MEDDELELSER OM GRØNLAND
UDGIVNE AF
KOMMISSIONEN FOR VIDENSKABELIGE UNDERSØGELSER I GRØNLAND
Bd. 98 · Nr. 1

TREAARSEXPEDITIONEN TIL CHRISTIAN DEN X's LAND 1931-34
Under Ledelse af Lauge Koch

THE PERMIAN AND EOTRIASSIC VERTEBRATE-BEARING BEDS AT GODTHAAB GULF (EAST GREENLAND)

BY

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WITH 34 FIGURES IN THE TEXT AND 1 PLATE

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BIANCO LUNOS BOGTRYKKERI A/S
1935

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PREFACE

The investigations on which the present paper is based were made during my stay in East Greenland from July, 1932, to the end of August, 1933, as a member of the Danish Three-Year Expedition to East Greenland.

My main task was to collect as large a material of vertebrates as possible from the Permian and Triassic deposits, where promising finds were made on Dr. KOCH's previous East Greenland expeditions. This task necessitated thorough stratigraphical investigations in the particular areas, viz. the south coast of Godthaab Gulf and Gael Hamkes Bay, and the Hird Bay area in the southern part of Clavering Island.

In July and August, 1932, I was assisted in my work by M. KÖIE and A. JENSEN, and for a short time further by E. JOHANSSON; in June, July, and August, 1933, by A. JENSEN, and in July and August further by J. TROELSEN. In August-September, 1932, as well as in July, 1933, Mr. A. NIELSEN, the radio operator of the Eskimonæs Station, gave me valuable assistance during excursions by motor-boat, and the Greenlander JOHAN DAVIDSEN never fatigued in his attempts to learn me the difficult art of dog-driving. To all these I wish here to tender my most cordial thanks.

Dr. L. F. SPATH of the British Museum, London, who has worked up the Triassic invertebrates, has with the greatest willingness furnished me with information on the various fossil horizons and their faunas, partly by letter and partly verbally during my visit to London in the beginning of May, 1934. I am greatly indebted to Dr. SPATH for his valuable help.

Professor Dr. H. FREBOLD has furnished me with valuable information on the Permian. Professor Dr. E. STENSIÖ has assisted me in every way during a rapid examination of the immense fish material; fil. lic. G. SÄVE-SÖDERBERGH has kindly supplied various data as to the Triassic stegocephalians; G. SEIDENFADEN has conducted the pre-

paration of the sketch maps, in part supported by a series of excellent air photographs taken on the Expedition, Dr. H. ALDINGER has supplied me with a list of the ganoid fauna of the Permian deposits, and Mr. A. ROSENKRANTZ has given me various interesting information.

I thank most cordially all these specialists as well as the leader of the expedition, Dr. LAUGE KOCH, who entrusted me with the task, and who has always taken a very great interest in my work.

The South Coast of Godthaab Gulf and Gael Hamkes Bay between Ekstraelv and River 26.

Introduction.

This area naturally falls into four parts (KOCH 1931), viz. farthest west Spath Plateau, bounded on the east by the fault of Blue River; east of this Stensiö Plateau, between Blue River and Yellow River; next Mt. Steensby; and finally, farthest east, the comparatively low area round Mt. Diener.

The north coasts of Spath Plateau and Stensiö Plateau and the large valley separating them have been most thoroughly investigated, since here the Triassic series is complete and beautifully exposed. To facilitate the general view of the many localities where vertebrates have been found, it proved necessary to prepare a special map of this area on a much larger scale than KOCH's map of the coast previously published. This large-scale map has been compiled partly on the basis of my own observations, partly from a series of excellent air photographs (figs. 1—4).

In 1930 ROSENKRANTZ (p. 361) pointed out that the "north coast of Hold-with-Hope" is divided into a number of blocks by faults running at right angles to the coast. He gives a figure (fig. 25) of the fault in Immacradal, one of the most prominent and best exposed faults of the area (see p. 8.) The individual blocks bounded by faults as a rule dip more or less towards the west and south; entirely different directions of dip may be observed in the many small slips which are especially frequent in the Blue River area (see the map, pl. 1). In the western part of Spath Plateau the beds dip towards the east and south, so that about 2 km east of Cape Stosch they form a syncline whose axis dips about 5° towards the southwest (KOCH 1931, p. 17).

On his map of the stretch from River 1 to River 26 KOCH has marked nine of the most important faults and numbered them consecutively from west to east. As regards their place and course most of these faults agree very well with my observations, but differ in some

minor details. Thus fault 3 (see p. 12) has by a mistake been indicated as ending at River 7, while actually (see p. 12) it can be traced as far as River 8. Fault 4 does not run at right angles to the coast, as in-

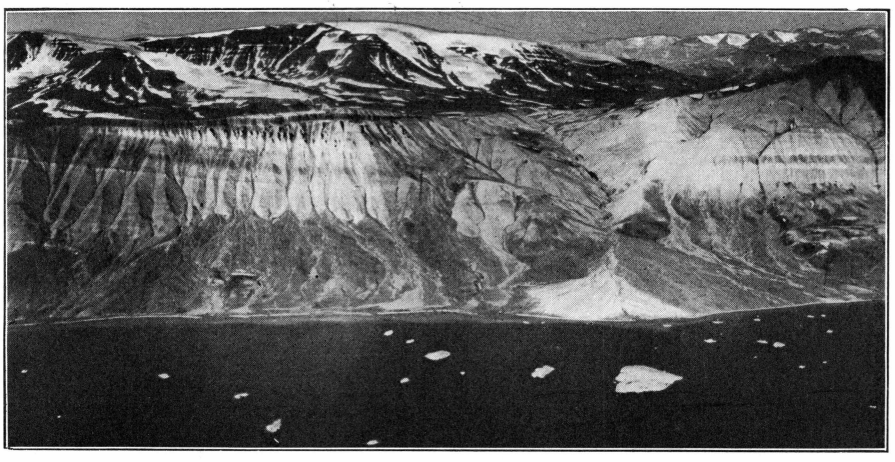


Fig. 1. Air photograph of the south side of Godthaab Gulf, showing the western part of Stensiö Plateau, the valley of Blue River, and the coast from Blue River to Wordie Creek. Mt. Tregletscherfjeld is seen behind Stensiö Plateau.

