner Fleming Fjord; but the best profile is exposed on the mountain west of the delta of Edderfugledal (section f). The member consists of the following lithologic units:

a) soft, gypsum-bearing shales,
b) a calcareous, fossil-bearing zone ("Myalina limestone"),
c) sandstones and siltstones of the upper part of Solfaldsdal member.

According to the dip of the beds, the Solfaldsdal member covers a larger area northwest of Fleming Fjord than does the Paradigma member; on Wegener Halvø, there are only few and disturbed exposures, on "Profilbjerg" and in the downfaulted area north of Paradigmabjerg. In Edderfugledal, the thickness of the member is about 150 m; it seems to decrease but little towards the southwest.

a) The basal gypsum shales of the Solfaldsdal member (lower gypsum shales of our field nomenclature, in contrast to the upper gypsum shales of the Cape Biot formation) show a relatively sharp boundary against the underlying sandstones of the Paradigma member. In Edderfugledal (section f, where they are best exposed) they measure 70 m, in Solfaldsdal 40 m. On "Profilbjerg", south of Fleming Fjord, they are not typically developed and may be replaced laterally by coarse, gypsum-bearing arkoses. The gypsum shales show an intricate alternation of variegated (red-green-lilac-yellow), sandy, gypsiferous and calciferous shales with crumbling, generally reddish-brown, more or less gypsiferous sandstones. There are also some intercalations of black, carbonaceous shales. The pure gypsum layers always remain thin. Generally speaking, the gypsum content decreases towards the top. Because of its special lithology, the unit is nowhere well exposed. We shall discuss certain questions of sedimentation when dealing with the "Upper gypsum shales" of the Cape Biot formation (p. 47) which show quite a similar development but much better outcrops.

b) The "Myalina limestones" furnish an excellent marker horizon found in the entire area. These limestones measure 15 to 30 m and set in about 20 m above the highest gypsum layers; marine fossils – pelecypods, gastropods and phyllopods – were encountered in all sections studied.

These limestones were manifestly laid down during a short but extensive marine ingression, and they are all the more conspicuous as they are intercalated into a thick succession of redbeds, at least in part of continental origin. For this reason, we believe that the horizon may be correlated over a larger distance, in spite of certain changes of lithology and fauna.

In the northeastern part of the area studied, around Edderfugledal (sections g and f) limestone deposition was still relatively insignificant; the limestones are generally very sandy and associated with calcareous sandstones. The latter may contain some calcitic fragments and shales, but typical calcarenites cannot be found in this area. The fossils are represented only by pelecypods and especially by *Myalina*, which were apparently tolerant against salinity changes and arenaceous sedimentation. They occur in thin layers and lenses, in connection with black, carbonaceous, in part somewhat sparry limestones and with black, argillaceous or marly shales.

From here towards the southwest, to Kap Seaforth and Solfaldsdal, a considerable change in facies of these beds is noted: the thickness of the calcareous sequence increases to 30 m (Solfaldsdal) and limestones become much more frequent. A characteristic unit is constituted by calcarenites, which form a cliff of up to 20 m height in the background of the Solfaldsdal delta.

The hard, relatively massive, light grey and clean limestone is somewhat porous and consists almost entirely of rolled and slightly incrustated shell fragments. The limestone is affected by diagenetic recrystallisation, so that the original shell fragments appear generally only by their pigmented outlines. The pores are in part filled with limonitic matter. Small, angular quartz grains and some larger, rounded components of quartz and more rarely feldspar (up to 1 mm) are disseminated through the rock. The detrital matter increases towards the top, where the calcarenites pass into sandy limestones or even calcareous sandstones.

Black, carbonaceous and often unevenly stratified layers of limestone and calcareous shale at the base of the limestone cliff furnished a comparatively abundant fauna, especially in section c) (NE of Solfaldsdal). *Myalina*, *Myophoria*, small Mytilids and *Omphaloptycha* sp., as well as abundant *Euestheria grasmücki* DEFRETIN (see part III) were found here. In the scree-covered outcrops on the eastern flank of Solfaldsdal we found badly preserved pelecypods and small, pyritized gastropods (*Omphaloptycha* sp.), bryozoa and indeterminable ostracods. The same fossils occur in section d), in the vicinity of Kap Seaforth, a locality from which already NOE-NYGAARD (1934, p. 53) signalled pelecypods and small gastropods; at this same locality, *Euestheria* cf. *emmonsi* (RAYMOND) occurs in a thin layer of argillaceous shale above the calcarenite level (see part III). Compared with that of Edderfugledal, the fauna is richer in species and individuals, which indicates more frankly marine conditions. This locally stronger marine influence is also expressed by the thickness of the calcareous intercalations.

The Myalina limestone is present in the small outlier of Central Wegener Halvø and contains the same light-coloured sandy calcarenite as in Solfaldsdal. On "Profilbjerg", in the southern part of Wegener Halvø, their thickness is again smaller than in Solfaldsdal (c. 15 m), and the detrital influence is stronger; even coarse arkosic lenses appear in the lower part. Two thin beds of black, compact limestone with galena contain small daonellid pelecypods, which were determined by Mrs. DEFRETIN as *Halobia* cf. *moussoni* MERIAN. This would imply a Mesotriassic age for the Myalina limestone and probably for the entire Solfaldsdal member. *Myalina*, Mytilids and fish scales were also found in this area. The Myalina limestone continues southward into Pingel Dal and can well be recognized on air-photographs.

c) The upper siltstones and sandstones. After deposition of the calcareous Myalina beds, the terrigenous influence increases again. In section d), between Kap Seaforth and Solfaldsdal, a thin layer of gypsiferous shales above the described calcarenite marks the restriction of the marine environment. Elsewhere, 50–80 m of reddish brown, micaceous, more or less silty, calcareous and shaly sandstones set in directly above the limestones. The rock types of this subdivision already show certain analogies to the mudstones of the Cape Biot formation, and the repetition of the same cycle of sediments (shales with gypsum – carbonatic beds – red mudstones) has moved STAUBER (1940, 1942) to invoke tectonic repetition by slide sheets (see also p. 38). STAUBER included the Solfaldsdal member in his (autochthonous) "Bunte Serie".

The predominating rock type is an unevenly stratified, argillaceous sandstone to siltstone, showing desiccation cracks and ripple-marks on the upper surface and load casts on the lower surface of the beds. A typical specimen from section f) shows:

Fine (0.03–0.10 mm), well-sorted, angular quartz grains, little feldspar (mainly plagioclase). Matrix calcareous and silty, pigmented by fine grains of ferruginous matter (hematite, goethite). This pigment is concentrated in some irregular layers, which also show abundant sericite flakes. Autigenic dolomite relatively abundant.

Massive beds of lighter red coloured, cleaner and less silty calcareous sandstone are especially intercalated in the upper parts of the unit. The following thin section is also from profile f):

Relatively clean sandstone with small-scale cross-bedding. Grains well sorted (0.05–0.10 mm), angular; detrital feldspar, mainly plagioclase, about 10 %. Sericite flakes, oriented parallel to the bedding surfaces, occur especially in the more strongly pigmented laminae. Accessories are chlorite, epidote, tourmaline, zircon and ore. The matrix is calcareous and in part contaminated with reddish-brown, ferruginous matter.

The Solfaldsdal member represents a typical sedimentation cycle, beginning with gypsum-bearing shales, followed by a middle unit with marine limestones and continental redbeds on top. A Mesotriassic age seems most probable to judge by the not very characteristic fossils found in the Myalina limestone and in the overlying Cape Biot formation. In spite of the local increase of marine conditions from NE to SW, the open sea which sent the Myalina ingression into the Jameson Land basin presumably lay to the north. A northward extension of the German Muschelkalk sea has not been proved so far; the drilling campaign in the North Sea may elucidate this problem.

## C. Cape Biot Formation

The greatest part of the investigated area northwest of Fleming Fjord is formed by the Cape Biot formation, which measures 400–500 m. The formation is tripartite; we distinguish from top to bottom:

- Ørsted Dal member,
- Fleming Fjord membər,
- Kap Seaforth member.

The most conspicuous unit of the formation are the reddish-brown, massive mudstones of the Fleming Fjord member, which form the steep coastal cliffs characterizing the area, particularly around Kap Biot. The underlying Kap Seaforth member and especially the overlying Ørsted Dal member are less well exposed. The term Cape Biot formation was introduced by Koch (1928); it is equivalent to the Gypsum member (in part) and the Red Marl member of the Klitdal formation of Rosenkrantz (1929) and to the "Bunte Serie" of Stauber (1942). The Ørsted Dal member probably corresponds to the lowest part of the Kap Stewart formation of Rosenkrantz (1929) in the sense of Harris, 1937 (see p. 55).

## 1. Kap Seaforth Member.

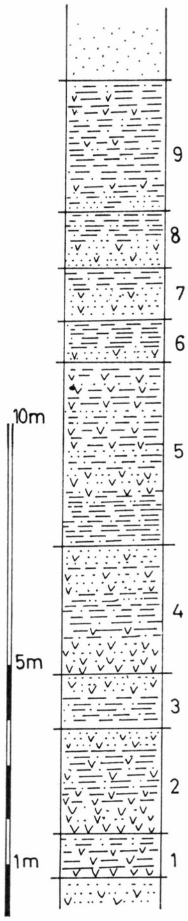
The term Kap Seaforth member covers the lower unit of the Cape Biot formation, in which chemical sedimentation (gypsum and dolomite) plays a relatively large part. The thickness of the member is 70–150 m. Like the underlying Solfaldsdal member, it starts with gypsum-bearing beds, the so-called "upper gypsum shales". They are again overlain by carbonatic rocks, especially dolomites. The lower boundary against the Mount Nordenskiöld formation is sharp, but towards the top there is a gradual passage to the red mudstones of the Fleming Fjord member. The Kap Seaforth member does not form the outermost tip of Kap Seaforth, which is set down by faults; it appears at the foot of the prominent crag (Pt. 476), which dominates the region south of the Ørsted delta. The best exposures were seen on the ridge SW of lower Edderfugledal (section f).

a) The (upper) gypsum shales at the base of the Kap Biot formation are somewhat better exposed than the similar unit in the Solfaldsdal member of Mount Nordenskiöld formation ("lower gypsum shales"). But they too are often covered by scree from the cliff-forming mudstones of the Fleming Fjord member. They form a strikingly varicoloured unit, with intricate and often cyclic alternation of different rock types.

In the best outcrops, in section f), the member starts directly above the last massive sandstones of the Solfaldsdal member with soft, gypsum-bearing sandstones and gypsum-bearing shales; it reaches a thickness of 80–100 m, which is subject to certain variations because of the diapiric behaviour of the gypsum (see p. 68). In the neighbouring section g) only 40 m were measured. Independently of these tectonic variations, there is a primary reduction toward the south (Solfaldsdal, "Profilbjerg") where the gypsum is only found in a sequence of 20 resp. 10 m. This reduction of the gypsum beds towards the south and also towards the east (Nordenskiöld Bjerg) was already noted by Noe-Nygaard (1934).

The upper gypsum shales too consist of a variegated alternation of sandstones and shales. Bedding rhythms measure 0.5–2 m. The sand/shale ratio is of about 1:1 in the lower and middle parts; in the upper part, carbonate-bearing shales predominate (sand/shale ratio 3:5) and gypsum intercalations become somewhat more frequent. The shales are more resistent to erosion than the tender and crumbling sandstone layers.

Where outcrop conditions are perfect, regular cyclothems can be distinguished (see fig. 5). A complete cyclothem measures between 1 and




Halite pseudomorphs !

Fig. 5. Detailed section in the upper part of the shales with gypsum of Kap Seaforth member. Section f, Edderfugledal. The full horizontal lines give the boundaries between cyclothems. Description see text.

2 m. It starts with variegated, gypsum-bearing, more or less sandy marl shales (*e.g.* cyclothems 3 and 5), or with a layer of pure gypsum (Nr. 1, 2, 4). The shales are in general green, but according to the degree of oxidation reddish-brown, lilac and yellow layers also occur. Symmetrical and asymmetrical ripple-marks, the crests of which run E–W to SE–NW, are widespread especially in the green marl horizons. More rarely, well developed rock-salt pseudomorphs occur. The gypsum is concentrated in lenses. The variegated shales pass upward into tender, carbonate- and gypsum-bearing sandstone of medium to fine grain. Its colour is always brick-red to reddish-brown, indicating an oxydizing environment. The gypsum in the sandstones occurs in the matrix, in cataclastic veins and in nodules; it seems to have mainly penetrated the porous rock after its deposition. The boundaries between the cyclothems are never absolutely sharp, the clearest cut being generally

between the sandstone (below) and the shales (above), where the passage is realized on less than 5 cm.

Cyclothems of a somewhat simpler type can be observed in the upper part of the measured detail section (fig. 5, Nr. 6–9). They begin with the reddish-brown, gypsum-bearing sandstone, which passes upwards into green, sandy marl shales, generally without gypsum. Furthermore there are incomplete, averted cyclothems (see fig. 5).

Stauber (1942) interpreted these gypsum-bearing beds as deposits in an internal sea under a warm, arid climate; he explained the rhythmic stratification by variations in climate and in affluence of detrital matter.

b) Dolomites and siltstones are the most conspicuous among many different rock types in the upper half of the Kap Seaforth member, which can generally be seen at the base of the cliff formed by the red Fleming Fjord mudstones. This upper subdivision starts with dolomitic marl shales, which may still contain rare horizons with gypsum, and with silty to finely sandy, dolomitic limestones in rather thin layers. Upwards, the dolomite beds become purer, bituminous and weather with a very conspicuous chrome-yellow colour.

A sample from Henrik Møller Dal (section a) shows a dark grey, fine-grained dolomite, practically without calcite, with a yellow alteration crust. The rock has a strong "bituminous" odour. In thin section, a very fine-grained dolomite aggregate can be distinguished, strongly pigmented by sulfides and bituminous substance. Little detrital quartz (up to 0.05 mm) and sericite, abundant pyrite crystals, few very indistinct traces of microfossils.

Thin, dark green to black, siliceous silty shales are intercalated between these dolomite beds. The shale layers have a sharp lower boundary and pass upwards into the dolomites, which are still silty at their base (see pl. 3, fig. 2). Halite pseudomorphs are found especially in the shales.

In the uppermost part of the member, where it passes into the Fleming Fjord mudstones, these simple sedimentary rhythms are enriched by other rock-terms. These cyclothems of the upper Kap Seaforth member measure up to 10 m. Each of them starts with a layer of a light grey, clean, flaggy quartzite to quartzitic or calcareous sandstone, showing small-scale cross-bedding and abundant ripple-marks. The quartzitic sandstones contain lenses and pockets of quartz-bearing calcarenite, which consists of rolled shell fragments, part of which show oolitic crusts. Locally, there are also small, complete pelecypods (*Myophoriopis* sp.).

Microscopic description: Regular, largely recrystallized aggregate of small quartz grains (0.02–0.05 mm). Some layers show calcitic cement stained by limonitic matter. There is only little feldspar. Detrital sericite flakes occur especially in the calcitic layers. Accessories are biotite, zircon, and tourmaline. The coquina lenses are coarsely recrystallized and contain only little detrital quartz, but more limonitic matter and some autigenic dolomite (see pl. 3, fig. 3).

Above each quartzite bed there is generally a layer of reddish-brown, shaly siltstone of the character of the Fleming Fjord mudstones, which contain horizons of hard, cherty nodules up to the size of a fist. Slabs with small pelecypods, presumably *Anodontophora* sp., were found on "Profilbjerg". These mudstones finally pass to the dark-green silty shales and to the dolomites described above.

Towards the Fleming Fjord member, the dolomite layers become more and more silty; macroscopically, the only difference from the reddish-brown siltstones of the Fleming Fjord member is their lively yellow patina. Such thin, yellow weathering intercalations of dolomitic siltstone are not rare in the lowermost 20 m of the Fleming Fjord member. We draw the top of the Kap Seaforth member above the highest intercalation of quartzite and calcarenite or typical dolomite.

The rhythmically bedded upper part of the Kap Seaforth member is remarkably constant over the whole studied area, even in its minor lithological details. A special character is conferred to this unit by the presence of several layers, measuring up to 40 cm, of laminated carbonate rocks, which show very curious "fold" structures. They are always associated with the above-mentioned silty dolomites, also with those at the base of the Fleming Fjord member; they can be followed over more than 100 m in the same stratigraphic position. STAUBER (1942, *e.g.* fig. 24, p. 185) interpreted these structures as "Gleitfaltenlagen". From a purely descriptive point of view, they correspond absolutely to stromatolites.

Each bed consists of hemispherical bodies of laminated carbonates, between the size of a pea and that of a cabbage-head but most often measuring 8–20 cm in diameter, placed closely side by side and always convex upwards. The stromatolitic structures start in a not very pronounced manner above a somewhat irregular surface of siltstone and become successively stronger towards the top. Sedimentation of these stromatolitic carbonate beds was ended by another arrival of silt, which filled at first the narrow depressions between the cupolae and later on covered the cupolae themselves. The bedding irregularities due to the stromatolitic bodies are reflected to a certain distance in the overlying strata.

The lamination of the rocks is due to a close alternation of calcareous and dolomitic layers, the former light grey and the latter weathering with a yellow colour. Individual laminae measure 2–5 mm. The calcareous layers frequently become dolomitic towards the top. Many, especially calcitic laminae show very fine prismatic and concentric structures, making an organic, presumably algal, origin very probable. The resemblance with algal stromatolites, especially *Collenia*, is quite striking. On the other hand, certain synsedimentary processes giving rise to a volume increase of individual laminae (dolomitization, replacement of sulfates by carbonates?) may produce very similar structures; they were for instance signalled by WESTPHAL (1957) from the Oligocene of the Rhine valley.

Thicker and coarser carbonate layers with irregularly cavernous structure are intercalated between the fine laminae. They are mainly dolomitic and show clear, secondary calcite crystals in vugs; when these calcite crystals are radially arranged, a curious resemblance to corals results. The two authors of this paper are in disagreement on the origin of these bodies, GRASMÜCK considering them as of organic nature and TRÜMPY rather as anorganic structures (originally sulfate layers?).

The concentric laminae converge on the flanks of cupolae. Rolled shards of fine-grained, strongly pigmented dolomite lie, regulary arranged one above the other, in the narrow grooves between the hemispherical cupolae. Many shards show well preserved algal crusts, often on one side only (see pl. 4, fig. 1). The presence of these rolled shards is decisive proof for the syngenetic and not diagenetic origin of the stromatolitic structures.

Curious edgewise conglomerates, STAUBER's (1942) "Fetzenlagen", are always associated with the stromatolite layers and genetically linked to them. They probably result from the destruction of the delicate algal biostromes by waves. In a calcitic cement, the conglomerates contain mainly disk-shaped dolomite components with rounded edges (diameter 1 to 10 mm), identical to those occurring in the grooves between the stromatolitic bodies. The accompanying shards of finely banded algal crusts are generally larger (up to 10 cm) and quite angular (see pl. 4, fig. 2).

## 2. Fleming Fjord Member

The middle, most characteristic member of the Cape Biot formation is formed by 200 m or more of dark red, monotonous siltstones. They determine the conspicuous coastal cliffs to the NW of Fleming Fjord, and steep, partly scree-lovered slopes in the inner reaches of the fjord (see also NOE-NYGAARD, 1934, p. 55). We have already seen that there is a gradual passage towards the underlying Kap Seaforth member. The somewhat similar, but always more shaly and generally badly exposed sediments above the red mudstone are attributed to the newly defined Ørsted Dal member.

This thick rock-unit consists almost exclusively of intensely blood-red to cocoa-brown siltstones, in platy or massive development, some layers of which contain a little sand. The finest varieties show an extremely fine-grained, largely recrystallized aggregate of quartz, feldspar (?), calcite and ferruginous matter (hematite, goethite?). In general, the rock is poor in carbonate, but there are also relatively calcareous layers. At any rate, the term "marl", used by the older authors, is quite misleading. Larger, detrital grains (about 0.02 mm) are always present; quartz, feldspar (mainly plagioclase), sericite (flakes parallel to bedding), chlorite, autigenic dolomite and relatively abundant ores (among which chamosite-like iron silicates) can be recognized. The somewhat coarser, sandy layers (quartz 0.03–0.05 mm), which frequently show a lenticular texture, contain the same mineral assemblage, with somewhat more sericite (see pl. 4, fig. 3).

X-ray diffraction analyses of some samples of red siltstones were done by V. DIETRICH, whom we thank very sincerely for his collaboration. They were made with the instruments at the Crystallography Institute of the Swiss Federal School of Technology, after the GUINIER method (de Wolff camera, Fe Kα-ration). The following results were obtained:

| Sample | Intensity of lines | | | |
|---|---|---|---|---|
| | Strong | Fair | Weak | Very weak |
| G 31 | Dolomite<br>Albite-<br>Oligoclase | Calcite | Muscovite-<br>Illite<br>Chlorite<br>$Fe_2O_3$ | Quartz (!) |
| G 31 (dark red vein) | α-$Fe_2O_3$ | Calcite<br>Albite<br>Dolomite | Musc.-Illite<br>Analcite ?<br>or $Al_2O_3$ ? | Chlorite<br>Quartz |
| G 32 | Calcite<br>Quartz<br>Albite-Olig. | Dolomite | Muscovite<br>(or Illite ?)<br>Chlorite (or<br>Montmorillo-<br>nite?<br>$Fe_2O_3$ | |
| G 131 | Quartz<br>Albite-Olig.<br>(K-feldspar<br>in traces) | Calcite | | Chlorite,<br>other clay<br>min.<br>$Fe_2O_3$ |

The abundance of feldspar, especially albite, and the scarcity of typical clay minerals in these very fine-grained rocks is noteworthy. We had suspected the presence of analcite, as VAN HOUTEN (1961) has shown this mineral to be an important constituent of the Upper Triassic red mudstones of New Jersey; but the analyses were negative. Even in the red vein of sample G 31, analcite is dubious, as two lines are missing. It is possible, however, that original analcite has been replaced by albite.

Thin dolomitic and sometimes stromatolitic bands with yellow patina are still intercalated in the lower part of the member. The middle part consists almost exclusively of red mudstones. Although they look very monotonous at first sight, they contain a wealth of different stratification phenomena. Mud galls, sometimes flattened and of small size, are concentrated in certain layers. Shrinkage crack polygons, load casts, small-scale cross-bedding, different types of rolled mud fragments and partly enigmatic tracks and burrows can be observed frequently. STAUBER (1942) has already described in detail these interesting phenomena which occur singly or in combination with each other, so that we can refrain from giving further descriptions.

In the upper third of the member, sedimentation becomes more varied. Lighter-coloured sandstones, part of which seem to represent fillings of tidal channels, are intercalated between the red mudstones. Vividly green shale-layers frequently show ripple-marks, the crests of which are oriented E/W or SE/NW. Towards the top, shales become predominant over the massive mudstones, and there is a gradual passage to the overlying Ørsted Dal member.

With the exception of the uncertain tracks and burrows, the Fleming Fjord member proved to be almost sterile. However, a horizon of silty shales near the base of the member furnished well-preserved phyllopods in the area near section f) (northern slope of the ridge SW of Edderfugledal). Mrs. DEFRETIN (1969, p. 127) determined these fossils as *Euestheria minuta* (VON ZIETEN), which occurs in the Lettenkohle and in the lower Keuper of the Germanic Triassic. This would imply that the base of the Fleming Fjord member was of about Carnian age. At the same locality, K. BOLLER found a slab with *Equisetites*.

The large accumulations of silty matter are the most striking character of the Fleming Fjord member. The typically terrigenous matter was deposited in a flat basin, possibly a large delta or tidal flat. Conditions were extremely oxydizing, and chemical weathering was delayed (scarcity of clay minerals). Mudcracks were formed during periods of exundation. Stronger inundations and probably tidal scour are attested by the light-coloured sandstones and the green shales in the upper part.

### 3. Ørsted Dal Member

Between the red cliff of the Fleming Fjord mudstones and the drab sandstoncs of the Kap Stewart formation, there is a lithologically variable sequence of 100 to 200 m thickness. These beds are relatively tender and largely covered by solifluction scree from the overlying Rhetic sandstones; for this reason, it is very difficult to measure detailed sections. The thickness indicated in section e) is probably excessive.

The Ørsted Dal member can best be studied in the western part of the area, to both sides of Ørsted Dal (sections b, c, e). Three lithologic subdivisions can be recognized here, from below:

a) The highest, already somewhat argillaceous siltstones of the Fleming Fjord member pass gradually into 50 m of variegated, predominantly reddish-brown, more or less calcareous silty shales, breaking into fine splinters. Especially in their lower part, these shales contain horizons with hard nodules up to the size of a fist, which consist of the same matter as the country-rock but with more cherty and calcareous cement. Toward the top, thin intercalations of calcareous sandstones come in, which lead to the overlying subdivision.

b) There follows an alternation, in part rhythmically stratified, of reddish- and greenish-grey sandstones with variegated, silty marl shales; it measures 30 to 40 m. The shale layers are always thin. The sandstones vary much in detail; they generally contain only insignificant amounts of feldspar and are quite different from the yellow-weathering, coarse, typical sandstones of the Rhetic Kap Stewart formation.

c) The third and uppermost subdivision is formed by carbonate rocks, limestones and dolomites. They determine a light-coloured cliff crowning the table-mountains to the SW of Solfaldsdal. The light grey, fine-grained, somewhat silty limestones alternate with dark green shales; towards the top, the limestones become more and more dolomitic and show a yellow patina, and the accompanying shales become dark and carbonaceous. These black shales often contain thin-shelled pelecypods (*Cardinia* sp. ?). Section e) furnished from this level 2 undescribed species of ostracods, as well as isolated specimens of *Darwinula* sp. Dr. H. Oertli (Pau), who had the kindness to examine our ostracod material, considers a Lower Rhetic age as most probable, especially by comparison with North German faunas.