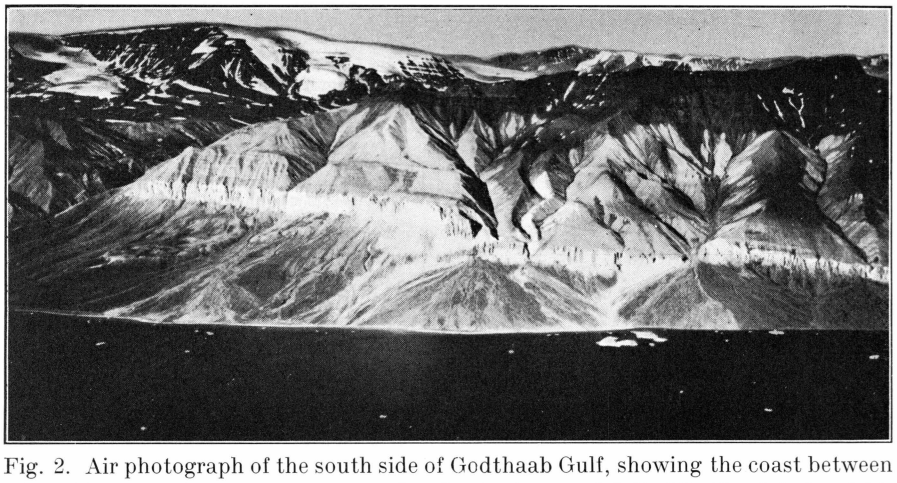


Fig. 2. Air photograph of the south side of Godthaab Gulf, showing the coast between Blue River and Nebalopokryggene. In the background left, Mt. Tregletscherfjeld.

dicated on KOCH's map, but rather in a direction from east-northeast to west-southwest. Fault 6 runs in a north and south direction.

The above-mentioned fault in Immacradal figured by ROSENKRANTZ in 1930 is not indicated on KOCH's map, since he believed to observe (KOCH 1931, p. 45) that the prominent conglomerates west of Immacradal continued without interruption east of the valley.

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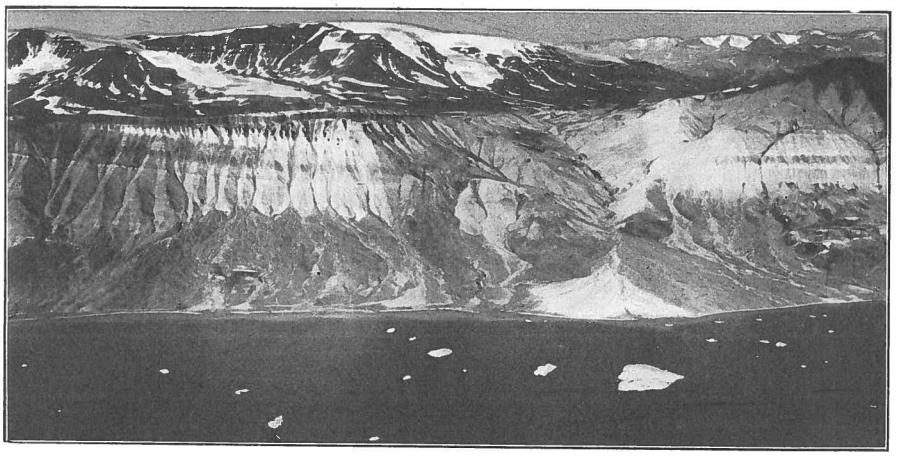


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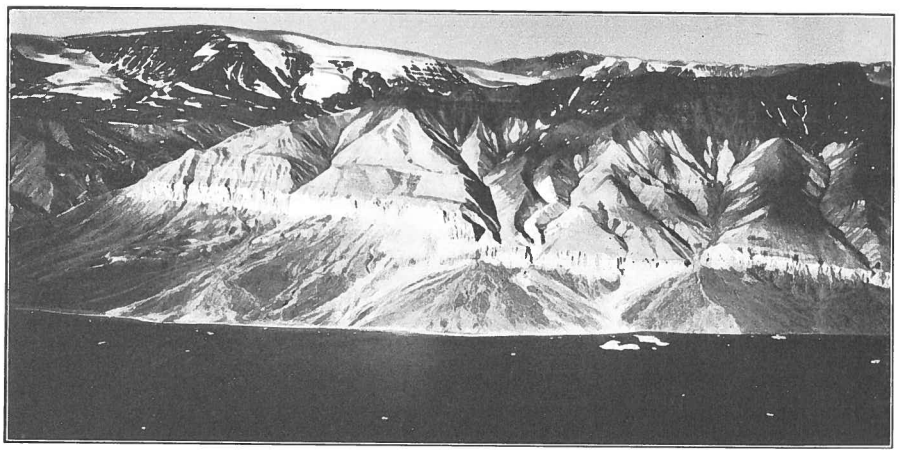


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The actual conditions are as shown in fig. 5, viz. that one of the largest faults of the north coast occurs in Immacradal, and thus ROSENKRANTZ's observation in 1929 was correct.

After an investigation of the stratigraphy by Red River KOCH

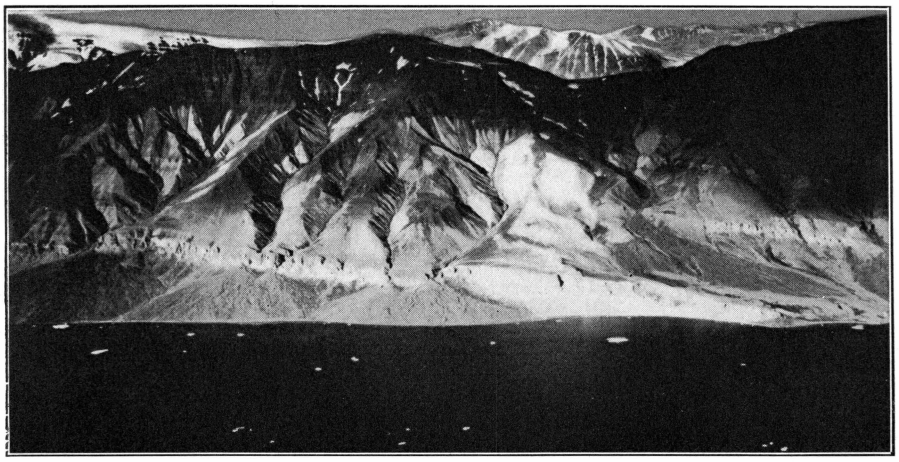


Fig. 3. Air photograph of the south coast of Godthaab Gulf, showing the stretch from Neviatiakdal to Immacradal.