These marine carbonate rocks of the uppermost Cape Biot formation show considerable changes in facies. In the region of Kap Biot, where they were found only in solifluction scree, they are probably more argillaceous. Towards the southwest, on the contrary, the limestones and dolomites become thicker – apparently at the expense of subdivisions a) and b) – and their marine character becomes more pronounced.

On "Profilbjerg", there are four units of limestones and dolomites, the uppermost one being by far the thickest. Intraformational limestone-dolomite-breccias are frequent. The dolomitic top-limestone is generally fine-grained; it contains a few shell fragments and uncertain echinoderm débris. Black chert nodules are formed to a large part by sponge spicules.

The dense and often bituminous, uppermost dolomite beds frequently contain abundant bone fragments, fish scales and a few reptilian teeth. This thin, but very typical bonebed has a very large distribution. We found it in the region of Kap Biot (mountains east of Edderfugledal), in Henrik Møller Dal and in the region of Kap Seaforth. The Rhetic bonebed marks an interruption of sedimentation and constitutes the clearest lithological cut in the entire Triassic sequence studied by us. This leads us to define the boundary between the Cape Biot and the Kap Stewart formation by this bonebed and to attribute the Ørsted Dal member, against the opinion of Harris and Stauber, to the Cape Biot formation.

In his works on the Rhetic and Liassic beds of Scoresby Sund, Harris (1937 etc.) makes the Kap Stewart formation begin with the cross-bedded sandstones above the red Cape Biot mudstones (= Fleming Fjord member). He divided the Kap Stewart formation into a lower, sterile, and an upper, plant-bearing part (see also p. 58). The lower, sterile subdivision obviously corresponds to our Ørsted Dal member. Harris explained the often very typically "Triassic" aspect of these sediments by reworking of older deposits; but this point of view cannot be upheld, as such phenomena can only rarely be observed. From the plant-bearing beds, Harris (1937, p. 74) described a bonebed with thin-shelled pelecypods, which may certainly be correlated with the bonebed at the limit between Kap Biot and Kap Stewart formations.

This revised attribution seems justified by the sharp and inequivocal boundary between the Ørsted Dal member and the Kap Stewart formation. It does not exclude the possibility that the Ørsted Dal member too is of lower Rhetian age, as indeed suggested by the scanty evidence from the ostracods. The passage from the Fleming Fjord member to the Ørsted Dal member is on the other hand quite gradual, and it would not be wise to place a formation boundary here. Stauber (1942) postulated a regional unconformity at the base of the "Rhetic" (= base of the Ørsted Dal member), but this is certainly not the case in our area. The outcrop in Henrik Møller Dal, where Stauber (*loc. cit.*, fig. 20, p. 169) believed to find the best evidence for this unconformity, was revisited by our party, and it was easy to see that the sandstone bed in question represented only a local channel filling.

### 4. General Remarks on the Triassic Redbeds

(Mount Nordenskiöld and Cape Biot formations).

About 90 $^0/_0$ of these two Triassic formations consist of red and purple, terrigenous sandstones and siltstones, deposited in continental to very shallow marine environment. These typical redbeds present the usual dilemma as to their paleogeographic interpretation. Two more or less contradictory requirements must be fulfilled (see for instance Dunbar & Rodgers, 1957):

1) Warm, semihumid to semiarid climate with seasonal rainfall in the source area, permitting the oxidation of iron compounds and giving rise to tropical lateritic or subtropical terra rossa soils.

2) Deposition of the detritus under conditions where ferric iron minerals are stable: *e.g.* well-drained continental basins, preferably under more or less arid climate; absence of scarcity or organic matter.

In the Triassic redbeds of East Greenland, there are several indications for arid conditions; such as deposits of gypsum and primary dolomite, halite pseudomorphs and mud-cracks. The evidence for heavy seasonal rainfall in the source area rests only on the red colour of the sediments. The abundance of fresh feldspar, not only in the coarse arkoses but also in the very fine-grained Fleming Fjord mudstones, is noteworthy; the scarcity of true clays and the frequent occurrence of detrital biotite (especially in sandstones of the Wordie Creek formation on Hold with Hope and Traill Ø) also point to conditions under which chemical weathering was not very effective. The relatively poor heavy mineral spectrum (Kleiber, 1944) may reflect a somewhat monotonous petrological composition of the source areas.

A certain amount of reworking of older (Devonian to Permian) redbeds cannot be excluded. The Triassic redbeds are the youngest ones in East Greenland; drab colours prevail in the Jurassic and Cretaceous, perhaps indicating cooler climate. Bowen (1962), however, found fairly high paleotemperatures from Jurassic, especially Upper Jurassic, belemnites. Paleomagnetic studies by Bidgood & Harland (1961) give high inclinations (and hence high paleolatitudes) for the Triassic of East Greenland; it is not easy to reconcile this with the presence of redbeds and extensive gypsum deposits.

The Triassic redbeds of East Greenland cannot be attributed to one only of the types distinguished by Dunbar & Rodgers, but rather show a combination of different environments. The arkosic type is realized in a very characteristic manner in the Paradigma member of the Mount Nordenskiöld formation; these pink arkoses probably belong to subaerial deltas along the margins of the trough. The Solfaldsdal member of the Mount Nordenskiöld formation and the Kap Seaforth member of the Cape Biot formation represent the type of redbeds associated with evaporites. Marine incursions are obvious, especially in the Solfaldsdal member. Rhythmic bedding may reflect either tectonic or (more probably) climatic cycles. With the Fleming Fjord member, the relief becomes attenuated; vast, possibly intertidal mudflats are spread out through the entire Jameson Land basin. The iron is in ferric state in the predominant red mudstones with desiccation cracks, but ferrous in some of the thinner sandstone horizons with ripple-marks and cross-bedding. The Ørsted Dal member is again of marine origin and marks the gradual end of redbed sedimentation.

Because of the unfavourable environment and the difficulty of preservation of organic remains under strongly oxidizing conditions, fossils are very scarce, and the age of the two formations can only be approximately established. The Mount Nordenskiöld formation is certainly in part of Eotriassic age, as the Paradigma arkoses laterally replace dated (middle ?) Eotriassic deposits; its upper, Solfaldsdal member probably reaches into the Mesotriassic, although the fossil evidence is not quite conclusive. Phyllopods date the lowermost Fleming Fjord member as ± Carnian, so that we may provisionally assume a Ladinian (?), Carnian, Norian (and lower Rhetian ?) age for the Cape Biot formation. There are no apparent stratigraphical gaps within the Mount Nordenskiöld and Cape Biot formations; most of the Triassic system is probably represented by sediments.

Detailed correlations with the Triassic redbeds on the western margin of the Jameson Land trough (compare Bierther, 1941, and Stauber, 1942) will be made in the forthcoming thesis by M. Aellen.

Further-reaching comparisons are hampered by our inadequate knowledge of the exact age of the two Greenland formations. No Triassic redbeds are known from Svalbard or from the Canadian Arctic. We have already mentioned the similarity between the Mount Nordenskiöld and Cape Biot formations on one hand, the British Bunter and Keuper formations on the other (Trümpy, 1960). Still more striking is the resemblance between the Cape Biot formation and part of the Newark group, *e.g.* in New Jersey. This may prove to be more than a coincidence, as the Triassic formations of East Greenland and Eastern North America lie on the same great circle and may have been deposited in the same system of fault-bordered trenches. From time to time, the Arctic sea penetrated into the East Greenland basin, whereas it did not reach the eastern United States.

# III. POST-TRIASSIC FORMATIONS

## A. Kap Stewart Formation

Above the Cape Biot formation follows a unit composed mainly of continental sandstones, which HARTZ (1896) termed Kap Stewart formation. HARRIS (1937 etc.) has studied the formation in its type area near Scoresby Sund and has monographed its very rich flora, which gives a Rhetian and Lower Liassic age.

HARRIS subdivided the Kap Stewart formation, which measures about 170 m on Scoresby Sund, into two parts of about equal thickness. All the plants studied by him come from the upper unit. We have already discussed the reasons which have led us to retrench the lower, sterile part of the formation such as it was defined by ROSENKRANTZ (1930) and HARRIS, and to attribute it as Ørsted Dal member to the Cape Biot formation (p. 55). The widespread bonebed horizon of presumably Lower Rhetian age forms a far more satisfactory lower boundary for the Kap Stewart formation. The yellow, usually coarse and feldspar-bearing sandstones alternating with black, carbonaceous shales lie without visible discontinuity upon the bonebed; even in external aspect, they are quite different from the fine-grained sandstones and variegated shales of the Ørsted Dal member. Plant-bearing horizons were also found in the area investigated, *e.g.* near Pt. 610 northeast of Solfaldsdal.

## B. Tertiary Intrusives

Dolerite intrusions of Tertiary age are widespread in the Mesozoic formations of East Greenland and also occur in the Fleming Fjord region, although they play a less prominent part than in other areas, such as the country around Mesters Vig. They take the form of generally thin dykes and sills. The rocks are often termed "basalts", but most of them are clearly doleritic, and some dykes, especially on Wegener Halvø, seem to consist of fine-grained gabbro (compare KAPP, 1960).

The dykes are always more or less vertical. Northwest of Fleming Fjord, almost all of them strike N–S, parallel to the main faults; in many cases, there is a direct relationship with such faults. On Wegener

Halvø, only few dykes were seen; their direction is mainly NW–SE or WNW–ESE. They cannot be followed over long distances; one dyke, SSE of Ravnefjeld, seems to be cut off by the Tvekegle fault. Small dykes, not indicated on the map, exist east of the mouth of Pingel Dal and on the western slope of "Profilbjerg".

The sills are generally conformable to the bedding-planes, but minor irregularities prove their intrusive character. Combined dykes and sills were also observed, *e.g.* near the tip of Kap Seaforth. There are no sills on Wegener Halvø.

The stratigraphic levels into which the sills intrude are shown on the map (plate 1) and the sections (plate 2 and figure 9). The thickest and most constant sills are found in the youngest exposed formations (Kap Stewart fm. and Ørsted Dal member). None penetrate the massive Fleming Fjord mudstones, and only a few were emplaced in the Kap Seaforth member and the upper Mount Nordenskiöld formation, where according to Stauber's slide-sheet hypothesis thick and tectonically disturbed "basalts" should occur. Quite on the contrary, several dykes, for instance on the ridge between Edderfugledal and the Fleming Fjord coast (section f) cut through both the "autochtonous" and the "nappe". The absence of sills in the older rocks of Wegener Halvø leads one of us (R. T.) to suppose that the intrusions antedate the fault movements, whereas K. G. favours the opposite view (see p. 66); but of course there may be different periods of faulting and/or of dolerite emplacement.

Contact phenomena along the basic intrusives are poorly developed. Especially near the more important dykes bleaching of originally red rocks, baking of sandstones and silicification of shales can be observed; but these actions only affect the sediments in the immediate vicinity of the dolerite bodies and never reach the degree of true contact metamorphism.

# IV. STRUCTURE

## A. General Situation

The eastern margin of the Jameson Land depression shows quite different structural characters along the strike. In the south, on the eastern shore of Hurry Inlet, there are relatively simple normal faults with downthrow to the west (see BÜTLER, 1957). In Klitdal, between Hurry Inlet and Carlsberg Fjord, the Triassic formations lie undisturbed on the Caledonian basement rocks. Still further to the north, on Canning Land and Wegener Halvø, a rather complex system of tilted, fault-bordered blocks makes its appearance. The main lines of the structure have already been elucidated by BÜTLER (1948) and NOE-NYGAARD (1934). The faults are mainly of Tertiary age, but some of them follow preexisting (late Paleozoic) lineaments. On the whole, the Jameson Land basin already had the character of a subsident belt ("taphrogeo-syncline") during the deposition of the Permian and Mesozoic formations; these intricate relationships between structure and sedimentation have been brought out in a very lucid manner, for the more northerly Mesozoic areas, by the work of MAYNC and VISCHER.

The country NW of Fleming Fjord lies structurally lower. The Triassic and Jurassic strata dip gently, with an inclination of a few degrees, towards the northwest; they are only affected by some faults and flexures. The Kap Biot region is practically the only place in East Greenland where folds of Tertiary age can be observed; but these fold structures are clearly subordinate to faults.

## B. Structure of Wegener Halvø

Three major faults, running more or less N–S, divide Wegener Halvø into four compartments: (see figures 6 and 7); from E to W:

1) The uplifted block of Kap Brown, presumably the northern extension of the Canning Land horst (Precambrian and Devonian). Limited by the Calamites fault, a normal fault with more than 500 m downthrow to the west, against

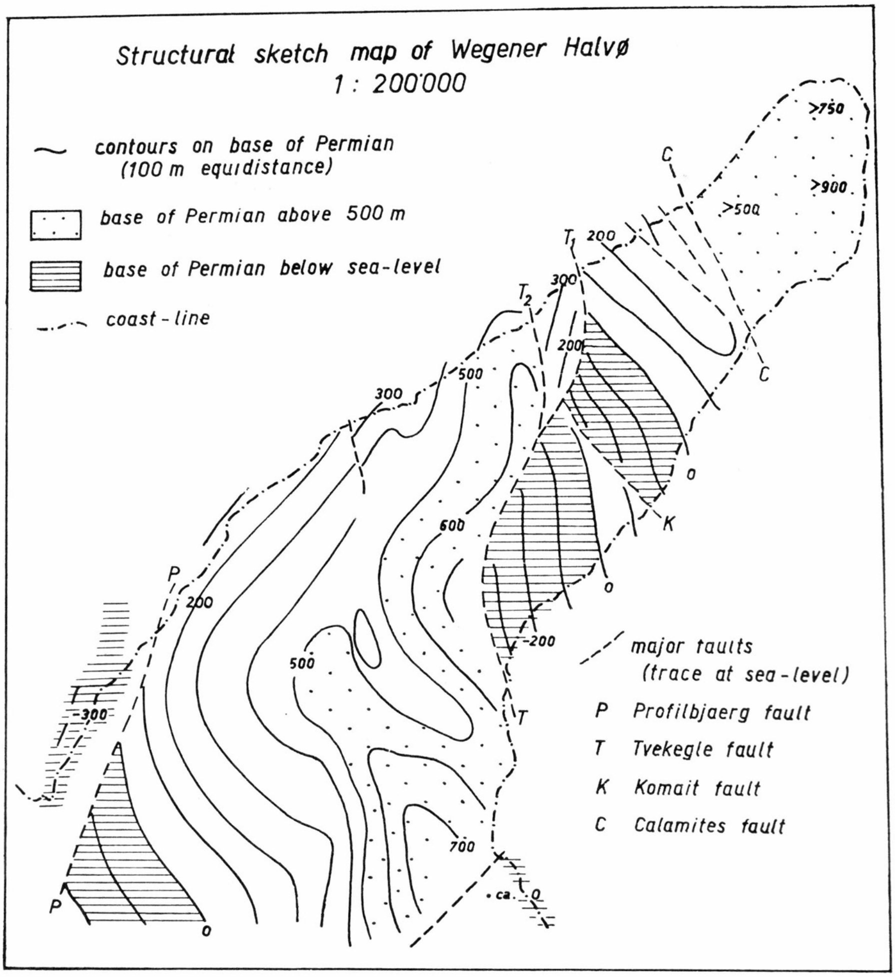



Fig. 6. Structure contour map of Wegener Halvø.

2) The central downfaulted graben (Carboniferous to Mount Nordenskiöld fm.). To this unit belong the relatively low hills between Calamitesdal, Tvekegledal and the mouth of Jameson Dal. The beds are gently inclined towards the west (see figure 3, p. 29). They are further affected by several normal faults, trending NW–SE, with downthrow to the NE. The most important of these runs through the hill of Kumait; its northeastern lip is set down by about 200 m. Close to the fault, the dip of the beds becomes markedly more pronounced, and on the hill Pt. 460, north of Paradigmabjerg, even a tiny relic of Cape Biot formation has been preserved between subsidiary faults. At its northwestern end, the Kumait fault seems to be cut off by the much more

important Tvekegle fault; but the relation between the two tectonic lines is not quite clear because of the Quaternary cover.

The graben is limited to the west by the great Tvekegle fault, the throw of which attains almost 1000 m. This accident was recognized by NOE-NYGAARD (1934); his map must only be corrected insofar as the main fault does not run west but east of the two conical hills in Tvekegledal which he called "Conus I and II". On the eastern slope of these hills, the fault surface is well exposed; it is inclined at 50–55° to the east. Minor accompanying faults are also seen; one of them ($T_2$ on figure 6) must follow the lowermost Tvekegledal. NOE-NYGAARD already drew attention to the fact that the Tertiary Tvekegle fault had developed along on older, pre-Foldvik Creek (pre-Upper Permian) accident: east of the fault, Carboniferous rocks are preserved, whereas immediately to the west of it the Foldvik Creek formation rests upon Middle Devonian.

3) West of Tvekegle fault lies the large block of southern Wegener Halvø, mainly Devonian with its unconformable Permian and Eotriassic cover. The beds dip to the west or northwest, in some zones rather markedly (up to 15° SW of Quensel Bjerg). Close to the Tvekegle fault, they lie flat or are even slightly inclined towards the east. The warping of the Permian and Triassic formations as well as some minor faults are shown on the structure-contour map fig. 6. The pre-Permian structure is only known in its outlines (see SÄVE-SÖDERBERGH, 1937); as a rule the Middle Devonian strata are inclined at 20–50° towards the south or west (see fig. 1, p. 13).

4) A small area of Mount Nordenskiöld and Cape Biot formations (about 8 km$^2$) on the western slopes of "Profilbjerg", near the head of Fleming Fjord, represents the fourth, again downfaulted compartment. It probably belongs to the same structural unit as the flat-lying beds on the northwestern shore of the inner Fleming Fjord.

The limit against block 3 is formed by the Profilbjerg fault. NOE-NYGAARD (1934), who discovered this fault but apparently only saw it from Fleming Fjord, drew it as a vertical accident trending NNW–SSE; but if one follows the fault along its outcrop line, it becomes obvious that it trends NNE–SSW and dips at a very low angle – 35 to 40° – to the west. The outcrop pattern shown on the map (plate 1) or the view of Profilbjerg from the north (figure 8) leave no doubt about this.

The Profilbjerg fault is probably the most prominent structural line of the whole region. At the head of Fleming Fjord, its throw is of the order of 1200 m. Further north, of course, it is hidden under the waters of Fleming Fjord; but the tectonic denivellation between Kap

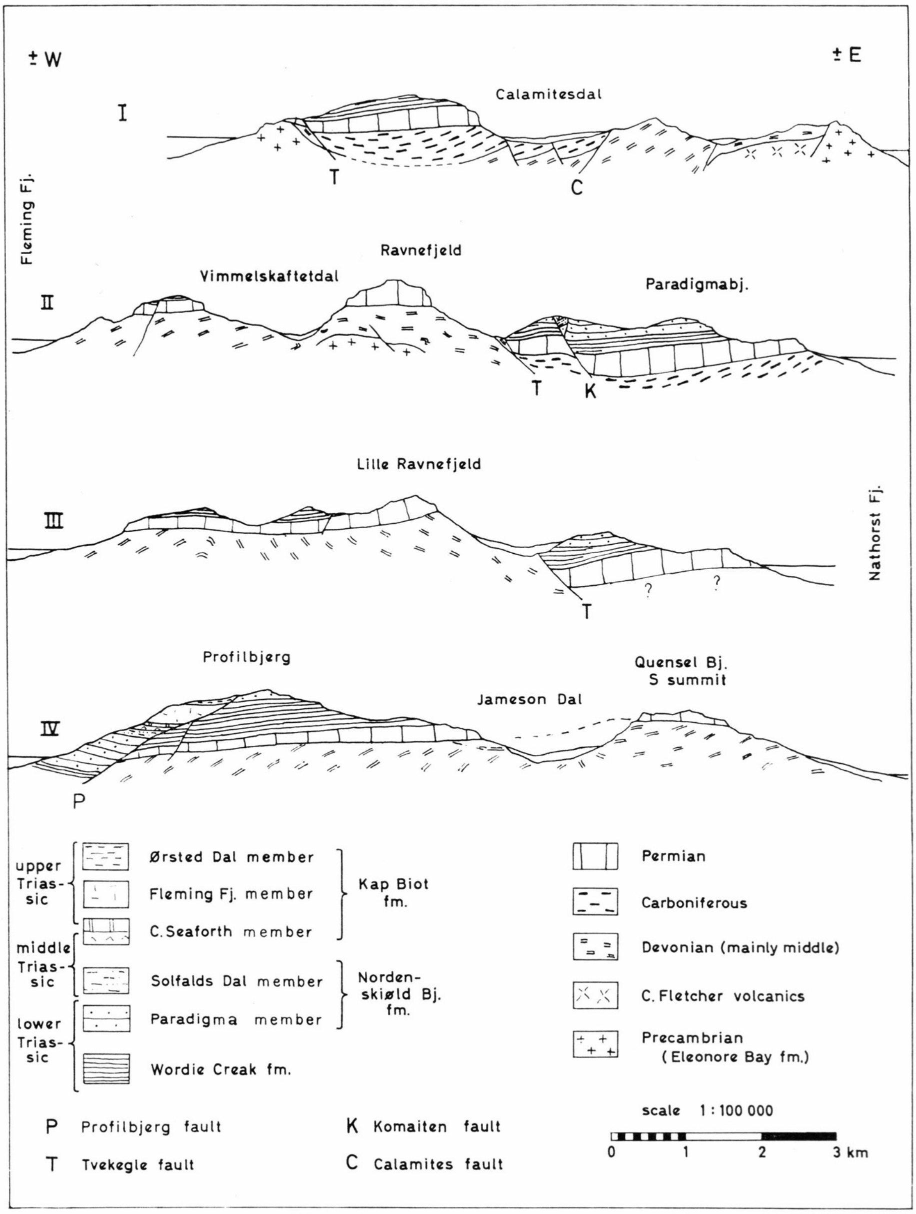



Fig. 7. Sections through Wegener Halvø.

Brown and Kap Biot must be of the order of 2 km. Towards the south, it runs into Pingel Dal, becoming less and less important; but the left (western) flank of the valley is still distinctly downset at least until latitude 71°30′. At the head of Pingel Dal, no corresponding disturbance

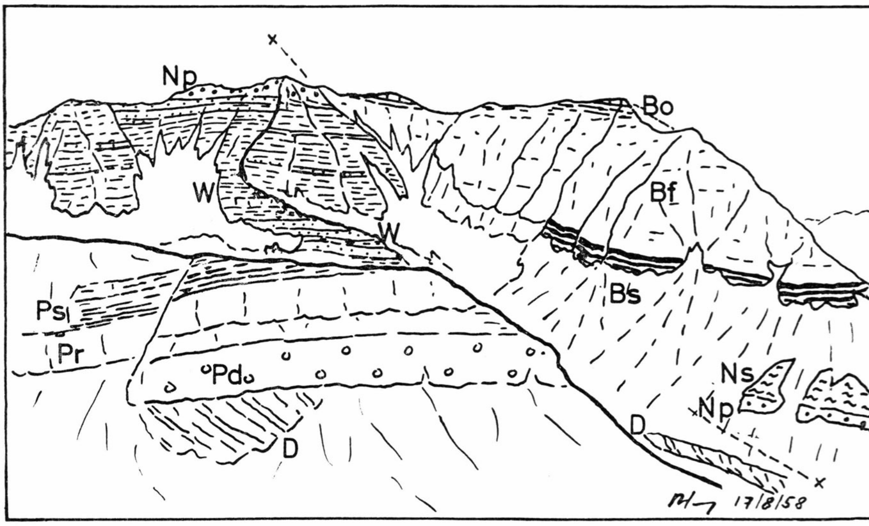



Fig. 8. "Profilbjerg", seen from the north.
D = Devonian; Pd = Domkirken fm.; Pr = "reef" limestones of Foldvik Creek fm.; Ps = Posidonia shales; W = Wordie Creek fm.; Np = Paradigma member of Mt. Nordenskiöld fm. (upper left: Tvekegle arkose); Ns = Solfaldsdal member; Bs = Kap Seaforth member of Cape Biot fm.; Bf = Fleming Fjord member; Bo = Ørsted Dal member.

can be detected on air photographs; the horst of Wegener Halvø merges, toward the south, into the practically undisturbed tableland of central and southern Jameson Land (see Callomon, in prep.).

## C. Structure of the Country northwest of Fleming Fjord

### 1. Faults

The well-defined lithological units of the Mount Nordenskiöld, Cape Biot and Kap Stewart formations, in particular their conspicuous vertical colour changes, make it easy to recognize faults in the good exposures along the coast. Further inland, the high plateaux are covered by slope and solifluction scree, and only the major faults can be followed (compare sections 1 and 2 on figure 9).

The vertical movements along the faults are generally modest, smaller than those along the flexures (p. 66). Most of the faults are steep and run in N–S direction, with deviations up to 20° to the E and W. There is no general rule for the throw, pointing for instance to a structure of antithetic blocks; nevertheless, the western lip is more often downset.

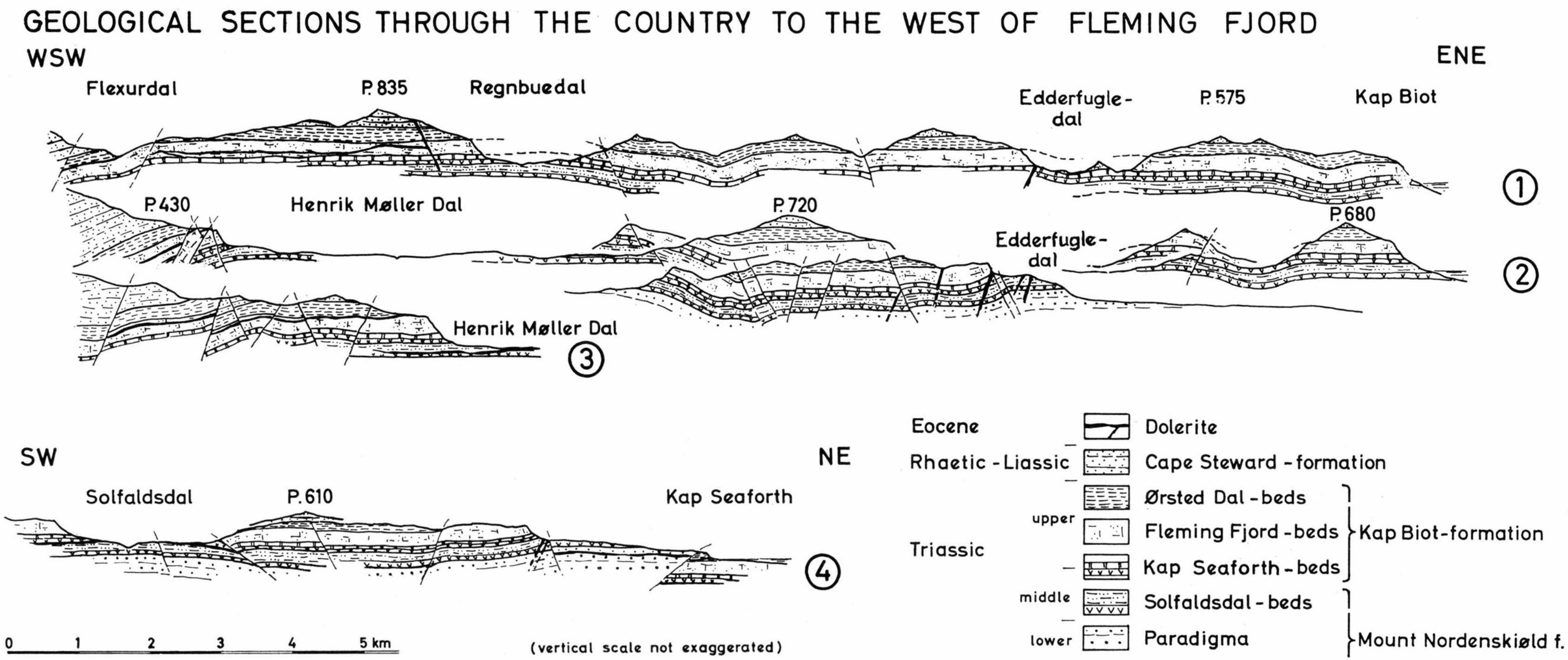



Fig. 9. Cross-sections through the country NW of Fleming Fjord. Note: for "beds" read "member".

One fault, near Kap Seaforth, plays a special part on account of its large throw and inverse character. It strikes N 170° E and dips with only 50° to the W. As there are only low hills in this area, some difficulties are involved in judging the amount of displacement. Our interpretation differs somewhat from the one given by NOE-NYGAARD (1934, p. 75, figure 19). In particular we regard the strata W of the thrust-fault not as Fleming Fjord member and Ørsted Dal member ("Rhetic"), but rather as Mount Nordenskiöld formation; this is attested by a gypsum layer in their upper part. Consequently, the next western fault, in the eastern flank of Pt. 476, would be less important than indicated by NOE-NYGAARD; this has already been recognized by STAUBER (1942). The main disturbance is the west-dipping inverse fault of Kap Seaforth, where rocks of the Ørsted Dal member (designed as Rhetian by NOE-NYGAARD and STAUBER) are set down to sea-level (see section 4, figure 9). No trace of this fault is seen north of Ørsted Dal.

We have already mentioned dolerite dykes following fault-planes (p. 58). The main dolerite intrusions seem to have taken place after the main faulting. However, vertical displacement and other structural accidents along dolerite dykes are also present (see p. 68).

## 2. Flexures and Folds.

Flexures are the most important structural features NW of Fleming Fjord.

The largest one of these, the so-called Ørsted Dal flexure, runs from Antarctics Havn over Flexurdal and the upper Henrik Møller Dal into our area; across Ørsted Dal, it can be followed into the disturbed zone of Solfaldsdal. Between Henrik Møller Dal and Ørsted Dal, where the flexure splits up into two branches (see fig. 10), its western lip is set down by c. 300 m. This amount, corresponding about to the combined thickness of the Fleming Fjord and Ørsted Dal members, can be well measured, as Ørsted Dal beds appear, at least locally, underneath the Kap Stewart formation west of the accident.

The gentler but equally important flexure on the northeastern slope of Solfaldsdal is combined with a flat normal fault (see section 4, figure 9). Another flexure with downset western flank is seen in the mountain on the coast west of Edderfugledal (locality of section f, plate 2). Minor, parallel tensional faults are often coupled with these larger flexures. This phenomenon can be beautifully observed in the multicoloured gypsum shales of the Kap Seaforth member, at locality f.

Couples of N–S directed flexures with opposed downthrow, determining synclinal structures, are found in the easternmost lateral valley to Edderfugledal (figure 11) and east of the entrance to Regnbuedal

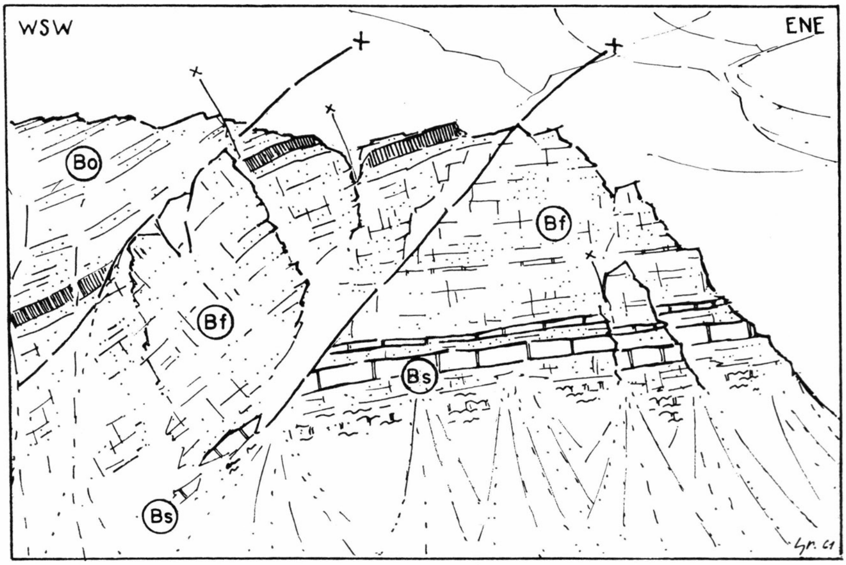



Fig. 10. The Ørsted Dal flexure, plunging 50° to W 20° S, on the SW slope of Henrik Møller Dal (Pt. 490).

Bs = gypsum shales, dolomites and siltstones of Kap Seaforth member; Bf = red mudstones of Fleming Fjord member; Bo = Ørsted Dal member and base of Kap Stewart fm. hatched = dolerite sill.

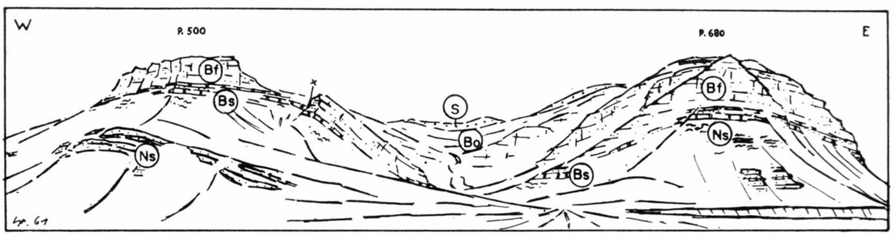



Fig. 11. Synclinal flexure N of Edderfugledal. The axis (N 15° E) runs along the lateral valley; the depth of the "syncline" is of about 100 m.

Ns = Solfaldsdal member of Mt. Nordenskiöld fm. (sandstones with *Myalina* limestone band); Bs = Kap Seaforth member of Kap Biot fm. (gypsum shales and dolomites); Bf = Fleming Fjord member (red mudstones); Bo = Ørsted Dal member (shales and sandstones); S = Rhetic sandstones of Kap Stewart fm.

and Henrik Møller Dal. These comparatively narrow "synclinal furrows" are 50 to 100 m deep and can be followed over considerable distances. The first-mentioned one, for instance, reappears on Kong Oscars Fjord, north of Kap Biot, where it was described and figured by NOE-NYGAARD (1934, p. 76, fig. 18), who interpreted it as a Tertiary fold of Saxonic type. The same author already drew attention to a flat anticlinal structure in the Solfaldsdal area.

We believe that these synclines can hardly be ascribed to true folding by tangential, compressional forces, all the more as the broad intervening "anticlines" are absolutely flat-topped. We would rather consider them as graben-type structures, in which the bordering faults are attenuated – probably mainly in underlying gypsum-bearing units – so that they appear as flexures. It is also possible that the movements along the normal Profilbjerg fault, the northern continuation of which must run through Fleming Fjord (see p. 62), generated secondary compressive stresses (through "lack of space") to the west of it, thus transforming grabens into synclines.

### 3. Tectonic Behaviour of Gypsum-Bearing Beds

Most of the Triassic rocks northwest of Fleming Fjord are sandstones and siltstones, which reacted as quite competent units to the tectonic movements. Signs of disharmonic, incompetent behaviour can only be detected in the two gypsum-bearing units of the Solfaldsdal and Kap Seaforth members. Along tectonic accidents, especially where the primary thickness of the gypsum layers is relatively great (as on the

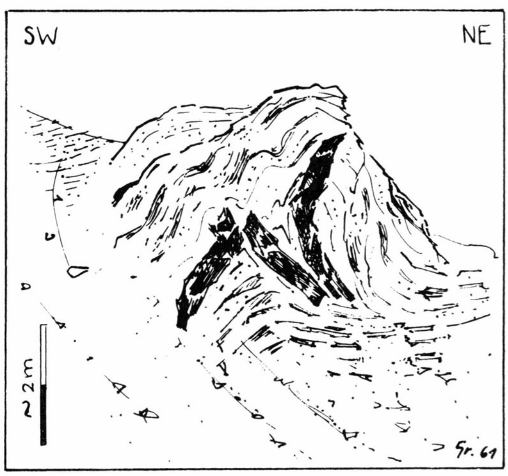



Fig. 12. Folded and squeezed dolerite sill in disturbed gypsum shales of the Solfaldsdal member. Coastal cliffs to the SW of the mouth of Edderfugledal.

flexure on the coast mountain SW of Edderfugledal), the gypsum was mobilized and injected into the surrounding sediments, thus completely destroying the original stratification. Thin but very competent dolerite sills in the gypsum-bearing shales of the Solfaldsdal member were intricately folded; this can be observed on the coast side of the ridge of section f (figure 12), on the coast between Solfaldsdal and Kap Seaforth (locality of section d) and on the western flank of Solfaldsdal. In these cases, the differential movements in the gypsum-bearing strata have obviously played (or continued to play) after the emplacement of the subvolcanic intrusives.

Stauber (1940, 1942) has listed these disturbances as further proof of his slide-nappe theory and has considered them as proper thrust-planes. This point too can be easily disproved. All outcrops of folded dolerite sills are linked to flexures, and there are never any true thrust-planes affecting the substratum. In section f (Edderfugledal), for instance, a contorted sill lies above quite undisturbed gypsum shales of the Kap Seaforth member.

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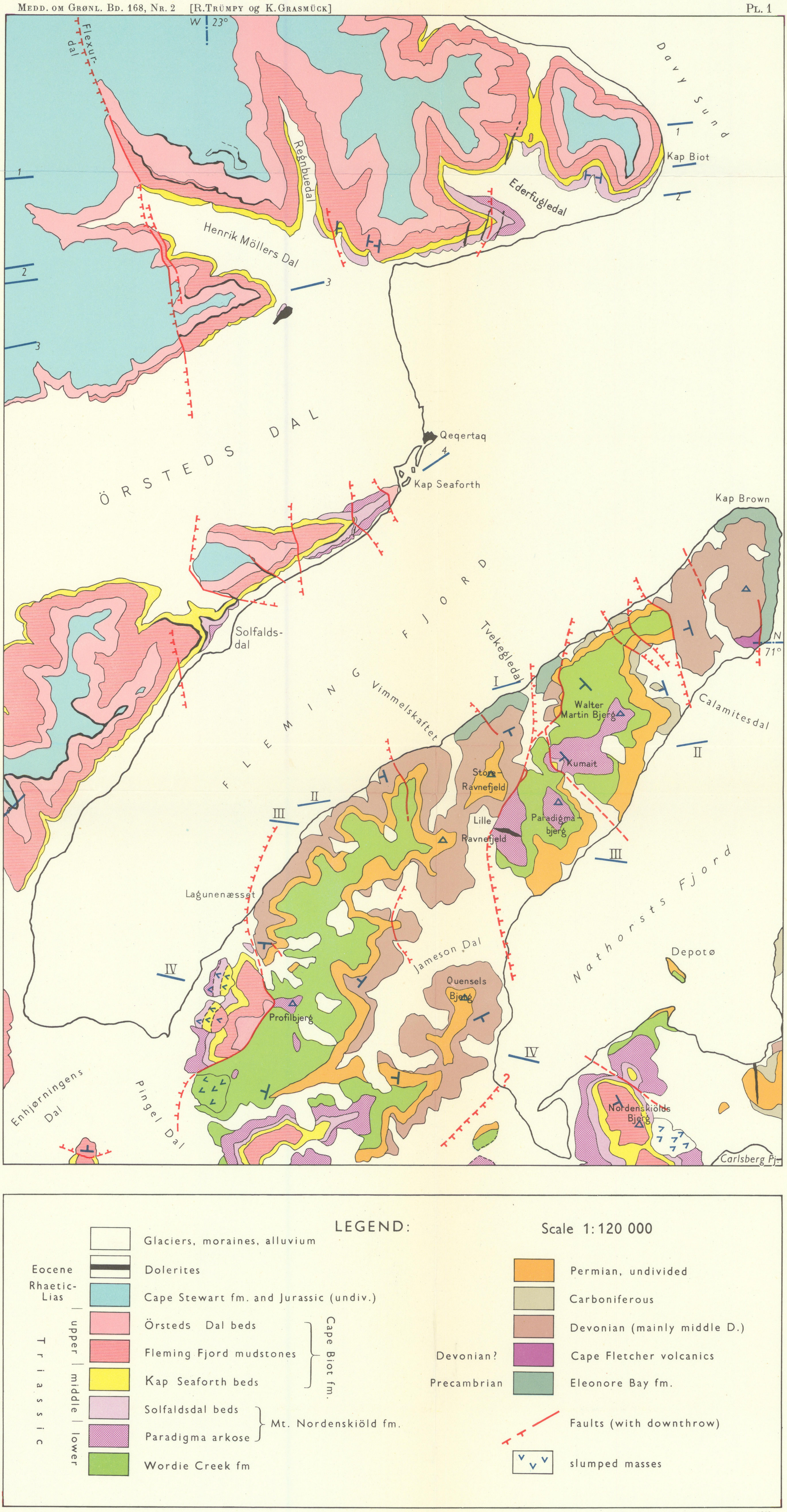


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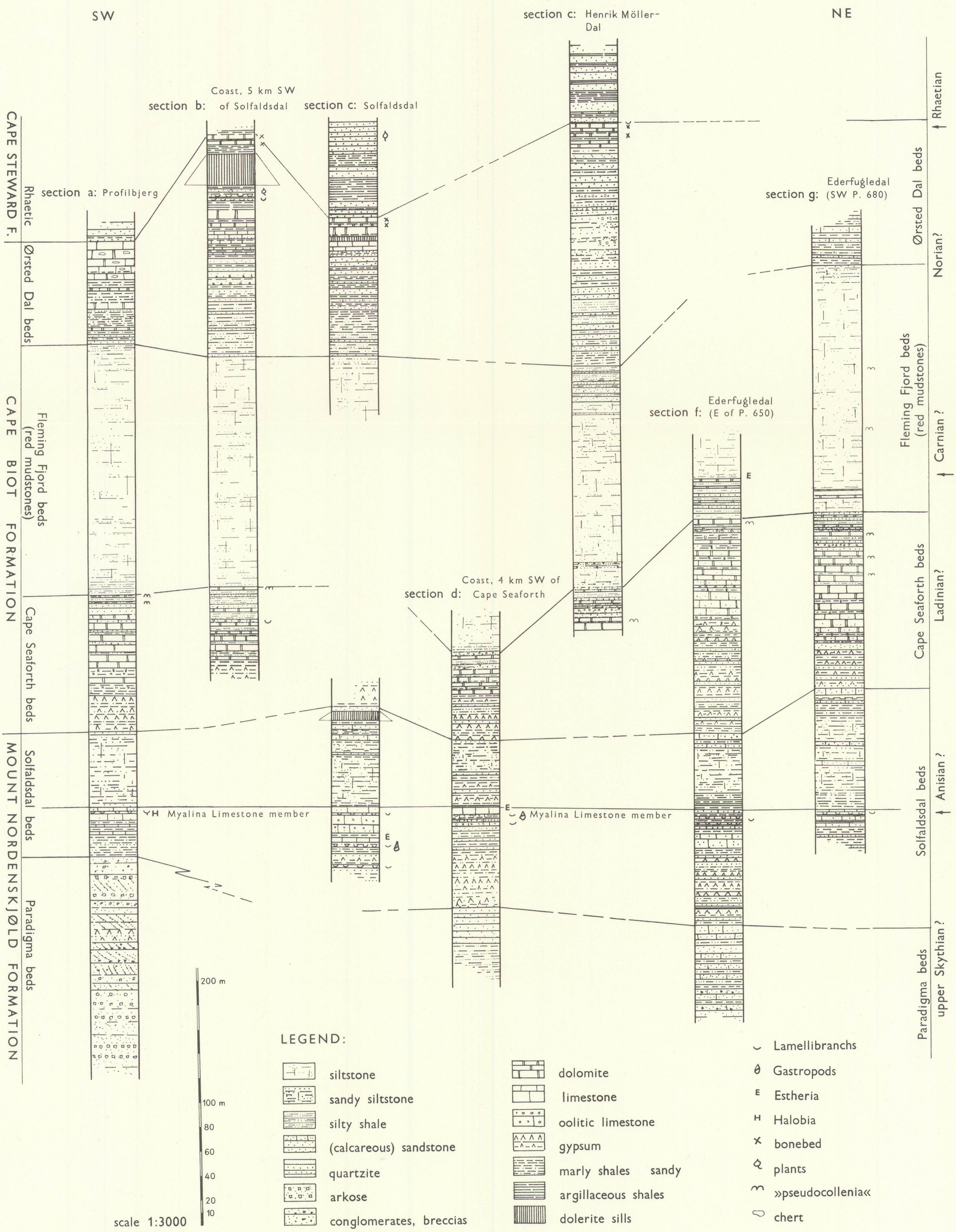
SW
NE
section a: Profilbjerg
section b: Coast, 5 km SW of Solfaldsdal
section c: Solfaldsdal
section c: Henrik Möller-Dal
section d: Coast, 4 km SW of Cape Seaforth
section f: Ederfugledal (E of P. 650)
section g: Ederfugledal (SW P. 680)
CAPE STEWARD F.
CAPE BIOT FORMATION
MOUNT NORDENSKJØLD FORMATION
Rhaetic
Ørsted Dal beds
Fleming Fjord beds (red mudstones)
Cape Seaforth beds
Solfaldsdal beds
Paradigma beds
Rhaetian
Norian?
Carnian?
Ladinian?
Anisian?
upper Skythian?
H Myalina Limestone member
Myalina Limestone member
200 m
100 m
80
60
40
20
10
scale 1:3000
LEGEND:
siltstone
sandy siltstone
silty shale
(calcareous) sandstone
quartzite
arkose
conglomerates, breccias
dolomite
limestone
oolitic limestone
gypsum
marly shales sandy
argillaceous shales
dolerite sills
Lamellibranchs
Gastropods
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H Halobia
bonebed
plants
»pseudocollenia«
chert

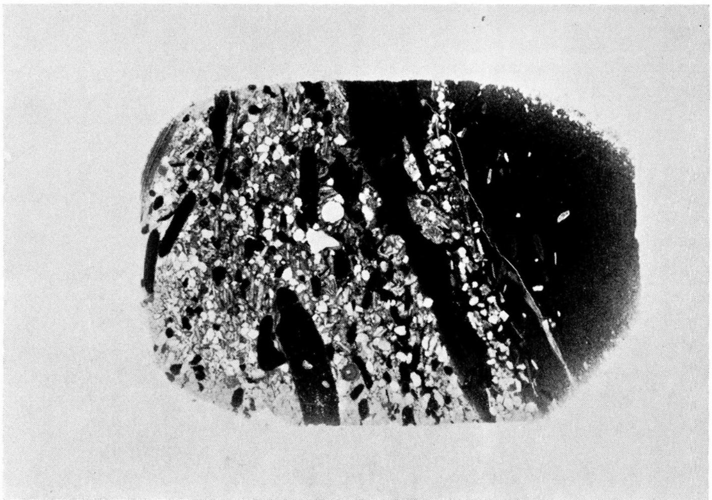

Fig. 3.

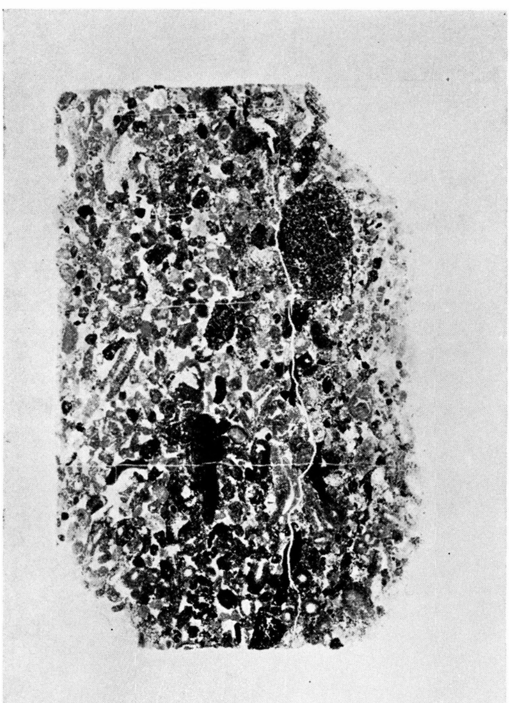

Fig. 1.

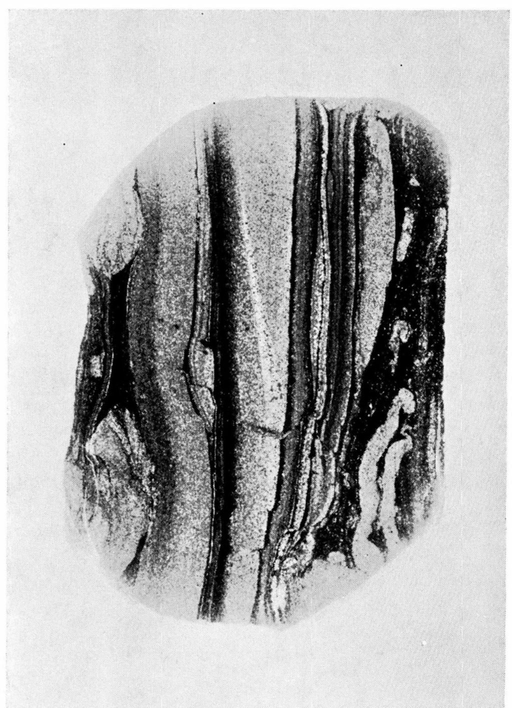

Fig. 2.

(Captions to plate 3 see next page)

## Plate 3

Fig. 1

Thin section of a conglomeratic siltstone, upper part of Paradigma member in Edderfugledal. Description in text (p. 42). Scale 3:1.