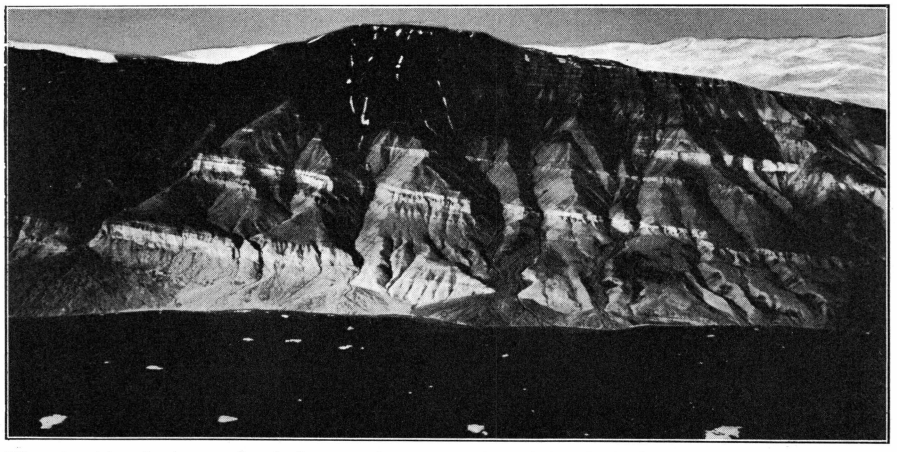


Fig. 4. Air photograph of the south coast of Godthaab Gulf, between Immacradal and River 5.

felt unable to decide whether or not a fault occurred there, but rather adhered to the opinion that only a flexure of the beds had taken place. (KOCH 1931). After the most recent investigations, however, there can be no doubt that a considerable fault actually exists at Red River (see pl. 1).

In 1932 ROSENKRANTZ published a sketch of the coast from Cape

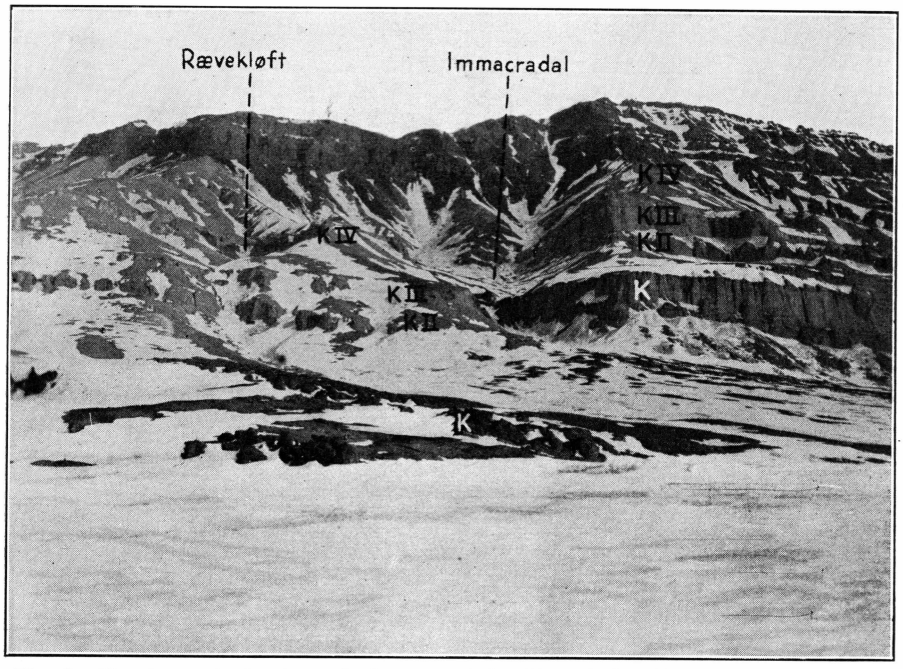


Fig. 5. The large fault through Immacradal. K = Carboniferous conglomerate; KII, KIII, KIV = Triassic conglomerates II, III, and IV.

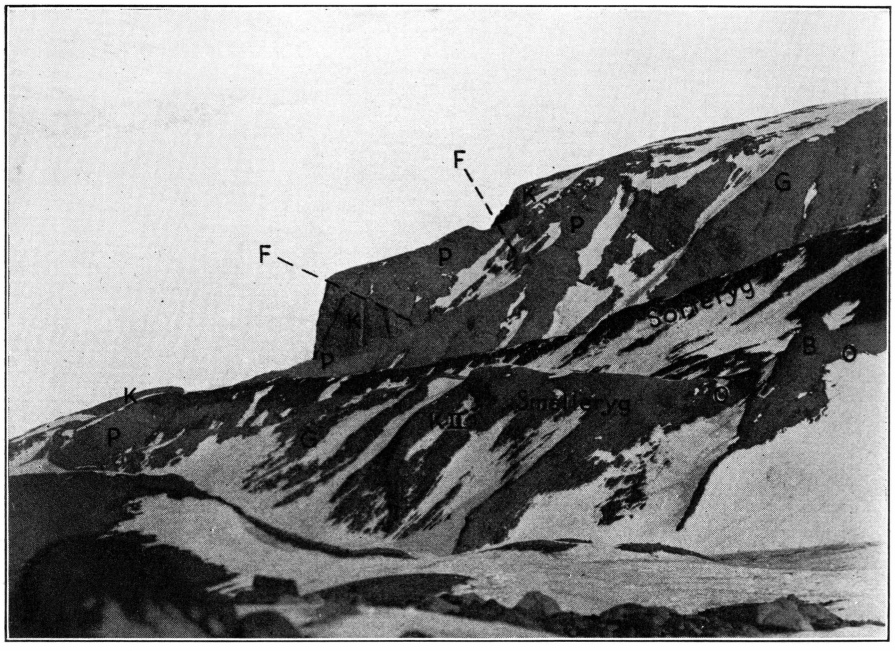


Fig. 6. The northern termination of Sorteryg and Smalleryg, and the faulted area at River 14. B = basalt dyke; F = fault; G = Upper *Glyptophiceras* zone; K = Carboniferous conglomerate; KII = conglomerate II sandstone; O = the two upper zones of the *Otoceras* beds; P = Permian.

Stosch to Cape James and a diagram of the tectonics of the area (1932, figs. 2—3). Probably on account of KOCH's criticism (see above) ROSENKRANTZ has omitted the fault in Immacradal, and accordingly his figs. 2 and 3 as also fig. 5 are fairly misleading.

Otherwise ROSENKRANTZ has inserted several faults that are not indicated on KOCH's map, but on the other hand has left out several of the faults found by KOCH, e. g. KOCH's fault 1, the existence of which ROSENKRANTZ doubted (1930, p. 352), and faults 2 and 3, the latter of which runs parallel to the coast, could not naturally be included in ROSENKRANTZ's diagram, even if he had been aware of their existence. I failed to detect ROSENKRANTZ's fault between Rivers 10 and 11, whereas a flexure of the beds could be observed here. By River 14 ROSENKRANTZ has marked three faults, while in fact only two occur (see pl. 1). Further, he has omitted KOCH's fault 6, which, it is true, has such a course that it could hardly be shown in the diagram. Of the faults not marked by KOCH, ROSENKRANTZ has further indicated that separating the western part of Mt. Steensby from the remaining part of the mountain, the fault by Red River, which, however, has been given a somewhat misleading direction (see pl. 1), and finally a fault east of the most easterly one indicated by KOCH.

On the map pl. 1 all the faults occurring between Rivers 5 and 19 are indicated. Of the new-discovered faults there is reason to mention the Blokdal fault and the fault that intersects the southernmost part of the valleys of Rivers 12 and 13. Possibly these two faults should be regarded as one fault, but since on one hand it is impossible to ascertain their course in the basalt-covered area, and on the other hand there is a possibility that the fault in the southern parts of Rivers 12 and 13 in connection with the faults in Rivers 14 and 13 bound a rather superficial slip (see pl. 1), it is impossible to take a definite standpoint.

The slips in the areas of Stribedal and Rødedal are also marked on the map, and the same applies to a small fault east of the highest part of Stensiö Plateau. The faults and slips within the Mt. Diener area will appear from pl. 1.

KOCH (1931, p. 97) ascribes the faults to the most recent considerable orogenic movements within the area, which probably took place at the transition between Cretaceous and Tertiary times. It must, however, be assumed that several of the slips mentioned are of a much younger date.

The Carboniferous Conglomerate.

As mentioned by KOCH (1929, p. 114, and 1931, p. 17), ROSENKRANTZ (1930, p. 352, and 1932, p. 9), and KULLING (1930, pp. 343 and 344) a conglomerate of a considerable thickness occurs on Spath Plateau

not far below the *Posidonomya* shale. Since no determinable fossils have been found in the conglomerate, its age, which has been much disputed, is not yet established. On account of its colour KOCH (1929, p. 114) referred it to the Devonian. ROSENKRANTZ, who investigated the conglomerate in 1929, referred it to the Mt. Pictet Formation (1930, p. 352, and 1932, p. 10), whereas KULLING (1930, p. 343) compared it with the conglomerates in the western part of Clavering Island, whose age, on account of the finding of plant fossils, is probably Namurian.

In 1931 KOCH provisionally referred the conglomerate to the Middle Carboniferous (1931, p. 20). In a footnote (p. 17 of the same paper), however, it is stated to be possibly lowermost Upper Carboniferous.

In the north side of Spath Plateau the conglomerate is exposed from Blue River to River 8. It is bounded on the east by a fault, while west of River 8, owing to the dip, it lies below the surface of the low coast land. According to KOCH (1931, pl. I, text-fig. 4, and p. 30) the conglomerate extends from Blue River to River 7. This, however, is due to a mistake, since the river designated River 8 on the map, in the text and in text-fig. 4 is erroneously designated River 7 (see p. 8).

Farther west the conglomerate crops out again. Thus KOCH (1931, p. 18) records it as subjacent to the basalt at Cape Stosch. Further it occurs along a considerable stretch southwest of this cape (cf. also KULLING 1930, p. 344). KOCH estimates the thickness of "the middle Carboniferous beds" immediately west of Blue River at at least 400 m (1931, p. 21), the lowermost 260 m of which are made up of conglomerates; they are overlain by yellowish-grey sandstones interbedded with thin, dark, more coarse-grained bands, frequently assuming the character of fine-grained conglomerates. About 400 m from the base of the section KOCH observed several beds of bluish-grey, sandy shales, here and there containing flat "clay balls". Som few hundred metres farther west I undertook an investigation in order to ascertain the position of the Permian beds, and measured the following series of strata:

The Carboniferous conglomerate occurs from an altitude of 281 m, i. e. the height of its lowermost visible part, to 373 m, where it is overlain by some few metres of dolomite. It is succeeded, up to a height of 381 m, by a hard, grey, unfossiliferous limestone. From 381 to 411 m occur the Permian *Posidonomya* shale, *Martinia* limestone, and *Productus* limestone (see p. 16). Above follow the yellowish-grey sandstones of the *Otoceras* series, which form the steep slope as far as Hjørnepunktet (see pl. 1) at 562 m altitude, and which in its upper part contain thin, bluish-grey, sandy shales, occasionally with flat "clay balls" (p. 34).

The considerable disagreement between the two investigations made in nearly the same place can easily be accounted for, since in the place

where KOCH made his investigation the Permian beds are concealed by considerable masses of débris originating from the superjacent Triassic sandstone, so that he failed to detect these beds. Consequently KOCH referred the whole superjacent series of hard Triassic sandstones to the Middle Carboniferous. Thus on KOCH's map the boundary between the Carboniferous and the Permian in the area between Blue River