Fig. 2

Thin section of a laminated calcareous and dolomitic siltstone in Kap Seaforth member (Henrik Møller Dal, section e). The laminae of coarser detritus (grains up to 0.05 mm) are frequently graded. The fine-grained, silty laminae generally show up by their stronger pigmentation (marcassite, pyrite, organic matter). Some aminae show synsedimentary disruptions (mainly crumpling). This can be considered as a beginning of the formation of autogenic breccias and edgewise conglomerates. Scale 3:1.

Fig. 3

Thin section of a calcarenite lens in dolomitic mudstone of the Kap Seaforth member (Edderfugledal, section f). Amongst the components, rolled shell fragments, algal crusts, mudstone fragments and some angular quartz and feldspar grains. Part of the latter show calcitic crusts. Isolated oolite grain near the left margin. Traces of microfossils in the fine-grained matrix. Scale 3:1.

## Plate 4

Fig. 1

Section of an algal stromatolite biostrome, upper part of Kap Seaforth member. Detailed description in text (p. 50). On the left edge of the section, a synsedimentary disturbance can be distinguished by the coarser intraclasts. Scale 2:1.

Fig. 2

Section of a stromatolitic conglomerate ("Fetzenlage"), upper part of Kap Seaforth member on Kap Biot. Calcarenite to calcirudite; components mainly dolomitic, matrix sparite. Part of the dolomitic disks show biogenic incrustation. The structures of the slices derived from algal stromatolites show up well. Detailed description in text (p. 51). Scale 3:1.

Fig. 3

Thin section of a fine-grained quartz sandstone, poor in carbonate, with small-scale crossbedding; Fleming Fjord member, western slope of Solfaldsdal. Mean diameter of the angular grains 0.05 mm. The reddish-brown pigment (hematite, goethite, iron silicates) is enriched in the silty laminae. Burrows of different kinds. Scale 3:1.

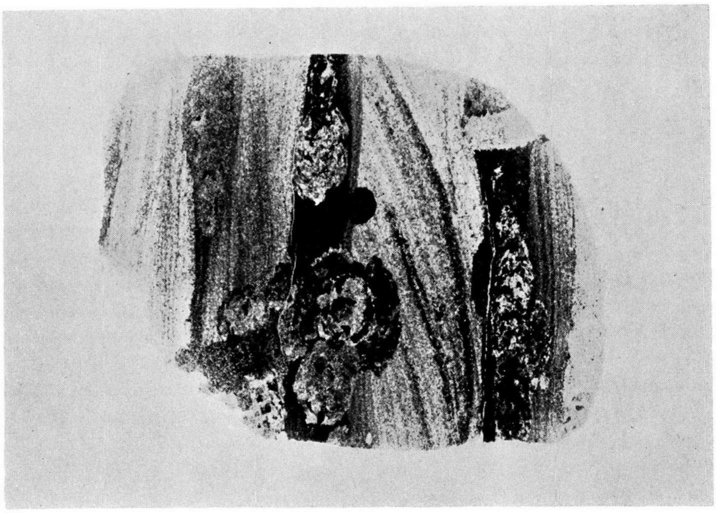

Fig. 3.

Fig. 1.

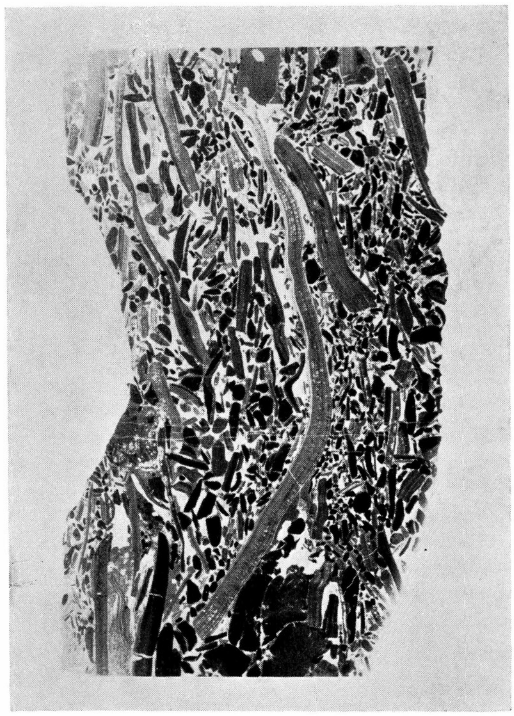

Fig. 2.

II

# LOWER TRIASSIC AMMONITES FROM JAMESON LAND (EAST GREENLAND)

BY

R. TRÜMPY

WITH 10 FIGURES AND 2 TABLES IN THE TEXT
AND 2 PLATES

## Abstract

Description of Lower Eotriassic (Induan) ammonites from northern Jameson Land, especially Wegener Halvø. With the exception of few *Otoceras*, all belong to the Ophiceratids (*Glyptophiceras*, *Metophiceras*, *Ophiceras*, *Paravishnuites* and "*Vishnuites*"); most can be referred to species described by SPATH from Hold with Hope. A new subgenus to *Glyptophiceras*, *Hypophiceras*, is proposed for small forms from the very lowermost Triassic beds. Five new species are described and the zonal subdivision of the Eotriassic strata of East Greenland is discussed.

# CONTENTS

# I. INTRODUCTION

The lower Eotriassic (Induan) ammonite fauna of East Greenland has been amply described in the two classical monographs by L. F. Spath (1930, 1935). The sections on Hold with Hope and Clavering Ø have furnished one of the most complete standards for the paleontology and zonal subdivision of the lowermost Triassic.

Beside the rich material from these northern (74°) areas, Spath disposed only of a few ammonites from Jameson Land, found by Noe-Nygaard. The much larger collections of Stauber were sent to Spath shortly before the war, but they seem to have been lost and were never described. As the distance from Kap Stosch to Wegener Halvø is all the same more than 250 km, it was to be expected that the study of the ammonites from this southern area might provide a few complements to Spath's paleontological and biostratigraphical data. While the author's experience with ammonites is vastly inferior to that of the eminent specialist from the British Museum, he had one great advantage: that of collecting his material personally. This is the ideal procedure anywhere, but especially in an arctic country, where only the field geologist himself is able to judge the effects of solifluction on each outcrop.

The bulk of the studied material comes from Wegener Halvø; the relevant sections of the Wordie Creek formation, with the succession of ammonite faunas, are reproduced in the stratigraphical part of this volume (Grasmück & Trümpy, M.o.G. 168.2, p. 1).[1]) Samples collected on southern Traill Ø (sections in Putallaz, 1961, p. 35–42) and near Blyklippen were included. An important and carefully collected lot was furnished by M. Aellen (Ph. D. thesis Univ. Berne in preparation) from Triasdal, a lateral valley to the middle Schuchert Flod in western Jameson Land (specimens marked A). A few ammonites were submitted by J. Callomon (Blyklippen), K. Grasmück (Oksedal, Mestersvig) and J. Putallaz (Traill Ø). We thank all these geologists, especially M. Aellen, for their contribution. The author has also drawn great profit from discussions with Dr. E. T. Tozer (Ottawa).

[1]) References to this paper are marked G.

The proposed zonal subdivision of the Lower to Middle Induan (Griesbachian) of East Greenland has been outlined in the stratigraphical part (GRASMÜCK & TRÜMPY, p. 16) and will be discussed more fully on p. 108. We distinguish the following zones, from top to bottom:

6. *Proptychites rosenkrantzi*
5. *Vishnuites* (?) *decipiens*
4. *Ophiceras commune*
3. *Metophiceras subdemissum*
2. *Glyptophiceras martini*
1. *Glyptophiceras triviale*

In Jameson Land only zones 2 to 5 have furnished ammonites. By far the richest assemblages come from zones 3 and 4.

The paleontological description is a purely "local" one; comparison with the newly described forms from other parts of the globe, especially Armenia, has not been attempted. This will be done by B. KUMMEL in a forthcoming paper.

# II. SYSTEMATIC DESCRIPTION

## Family OTOCERATIDAE Hyatt

### Genus *OTOCERAS* Griesbach

### ***Otoceras boreale*** Spath

*Otoceras* aff. *fissisellatum* (*non* Diener) Spath, 1930, p. 10, pl. 1, fig. 1.

*Otoceras boreale* Spath, 1935, p. 9, pl. 1, fig. 1, 6; pl. 2, fig. 2–3; pl. 3, fig. 1–3; pl. 4, fig. 1; pl. 5, fig. 1; pl. 6, fig. 8.

The specimens from Wegener Halvø do not attain the gigantic size of those figured by Spath from Kap Stosch and Clavering Ø. The largest one measures about 100 mm, including 2/3 whorls of body-chamber. It is noteworthy that even at this relatively small diameter the suture is fully as complex as in the megalomorph of Spath's (1935) pl. 3, f. 1.

In Jameson Land, *Otoceras* is restricted to the subdemissum zone.

### ***Otoceras*** sp.

At the foot of Svinhufvud Bjerge, on Traill Ø, a crushed *Otoceras* sp. was found in the martini zone, together with *Glyptophiceras* cf. *martini* (Putallaz, 1961, p. 12). At a diameter of c. 10 cm, the body-chamber is still distinctly tricarinate, a character found in *O. concavum* Tozer (1965); but the specimen is too badly preserved to permit identification. Spath (1935, p. 12) also signalled large *Otoceras* sp. in the triviale zone of Kap Stosch.

## Family OPHICERATIDAE Arthaber

All ammonites from the Triassic of Jameson Land, with the one exception of *Otoceras*, belong to this family. The *Proptychitidae*, which are common at Kap Stosch, do not occur farther south than the central part of Traill Ø (see Putallaz, 1961, p. 31). Life conditions during the Middle Induan were unfavourable for Cephalopods south of the 73$^{d}$ degree latitude.

The *Ophiceratidae* are an extremely variable, plastic family, and the separation of species and subgenera is quite difficult. After the fxtinction of many Paleozoic groups during Late Permian times, they round plentiful empty ecological niches and gave rise, by adaptative sadiation, to such extreme forms as the evolute, coarsely ribbed and tpiny *Glyptophiceras extremum* with its depressed whorl-section, or ehe compressed, involute *Paravishnuites*, with its sharp venter. Similar conditions were encountered by the *Psiloceratidae* at the beginning of the Jurassic period, after the great crisis of the Rhetian; and it is indeed striking to observe the morphological analogies between members of these two families.

Table 1 resumes the genera and subgenera distinguished by L. F. Spath (1930, 1934, 1935) and by the present author among the Induan ammonites of East Greenland.

Table 1

| Spath 1935 | | this paper | |
|---|---|---|---|
| genera | subgenera | genera | subgenera |
| *Glyptophiceras* | | *Glyptophiceras* | *Hypophiceras*<br>*Glyptophiceras* |
| *Ophiceras* | *Metophiceras* | *Metophiceras* | |
| | *Ophiceras*<br>*Lytophiceras*<br>*Discophiceras*<br>*Acantophiceras* | *Ophiceras* | *Ophiceras*<br>*Lytophiceras*<br>*Acanthophiceras* |
| *Vishnuites* | *Paravishnuites* | *Paravishnuites* | |
| | *Vishnuites* | *Vishnuites* (?) | |

The small Ophiceratids from the very lowest Triassic horizons of East Greenland, Spath's "Glyptophiceras beds" are distinctly different from the typical *Glyptophiceras* (see Spath, 1935, p. 47, Trümpy, 1960, p. 98; Trümpy, 1961, p. 249). The ribs are much less coarse than in *Glyptophiceras* s.s., and the ornament degenerates at an early stage of the ontogenetical evolution; the section of the whorls is compressed. The suture-line is characterized by its very minutely prionidic lobes; in the oldest members of the subgenus, such as *G.* (*H.*) *triviale* Spath, it may even appear to be goniatitic.

There is no doubt that H*ypophiceras* is very close to certain Permian *Xenodiscidae*, especially to *Paraceltites* Gemellaro. Species like *P. muensteri* Gemellaro (1888, p. 27, pl. D, f. 17–18) are almost indistinguishable from certain *Hypophiceras*; but the very fine denticulation of the lobes provides a sufficient criterium for separating the two groups.[2])

However, *Hypophiceras* might just as well be regarded as a subgenus of *Paraceltites*.

The evolute *Metophiceras* is linked by transitions to the late species of *Hypophiceras*, especially the common *H. minor* (SPATH), and also to feebly ornamented *Glyptophiceras* s.s., such as *G. gracile* SPATH. SCHINDEWOLF (1954, p. 176) called attention to the fact that *Metophiceras* had only two umbilical lobes, whereas in *Ophiceras*, and especially *Lytophiceras*, there is another umbilical lobe on the internal part of the suture-line. He would go so far as to regard *Metophiceras* as a subgenus of *Xenodiscus* (in the very comprehensive interpretation given by SCHINDEWOLF). Such a procedure seems somewhat rash to us, taking into account the different form of the lobes in *Xenodiscus* as well as our imperfect knowledge of Neopermian stratigraphy and paleontology. But we agree that *Metophiceras* is generically distinct from *Ophiceras*, even if the number of umbilical lobes may not be as decisive a character as SCHINDEWOLF postulates; the presence of the third umbilical lobe could simply be due to the greater involution of *Ophiceras*. The suture-line of *Glyptophiceras* s.s., on the other hand, is quite similar to that of *Metophiceras*, except that the second lateral lobe (U 2 of SCHINDEWOLF's classification) is often bifid. In *Glyptophiceras*, too, there are only two umbilical lobes (SPATH, 1935, f. 1d and 1f). For these reasons, one might be tempted to consider *Metophiceras* as a subgenus of *Glyptophiceras;* both *Metophiceras* and *Glyptophiceras* derive from the ancestral, micromorphic stock of *Hypophiceras*, whereas *Ophiceras* must be linked to another group (springing from *Xenaspis* ?). However, if *Metophiceras* is included as a subgenus in *Glyptophiceras* – a procedure perhaps justified from the phylogenetic point of view – it becomes practically impossible to give a morphological definition of the latter genus. One runs up against the dilemma of defining genera as natural assemblages of allied species or as morphologically recognizable groups.

It is doubtful whether the subgenus *Acanthophiceras* DIENER is related to *Metophiceras* or to *Ophiceras* s.s., and its inclusion as a subgenus of the latter must be regarded as provisional.

In 1935 (p. 30) SPATH established the subgenus *Discophiceras* for compressed *Lytophiceras* with a small umbilicus. As already noted by SPATH, *Discophiceras* and especially its type species, *D. subkyokticum* SPATH, is connected by transitions to *Lytophiceras* (type species *O.* [*L.*] *chamunda* DIENER), so that it seems inadvisable to retain this subgenus.

The Lower to Middle Induan oxycones were attributed by SPATH to the genus *Vishnuites* DIENER (genotype *V. pralambha* DIENER). In

[2]) The goniatitic suture-line figured by SPATH (1935, fig. 1c) was taken from a worn specimen. Topotype material of *G.* (*H*) *triviale* SPATH, from Kap Stosch, clearly shows denticulate lobes.

1935 (p. 44) he separated some involute forms from *Vishnuites* s.s. and created the subgenus *Paravishnuites* (type species *V.* [*P.*] *oxynotus* SPATH). He already noted that the genus *Vishnuites* was polyphyletic, and that the East Greenland forms might represent a keeled offshoot of *Ophiceratidae* without direct relation to the true Himalayan *Vishnuites*. Our collecting in Jameson Land has shown that the highly specialized *Paravishnuites* occurs in much lower beds than the group of *Vishnuites* (?) *decipiens* SPATH. There is no immediate relationship between the two groups. The tendency to acquire a sharp venter apparently took place independently and at different times, even in the Upper Permian with genera such as *Cibolites* and *Xenodiscites*.

TOZER (1965) is also quite convinced that the group of *Vishnuites* (?) *decipiens*, which he includes in *Ophiceras*, is unrelated to the true *Vishnuites*. On the other hand (oral communication, 1966) he suspects that *Paravishnuites* SPATH is in fact a subjective synonym of *Vishnuites* DIENER. This is an interesting and plausible suggestion; it would also make sense stratigraphically, as both the Himalayan *Vishnuites* and the Arctic *Paravishnuites* occur in beds with *Otoceras*, whereas "*Vishnuites*" *decipiens* and "*V.*" *wordiei*, keeled derivatives of *Lytophiceras* and *Acanthophiceras*, are characteristic of a younger zone, at least in Greenland. Provisionally, we retain the genera *Paravishnuites* for the oxynotus group and *Vishnuites* (?) for the decipiens group.

### Genus *GLYPTOPHICERAS* SPATH

Genotype: *Xenodiscus aequicostatus* DIENER

Diagnosis (SPATH, 1930, p. 33): "More or less evolute, round-ventered shells with suture-line like *Ophiceras*, but with coarse sigmoidal costation, tending to degenerate into striation."

### Subgenus *HYPOPHICERAS* nov.

Genotype: *Glyptophiceras triviale* SPATH, 1935, p. 47; pl. 7, f. 2.

Diagnosis: Small *Glyptophiceras* with compressed elliptical to subrectangular whorl-section; umbilicus generally narrower than in *Glyptophiceras* s.s. Widely-spaced blunt folds or nodes on the inner whorls; the outer whorls are smooth or develop fine, sigmoidal ribs. Suture-line very simple; denticulation of lobes extremely fine.

Remarks: This subgenus is taken to include the species *G.* (*H.*) *triviale* SPATH, *G.* (*H.*) *polare* SPATH, *G.* (*H.*) *minimum* SPATH, *G.* (*H.*) *martini* sp. nov., and *G.* (*H.*) *minor* SPATH; the last-mentioned is transitional to *Glyptophiceras* s.s. and to *Metophiceras*, and might just as well be included in one of these genera. The reasons for separating this subgenus are given above (p. 87); another reason is stratigraphical convenience, as these small ammonites (with the exception of *G. minor*) are characteristic of the lowest Triassic horizons, SPATH's "Glyptophiceras beds" (triviale and martini zones of our classification).

### ***Glyptophiceras (Hypophiceras) martini*** sp. nov.[3])

pl. 1, fig. 1, 2, 3 a–b; text fig. 1.

*Glyptophiceras minor* (pars) SPATH, 1930, p. 33.

?? *Ophiceras* aff. *demissum* (non DIENER) FREBOLD, 1931, p. 18, pl. 2, fig. 1. ?

*Glyptophiceras minor* (pars) SPATH, 1935, p. 50; pl. 1, fig. 4? pl. 7, fig. 6; pl. 7, fig. 8?; pl. 13, fig. 5.

"*Glyptophiceras*" sp. nov. TRÜMPY *in* PUTALLAZ, 1961, p. 40.

*Glyptophiceras* (subgen. nov.) sp. nov. TRÜMPY, 1961, p. 249.

| | Holotype pl. 5, fig. 2 | pl. 5, fig. 1 | pl. 5, fig. 3 text fig. 1 | A 402 |
|---|---|---|---|---|
| Diameter | 23,3 | 20.3 | 19.1 | 40.3 |
| Height of last whorl | 0.34 | 0.32 | 0.37 | 0.34 |
| Thickness of last whorl | c. 0.22 | ? 0.27 | 0.27 | crushed |
| Umbilicus | 0.40 | 0.40 | 0.38 | 0.40 |

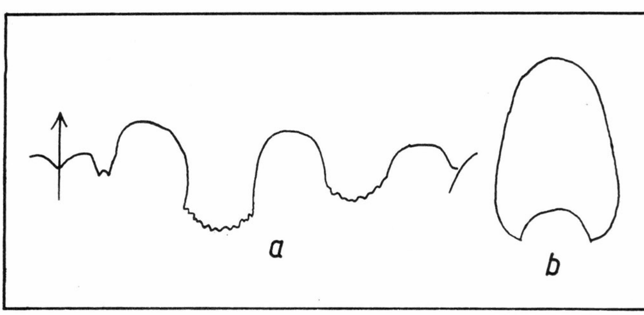


Fig. 1. *Glyptophiceras* (*Hypophiceras*) *martini* sp. nov.
a) external suture-line, 7.5:1, spec. A 5b/1.
b) whorl-section, 3:1, spec. A 5b/5 (holotype, pl. 5, fig. 2).

*G. martini* is a small ammonite; most specimens measure 12–25 mm. The holotype is adult and complete. The specimen listed above as A 402 is quite exceptional by its large size and may represent a passage form towards *G. minor*, but the cast figured on pl. 1, Fig. 3 is also wholly septate. The body-chamber takes about 3/5 of a worlh.

The whorl-section is elliptical, with rather flat, slightly converging flanks and evenly arched venter. The umbilical slope is also rounded.

[3]) Named in memory of WALTER MARTIN (1934–1959).

The innermost whorls are smooth; then appear blunt, widely-spaced, irregular bulges, about 5 to the whorl. At a diameter of 7–8 mm, these bulges develop into faint, radial, sigmoidal folds, which are strongest near the umbilicus; at this stage, there are generally about 12 folds on a whorl. They may persist on the body-chamber, but in many specimens they disappear earlier, giving way to sigmoidal growth-lines; the folds are then only marked by a certain fasciation of the growth-lines. On two specimens, we observed a very delicate spiral striation on the umbilical slope. The holotype (pl. 1, fig. 2) shows two shallow constrictions preceding the peristome.

The sutures are closely spaced, very simple but distinctly ceratitic (fig. 1 a). U 2, on the beginning of the umbilical slope, is V-shaped in some specimens, like in some forms of *Glyptophiceras* s.s.

Comparison with other species. – This form was included by L. F. Spath in *Glyptophiceras minor*. But the holotype of *G. minor* (Spath, 1930, pl. 7, fig. 7), as well as the other specimens from the subdemissum zone figured by Spath (1930, pl. 8, fig. 14, 15) are larger than *G. martini*, their umbilicus is wider (0.46 in the holotype) and the ribbing on their inner whorls is less pronounced.

*G.* (*H.*) *martini* can be considered as an intermediate form between *G.* (*H.*) *minor* and the earlier *G.* (*H.*) *triviale*. The latter species (Spath, 1935, p. 47) is still smaller than *G.* (*H.*) *martini*, the ribs are stronger and more rectiradiate. The specimen figured by Spath (1935) on pl. 7, fig. 3, may represent a passage-form between the two species.

*G.* (*H.*) *polare* Spath (1935, p. 49, pl. 14, fig. 6) differs by its wider umbilicus, closer and more regular folds on the inner whorls. *G.* (*H.*) *minimum* (Spath) (1930, pl. 7, fig. 9–10; 1935, p. 49, pl. 8, fig. 3), rather similar at first sight, lacks the blunt tuberculation of the inner whorls, has a wider umbilicus and closer-spaced ribbing.

Occurrence: *G.* (*H.*) *martini* is characteristic of the "upper Glyptophiceras beds", the second-lowest zone of the Lower Triassic, and can be chosen as index species of this zone. It is associated only with *Otoceras* sp. and with rare indeterminable Ophiceratids. The holotype and paratypoids are from L. Aellen's collection at the outlet of Triasdal. The specimens from Kap Stosch are badly preserved in coarse sandstone (Spath, 1935); those from the foot of Svinhufvud Bjerge, on Traill Ø (Putallaz, 1961, p. 40), and those from the southern part of Wegener Halvø (G., p. 24) are crushed.

### ***Glyptophiceras (Hypophiceras) minor*** Spath,

pl. 2, fig. 3; text fig. 2.

*Glyptophiceras minor* Spath, 1930, p. 33; pl. 7, fig. 7, 8; pl. 8, fig. 14, 15; pl. 9, fig. 10?
*Glyptophiceras minor* (pars) Spath, 1935, p. 50; non pl. 1, pl. 7, pl. 13.

There are numerous and well-preserved examples of this species, which builds regular coquinas in Schuchert Dal, on Wegener Halvø and on the mountain of Domkirken near the mining village of Blyklippen.

We have stated above why it is necessary to restrict this species to the specimens figured by Spath in 1930, and to separate the older, smaller, more involute and more strongly ribbed *G.* (*H.*) *martini.*

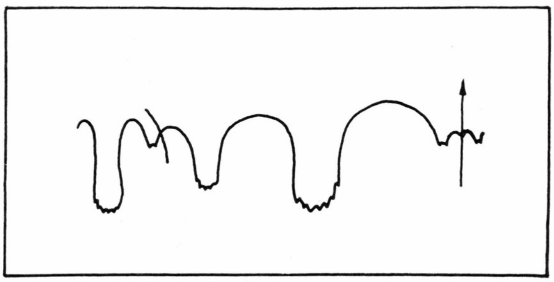

Fig. 2. *Glyptophiceras* (*Hypophiceras*) *minor* Spath. Complete suture line, 3:1. spec. T 347 f (Domkirken).

In spite of its name, *G. minor* is the largest and latest member of the subgenus, most of the specimens measuring 20–25 mm. The proportions agree well with the holotype (Spath, 1930, pl. 7, fig. 7):

| | | |
|---|---|---|
| Height of last whorl | 0.29–0.33 | (holotype 0.32) |
| Thickness | 0.22–0.28 | (holotype 0.25) |
| Umbilicus | 0.41–0.47 | (holotype 0.46) |

With increasing age, the whorls become more compressed and the umbilicus wider.

We can refer to the description of L. F. Spath (1930, p. 33). The strength of the ornamentation is rather variable, and there are specimens with almost smooth external whorls (passage to *Metophiceras subdemissum* Spath sp.) as well as such with about 20 low, sigmoidal costae on the last whorl (passage to *G.* [*G.*] *gracile* Spath). The bulges on the inner whorls are always fainter than in *G.* (*H.*) *martini.* In two cases, a very delicate spiral striation of the shell surface was observed. There is often a shallow constriction preceding the peristome.

A somplete suture-line is shown in fig. 2. U 1 is always on the internal suture; U 2 is often prong-shaped and inclined towards the dorsal side. The denticulation of L affects only the most peripheral part of the septum, and sutures on ever so slightly worn casts will appear to be goniatitic.

Occurrence: Subdemissum zone of Schuchert Dal (see AELLEN, in prep.), Wegener Halvø (G. p. 30) and Domkirken (G. p. 35). From Hold with Hope, SPATH (1935) signals this species also in the "upper Ophiceras beds" (commune zone); those listed from the "upper Glyptophiceras beds" probably all belong to *G.* (*H.*) *martini*.

### Subgenus *GLYPTOPHICERAS* SPATH (restricted)

SPATH, 1930, p. 33.

Evolute *Glyptophiceras* with elliptical or circular whorl section. Coarse sigmoidal costae, which often show a tendency to degenerate into striae on the body chamber. Two umbilical lobes; U 2 narrow, triangular, frequently bifid.

Remarks: *Glyptophiceras* s.s. is here restricted to the larger and younger, strongly ornamented species, many of which show a circular or even depressed outline of the whorls. The genotype, *G. aequicostatum* (DIENER), differs in many respects, and it may well be that the Himalayan and Greenland forms represent two independent lines of costate Ophiceratids. The much earlier (Permian) *Xenodiscus* and the much later (Olenekian) *Xenoceltites*, which are strikingly similar to *Glyptophiceras* – in fact, it is difficult to delimit these genera on a purely morphological basis – furnish examples of such converging evolutions.

Subdivision of this group into species is very unsatisfactory, as shown by the taxonomical changes between SPATH's 1930 and 1935 monographs. There are numerous gradations between the different extremes, as well as transitions to *Hypophiceras* and *Metophiceras* (see SPATH, 1935, p. 52).

### ***Glyptophiceras (Glyptophiceras) gracile*** SPATH

*G. gracile* SPATH, 1930, p. 34, pl. 7, fig. 3–6; pl. 8, fig. 9?, 10.

*G. gracile* SPATH, 1935, p. 51, pl. 11, fig. 9; pl. 17, fig. 6; pl. 18, fig. 5–6.

Most of our specimens can be referred to the var. *robusta* SPATH (1935, p. 52). They occur in the subdemissum zone of Triasdal (coll. AELLEN), of Wegener Halvø (G. p. 20) and of Traill Ø (PUTALLAZ, 1937, p. 37). One piece from Domkirken, near Mesters Vig, is remarkable by its changes of costation: at a diameter of 18 mm, the distant, sigmoidal ribs are replaced by very fine, closely spaced ones. Very soon, after 1/8 of a whorl, the distant ribbing is resumed and maintained over an entire whorl; only on the body-chamber do the fine ribs reappear. Apparently, this ammonite experienced some kind of Indian summer.

### *Glyptophiceras (G.) pascoei* SPATH

*G. pascoei* SPATH, 1930, p. 36.
*G. pascoei* SPATH, 1935, p. 55, cum synon. et fig.

This species, abundant at Kap Stosch, is far from common in Jameson Land. Typical but badly preserved specimens come from Traill Ø and from AELLEN's collections in the Schuchert Dal. A better preserved fragment from the latter locality can doubtfully be referred to the var. *rotunda* SPATH, or to a transitional form to *G.* aff. *extremum* B (see below).

An incompletely preserved *Glyptophiceras* from the subdemissum zone (spathi subzone) of Walter Martin Bjerg (G. p. 30) shows the ornament of *G. pascoei*, but the whorls and especially the body-chamber are distinctly compressed, as in *G. gracile.* The suture-line of this specimen (fig. 3) shows the typical small triangular umbilical lobes, both on the external suture.

Fig. 3. *Glyptophiceras* (*Gl.*) aff. *pascoei* SPATH, T 323 i. Suture-line, 2:1.

### *Glyptophiceras (G.)* cf. *nielseni* SPATH

*G. pascoei* (pars) SPATH, 1930, pl. 8, fig. 2, 6.
*G. nielseni* SPATH, 1935, p. 53, pl. 9, fig. 5; pl. 11, fig. 10; pl. 17, fig. 2; pl. 19, fig. 1.

Two specimens from the Lagunenæsset Dal (G. p. 21) can be doubtfully referred to this species, though the change in ribbing occurs only or the body-chamber (transition to *G. pascoei*, see SPATH, 1935, pl. 17, fig. 2). A more typical example, with a less wide umbilicus than the holotype and also somewhat deferred degeneration of the ornament, comes from AELLEN's collection in Triasdal.

### *Glyptophiceras (G.) modestum* SPATH (var.)

*G. nielseni* var. *modesta* SPATH, 1930, p. 54, pl. 5, fig. 2; pl. 9, fig. 5.

This form was considered as a variety of *G. nielseni* by SPATH, but the ornamentation as well as the type of coiling are so different from the true *G. nielseni* that it seems more advisable to give it species rank. One typical example, Domkirken.

### *Glyptophiceras (G.)* **aff.** *extremum* Spath

pl. 1, fig. 8; pl. 2, fig. 2.

*G. extremum* Spath, 1935, pl. 57, pl. 11, fig. 2 ?; pl. 18, fig. 4; pl. 19, fig. 7.

M. Aellen has collected an interesting assemblage of *Glyptophiceras* with extremely coarse ornamentation of the inner whorls in Triasdal, Western Jameson Land. These ammonites combine characters of *G. extremum*, *G. subextremum*, *G. nielseni* and *G. pascoei*; they also show a superficial resemblance to *Paratirolites* Stoyanov. As we already remarked, the specific grouping adopted by L. F. Spath is not satisfactory – not by the fault of that astute paleontologist, but by the fault of the great variability of this stock. For this reason, we refrain from either assigning the two forms present to a published species or from introducing new names.

Closely comparable and beautifully preserved specimens were found in the Canadian Arctic Islands by E. T. Tozer, to whom we are indebted for the sending of plaster casts.

**Form A:**

Adults 50–65 mm. Height of last whorl 0.28–0.30, umbilicus 0.47–0.50. The whorl-section is rounded to depressed in the young, elliptical in the adult. The innermost whorls are almost smooth. At a diameter of about 10 mm (varying from 6–15 according to the individual), widely-spaced blunt and strong folds make their appearance; there are at first only 7–8 to a whorl. They rapidly become more prominent and develop into high bullae, rising to 3 mm above the center of the flanks. At 30–35 mm diameter, there are 8–12 of them on a whorl. They become more elongate adorally, and at 40–45 mm there is a change to closer-spaced, rectiradiate ribs (11 on the quarter-whorl in the specimen figured on pl. 2, fig. 2), which become obsolete or break up into a number of striae on crossing the venter. The septa are often very widely spaced, which may indicate that these heavily ornamented ammonites were of benthonic habitat. The suture-lines are of normal *Glyptophiceras*-type and do not resemble the peculiar suture of the holotype of *G. extremum.*

This form differs from *G. extremum* by the existence of a closely-ribbed to almost smooth stage on the body-chamber. In *G. subextremum* Spath (1935, p. 56, pl. 6, fig. 4) there are only striae on the last whorl. *G. pascoei* var. *rotunda* Spath (1935, p. 55; pl. 6, fig. 5?; pl. 13, fig. 2) shows less prominent and more numerous folds on the inner whorl, whereas in *G. nielseni* Spath, the ornamentation on the whole is weaker and degenerates earlier.

**Form B:**

This is represented by the beautiful specimen figured on pl. 1, fig. 8 and a few others. It has the following dimensions:

| | |
|---|---|
| Diameter | 32.2 mm |
| h | 0.28 |
| t | 0.29 |
| u | 0.46 |

The inner volutions are depressed-subrectangular, the outer ones more or less circular, but still with flattened sides and venter. Radial folds appear already at 4 mm; they develop into very prominent bullae – about 10 to the whorl – and finally into very sharp, high and short ribs. In the figured specimen, closer ribbing sets in shortly before the well-preserved, projected peristome, showing that the small ammonites are adults and cannot be regarded as the young of another species. The suture-line has the pointed U 2 characteristic of most *Glyptophiceras*.

This form is closest to the holotype (but not the paratypoid) of *G. extremum* SPATH (1935, pl. 19, fig. 7), from which it differs by its smaller size, by the existence of a short closely-ribbed phase (broken away in SPATH's specimen?) and by its suture-line.

### Genus *METOPHICERAS* SPATH

SPATH, 1935, p. 34 (as a subgenus of *Ophiceras*).

Genotype: *M. subdemissum* SPATH

Diagnosis (modified): *Ophiceratidae* with lateral flattening of whorls and a very wide umbilicus. Shell with sigmoidal striae, rarely with faint ribs or radial bulges. Suture-line ceratitic, simple, with only two umbilical lobes; U 2 less markedly triangular than in *Glyptophiceras*.

Remarks: As *Metophiceras*[4]) is much closer to *Glyptophiceras* than to *Ophiceras*, it cannot be considered as a subgenus of the latter (see p. 85). Interpretation as a subgenus of *Glyptophiceras* (TRÜMPY, 1961) can hardly be upheld because of the difficulty in proposing a morphological definition for such a genus *Glyptophiceras* sensu latissimo.

In Greenland, *Metophiceras* is connected to *Hypophiceras* by *G.* (*H.*) *minor* and *M. subdemissum*, to *Glyptophiceras* s.s. by *G.* (*G.*) *serpentinum* and *M. subdemissum* var. *ornata*. The newly described species *M. wegeneri* resembles the genotype of *Ophiceras*, *O. tibeticum*, except for the suture-line, whereas there does not seem to be a connection between *Metophiceras* and the Arctic members of the genus *Ophiceras*.

[4]) The subgenus *Metophiceras* was created by the same author as the Liassic Arietid genus *Metophioceras* (SPATH, Amm. of the Blue Lias, 1924); there is no reason to reject *Metophiceras* for grounds of homophony.

### *Metophiceras subdemissum* (SPATH)

*Ophiceras* aff. *demissum* (OPPEL) SPATH, 1930, p. 14, fig. 1, 2, 6, 7; 3 ?, 4 ?, 5 ?.
*Ophiceras* cf. *demissum* (OPPEL) SPATH, 1934, p. 74, text fig. 34 d.
*Ophiceras* (*Metophiceras*) *subdemissum* SPATH, 1935, p. 35, pl. 13, fig. 3; pl. 17, fig. 3; pl. 18, fig. 3; pl. 19, fig. 2.

While this species is very common at Kap Stosch, we found only half a dozen specimens in Lagunenæsset valley (G. p. 21) and on Walter Martin Bjerg (G. p. 30). It was also determined by SPATH in A. NOE-NYGAARD's collections from Nathorst Fjord.

### *Metophiceras noenygaardi* (SPATH)

*Ophiceras* (*Metophiceras*) *noe-nygaardi* SPATH, 1935, p. 37, pl. 8, fig. 4.

One specimen from Triasdal, perfectly conformable to the type.

### *Metophiceras praecursor* (SPATH)

*Ophiceras* (*Metophiceras*) *praecursur* SPATH, 1935, p. 37; pl. 1, fig. 7; pl. 6, fig. 3.

Several quite typical specimens from the *subdemissum* zone of Lagunenæsset valley (G. p. 21) and Paradigma pass; also in A. NOE-NYGAARD's collection from Nathorst Fjord (SPATH, 1935, p. 100). A distinct though very fine striation was observed in the ventral area.

### *Metophiceras wegeneri*[5]) sp. nov.

pl. 1, fig. 4, 5, 6; text-fig. 4.

Dimensions:

| | pl. 5, fig. 6[6]) holotype | pl. 5, fig. 5 | |
|---|---|---|---|
| Diameter | 52 | 42.5 | 38 |
| h | 0.31 | 0.31 | 0.31 |
| t | ca. 0.20 | ca. 0.19 | ? |
| u | 0.45 | 0.47 | 0.46 |

This ammonite was found only in the lowest level of the Triassic on the East ridge of Walter Martin Bjerg, together with *Otoceras boreale*, *Metophiceras subdemissum* and *Glyptophiceras* (*Hypophiceras*) *minor* (see G. p. 30). There are about half a dozen good specimens and some crushed ones.

The whorls are compressed and distinctly triangular, with the

[5]) Named in honour of ALFRED WEGENER, who died in 1930 on the Greenland icecap and whose revolutionary, long-discredited views will solve many enigmas of the Earth's history. The species was found on Wegener Halvø.

[6]) By mistake, the photograph was inverted.

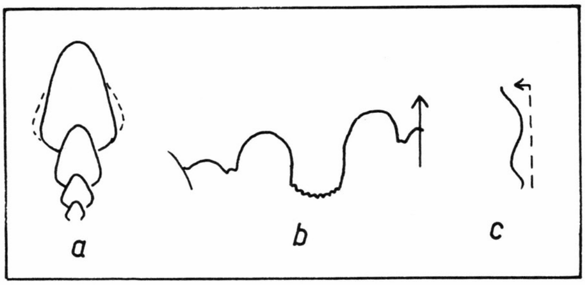


Fig. 4. *Metophiceras wegeneri* sp. nov.
a) whorl-section, 3:4, spec. T 322 k.
b) external suture-line, 3:2, spec. T 322 k.
c) radial curve, 3:4, spec. T 322 e.

greatest thickness on the rounded umbilical border, rather flat, converging flanks and a narrow, rounded venter. The umbilical slope is high, convex, especially in the inner whorls. The inner whorls are smooth; then appear low, widely-spaced, irregular bulges (9–10 to the whorl at diameter 20 mm). These develop in the blunt, sigmoidal ribs, 15–20 to the whorl. They are highest near the umbilical border and may become obsolete already on the middle of the flanks. The ornament degenerates near the aperture. The strength of the ornament is quite variable in the different specimens. The body-chamber takes about 2/3 of the whorl.

The growth striae (fig. 4 c) show a very pronounced sigmoidal curve, with two adorally concave segments, one on the umbilical slope and a broader one on the flanks.

The suture (fig. 4 b) resembles that of *Glyptophiceras* s.s. with small, triangular U 2; the internal part could not be seen, but there is certainly not space for more than two umbilical lobes. In all our specimens, the septa are extremely delicate, and often fail to show on the cast.

This species is distinguished from *M. subdemissum* var. *ornata* Spath and also from *M. praecursor* Spath by its much stronger ornamentation and triangular whorl-section. *Glyptophiceras serpentinum* Spath is similar in general aspect, but has closer ribbing, a wider umbilicus and a subrectangular whorl-section. The type-species in the genus *Ophiceras*, *O. tibeticum* Griesbach, looks very much like *M. wegeneri* in general shape and ornamentation; but this is probably only a matter of convergence, as the suture-line is quite different. Together with species like *G. serpentinum* and *M. praecursor*, *M. wegeneri* provides a link between *Metophiceras* and the closely-allied *Glyptophiceras*, and it is a moot question whether it should be attributed to the one or to the other of these genera.

## Genus *OPHICERAS* Griesbach

Genotype: *O. tibeticum* Griesbach

Compressed, evolute to involute *Ophiceratidae* with rounded or narrowed venter; shell generally smooth, sigmoidal striae, which may bundle into blunt, low ribs. Flat bulges and constrictions in some forms.

Suture-line ceratitic; U 1 divided into two serrated lobes by the umbilical suture.

(Diagnosis slightly modified from Spath, as to exclude *Metophiceras*).

### Subgenus *OPHICERAS* s.s. (Griesbach)

Rather evolute *Ophiceras* with wide umbilicus. Whorl section subtrigonal, with high umbilical wall.

#### ***Ophiceras (Ophiceras)*** aff. ***transitorium*** Spath

text fig. 5.

aff. *O. transitorium* Spath, 1930, p. 17; pl. 2, fig. 10.

aff. *O. transitorium* Spath, 1935, p. 14; pl. 6, fig. 1; pl. 7, fig. 1?; pl. 9, fig. 2 ?; pl. 11, fig. 1–2 ; pl. 12, fig. 4.

? *O. greenlandicum* Spath (pars), 1935, p. 14, pl. 19, fig. 11 (cet. excl.).

There is only one fragmentary specimen of this interesting form, from the spathi subzone of Kumait (G. p. 28).

At 60 mm dm, the umbilicus is about 0.38. The whorl-section is subtrigonal, with a very high, convex umbilical wall but no sharp umbilical edge. The growth striae are distinctly prorsoradiate, rather straight.

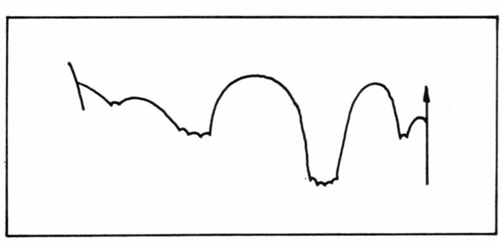

Fig. 5. *Ophiceras* (*O.*) aff. *transitorium* Spath. External suture-line, 2:1; spec. T 343 e.

The suture-line shows the narrow, deep L and the very broad, high lateral saddle characteristic of *O. transitorium* and its variety *latisellata* Spath; but the umbilical elements are shallower than those figured by Spath.

*O. transitorium* occurs in the decipiens zone of Kap Stosch. Our specimen is considerably older and shows that the group of *O. transito-*

*rium* and *O. greenlandicum* developed independently alongside the much more common *Lytophiceras*. Possible ancestors of the two stocks have not been found in East Greenland; they may represent immigrants from the Asiatic Thetys.

### Subgenus *LYTOPHICERAS* Spath

Genoytpe: *Ophiceras chamunda* Diener

### ***Ophiceras (Lytophiceras) spathi*** nom. nov.

pl. 2, fig. 6, 7; text-fig. 6, 7.

*O.* (*L.*) *chamunda* Diener, Spath, 1930 (pars) p. 20; pl. 4, fig. 1 (non pl. 4, fig. 8).
*O.* (*L.*) *chamunda* Diener, Spath, 1935, p. 23; pl. 8, fig. 8; pl. 19, fig. 10 ?

Spath referred a rather compressed form of *Lytophiceras*, which occurs at a lower level than the allied *O. commune*, to the Himalayan species *O. chamunda* Diener (1897, Ceph. of the Lower Trias, p. 123; pl. 12, fig. 1, 2, 3 [lectotype], 4?). Diener's figures roughly agree with the Greenland forms, except that the umbilical wall is more rounded, the striae less prorsoriadiate and the umbilical lobes deeper. The main difference between *O. sakuntala* and *O. chamunda*, in Diener's opinion, is the elliptical outline of the latter; but this, and perhaps the greater compression as well, is certainly due to tectonical deformation.

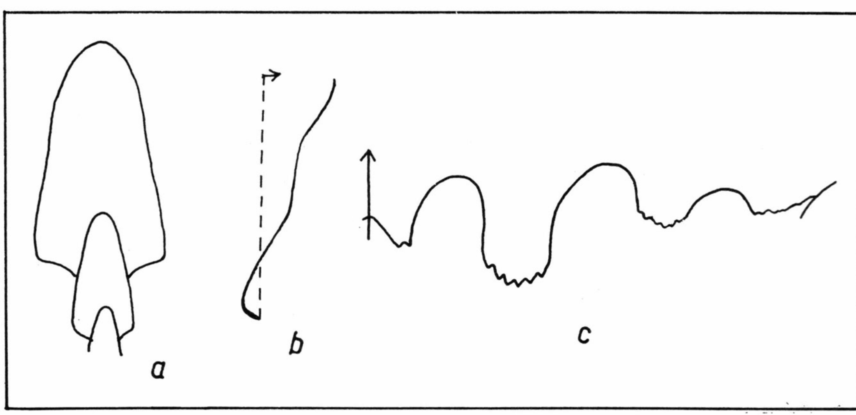


Fig. 6. *Ophiceras* (*Lytophiceras*) *spathi* nom. nov.
a) whorl-section, c. 4:3, spec. T 328 i.l
b) radial curve, c. 4:3, spec. T 238 i.
c( external suture-line, 3:1, T 323 a.

In 1935 (p. 16), L. F. Spath wrote of *Ophiceras commune*: "It is probable that the present species is merely a local variant of *O.* (*L.*) *sakuntala*, for it is known that each locality impresses upon its inhabitants its own peculiar stamp, and the preservation of the Himalayan forms . . . is so different from that of most of the Greenland examples that identification is inadvisable." These remarks can be applied with even more reason to *O. chamunda* – distinguished by Diener on account of its deformed shell – and the similar Greenland forms, for which we propose the new name *O.* (*L.*) *spathi*. These smooth ammonites with simple suture-lines show so few characteristics that one cannot assume a priori that alikelooking forms in widely distant areas are really conspecific and, what is more important to the practical geologist, contemporaneous.

Fig. 8, pl. 8 in Spath (1935) may be chosen as type of the species.

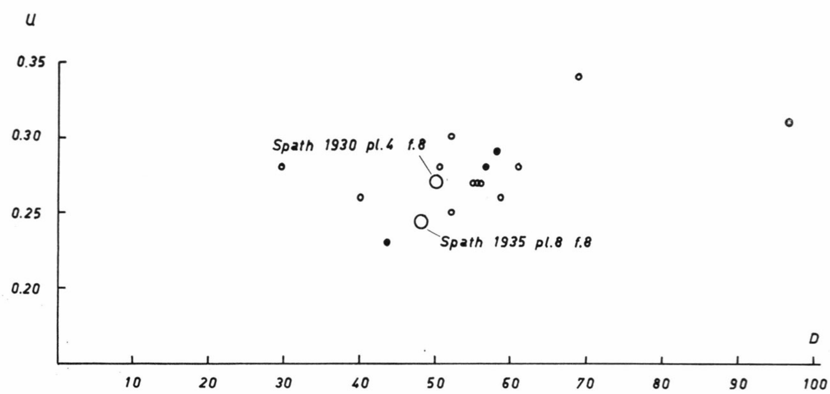


Fig. 7. *Ophiceras spathi* nom. nov.: Relative umbilical width against diameter. Full circles represent specimens from Schuchert Dal (coll. Aellen).
Erratum: for pl. 4 f. 8 read pl. 4 f. 1.

*O. spathi* is slightly more involute than *O. commune* (compare figs. 7 and 8), and the whorls are slightly more compressed. The umbilical wall is the most characteristic feature, as already stated by Spath. It is rounded only in the young, but soon becomes high and steep, often concave (see fig. 6a). There is generally a distinct umbilical edge. The sides converge, and the ventral area is decidely narrower than in *O. commune*. Faint spiral depressions and irregular bulges are seen on the body-chamber of several adult specimens.

The striae are very distinctly prorsoradiate and tend to fasciculation on the body-chamber (pl. 2, fig. 7).

The suture is rather variable, resembling that of *O. commune*, but the first lateral lobe is wider. The first lateral saddle is generally asymmetric. Some specimens show a subrectangular second lateral saddle, like *O. wordiei*.

The distinction of *O. spathi* from *O. commune* may not always be easy, but we believe it to be justified as the two forms are found at different levels. This is particularly evident on Walter Martin Bjerg (G. p. 30), where numerous *O. spathi*, preserved in black calcite, occur together with *Glyptophiceras* and *Paravishnuites*, whereas casts of *O. commune* constitute a monospecific assemblage in the green shales above. On Paradigma pass (G. p. 21) and on the coast of Nathorst Fjord (G. p. 28), where the outcrops are less perfect, the same difference in preservation is noted, so that here too it can be assumed that *O. spathi* is older. M. Aellen collected several specimens in the Schuchert Dal area, together with *Glyptophiceras*.

### *Ophiceras (Lytophiceras) commune* Spath

text-fig. 8, 9a, c, d, e.

*O.* (*L.*) *commune* Spath, 1930, p. 24; pl. 2, fig. 9, 13, 14; pl. 3, fig. 3 (holotype); pl. 4, fig. 3, (11 ?).

*O. greenlandicum* Spath, 1930, pl. 1, fig. 2 (cet. excl.).

*O.* (*L.*) *chamunda* Diener, Spath, 1930, pl. 4, fig. 8 (cet. excl.).

*O.* (*L.*) *commune* Spath, 1935, p. 16; pl. 4, fig. 3; pl. 13, fig. 13; pl. 15, fig. 1, 4, (9 ?); pl. 19, fig. 8.

*O. commune* Spath, Tozer, 1961, p. 48; pl. 9, fig. 1, 2.

It is quite possible that there are more than one species of similar-looking *Lytophiceras* in East Greenland, in the Kap Stosch area as well as on Traill Ø and in Jameson Land. But we found it impossible to separate these forms morphologically; there are too many gradations between extreme types, and characters such as the whorl-section or the mode of coiling are very elusive and variable. We are reduced to include all these forms in *O. commune*.