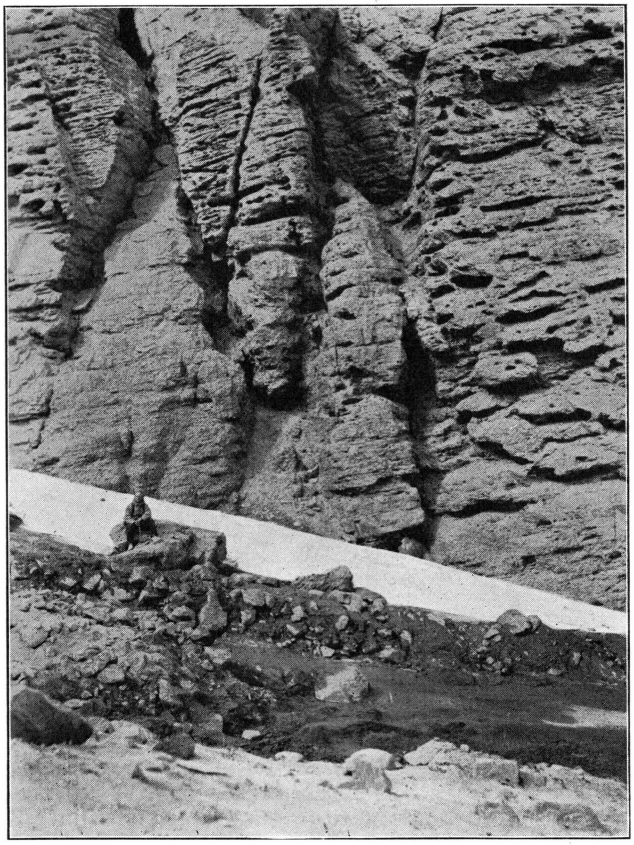


Fig. 7. Steep wall of Carboniferous conglomerate, River 13.

and River 9 is drawn too high; it should have been drawn at the upper surface of the lowermost conglomeratic rock wall indicated on the map.

As regards the distribution of the Carboniferous conglomerate in the western part of Spath Plateau, I may mention that this conglomerate, which, as mentioned above, is exposed in several places between Cape Stosch and River 1, is traceable along a considerable stretch south of River 1, though not as far as Ekstraelv (p. 29)

On Stille Island, the southernmost of the Finsch Islands, KOCH (1931, p. 21, fig. 2) and ROSENKRANTZ (1932, p. 11, fig. 9) found a con-

glomeratic bed, 40—50 m thick, resting directly on the gneiss. Since this conglomerate seemed to be identical with the Carboniferous conglomerate on Spath Plateau, KOCH referred it to the Middle Carboniferous. Whether it extends without interruptions by transverse faults from Stille Island in below Stensiö Plateau, cannot be decided, but it seems hardly improbable, since the lowermost exposed beds in Stensiö Plateau belong to the middle *Vishnuites* zone. The thickness of the Carboniferous conglomerate is unknown. According to KULLING (1930, p. 344), 160—170 m are exposed at River 2, while in the north coast of Spath Plateau the exposed parts of the conglomerate rarely exceed a thickness of about 100 m.

The slight thickness (10 m) recorded by MALMQVIST (1932, p. 27) for the Carboniferous conglomerate at Cape Stosch is probably due to KULLING's statement (1930, p. 344) that it rests disconformably on the presumed Upper Devonian in the western part of Spath Plateau (p. 29) (cf. also ROSENKRANTZ 1930, p. 352), while actually it is bounded on the west by a fault (KOCH 1931, p. 17).

The unfossiliferous beds between the Carboniferous conglomerates and the marine Permian beds.

On account of the difficulty in drawing a sharp boundary between the Schwagerina and the Artinsk deposits in East Greenland, and on account of the considerable agreement between the deposits of these two zones in East Greenland on the whole, it was agreed upon by KOCH, FREBOLD, and myself to draw the boundary between the Carboniferous and the Permian deposits below the Schwagerina zone. In several works FREBOLD (1932 a and b) has discussed this question, but writes (1932 b, p. 53): "Wie bereits früher betont, soll jedoch ein abschliessendes Urteil über die Grenzziehung in Ostgrönland erst nach der vollendeten Bearbeitung sämtlicher in Frage kommenden Faunen gefällt werden." The reason why the above decision was made before the faunas in question have been worked up, is that it was of importance for the geological description and the vertebral palæontological works to take up a definite standpoint.

On Spath Plateau, between the Carboniferous conglomerate and the *Posidonomya*-bearing shales, there occurs a series of unfossiliferous beds made up of dolomite and limestone frequently interstratified with gypsiferous bands.

Thus at River 1, separated by a fault from presumed upper Devonian, KOCH (1931, p. 22) found dolomite and limestone from 40 to 80 m altitude, overlain by about 15 m of gypsum. At River 2 KULLING found the Car-

boniferous conglomerate to be overlain by 9 m of dolomite with gypsum, succeeded by 6 m of light-grey limestone (1930, p. 344). The dolomite increases in thickness to the north, so that south of the Norwegian house at River 3 it attains a thickness of no less than 40—50 m.

At River 8 (Koch's River 7, see p. 12) Koch found (1931, p. 25) the Carboniferous conglomerate to be overlain by $^1/_2$—1 m of dolomite and gypsum. According to my observations the conglomerate is here overlain by about 3 m of dolomite, and this again is overlain by about 24 m of grey, compact limestone interstratified with bands of gypsum of a thickness of up to $^1/_2$—1 m. At River 9, too, dolomite and grey limestone with gypsum occur, but the total thickness is here only 11—12 m. Farther east the gypsum is entirely absent. At River 14 the dolomite and limestone series has a thickness of about 7 m, very nearly the same as at Blue River, where the Carboniferous conglomerate is overlain by 2 m of dolomite and about 6 m of grey limestone.

To sum up, on Spath Plateau the Carboniferous conglomerate is overlain by a bed of dolomite, which in the western part of the area contains gypsiferous zones of varying thickness; it attains its greatest thickness to the west, and decreases in thickness towards the east, so that at Blue River it is only 2 m thick. The dolomitic bed is generally followed by a series of hard limestones, which passes upwards without sharp limits into the *Posidonomya* shale. The limestone series attains its greatest thickness in the area between River 9 and Cape Stosch, where it frequently contains a greater or smaller number of gypsiferous bands.

Several suggestions have been made as to the age of these fossiliferous deposits.

Rosenkrantz (1930, p. 352 et seq.) refers the dolomite to the Mt. Pictet Formation, and the gypsiferous limestone above the dolomite to the Foldvik Creek Formation, to which it was already referred in 1929 by Koch (1929, p. 118).

Koch states (1931, p. 22) that the dolomite-gypsum zone at River 1 is of Middle Carboniferous age.

Frebold (1932 b, p. 46, se further 1932 a and 1931) parallels the series with the gypsum-dolomite horizons known from the Hird Bay area, Wollaston Foreland, Cape Franklin, and the Nathorst Fjord—Fleming Inlet region, which he, partly on the basis of corals from Wollaston Foreland and the Cape Franklin dolomite, is inclined to consider as the lowermost member of the East Greenland Schwagerina beds. Thus according to Frebold the lower boundary of the Permian on Spath Plateau should be drawn immediately above the Carboniferous conglomerate.