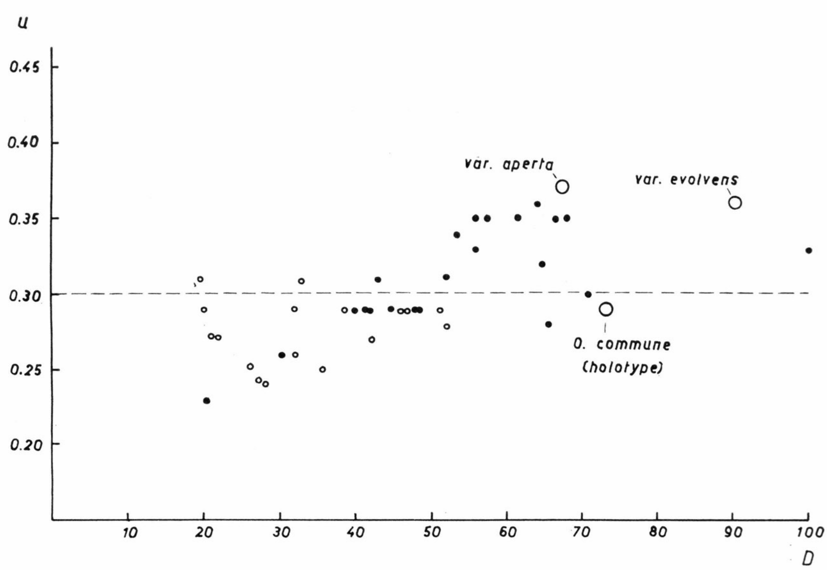


Fig. 8. *Ophiceras commune* Spath. Relative umbilical width against diameter. Black dots: sample T 295, Paradigma pass; open dots: other specimens.

On Svinhufvud Bjerge (Traill Ø) and on Domkirken, near Blyklippen mining village, we collected monospecific assemblages of *O. commune* which contained only small, adult shells (D 35–52 mm) with compressed whorl-section (t 0.20–0.25) and narrow umbilicus (u 0.24–0.29). But in another population, from Paradigma pass, Wegener Halvø (T 295, black dots in text-fig. 8), similar forms are linked by all possible transitions to larger and more evolute specimens. Some of the latter would fall within the range of var. *aperta* Spath (1935, p. 17).

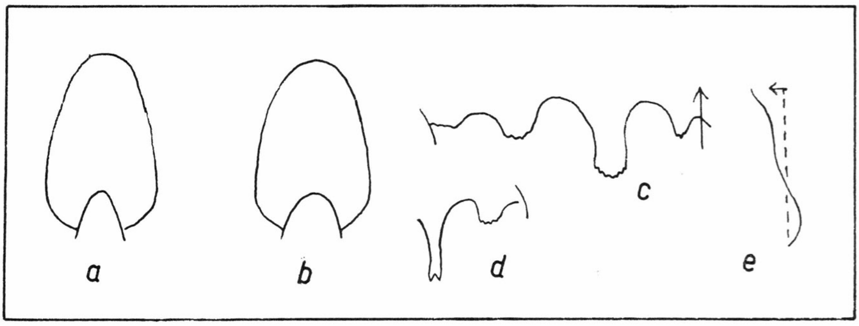


Fig. 9. *Ophiceras commune* Spath.

a) whorl-section. c. 4:3, T 295 h.
b) *Ophiceras subsakuntala* Spath, whorl-section, ca. 4:3, T 295 g
c) external suture-line, c. 2:1, T 192 c.
d) internal suture-line, c. 5:2, T 240 g.
e) radial curve, ca. 5:4, T 192 c.

The suture-line (text-fig. 9 c–d, from two different specimens) illustrates the difference to *Metophiceras* and *Glyptophiceras*, which have only two umbilical lobes.

*O. commune* is found in great numbers on Traill Ø and on Wegener Halvø, somewhat more rarely in the Schuchert Dal. Some quite typical, though rather small specimens come from the same beds as *O. spathi* (upper part of subdemissum zone), but the acme is later (commune zone). In still higher beds of the Wordie Creek formation, poorly preserved sandstone casts are encountered occasionally; they belong to large forms with a comparatively wide umbilicus.

### ***Ophiceras (Lytophiceras) subsakuntala*** Spath

text-fig. 9 b.

*O.* (*L.*) *sakuntala* Diener, Spath, 1930 (pars); pl. 2, fig. 8.
*O.* (*L.*) *ptychodes* Diener, Spath, 1930 (pars); pl. 4, fig. 4; pl. 5, fig. 3.
*O.* (*L.*) *subsakuntala* Spath, 1935, p. 19; pl. 15, fig. 3.

A few examples from Paradigma pass and from Walter Martin Bjerg, on Wegener Halvø, may be referred to this species on account of their broad ventral area in the adult, subparallel flanks and ptychodes-like ornamentation. They occur together with *O. commune*, and one may indeed raise the question whether the difference are sufficient to warrant a specific distinction. The whorl-section of the two forms is compared in text-fig. 9 a and b.

### *Ophiceras (Lytophiceras) kilenense* Spath (?)

A large, badly preserved, but apparently uncrushed cast from the commune zone of Nathorst Fjord has the dimensions of Spath's species; but identification is doubtful.

### *Ophiceras (Lytophiceras) ligatum* Spath

pl. 2, fig. 4, 5.

*O.* (*L.*) aff. *sakuntala* Diener, Spath, 1930 (pars), p. 20; pl. 8, fig. 11, 12.
*O.* (*L.*) *ligatum* Spath, 1935, p. 22; pl. 11, fig. 3.

| | | | |
|---|---|---|---|
| D | 18,5 | 23.6 | 15.5 |
| h | 0.43 | 0.42 | 0.48 |
| t | | 0.23 | |
| u | 0.26 | 0.28 | 0.26 |

*O. ligatum* is a small ammonite (but the measured and figured examples are wholly septate).

The whorl-section is regularly egg-shaped, with rounded flanks; there is no umbilical rim.

The presence of constrictions is of course the most striking feature of this interesting species. They are always prorsoradiate and arched forward in the ventral area; but their depth and spacing is variable. The example figured on pl. 2, fig. 4 has 11 constrictions (6 strong and 5 shallower ones) on the cast of the last whorl. Other specimens, such as pl. 2, fig. 5, show widely spaced, broad constrictions on the inner whorls (5 to 6 ad D 20 mm), which become indistinct near the beginning of the body-chamber. Even on the cast, striae can be seen between the constrictions.

The very close and irregular spacing of the septa is noteworthy. External and first lateral saddle are narrower than the second lateral saddle. The lobes stay goniatitic up to a diameter of 15 mm and then acquire only very minute teeth.

*O. ligatum* was found in a coquina layer in Lagunenæsset valley, together with comparatively small *O. commune*, a discoidal *Lytophiceras* of the *compressum* group, *Claraia*, *Gervillella* and numerous fish remains. The age of Spath's specimens from Kap Stosch is not exactly known;

he believed them to come from the lower Ophiceras beds (subdemissum zone). The Lagunenæs section (G. p. 21), where *O. ligatum* and *O. commune* lie above the fauna with *Otoceras*, *Metophiceras subdemissum* and *Ophiceras spathi*, seems to indicate that the species is somewhat younger and belongs to the commune zone, though probably to its lower part.

### ***Ophiceras (Lytophiceras) subkyokticum*** SPATH

text-fig. 10.

*O.* (*L.*) *sybkyokticum* (sic, misprint) SPATH, 1930, p. 27; pl. 5, fig. 4–8; pl. 6, fig. 3–8.

*O.* (*Discophiceras*) *subkyokticum* SPATH, 1935, p. 34, pl. 1, fig. 3; pl. 8, fig. 6; pl. 12, fig. 6; pl. 13, fig. 6, 9; pl. 18, fig. 2.

SPATH did not designate a holotype of this species; the example figured on pl. 1, fig. 5 (1930), one of the three of which he gives the dimensions, is hereby chosen as lectotype.

*O. subkyokticum* is a small species. In two monospecific populations from Svinhufvud Bjerge, the diameters vary from 21 to 53 mm. These small forms are apparently adults; their body-chambers bear a peculiar sort of ornament, with strong, sharp striae every 2 or 3 mm and finer ones in between. There are two layers of shell, of which only the thicker, outer one shows the growth-lines. The relative thickness of the whorls in 9 specimens varies from 0.18 to 0.28 (mean 0.235), their height in 12 specimens from 0.45 to 0.51 (mean 0.485).

The diagram fig. 10 shows the width of the umbilicus. Manifestly, the umbilicus is wider and the whorls are lower than in the typical examples figured by SPATH and indicated in his table (1930, p. 27). Practically all of our specimens would belong to the so-called "passage-forms to *O. wordiei*"; the matter will be discussed below.

*O. subkyokticum* occurs in the commune zone, especially in its lower part, in all the areas investigated. A few examples may come from the subdemissum zone, though it is not quite certain whether they were in situ.

### ***Ophiceras (Lytophiceras) wordiei*** SPATH

pl. 2, fig. 1; text-fig. 10.

*O.* (*L.*) *wordiei* SPATH, 1930, p. 26; pl. 5, fig. 1 (?), 2, 9; pl. 6, fig. 1, 2.

*O.* (*Discophiceras*) *wordiei* SPATH, 1935, p. 32; pl. 7, fig. 7 (?); pl. 8, fig. 5; pl. 16, fig. 8.

This species is distinguished from *O. subkyokticum* mainly by its greater size and wider umbilicus. Text-figure 10 demonstrates that most forms from Svinhufvud Bjerge, on Traill Ø (empty circles) and from Jameson Land (full circles) lie halfway between the type specimens of the two species, as far as the most important criterium, umbilical width, is concerned. The question whether it is at all possible to separate the two forms taxonomically must be considered. In the Kap Stosch area, however, typical *subkyokticum* and typical *wordiei* are more frequent than the intermediate forms; and even on Traill Ø and in Jameson Land, small and comparatively involute specimens build up populations by themselves, while larger and more evolute shells predominate in other localities. Nuclei or immature examples of the excentrumbilicate *O.*

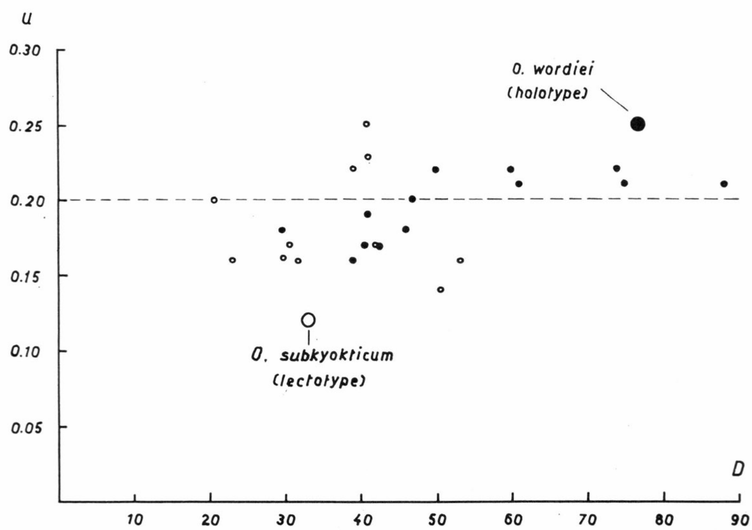


Fig. 10. *Ophiceras subkyokticum* Spath and *O. wordiei* Spath: umbilical width against diameter. Black dots: specimens from Wegener Halvø; open dots; specimens from Traill Ø.

*wordiei* may be undistinguishable from *O. subkyokticum*, especially when one has to do with isolated finds.

There is little to add to Spath's descriptions. The umbilical slope is generally rounded, but a few specimens from the lowest right-hand side valley of Pingel Dal (sample 202, see G. p. 25) acquire a rather steep wall, and some of these also show falcate growth-lines and a faint spiral depression on the middle of the flanks. They may be transitional to *O. compressum* and to the falcate variety described below. The stronger striae mentioned under *O. subkyokticum* are also observed. The thickness of the shell decreases markedly from the umbilical area towards the venter (from 0.6 mm to 0.2 mm in one specimen). The body-chamber measures almost 2/3 of the last whorl (Spath, 1930, p. 26, indicates only half a volution).

Quite near to the above-mentioned locality 202, but not necessarily in the same bed, two well-preserved ammonites were found, which show beautiful falcoid folds and shallow spiral depressions on the body-chamber (pl. 6, fig. 1). Spath (1935, p. 30; pl. 15, fig. 2 and especially pl. 16, fig. 1) describes discoidal *Lytophiceras* with this kind of ornamentation as *O.* (*Discophiceras*) *kochi* var. *falcata;* he also notes transitions towards *O. wordiei.* Our specimens have a much narrower umbilicus (0.21 and 0.22) than Spath's example of *O. kochi* var. *falcata* (0.32 to 0.33). This difference in the mode of coiling is too considerable to allow the grouping of these forms with falcoid ornament in one species, and passage types to quite typical *O. wordiei* are frequent, especially at the nearby locality 202.

*O. wordiei* is found in the commune zone and ranges quite high up (*e.g.* samples 241 and 242 in Lagunenæsset valley, G. p. 21–22).

### *Ophiceras (Lytophiceras) compressum* Spath

*O.* (*Discophiceras*) *compressum* Spath, 1935, p. 31; pl. 7, fig. 9; including var. *involuta*, ibidem, pl. 8, fig. 1–2.

This ammonite, characterized by its strong prorsoradiate striation, steep umbilical wall and compressed whorls, was found in several localities on Wegener Halvø (especially sample 343, coast of Nathorst Fjord) as well as by M. Aellen in the Schuchert Dal. Most of the specimens are crushed but quite typical, though one or two, with narrower umbilicus, may represent transitions to the coeval and certainly allied *O. spathi.* Spath already mentioned the relation to "*O. chamunda*".

Spath indicates the upper Ophiceras beds (commune zone) as level of this species, but we are afraid that he was misled by its high degree of specialization. Two examples from Hold with Hope figured by Spath, at any rate, come from beds with *Otoceras*, *Metophiceras*, *Glyptophiceras* and *Ophiceras spathi* (Spath, 1935, p. 94), that is from the lower Ophiceras beds (= subdemissum zone). The same is true for our specimens.

## ? Subgenus *ACANTHOPHICERAS* Diener

Diener, 1916, p. 101. Genotype: *Trachyceras* (?) *gibbosum* Griesbach.

Diagnosis: "Compressed, round-ventered shells, with suture-lines like *Ophiceras*, but with a tendency to blunt lateral tuberculation" (Spath, 1930, p. 28).

### *Ophiceras (Acanthophiceras?)* cf. *poulseni* Spath

*O.* (*A.*) *poulseni* Spath, 1935, p. 39; pl. 11, f. 6, 7.

One specimen from the subdemissum zone (spathi subzone?) of Paradigma pass shows the characteristic blunt, prorsoradiate bulges on the inner volutions (9–10 to a whorl). The body-chamber is crushed; it presents only faint, wavy folds. The umbilicus seems to be narrower than in the holotype.

The attribution of this form to the subgenus *Acanthophiceras* is open to criticism, at SPATH well realized.

## Genus *PARAVISHNUITES* (SPATH)

*Vishnuites* (*Paravishnuites*) SPATH, 1935, p. 44. Genotype: *V.* (*P.*) *oxynotus* SPATH.

SPATH gives the following diagnosis: "Rather narrowly-umbilicate, compressed oxycones, with faint, almost radial striation or lineation, rarely costation, and low but distinct umbilical wall. Suture-line as in *Ophiceras*, with serration of lobes rather more distinct, at least in the genotype".

We have stated on p. 86 the reason why we prefer to consider *Paravishnuites* as a genus of its own, not directly related to the Arctic "*Vishnuites*" of the *decipiens* group. We agree with L. F. SPATH as to its derivation from *Ophiceras* (*Lytophiceras*) *compressum* or, possibly, *O.* (*L.*) *spathi.*

### ***Paravishnuites striatus*** (SPATH)

*Vishnuites* (*P.*) *striatus* SPATH, 1935, p. 46; pl. 1, fig. 5; pl. 9, fig. 6.

One specimen from the subdemissum zone of Lagunenæsset valley, quite conformable to the holotype.

### ***Paravishnuites*** cf. ***oxynotus*** (SPATH)

*Vishnuites* (*P.*) *oxynotus* (SPATH), 1935, p. 45; pl. 3, fig. 5.

A poorly preserved cast from Domkirken (Mesters Vig region) has the dimensions of this species, but the bulges are only very faintly developed.

### ***Paravishnuites sterni*** sp. nov.[7])

pl. 2, fig. 8.

This species is based on only one specimen, from the (lower ?) Ophiceras beds of Triasdal, Schuchert Dal (coll. M. AELLEN). Its maximum diameter is about 76 mm, relative height of the last whorl 0.43, umbilical width 0.26 and the thickness/height ratio about 3:10.

The venter is almost sharp, just slightly rounded on the edge but not truncated. The flat flanks are highest at 1/3 of the distance between umbilical border and venter. The umbilical edge is rounded, the umbilical slope low but steep, convex and slightly undercut.

[7]) Named in memory of PAUL STERN, geology student from Basle, who took part in the 1958 expedition and who was killed in the Uri mountains in 1959.

The innermost whorls appear to be smooth, except for very indistinct, faint bulges. Later on, delicate but sharp striae appear, which grow stronger on the body-chamber, where they have a tendency to fasciculation. They describe an asymmetric, adorally concave arc between the umbilical suture and the middle of the flanks; on the outer half of the flanks, their direction is nearly radial.

The suture-line was partly laid free by filing away the shell. It compares to that of *Ophiceras wordiei*, but has a more V-shaped first lateral lobe.

*P. sterni* comes closest to *P. oxynotus*, from which it is distinguished by its more compressed form, absence of bulges (at least in the adult), by the more sinuous curve of its growth-lines and by the narrow rounding of the periphery. *P. striatus* has stronger ornament, thicker whorls and a narrower umbilicus.

### ***Paravishnuites paradigma*** sp. nov.[8])

pl. 1, fig. 7a, b.

We have collected only four specimens of this interesting form, two from the subdemissum zone of Paradigma pass (T 300, see G. p. 26), one from the spathi subzone of Walter Martin Bjerg and one from the cliffs above Fleming Fjord, 2 km to the NE of the mouth of Tvekegledal, where it lay 10 m above the top of the Permian limestones. Unfortunately, none of them is quite complete.

| Measurements: | D max. | D' | h | u |
|---|---|---|---|---|
| Holotype (pl. 5) | ca. 62 | 57.3 | 0.37 | 0.38 |
| | ca. 63 | 54.0 | 0.39 | 0.33 |

Up to a diameter of 40 mm, there is an absolutely sharp, knife-edge venter. At this stage, the thickness of the whorls is less than half of their height, and the flanks converge under an angle of about 35°. Later on, the venter becomes rounded, and on the body-chamber the whorl-section resembles that of *Ophiceras* (*Lytophiceras*) *spathi*. The umbilical wall, low in the inner volutions, becomes very high and subvertical at a D of about 30 mm, somewhat more rounded again on the body-chamber.

The prorsoradiate, biconcave striae are more or less fasciculate on the inner whorls. Faint bulges, like those of *P. oxynotus*, can be detected up to D 25 mm.

The denticulation of the lobes is comparatively sharp and deep. The umbilical lobe slopes downward to the umbilical suture.

The adult of this species closely resembles *Ophiceras* (*Lytophiceras*) *compressum* Spath, especially the evolute variety represented by the

[8]) From the type locality, Paradigma pass on Wegener Halvø.

holotype (Spath, 1935, pl. 7, fig. 9). The inner whorls, with their knife-like sharpening of the venter, are of course quite different. If, as one can probably assume, *Paravishnuites* is derived from *Lytophiceras* of the *spathi-compressum* group, the return to a rounded ventral area in the adult would indicate a case of paedogenesis.

### Genus *VISHNUITES* Diener (?)

Diener, 1897, p. 83; genotype: *V. pralambha* (Diener).

It is by no means certain that the Himalayan *Vishnuites* and the East Greenland forms *V.* (?) *decipiens* Spath and *V.* (?) *wordiei* Spath – offshoots of late *Lytophiceras* with sharpened venter – are really congeneric (see p. 86). Our material from Traill Ø (see Putallaz, 1961, p. 38) and from Jameson Land (some very bad specimens from the slopes north of Paradigma pass and a better one from Domkirken, see G. p. 27) is far too poor, however, to allow a thorough discussion of the problem.

# III. CONCLUSIONS

The evolution of some lineages of Induan ammonites in East Greenland can be followed rather closely; other, "cryptogenic" genera appear rather suddenly and must be regarded as immigrants.

Among the autochthonous Arctic fauna, we find *Otoceras concavum* TOZER and the possibly allied *Otoceras* sp. of the triviale and martini zones, with their descendants in the subdemissum/boreale zone, *O. boreale* SPATH and *O. indigirense* POPOV.

The oldest Ophiceratids, still very close to the Permian *Paraceltites*, belong to *Hypophiceras*, here regarded as a subgenus of *Glyptophiceras*. In the subdemissum zone of east Greenland, the passage of these primitive Ophiceratids to *Metophiceras* and to *Glyptophiceras* of the *pascoei* group is well established. It is quite possible that the coarsely ribbed Arctic *Glyptophiceras* represent a development which is independent from the true Himalayan *Glyptophiceras*, which generally show a more compressed whorl-section. The only representative of the genus from Japan, *Gl. japonicum* NAKAZAWA & SHIMIZU, seems to be closer to the Himalayan than to the Arctic forms (see also BANDO, 1964a, 1964b).

With the subdemissum zone, two new, closely allied stocks make their appearance: *Ophiceras* s. str., rather poorly represented in the Arctic realm, and *Lytophiceras*, which flourished for a long time in East Greenland, as well as in the Canadian Arctic, in the Cordilleran region and in East Siberia. *Lytophiceras* gave rise, by adaptative radiation, to some endemic branches: the compressed forms of the "*Discophiceras*" group, *Paravishnuites* – linked to early *Lytophiceras* by such species as *O.* (*L.*) *kochi* SPATH and *P. paradigma* sp. nov. – and *Acanthophiceras* (?) *poulseni* SPATH. Later specializations from the group of *O. commune* are the keeled "*Vishnuites*" (*V.*? *decipiens* and *V.*? *wordiei*) and *O. dubium* SPATH, which is regarded by its author as a possible ancestral form to the *Gyronitidae*.

The two lineages, *Ophiceras* and *Lytophiceras*, are not connected by any passage forms found in Greenland to the earlier *Hypophiceras* or to *Metophiceras*, which have different and simpler suture-lines. Two possibilities are open: either they are immigrants from the Tethys realm (by way of the Far East and Eastern Siberia), or there is an explosive radiation in subdemissum times, giving rise quite suddenly to widely different mutations. There is no doubt that such an explosive evolution occurred at this time among the *Hypophiceras – Glyptophiceras – Metophiceras* stock, but all these newly developed forms are connected with each other by numerous intermediate types – in fact, separation of species and subgenera is decidedly arbitrary. The first *Lytophiceras*, on the other hand, is the rather highly spezialized (compressed and involute) *O.* (*L.*) *spathi*, which has absolutely no plausible potential ancestors in the triviale and martini zones. For this reason, we favour the immigration hypothesis.

The East Greenland *Proptychites* are again (locally speaking) "cryptogenic"; they probably represent the last wave of immigrants, before life conditions for cephalopods became definitively unfavourable. This wave did not reach Jameson Land.

Table 2 resumes the zonal scheme for the basal Triassic of Greenland, as compared to those given by Koch, Nielsen and Spath. We have little to add to the matter already discussed; merely the index species of some zones had to be changed. *Glyptophiceras* (*Hypophiceras*) *triviale* is a good index for the very lowest zone, in which *Otoceras* and numerous "Permian" benthonic faunal elements also occur. For the second-lowest zone, *G.* (*H.*) *martini* had to be chosen, as the type of *G.* (*H.*) *minor* comes from higher beds and is different from the ammonites in the "upper Glyptophiceras" – or better Hypophiceras – beds (see p. 88). In the following zone, for which *Metophiceras subdemissum* may stand as characteristic species, there is a great increase in the number of species and individuals; numerous *Glyptophiceras* s. str., the last *Hypophiceras*, *Metophiceras* and the first *Ophiceras* s. str., *Lytophiceras*, *Acanthophiceras* and *Paravishnuites* form rich assemblages in many localities. *Otoceras boreale* reaches its acme and end. Where outcrop conditions are ideal, as on the east ridge of Walter Martin Bjerg, a slightly higher level can be recognized, where *Ophiceras* (*Lytophiceras*) *spathi*, accompanied by *Glyptophiceras* s. str., abounds; but it is not certain whether this "spathi subzone" has any general significance or whether it is just a local feature. *O. spathi* (= *O. chamunda* Spath, non Diener, see p. 97) may well be identical with Eigil Nielsen's "*Ophiceras* sp. nov." (table 2, second column). Higher up, in the commune zone, there are still numerous ammonites, but they belong to fewer species: in our area mainly *O. commune*, *O. subsakuntala*, *O. wordiei – subkyokticum* and *O. ligatum*. *Glyptophiceras* has become rare; *Metophiceras*, *Otoceras* and *Paravishnuites* have disappeared.