The Fossiliferous Permian Beds.

Fossiliferous Permian deposits occur both in the north and west slopes of Spath Plateau. In the north side of the plateau these Permian

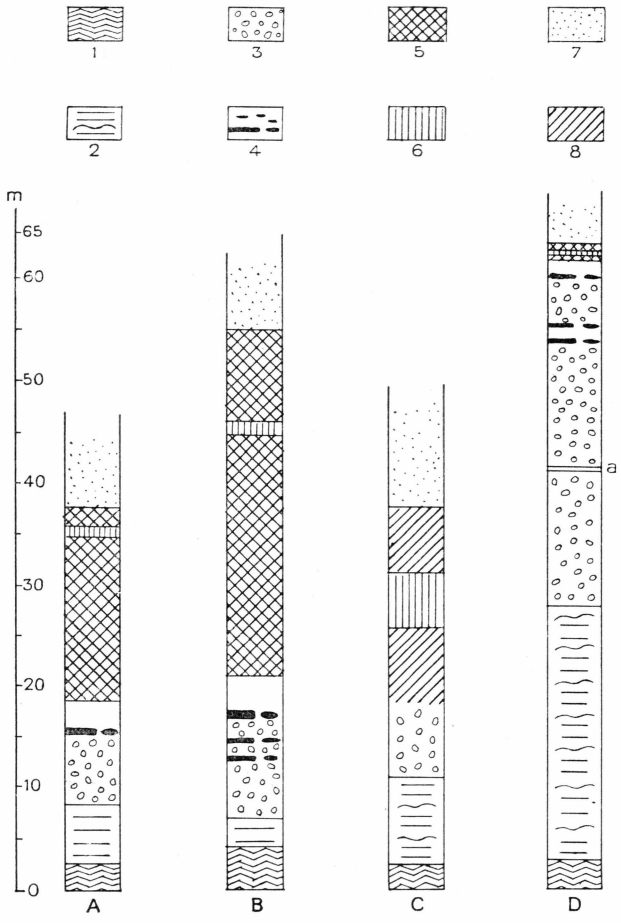


Fig. 8. The structure of the Permian on the north side of Spath Plateau. A = west of Blue River; B = immediately west of the western fault at River 14 (the *Productus* limestone based on a section measured between River 14 and Wordie Creek); C = immediately west of the fault of Immacradal; D = region of River 8 (based on observations both west and east of the river). The base of the four sections = the upper boundary of the conglomerate. 1 = dolomite; 2 = grey, unfossiliferous limestone, sometimes with gypsiferous beds; 3 = *Posidonomya* shale; 4 = Fish zone of the *Posidonomya* shale with limestone bands and concretions; 5 = *Martinia* limestone; 6 = *Productus* limestone. 7 = Trias; 8 = débris; a = a thin, plant-bearing zone in the *Posidonomya* shale.

deposits are exposed from Blue River westward to the delta of River 5, and in the west side from River 3 to some distance south of the valley of Ekstraelv.

Since the main object of my stay at the coast was to collect vertebrates, I was able to make rather detailed investigations of the Permian beds, which contain a fish zone, discovered by KOCH, and which has yielded beautifully preserved Elasmobranchs and Palaeoniscids (KOCH 1931, p. 25 and E. NIELSEN 1932). My investigations of the Permian beds were mainly restricted to the north coast, the conditions at Rivers 1 and 2 having been thoroughly investigated by KOCH (1931, p. 22 et seq.) and KULLING (1930, p. 344). The valley of Ekstraelv I visited twice, but on both occasions my investigations were much impeded by snow. KOCH has investigated the Permian beds in two places on the north coast, partly at River 8 (KOCH's River 7, see p. 12), where he discovered the fish zone in the *Posidonomya* shale, and partly in the valley of Blue River, where he observed *Martinia* limestone *in situ*, and from numerous finds of loose blocks of *Productus* limestone he could infer that this, too, must occur *in situ* in this place. KOCH points out that it is the only place where the *Martinia* limestone and the *Productus* limestone are known to occur together (1931, pp. 24—28).

As will appear from fig. 8, the structure of the Permian is rather uniform in various places along the north side of Spath Plateau even if the thickness of the individual zones may vary considerably. Above the gypsiferous zone there follows everywhere, when the section is not covered by scree, *Posidonomya* shale, in the upper part of which the fish horizon occurs; it is overlain by *Martinia* limestone, interstratified with a band of *Productus* limestone. The *Martinia* limestone is overlain by Triassic beds everywhere.

A. The *Posidonomya* shale and the fish zone. Like the above-mentioned dolomite-limestone zone, the *Posidonomya* shale decreases in thickness from west to east. At River 8 it is still over 30 m, at River 14 10—11 m, and immediately west of Blue River only 7 m. To this must be added the upper, not *Posidonomya*-bearing, part of the fish zone, the thickness of which varies from 1.5 to 4 m. In the upper part of the *Posidonomya*-bearing zone mostly two limestone zones of varying thickness occur, which will be more closely discussed below. Between these two limestone zones the *Posidonomya* shale is frequently somewhat arenaceous. There is no marked boundary between the subjacent, in places gypsiferous, grey limestone and the *Posidonomya* shale, the beds seem to pass evenly into each other. In the lower portions of the *Posidonomya* shale *Posidonomya* is rarely met with, whereas it is extremely common in a 5—10 m thick zone in the upper part of the shale, but decreases again above limestone band No. 2 (see above) and gradually disappears.

As will appear from fig. 8, the *Posidonomya* shale at River 8 con-

tains a thin, sandy bed carrying badly preserved plant remains (about 8 cm thick).