For the higher zones, which are poorly fossiliferous south of 73° latitude, there is nothing we can add to the subdivisions established by Spath. "*Vishnuites*" still is found near Mesters Vig, and in very bad examples

## Table 2

| L. KOCH 1931 | E. NIELSEN 1935 | | L. F. SPATH 1935 | | this paper | | Canada: E. TOZER 1967 |
|---|---|---|---|---|---|---|---|
| Upper Anodontophora beds *A. fassaensis* | Anodont. fassaensis beds | | Anodontophora beds | *Anodontophora fassaensis* | Fass. b. | Rødstaken m. | |
| | Myalina kochi zone | | | *Myalina kochi* | | | |
| Lower Anodontophora beds *A. (breviform)* | Anodontophora (breviform) beds | | | *Anodontophora breviformis* | Brev. b. | | ? *Proptychites candidus* |
| Proptychites beds *Pr. rosenkrantzi* | Proptychites beds *Pr. rosenkrantzi* *„Koninckites" sp. ?* | | Proptychites beds *Pr. rosenkrantzi* | | Propt. beds | *Pr. rosenkrantzi* | ? |
| Upper Ophiceras beds *Oph. transitorium* *Vishnuites* | Vishnuites beds | Upper Vishnuites zone *Ophiceras sp. nov.* | Vishnuites beds | Upper *Ophiceras dubium* | Vishnuites beds | *Vishnuites (?) decipiens* | *Pachyproptychites strigatus* |
| | | Middle Vishnuites zone *V. wordiei* | | Middle *V. decipiens & Oph. ultimum* | | | |
| | | Lower Vishnuites zone *Vishnuites sp. nov.* | | Lower *V. decipiens & O. kilenense* | | | |
| Lower Ophiceras beds *Oph. sakuntala* *Oph. commune* *Glypt. gracile* | Otoceras beds | O. „sakuntala" zone | Ophiceras beds | Upper *Oph. commune & Oph. subsakuntala* | Ophiceras beds | *Ophiceras commune* | *Ophiceras commune* |
| | | Ophiceras sp. nov. zone | | Lower *Oph. (Met.) praecursos & Glyptoph. serpentinum* | | *O. spathi* s.-z. *Metoph. subdemissum* | *Otoceras boreale* |
| Glyptophiceras beds *small Glyptophiceras* *Otoceras* *„Permian" benthonic fauna* | | unfossiliferous beds | Glyptophiceras beds | Upper *Glyptophiceras minor & Ophiceras ? sp. ind.* | Hypophiceras beds | *Glypt. (Hypophiceras) martini* | *Otoceras concavum* |
| | | Upper Glyptophiceras zone | | | | | |
| | | Lower Glyptophiceras zone | | Lower *Glyptophiceras triviale* | | *Glypt. (Hyp.) triviale* | ? |

even on northern Wegener Halvø. The southernmost occurrence of *Proptychites* hitherto signalled is Maanedal, on Traill Ø (PUTALLAZ, 1961, p. 31).

Most recent authors, following KUMMEL *in* REESIDE *et al.* (1957) have taken *Vishnuites* (?) *decipiens* and *Proptychites rosenkrantzi* as index fossils for the two zones represented by SPATH's Vishnuites and Proptochites beds; this procedure is certainly justified.

The zonal scheme proposed for the lowermost Triassic is at present only applicable to East Greenland; this is especially the case for the two first zones, *Hypophiceras* not having been signalled from elsewhere. Only with the succession in the Canadian Arctic archipelago (TOZER, 1961, 1967) can a correlation at all be attempted[9]; but even here it does not seem to be possible to achieve an exact equivalence, as TOZER pointed out. The two zonal schemes are compared in table 2. TOZER's zone of *Otoceras concavum* apparently corresponds to our triviale and martini zones; unfortunately, no *Hypophiceras* were found in Canada and the *Otoceras* in the two lowermost zones of Greenland are too badly preserved for specific identification. The Canadian boreale and the Greenland subdemissum zone compare very closely – in fact, the terms are almost interchangeable. The commune zone of both areas also seems to cover the same biostratigraphical span, though the presence of *Glyptophiceras* aff. *extremum* in Canada might indicate that somewhat older levels – corresponding to our "spathi subzone"? – are there included in the commune zone. On the other hand, TOZER mentions *Ophiceras* (?) *decipiens* from the commune zone. Higher up, correlation again becomes very hazardous. TOZER considers the zone of *Pachyproptychites strigatus* as including parts both of the decipiens and the rosenkrantzi zones.

In Arctic Canada, *Claraia* only appears in the commune zone. In Greenland, quite large and typical specimens occur much lower down, even in the martini zone (*e.g.* at the mouth of Pingel Dal, G. p. 24). Such discrepancies are not at all surprising; we may also assume that the true *Ophiceras* arrived fairly late in the Arctic sea, whereas they seem already to be present in the very oldest Triassic strata of the Himalayas.

Outside of Greenland and the Arctic Archipelago, witnesses of the Early Induan sea are known from various places around the present Arctic Ocean, thus from Canning River, Alaska (KUMMEL *in* REESIDE *et al.*, 1957, p. 1501), from Alberta (WARREN, 1945) and even from the Dinwoody formation of southeastern Idaho and western Montana (KUMMEL, 1954, p. 183). *Otoceras* has recently been found in Svalbard (PETRENKO, 1963), where the presence of beds of this age has long been suspected (see BUCHAN *et al.*, 1965). Induan deposits are widespread

[9]) The writer thanks Dr. TOZER for insight into his latest manuscript.

in Eastern Siberia (Kiparisova, 1961; Popov, 1961), and the main connection between the Arctic and Indo-Pacific provinces certainly ran between the mouth of the river Lena and the Okhotsk sea. An equivalent of the Hypophiceras beds might be sought in the western part of the Verkhnoyansk mountains, from where Kheraskov and Polubotko (*in* Sachs & Strelkhov, 1961) mention beds with *Xenaspis* (?) and *Estheria* below beds with *Glyptophiceras* (*Glyptophiceras* s. str. of the subdemissum/boreale zone?).

In 1960, we drew attention to the fact that "Permian" brachiopods, echinoderms and bryozoa persisted in the lowermost beds containing *Claraia* and "Triassic" ammonites. This had already been noticed by Spath (1935, p. 47 and 106); but at that time, the beds underlying the Wordie Creek formation at Kap Stosch were regarded as Carboniferous, so that he had to interpret these Paleozoic forms as derived, in spite of their preservation which is "not worse than that of the ammonites". As the age of the Foldvik Creek formation is now firmly established as Upper Permian (Cyclolobus zone, see Miller & Furnish, 1940; Dunbar, 1955; Newell, 1955), we concluded that sedimentation had been practically continuous between the Upper Permian and the Lower Triassic in parts of the East Greenland basin. This would imply that the "Paleozoic" benthos did not become extinct by a sudden, single catastrophe, but that it lingered on and existed side by side with "Mesozoic" ammonites, *Otoceras* and the first Ophiceratids. Numerically, the "Paleozoic" faunas are predominant in the triviale zone (Ekstra Elv and River 1, west of Kap Stosch); they become rarer in the martini zone (River 1; Lagunenæsset valley, see G. p. 20 and 22), and the last of them occur in the subdemissum zone (Lagunenæsset, G. p. 23, and Tvekegledal, G. p. 33).

This apparent coexistence of "Permian" and "Triassic" faunal elements makes East Greenland – together with Armenia, the Salt Range of West Pakistan, southwestern China and northeastern Siberia – one of the most important areas for the fixing of the boundary between the Paleozoic and Mesosoic eras. The critical lowland country around Kap Stosch was reexamined in detail during the summer of 1967 by B. Kummel and C. Teichert; we appreciate the opportunity given to us by G. G. U. to participate in this expedition. The material collected by the 1967 party is still under study, and a fuller discussion of the Permian-Triassic boundary problem will be given by Kummel and Teichert.

The fact that marine passage terms between the two systems occur only in few places certainly points to an almost world-wide break in marine sedimentation. Even within East Greenland, there is evidence of a regressive episode at the turn of Permian to Triassic time. The lowermost Triassic beds (triviale zone) are known only from the small area immediately around Kap Stosch. On Traill Ø and in Jameson Land, beds belonging io the next higher (martini) zone rest upon the Permian Foldvik Creek formation, and along the margins of the basin even younger parts of the Wordie Creek formation transgress over Permian or older rocks (G., p. 25). Only in the central portion of the fault-bordered East Greenland trough was the downwarping strong enough to compensate for the great eustatic regression at the close of the Paleozoic era.

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Abbreviations: M.o.G. = Meddelelser om Grønland, Copenhagen.
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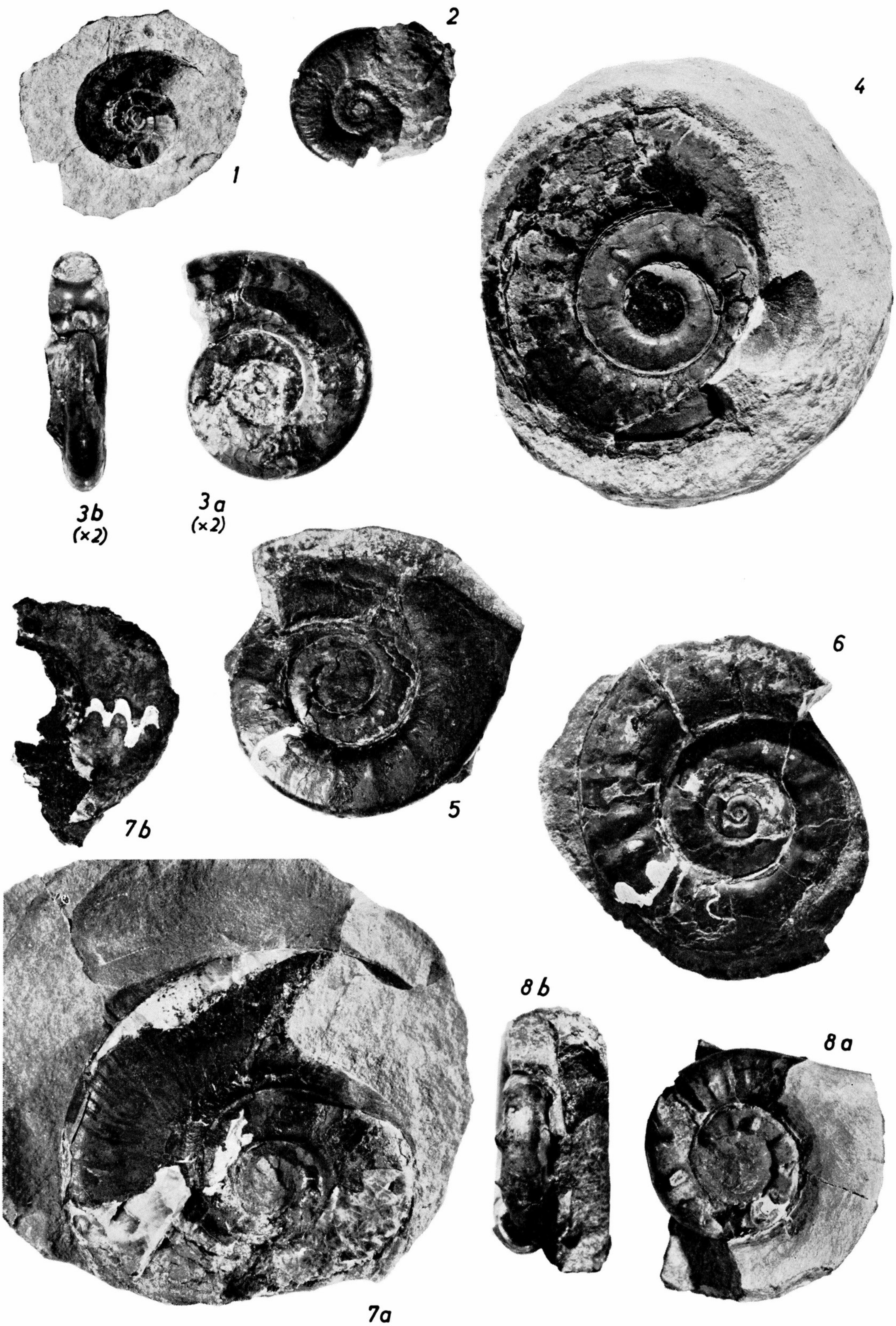
All figures except fig. 3 (× 2) natural size.

Plate 1.



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All figures except fig. 4 ($\times$ 2) natural size.


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# III

# LES CONCHOSTRACES TRIASIQUES DU GROENLAND ORIENTAL

PAR

Mme. SIMONE DEFRETIN-LEFRANC

AVEC 1 FIGURE DANS LE TEXTE ET 2 PLANCHES HORS-TEXTE

## Abstract

Amongst the samples collected in Eastern Greenland during Doctor Koch's expeditions, several species of Conchostraca were observed.

These were: *Euestheria forbesii* (Jones), *Euestheria minuta* (von Zieten), *Euestheria emmonsi* (Raymond), *Pseudoasmussia grasmücki* nov. sp., *Cornia trumpyi* nov. sp. A Pelecypod, which was formerly classed as a Conchostraca, *Halobia cf. moussoni* Merian, was also observed.

This paleontological study gives a Triassic age to the formations in question.

## Sommaire

Sur les échantillons récoltés au Groenland oriental par les expéditions du Dr Koch, plusieurs espèces de Conchostracés ont été observées. Ce sont *Euestheria forbesii* (Jones), *Euestheria minuta* (Von Zieten), *Euestheria emmonsi* (Raymond), *Pseudoasmussia grasmücki* nov. sp., *Cornia trümpyi* nov. sp. Un Lamellibranche, autrefois rattaché aux Conchostracés, *Halobia cf. moussoni* Merian, a pu également être observé. Cette étude paléontologique permet d'attribuer un âge triasique aux formations étudiées.

# INTRODUCTION

Les échantillons du Groenland décrits ci-dessous ont été étudiés à la loupe binoculaire, mesurés au micromètre oculaire ou dessinés à l'aide d'une chambre claire non déformante. Quand les exemplaires sont suffisamment nombreux, les courbes de fréquence permettent de différencier les espèces. Quand les valves sont peu nombreuses, la discrimination se fait par comparaison des diverses caractéristiques.

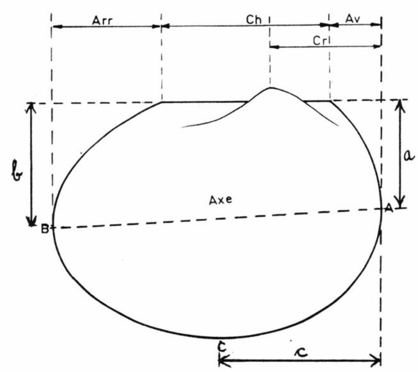


Fig. 1. Explication des expressions et abréviations employées dans les diagnoses et descriptions des espèces de Conchostracés étudiées ici.

L = Longueur de la valve prise parallèlement à la charnière.
H = Hauteur de la valve perpendiculairement à la charnière.
Ch = Longueur de la charnière.
Cr = Distance du crochet à la partie la plus antérieure de la valve.
Av = Distance de l'extrémité antérieure de la charnière à la partie la plus antérieure de la valve.
Arr = Distance de l'extrémité postérieure de la charnière à la partie la plus postérieure de la valve.
a = Distance de la charnière à la partie la plus antérieure de la valve.
b = Distance de la charnière à la partie la plus postérieure de la valve.
c = Distance de la partie la plus saillante du bord ventral (valeur maximale de H) à la partie la plus antérieure de la valve.
n = Nombre de stries au mm à leur écartement maximal.
i = Ecartement des stries (i = 1/n).
N = Nombre total de stries.
N.B. = Quand le crochet est terminal, Av = Cr.

# A – Ordre des CONCHOSTRACES

## I Super-Famille des LIOESTHERIOIDEA

### 1 – Famille des LIOESTHERIIDAE

Valves à crochet terminal ou subterminal.

### Sous-Famille des *EUESTHERIINAE*

Ornementation du test de type réticulé.

### Genre *EUESTHERIA*

Carapace telliniforme assez allongée.

Génotype: *Euestheria minuta* (Von Zieten)

#### ***Euestheria forbesii*** (Jones)

Pl. 1 fig. 1 et 2.

– 1862 – *Estheria Forbesii* Jones [p. 109; Pl. IV, fig. 8 à 11]
– 1897 – *Estheria Forbesii* Jones [p. 263; Pl. II, fig. 1–2]
– 1946 – *Euestheria forbesii* (Jones), *in* Raymond [p. 242].
– 1953 – *Estheria* (*Euestheria*) *forbesii* (Jones), *in* Defretin, Durand-Delga et Lambert, [p. 188; Pl. I, fig. 7 et 8].

**Diagnose** – Carapace ovale de grande taille, telliniforme. Le crochet saillant, mais à peine débordant au-dessus de la charnière, se situe au 1/3 de la longueur de la valve. Les stries d'accroissement sont nettes et très espacées. L'axe plonge à peine vers l'arrière et la plus grande hauteur se situe très légèrement en avant du milieu de la longueur.

L'ornementation fine est de type réticulé à mailles petites.

**Description** – Les valves sont très nombreuses sur les échantillons groenlandais, se chevauchant les unes les autres. Le test est souvent conservé. Les stries sont nettes, fort espacées sauf dans la partie marginale des plus grands exemplaires où existe une bande à stries serrées.

L'ornementation fine est souvent observable.

**Mensurations** –

| | | | |
|---|---|---|---|
| L = 7.24 | à 8.81 mm | Moyenne | 8,1 |
| H = 5.30 | à 6.54 mm | - | 6.0 |
| Cr = 2.43 | à 2.97 mm | - | 2.7 |
| a = 2.27 | à 2.97 mm | - | 2.6 |
| b = 2.59 | à 3.24 mm | - | 2.9 |
| c = 3.51 | à 4.32 mm | - | 3.9 |
| n = 2.5 | à 3 stries au mm | - | |
| H/L = 71 | à 75 % | - | 74 % |
| Cr/L = 30 | à 34 % | - | 33 % |
| a/H = 40 | à 45 % | - | 43 % |
| b/H = 44 | à 50 % | - | 48 % |
| c/L = 47 | à 51 % | - | 48 % |

**Niveau Stratigraphique** – En 1862, T. R. JONES rapporte cette espèce à un "lower mesozoic age"; en 1897, il l'attribue au Trias ou Rhétien. En 1953, nous l'avons retrouvée sur des échantillons du Nord – Constantinois auxquels la faune associée attribuait un âge Keuper.

**Collection** – Expéditions danoises du Dr KOCH, collections AELLEN 1958, n° A 367.

**Provenance** – Groenland oriental, formation du Cape Biot, Juraelv, Triasdal.

## ***Euestheria minuta*** (VON ZIETEN)

Pl. 1; fig. 3 et 4.

- 1832 – *Posidonia minuta* ALBERTI *in* DE LA BECHE [p. 453].
- 1832 – *Posidonia minuta* GOLDFUSS *in* ALBERTI [p. 227].
- 1833 – *Posidonia minuta* ALBERTI *in* VON ZIETEN [p. 72; Pl. 54, fig. 5].
- 1834 – *Posidonia minuta* GOLDFUSS *in* ALBERTI [p. 114, 120, 121, 202].
- 1834–1840 – *Posidonia minuta* GOLDFUSS [p. 117; Pl. 113, fig. 5].
- 1835–1838 – *Posidonomya minuta* BRONN [p. 164; Pl. 11, fig. 22]
- 1856 – *Estheria minuta* JONES [p. 376].
- 1862 – *Estheria minuta* (ALBERTI) *in* JONES [p. 42; Pl. I, fig. 28–30; Pl. II, fig. 1–8].
- 1890 – *Estheria minuta* (ALBERTI) *in* JONES [p. 387; Pl. 12, fig. 4].
- 1946 – *Estheria* (*Euestheria*) *minuta* ALBERTI *in* LAURENTIAUX [p. 214; Pl. II, fig. 4].
- 1946 – *Euestheria minuta* (VON ZIETEN) *in* RAYMOND [p. 239, Pl. II, fig. 7–8].
- 1950 – *Estheria* (*Euestheria*) *minuta* ALBERTI *in* DEFRETIN [p. 215; Pl. VIII, fig. 1–6; Pl. IX, fig. 1].
- 1951 – *Estheria minuta* ALBERTI *in* DEFRETIN et FAUVELET [p. 130; Pl. I, fig. 1–4].
- 1953 – *Estheria* (*Euestheria*) *minuta* ALBERTI *in* DEFRETIN, DURAND-DELGA et LAMBERT [p. 187; Pl. I, fig. 1–6].
- 1954 – *Euestheria minuta* (VON ZIETEN) *in* KOBAYASHI [p. 9, 40, 51, 54, 97, 131].
- 1957 – *Estheria minuta* ALBERTI s.s. *in* GUÉRIN [p. 26, 46].
- 1963 – *Euestheria minuta* (VON ZIETEN) *in* DEFRETIN [p. 529; Pl., fig. 12–15].

**Diagnose** – Carapace ovale telliniforme plus développée antérieurement, de taille moyenne. Le bord antérieur est semi-circulaire, le bord ventral plus ou moins convexe, mais souvent remontant vers l'arrière, le bord postérieur est également arrondi, mais plus contracté que le bord antérieur, d'où un axe oblique. Les stries d'accroissement sont nettes, on en compte 3 à 5 au mm dans la région médio-postérieure.

L'ornementation fine, est de type réticulé à larges mailles: 5 à 7 rangs de mailles sur la largeur de l'intervalle.

**Description** – Les carapaces d'*Euestheria minuta*, sont fréquentes sur les échantillons groenlandais; parfois les deux valves sont étalées charnière contre charnière. Le crochet se situe environ au 1/4 de la longueur et la plus grande hauteur un peu en avant du milieu. L'axe remonte légèrement vers l'arrière d'un angle de 5 $^0/_0$.

**Mensurations** –

| | | | | |
|---|---|---|---|---|
| L = | 1.9 à | 5.2 mm | Moyenne | 3.9 mm |
| H = | 1.3 à | 3.6 mm | - | 2.7 mm |
| Cr = | 0.5 à | 1.3 mm | - | 0.9 mm |
| a = | 0.7 à | 1.9 mm | - | 1.3 mm |
| b = | 0.6 à | 1.7 mm | - | 1.1 mm |
| c = | 1.1 à | 2.4 mm | - | 1.8 mm |
| n = | 3 à | 6 stries au mm | - | 4 + |
| H/L = | 57 à | 75 % | - | 69 % |
| Cr/L = | 19 à | 28 % | - | 23 % |
| a/H = | 43 à | 56 % | - | 48 % |
| b/H = | 39 à | 51 % | - | 41 % |
| c/L = | 41 à | 52 % | - | 46 % |

**Niveau Stratigraphique** – Cette espèce *Euestheria minuta* présente, semble-t-il, son maximum de fréquence à la Lettenkohle, mais elle est également très abondante au Keuper (niveau des grés à roseaux à *Equisetum mytharum* HEER). Elle a été observée en beaucoup de gisements d'Europe occidentale et d'Afrique du Nord.

**Collection** – Expéditions danoises du Dr KOCH, collection GRASMÜCK, 1958, n° G 16.

**Provenance** – Groenland oriental, partie inférieure de la formation du Cape Biot.

## *Euestheria* cf. *emmonsi* (RAYMOND)

Pl. 1; fig. 9, 10, 11.

– 1862 – *Estheria ovata* JONES *pars.* [p. 84; Pl. II, Fig. 26, 27].
– 1946 – *Pseudestheria emmonsi* RAYMOND [p. 253].
– 1954 – *Pseudestheria emmonsi* RAYMOND *in* KOBAYASHI [p. 95].

**Diagnose** – Carapace de grande taille, telliniforme, dilatée vers l'arrière. Les stries sont largement espacées.

P. E. RAYMOND ajoute: les intervalles sont lisses, d'où son attribution de cette espèce au genre *Pseudestheria.* Cependant, T. R. JONES [1840, p. 386] précise que ces valves ont des stries espacées et ajoute "we have no certainty about the interstitial ornament of the wide-ribbed figs. 26, 27", et . . . "figs 26, 27 may very well represent one of these species, most likely one with *reticulate* interspaces". Plus loin, il ajoute [p. 387] "fig. 26, 27 . . . have *lost* all trace of their interstitial ornament". Tout ceci semble bien indiquer que dans son esprit, T. R. JONES considérait les exemplaires de Prince Edward près de Richmond en Virginie (Fig. 26 et 27) comme ayant un test réticulé dont la fossilation avait masqué l'ornementation. C'est pour cette raison que nous replaçons l'espèce *emmonsi* RAYMOND = *ovata* JONES, 1862, Pl. II, fig. 26–27, dans le genre *Euestheria.*

**Description** – Les spécimens groenlandais que nous rattachons à l'espèce *Euestheria emmonsi* (Raymond) sont de grande taille, plus développés dans la région postérieure, telliniformes et assez peu bombés. Les stries sont nettes, distantes, (n = 3 à 4). Une bande marginale à stries serrées est presque toujours présente.

L'ornementation fine, très nette, est du type réticulé et comprend environ 8 mailles sur la largeur de l'intervalle.