Let us consider now a section through the uppermost part of the *Posidonomya* shale and the fish zone in its typical development, as it appears at River 14 (fig. 10). Above a bed of *Posidonomya* shale about 6 m thick there follows, at 218 m altitude, a more compact zone consisting of two or three limestone bands of a thickness of about 10 cm, separated by zones of a looser consistency only few centimetres thick. These



Fig. 9. Detail picture of the fish zone of the *Posidonomya* shale immediately east of River 8. Three big concretions are seen *in situ* in the loose shales. On the surface of the slope numerous basalt blocks.

limestone bands, which here and there are represented by large concretions, in addition to the *Posidonomya*-Orthoceratite fauna contains loose Palaeoniscid scales and fragments of calcified Elasmobranch cartilage. Superjacent to this zone is a bed of *Posidonomya* shale 1.5—2 m thick, which, as already mentioned, is somewhat arenaceous, and is overlain by a zone of limestone bands similar to the preceding one. In this second limestone zone *Posidonomya* is rarer, but fish remains are commoner than in the preceding zone. In addition to Elasmobranch remains it contains well preserved Palaeoniscids. Above follows a band of *Posidonomya* shale about 1 m thick, overlain by looser, dark shales without

Posidonomya. At 222 m altitude the loose shales are interbedded with a limestone band up to 30 cm thick and often split up into very large concretions (diameter $^1/_2$—1 m). From this band by far the greater number of the collected Elasmobranchs and Palaeoniscids are derived, and in addition the band is fairly rich in plant remains. Then follow dark, friable shales up to 225 m, where they are overlain by *Martinia* limestone. Here and there in the loose shaly zone overlying the upper limestone band there occur big limestone concretions containing Elasmobranchs and Palaeoniscids. Thus, as has already been mentioned,

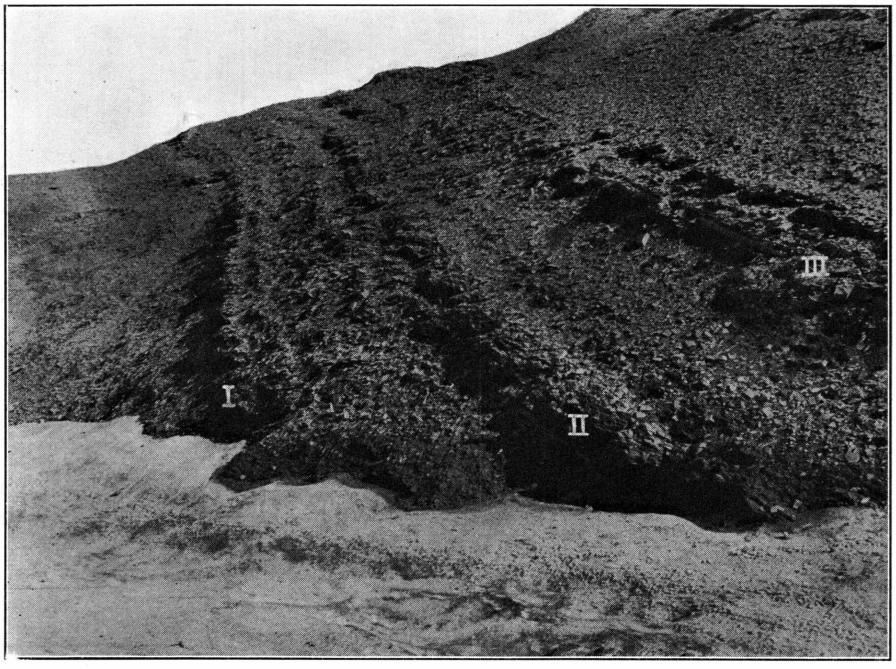


Fig. 10. Fish horizon of the *Posidonomya* shales immediately west of the western fault at River 14. I, II, III = the three limestone bands and concretionary zones with fish remains.

fish remains are most numerous in the upper limestone band and in the concretions of the superjacent loose shale, even if they occur in the two lowermost limestone zones too.

The development of the fish zone in the *Posidonomya* shale by River 14 seems in broad features to be found throughout the north side of Spath Plateau even if the stratigraphy in many places is concealed by loose material originating from the *Martinia* limestone and the Triassic beds. Near River 14 an involute nautiloid was found loose, which to all appearance originated from the lowermost limestone zone of the *Posidonomya* shale. A similar specimen was collected west of River 16,

also lying loose on the surface of the *Posidonomya* shale. In several places the whole surface of one of the two lower limestone bands can be seen to be covered with long, acute Tetracorals (?), all pointing in the same direction. These Tetracorals (?) were also occasionally found singly, but seem to be absent from the uppermost limestone band of the fish zone.

The Palaeoniscids of the fish zone are often of a considerable size, and the same applies to the Elasmobranchs. In a single place at River 14, where a large part of the surface of the uppermost limestone band was exposed, remains of fins and parts of a cranium with teeth (fig. 34) were found under circumstances which distinctly indicated that they



Fig. 11. Detail picture of the weathered surface of one of the limestone bands in the fish zone of the *Posidonomya* shale, showing numerous fish remains. Most conspicuous are teeth of *Fadenia* and fragments of calcified Selachian cartilage; further, scales and fragments of dermal bones of Palaeoniscids.

belonged together. The head, in which the Sclerotica cartilage of one eye was well preserved, was much compressed, and only some few teeth were found among the cartilage remains. These teeth were of the *Fadenia crenulata* type. The whole surface of the limestone band was penetrated by cracks, and the remains of the shark were so greatly damaged by the frost that only three fins, the Sclerotica cartilage, and the teeth were secured. Otherwise fin remains and other parts of the calcified chondral skeleton of Elasmobranchs are of rather frequent occurrence in the fish zone. The calcified cartilage is very prominent on weathered surfaces, where it is most frequently of a reddish colour, but is very little conspicuous in fresh fracture surfaces, where it is black like the surrounding rock. Frequently large parts of the dentition and the

calcified cartilage of the head of *Fadenia*, *Agassizodus*, or other Elasmobranchs are found in a limestone band or in one of the large concretions. Occasionally even a larger number of teeth are found, apparently in place in the jaws, but as a rule the crania are much compressed, and the teeth forced out of their original position. Now and then a larger or smaller area of the surface of a limestone band or a concretion may be covered with isolated teeth of different types of Elasmobranchs, Palaeoniscids scales, Placoid scales, cartilage fragments, etc. (fig. 11), evidently accumulated by the water. It is noteworthy that isolated Productid spines may be found in these accumulations. Such Productid spines also occur in small heaps washed together in the lower limestone zones in company with Bryozoan fragments, etc., which, as is well known, do not otherwise occur in the *Posidonomya* shale. Their occurrence seems very natural when it is borne in mind (Frebold 1932) that the *Posidonomya* shale, the *Productus* limestone, and the *Martinia* limestone may in part be regarded as different facies of the Schwagerina beds; various fishes have possibly devoured Productids, etc., in a nearby Productid facies and have subsequently died in such a place that the contents of their stomachs now occur in the fish zone of the *Posidonomya* shale.