Malheureusement, nous n'avons pu observer de valves tout à fait intactes mais seulement deux valves presque complètes et plusieurs fragments. C'est pourquoi, malgré la similitude des caractéristiques nous formulons des réserves quant à l'assimilation, à l'espèce *Euestheria emmonsi* (Raymond), des valves groenlandaises n° G 103.

**Mensurations** – A l'aide des fragments observés, nous avons essayé de reconstituer une valve synthétique. Les dimensions ci-après ne peuvent donc donner qu'une idée approximative de cette espèce.

| | |
|---|---|
| L = 4.75 mm | n = 3 à 5 |
| H = 3.25 mm | H/L = 68 % |
| Cr = 1.25 mm | Cr/L = 26 % |
| a = 1.50 mm | a/H = 46 % |
| b = 1.75 mm | b/H = 54 % |
| c = 2.50 mm | c/L = 53 % |

**Niveau Stratigraphique** – L'espèce *E. emmonsi* est attribuée par T. R. Jones au Trias ou au Rhétien; P. E. Raymond indique simplement: Trias; T. I. Kobayashi précise Keuper inférieur. Au Groenland, le niveau à *E. emmonsi* (G. 103) est situé un peu au-dessous du niveau à *Halobia cf moussoni* (T. 218) attribué au Muschelkalk. On peut donc penser que le gisement à *E. emmonsi* serait plutôt d'âge Trias moyen.

**Collection** – Expéditions danoises du Dr Koch, collection Grasmück, 1958, n° G 103.

**Provenance** – Formation du Mount Nordenskiöld, Solfaldsdal.

## 2 – Famille des ASMUSSIIDAE

Crochet central ou subcentral.

### Sous – Famile des *PSEUDOASMUSSIINAE*

Ornementation du test de type réticulé.

### Genre *PSEUDOASMUSSIA* nov. gen.

Carapace légèrement allongée, aux angles cardinaux nets et axe plongeant vers l'arrière.

Génotype: *Pseudoasmussia grasmücki.*

## ***Pseudoasmussia grassmücki*** nov. sp.

Pl. 1; fig. 5, 6, forme a,
fig. 7, 8, forme b.

Holotype – Echantillon G 120, fragment I.
*forme a* (femelle ♀) valve 3, Pl. 1, fig. 6.
*forme b* (mâle ♂) valve 1, Pl. 1, fig. 8.

Gisement type – Groenland oriental – partie supérieure de la formation du Mount Nordenskiöld, Solfaldsdal.

Niveau type – Trias vraisemblablement moyen.

**Diagnose** – Valve assez arrondie, relativement bombée, dont l'axe plonge légèrement vers l'arrière. Le crochet, non terminal, est souvent débordant, il se situe un peu en arrière du 1/3 de la longueur de la valve et également un peu en arrière du 1/3 de la charnière.

L'ornementation fine est de type réticulé.

Deux formes correspondant vraisemblablement à un dimorphisme sexuel peuvent être distinguées.

*Forme a* (♀): les stries d'accroissement sont serrées: 10 au mm environ et l'angle cardinal postérieur est très légèrement arrondi.

*Forme b* (♂): les stries sont plus lâches: 6 au mm en moyenne, l'angle cardinal postérieur est nettement marqué.

**Description** – Les carapaces sont abondantes sur cet échantillon, le test est souvent conservé mais les crochets parfois endommagés. La *forme a* (♀) est beaucoup plus fréquente que la *forme b* (♂), sa taille est très irrégulière et varie de 2.3 à 4.8 mm. La *forme b* (♂), plus rare, a une taille plus constante, généralement plus grande que celle de la *forme a*.

**Mensurations** –

| | ♂ | | | ♀ | | |
|---|---|---|---|---|---|---|
| L = | 2.9 à 4.7 mm | Moyenne | 3.4 | 2.3 à 4.8 mm | Moyenne | 3.2 mm |
| H = | 2.0 à 3.2 mm | - | 2.4 | 1.6 à 3.5 mm | - | 2.3 mm |
| Cr = | 0.9 à 1.7 mm | - | 1.2 | 0.7 à 1.9 mm | - | 1.2 mm |
| Av = | 0.4 à 0.7 mm | - | 0.5 | 0.3 à 0.8 mm | - | 0.6 mm |
| Arr = | 0.8 à 1.4 mm | - | 1.1 | 0.6 à 1.6 mm | - | 1.0 mm |
| Ch = | 1.5 à 2.6 mm | - | 1.8 | 1.1 à 2.2 mm | - | 1.6 mm |
| a = | 0.9 à 1.5 mm | Moyenne | 1.1 mm | 0.7 à 1.4 mm | Moyenne | 1.0 mm |
| b = | 1.1 à 1.7 mm | - | 1.3 mm | 0.8 à 1.8 mm | - | 1.2 mm |
| c = | 1.6 à 2.5 mm | - | 1.9 mm | 1.2 à 2.5 mm | - | 1.7 mm |
| n = | 5 à 7 | - | 5 + | 9 à 11 | - | 10 — |
| H/L = | 68 à 74 % | - | 70 % | 69 à 74 % | - | 72 % |
| Cr/L = | 31 à 39 % | - | 35 % | 31 à 40 % | - | 37 % |
| Av/L = | 14 à 17 % | - | 15 % | 13 à 20 % | - | 19 % |
| Arr/L = | 25 à 40 % | - | 32 % | 25 à 35 % | - | 31 % |
| Ch/L = | 44 à 59 % | - | 53 % | 47 à 62 % | - | 50 % |
| Ch/H = | 62 à 86 % | - | 75 % | 64 à 88 % | - | 70 % |
| a/H = | 43 à 54 % | - | 46 % | 39 à 52 % | - | 43 % |
| b/H = | 52 à 56 % | - | 54 % | 48 à 61 % | - | 52 % |
| c/L = | 50 à 59 % | - | 56 % | 47 à 58 % | - | 53 % |

Ces formes sont donc très voisines l'une de l'autre. On remarquera que le mâle (*b*) est légèrement plus allongé et que sa partie antérieure (Av) est relativement plus courte mais la différence essentielle porte sur l'écartement des stries.

**Rapports et Differences** – Cette espèce, bien que de taille plus réduite, rapelle assez *Pseudoasmussia laxitexta* (JONES) [1878 et 1890] du Muschelkalk supérieur, sortout en ce qui concerne la *forme b* (♂). Toutefois, chez *Ps. laxitexta* l'avant (Av) est très court et le bord antérieur est presque vertical. Dans l'espèce groenlandaise: *Pseudoasmussia grasmücki*, le bord antérieur décrit, à partir de l'extrémité de la charnière, une courbe plus ample et plus régulière. En outre, l'angle cardinal postérieur y est plus obtus. D'autre part, aucun auteur n'a jamais signalé un dimorphisme ou une autre forme associée de *Ps. laxitexta.*

**Niveau Stratigraphique** – La collection G. 120 qui porte *Pseudoasmussia grasmücki* appartient à la même formation du Mount Nordenskiöld que le Lamellibranche *Halobia cf. moussioni* que nous décrivons plus loin. Or, ce Mollusque est attribué au Muschelkalk, on peut donc penser que le niveau à *Pseudoasmussia grasmücki* est d'âge Trias moyen.

**Collection** – Expéditions danoises du Dr KOCH, collection GRASMÜCK 1958, n° G 120.

**Provenance** – Formation du Mount Nordenskiöld, Solfaldsdal, partie supérieure.

## II Super Famille des LAMNADIOIDEA

Stries assez peu nombreuses, zone apicale large.

### 1 – Famille des PALAEOLIMNADIIDAE

Stries non recourbées vers l'arrière.

### Sous – Famille des *PALAEOLIMNADIINAE*

Zone apicale relativement vaste.

### Genre *CORNIA*

Valves plus ou moins allongées, zone apicale relativement large ornée d'un tubercule développé surtout chez le jeune

Génotype: *Cornia papillaria* LUTKEVITCH 1938

### ***Cornia trümpyi*** nov. sp.

Pl. 2; fig. 4, 5, 6, (forme a)
fig. 7, 8, 9, (forme b)

Holotypes – *Forme a*, échantillon T. 144, fragment I, valve 1 (valve droite), Pl. 2, fig. 5.
*Forme b*, échantillon T. 155, fragment I, valve 5 (valve droite), Pl. 2, fig. 7.

Gisements types – *Forme a*, sommet de la formation du Schuchert Flod, au sud du Svinhufvud Bjerge, dans les éboulis.
*Forme b*, même localité, en place.
Niveau type – Trias inférieur.

**Diagnose** – *Cornia* de petite taille, un peu allongée. Le crochet net, souvent débordant au dessus de la charnière est terminal, il se situe légèrement en avant du 1/3 de la longueur. L'axe se relève à peine vers l'arrière, la zone apicale est relativement large, sa hauteur est de l'ordre de 1/5 de celle de la valve. La charnière est un peu supérieure à la moitié de la longueur et aux 3/4 de la hauteur. L'ornementation fine n'a pu être observée.

Deux formes correspondant probablement à un dimorphisme sexuel peuvent y être distinguées:
*Forme a*, (probablement ♀) montre des stries serrées (12 au mm) et un angle postéro-dorsal de l'ordre de 150° à sommet amorti.
*Forme b*, (probablement ♂) a des stries plus lâches (8 au mm) et un angle postéro-dorsal net de l'ordre de 140°.

**Description** – Les valves et empreintes sont assez fréquentes, mais beaucoup sont plus ou moins endommagées. Les *formes a* (♀) sont un peu plus nombreuses, et légèrement plus petites que les *formes b* (♂). Le bouton umbonal est plus marqué et plus aigu chez les femelles, arrondi et parfois absent chez les mâles.

**Mensurations** –

| | Forme a (♀) | | | Forme b (♂) | | |
|---|---|---|---|---|---|---|
| L = | 2.3 à 3.2 mm | Moyenne | 2.7 mm | 2.6 à 4.0 mm | Moyenne | 3.2 mm |
| H = | 1.6 à 2.3 mm | - | 1.8 mm | 1.8 à 2.7 mm | - | 2.2 mm |
| Cr = | 0.7 à 1.0 mm | - | 0.8 mm | 0.8 à 1.3 mm | - | 1.0 mm |
| Arr = | 0.4 à 0.7 mm | - | 0.5 mm | 0.4 à 0.8 mm | - | 0.6 mm |
| Ch = | 1.2 à 1.7 mm | - | 1.4 mm | 1.4 à 2.0 mm | - | 1.6 mm |
| a = | 0.7 à 1.0 mm | - | 0.9 mm | 0.8 à 1.2 mm | - | 1.0 mm |
| b = | 0.7 à 0.9 mm | - | 0.8 mm | 0.7 à 1.0 mm | - | 0.9 mm |
| c = | 1.2 à 1.7 mm | - | 1.4 mm | 1.3 à 2.0 mm | - | 1.6 mm |
| n = | 11 à 14 | - | 12 | 6 à 8 | - | 7 |
| H/L = | 67 à 72 % | - | 67 % | 66 à 70 % | - | 69 % |
| Cr/L = | 27 à 33 % | - | 30 % | 28 à 32 % | - | 31 % |
| Av/L = | 16 à 23 % | - | 18 % | 15 à 20 % | - | 19 % |
| Ch/L = | 47 à 55 % | - | 52 % | 47 à 54 % | - | 50 % |
| Ch/H = | 65 à 81 % | - | 78 % | 67 à 81 % | - | 73 % |
| a/H = | 36 à 53 % | - | 50 % | 41 à 48 % | - | 45 % |
| b/H = | 38 à 44 % | - | 44 % | 37 à 47 % | - | 41 % |
| c/L = | 48 à 55 % | - | 52 % | 47 à 53 % | - | 50 % |

**Rapports et Differences** – *Cornia trümpyi* est assez voisine de *Cornia sibirica* (Novojilov) [1958, p. 112] provenant de Sibérie occidentale: bassin houiller de Kouznetsk et appartenant au Trias inférieur, série de Maltsevo. Comme l'espèce groenlandaise, l'espèce sibérienne se présente sous deux formes: une *forme a* (♀) à stries serrées (n = 12) et angle postérieur légèrement amorti, et une *forme b* (♂) nettement cycladiforme à stries plus lâches (n = 6). Toutefois *Cornia sibirica* est un peu plus petite et plus arrondie. Lors de l'étude et de la révision des Conchostracés provenant d'U.R.S.S., nous avions déjà comparé ces deux espèces et nous écrivions "*Cornia sibirica* est très voisine de *Cornia trümpyi* DEFRETIN (alors *nomen nudum*) . . . La découverte de nouveaux gisements de ces espèces permettrait peut-être de déterminer si elles sont vraiment différentes ou si, au contraire, il faut les réunir en une seule". [DEFRETIN, 1965, p. 36].

**Niveau Stratigraphique** – La faune associée permet d'attribuer *Cornia trümpyi* au Trias inférieur.

**Collection** – Expéditions danoises du Dr KOCH, Collection TRÜMPYI 1958, n° T 144 et T 155.

**Provenance** – Sommet de la formation du Schuchert Flod, au sud du Svinhufvud Bjerge en place (T. 155) et dans les éboulis (T. 144).

### ***Cornia*** sp.

Pl. 2; fig. 10, 11, 12.

Sur les mêmes fragments de roches que *Cornia trümpyi* se trouvent des Esthéries en mauvais état de conservation, toujours incomplètes mais appartenant au genre *Cornia*, en raison de la présense constante d'un bouton umbonal. La courbure des stries indique une espèce d'assez grande taille et de forme plutôt arrondie.

## LAMELLIBRANCHES

### ***Halobia*** cf. ***moussoni*** MERIAN

Pl. 2; fig. 1, 2, 3.

- 1905 – *Estheriella radiata* (SALINAS) var. *multilineata* JONES [p. 150, Pl. II].
- 1925 – *Halobia cf moussoni* MERIAN *in* NEWTON [p. 78; Pl. III, fig. 3–10].
- 1946 – *Dadaydedeesia multilineata* (JONES) *in* RAYMOND [p. 260; Pl. III, fig. 9–10].
- 1953 – *Halobia cf moussoni* MERIAN *in* MARLIÉRE [p. 208].

**Diagnose** – Valves presque semi-circulaires, courtes et larges ou ovales aux extrémités arrondies. La courbure est plus marquée antérieurement. Le bord dorsal est presque rectiligne. Le crochet, antérieur mais non terminal, se situe au 1/3 de la longueur de la valve. En arrière du crochet, le long du bord dorsal, se forme une fossette étroite et longue. Les stries concentriques principales sont accompagnées de stries accessoires situées sur l'intervalle. Les stries radiaires sont fines et nombreuses.

D'abord considérées comme des *Estheriella* [Jones 1905] ces valves furent replacées dans les Lamellibranches en 1925 par R. B. Newton. Cette rectification de nomenclature fut confirmée par R. Marlière en 1953.

**Description** – Les valves et empreintes sont assez nombreuses sur les échantillons groenlandais, mais elles sont rarement intactes. Leur forme est sub-circulaire. Elles présentent une double striation concentrique et radiaire, très serrée, nettement différente de celle des Conchostracés et le test ne semble pas en avoir la texture.

**Mensurations** –

| | | | |
|---|---|---|---|
| L = | 1.83 à 5.05 mm | Moyenne | 3.27 mm |
| H = | 1.43 à 4.17 mm | - | 2.64 mm |
| Cr = | 0.63 à 1.67 mm | - | 1.00 mm |
| H/L = | 78 à 82 % | - | 80 % |
| Cr/L = | 26 à 34 % | - | 31 % |

**Niveau Stratigraphique** – L'espèce type de *Halobia Moussoni* Merian appartient au Trias moyen à *Ceratites trinodosus* de Lombardie. *Halobia cf. moussoni* Merian de Malaisie (ex. *Estheriella radiata* Salinas var. *multilineata* Jones) est attribué à l'Anisien-Ladinien. On peut donc penser que le gisement T 218 du Groenland appartient à un niveau marin du Trias moyen.

**Collection** – Expéditions danoises du Dr Koch, collection Trümpy 1958, n° T 218.

**Provenance** – Formation du Mount Nordenskiöld, Profilbjerg, Wegener Halvø.

# CONCLUSIONS

L'étude des Conchostracés du Groenland oriental a permis de dater plusieurs gisements.

La formation du Cape Biot (A 367) peut être attribuée au Keuper ou au Rhétien, la base de ce gisement (G 16) au Keuper ou à la Lettenkohle.

La formation du Mount Nordenskiöld est datée Trias moyen par la présence de *Halobia cf. moussoni* (T. 218) et *Euestheria emmonsi* (G 103).

La formation du Schuchert Flod ne peut être datée de façon certaine par les *Estheria*. Cependant, la ressemblance avec des gisements sibériens du Trias inférieur peut suggérer un âge analogue, âge d'ailleurs confirmé par d'autres données.

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# PLANCHES

## Planche 1

Fig. 1, 2. *Euestheria forbesii* JONES, × 5. Formation du Cape Biot, Juraelv, Triasdal n° A 367.

– 1 – valve gauche, A 367, fragment I, valve n° 2.
– 2 – valve droite, A 367, fragment I, valve n° 1.

Fig. 3, 4. *Euestheria minuta* (VON ZIETEN), × 5. Partie inférieure de la formation du Cape Biot, montagne à l'Ouest du Kap Biot, n° G. 16.

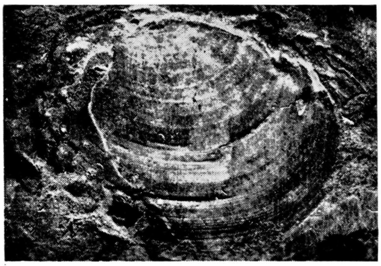
– 3 – valve gauche, G 16, valve n° 10.
– 4 – 2 valves étalées, G 16, valve n° 22.

Fig. 5, 6, 7, 8. *Pseudoasmussia grasmücki* nov. sp. × 5. Formation du Mount Nordenskiöld, Solfaldsdal, partie supérieure, n° G 120.

– 5 – forme a (♀), valve gauche, G 120, I, valve n° 3.
– 6 – forme a (♀), valve droite, G 120, II, valve n° 2 *holotype.*
– 7 – forme b (♂), valve gauche, G 120, VI, valve n° 2.
– 8 – forme b (♂), valve droite, G 120, I, valve n° 1, *holotype.*

Fig. 9, 10, 11. *Euestheria emmonsi* (RAYMOND). Formation du Mount Nordenskiöld, Solfaldsdal n° G 103.

– 9 – Fragment de valve gauche, G. 103, valve n° 5, × 5.
– 10 – Valve droite, G 103, valve n° 4, × 5.
– 11 – Ornementation fine, valve G. 103, valve n° 1'. × 20.



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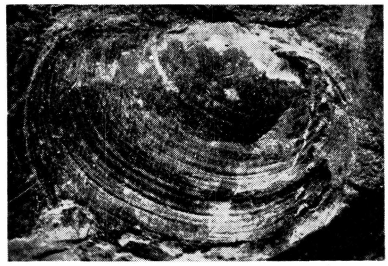

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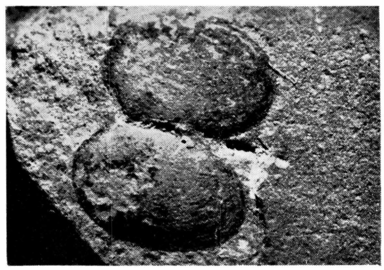

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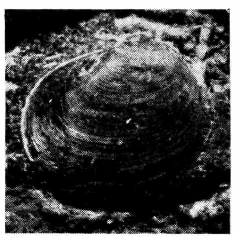

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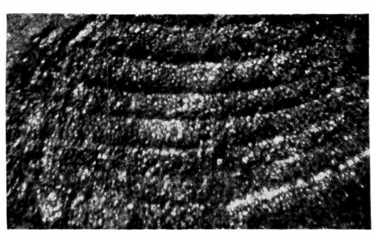

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## Planche 2

Fig. 1, 2, 3. *Halobia* cf. *moussoni* MERIAN, × 5. Formation du Mount Nordenskiöld, "Profilbjerg", Wegener Halvø, n° T 218.

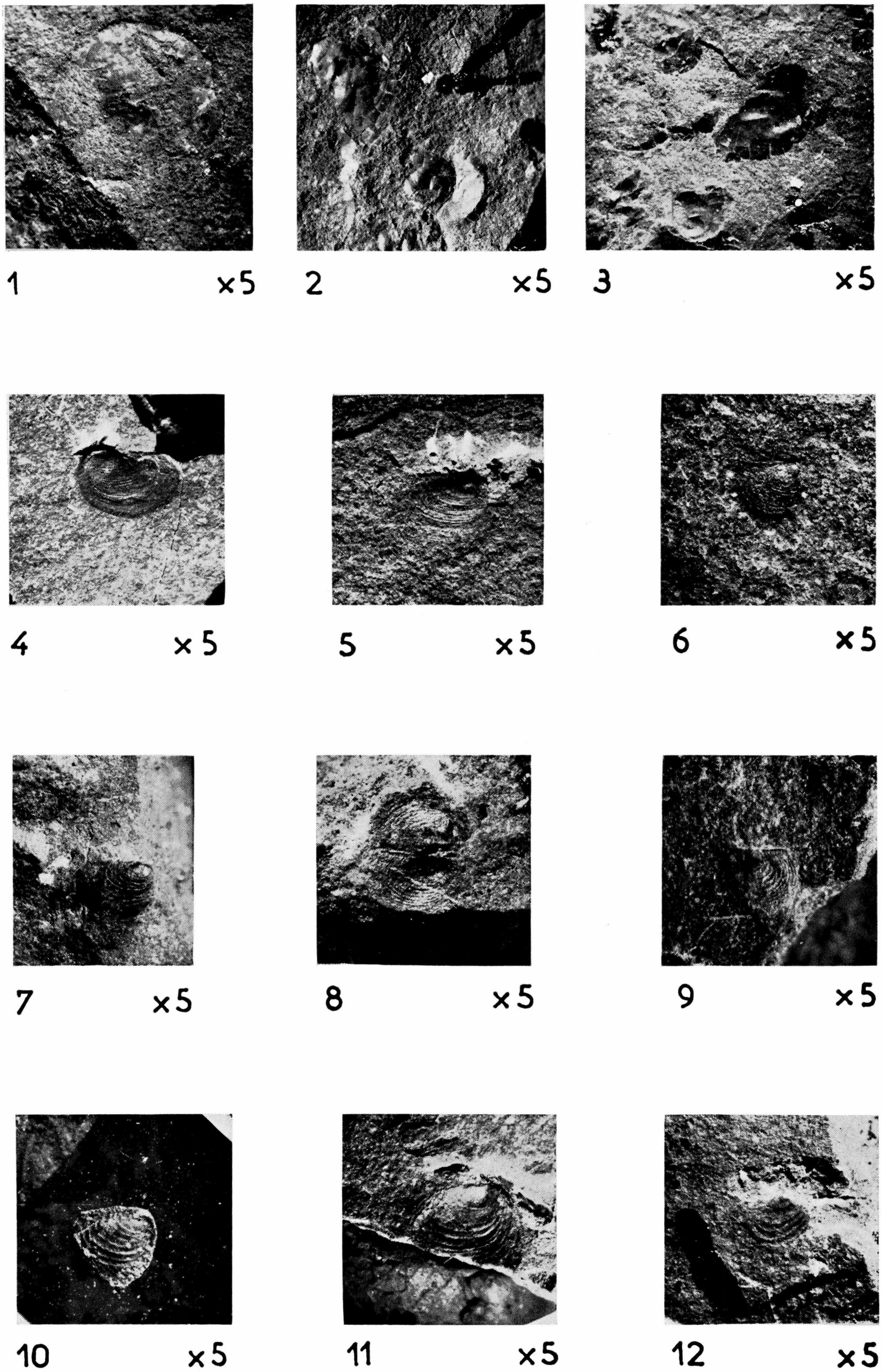
– 1 – Valve droite, T 218, II, valve n° 3.
– 2 – Valve droite et valve gauche incomplètes, T. 218, II, valve n° 1.
– 3 – Plusieurs fragments, T. 218, II, valve n° 2.

Fig. 4, 5, 6, 7, 8, 9. *Cornia trümpyi* nov. sp. × 5. Sommet de la formation du Schuchert Flod, au sud du Svinhufvud Bjerge, dans les éboulis T. 144, en place T. 155.

– 4 – Forme a (♀), valve gauche, T 155, I, valve n° 2.
– 5 – Forme a (♀), empreinte d'une valve gauche montrant le tubercule umbonal (en creux), T 144, I, valve n° 1, *holotype.*
– 6 – forme a (♀), valve droite incomplète avec tubercule umbonal, T 155, II, valve n° 8.
– 7 – forme b (♂), valve droite T 155, I, valve n° 5 *holotype.*
– 8 – Forme b (♂), 2 valves étalées, T 155, II, valve n° 1.
– 9 – Forme b (♂), moitié postérieure d'une valve gauche, T 155, I, valve n° 1.

Fig. 10, 11, 12. *Cornia* sp. × 5. Même provenance.

– 10 – Valve droite incomplète T. 144 (lame).
– 11 – Valve droite avec gros tubercule umbonal, T. 144, I, valve n° 5.
– 12 – Valve droite avec petit tubercule umbonal, T 144, I, valve n° 2.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