For information on the best localities for collecting fishes from the fish zone of the *Posidonomya* shale, the reader is referred to p. 96.

B. The *Martinia* limestone and the *Productus* limestone.

Throughout the north side of Spath Plateau the fish zone is overlain by *Martinia* limestone and *Productus* limestone, the latter occurring as a band in the *Martinia* limestone (fig. 8). As appears from fig. 8, the thickness of the *Productus* limestone and the *Martinia* limestone varies considerably from place to place.

At Blue River, in the valley of which Koch (1931, p. 28) presumed the occurrence of *Productus* limestone and *Martinia* limestone together, the fish zone is overlain by 16 m of *Martinia* limestone. Above follows a hard band of *Productus* limestone 0.5—1 m thick. This again is overlain by a couple of metres of *Martinia* limestone. At River 14 the thickness of the *Martinia* limestone is 30—35 m, and the band of *Productus* limestone, whose position was not exactly measured (in fig. 8 indicated at River 15), but which is clearly intercalated between *Martinia* limestone, here, too, seems to be between 0.5 and 1 m thick. At River 9, where the beds are poorly exposed, the *Productus* limestone attains a thickness of 6 m. The lowermost part of this thick limestone band seems to contain more Bryozoans and less big Productids than the upper part. The *Martinia* limestone has not been observed at River 9, probably on account of the poor exposure; if present, its thickness must be con-

siderably less than farther eastward. Of fairly great interest are conditions round Rivers 7 and 8. As appears from fig. 8, the *Productus* limestone and the *Martinia* limestone here present inconsiderable thicknesses. In a section between Rivers 7 and 8 the upper limestone band of the fish zone has a thickness of 10—30 cm and is overlain by about 50 cm of a dark, crumbling shale; this is succeeded by a grey, calcareous shale, about 50 cm thick, followed by about 12 cm of dark, crumbling shales. This series, over 1 m thick, overlying the upper limestone band of the fish zone probably corresponds to the uppermost

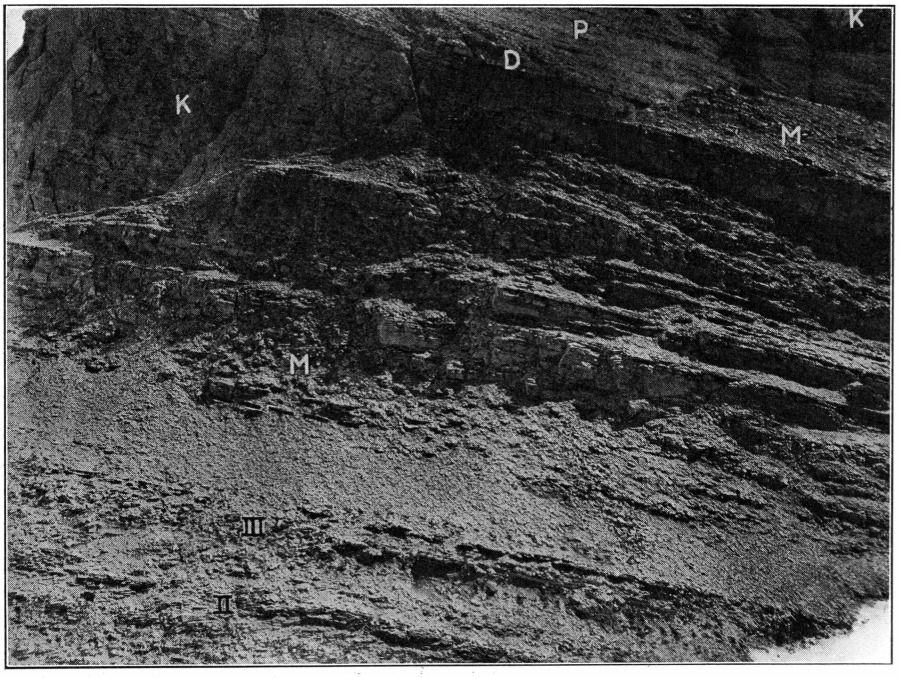


Fig. 12. Permian beds immediately west of the westernmost fault at River 14. In the background, the Carboniferous conglomerate and *Posidonomya* shales east of the fault. II and III = the two upper limestone bands and concretionary zones of the fish horizon of the *Posidonomya* shales; D = dolomite; K = Carboniferous conglomerate; M = *Martinia* limestone; P = *Posidonomya* shales.

concretion-bearing portion of the fish zone as developed farther east (p. 18).

Above this zone there follow about 1 m of *Martinia* limestone and numerous loose blocks of *Productus* limestone; the blocks occur below the upper boundary of the *Martinia* limestone, but rather frequently above the lower boundary of this limestone. Accordingly it must be assumed that here the *Productus* limestone, like farther east, occurs as a band in the *Martinia* limestone. Judging from the aspect

of the *Productus* limestone blocks, the thickness of the band may be estimated at about 8 cm.

While the *Martinia* limestone along the north coast of Spath Plateau hardly contains fish remains (as regards Hird Bay, see p. 38), the *Productus* limestone band at River 8 has yielded both *Arctacanthus* and *Janassa*, of which no specimens were found in the lower fish zone. Judging from the rock in which it is embedded, the *Cladodus* tooth previously described by me (1932, p. 8) seems to originate from the *Productus* limestone, while later finds have proved that *Cladodus* (possibly more than one species) occurs in the fish zone proper.

In the western part of Spath Plateau the exposures of the Permian rocks are not very clear, but to all appearance *Posidonomya* shale, *Martinia* limestone, and *Productus* limestone occur there in the same succession as on the north side of the plateau. Both on the north and the west sides the uppermost part of the *Martinia* limestone is often of a slight reddish colour or sometimes red and green mottled, and generally somewhat arenaceous.

On the presumed Permian sandstone near Rivers 1 and 2.

It appears from the numerous Zechstein blocks in the conglomerates near Cape Stosch that at the time the conglomerates were formed Permian sediments were present not very far from Spath Plateau.

Thus Frebold (1933, pp. 51 and 58) presumed that these blocks originated from the area west of Spath Plateau; however, on his map (1933, p. 51) the conglomerates carrying the young Palæozoic blocks have been given a somewhat too wide distribution to the east.

Before Frebold set forth this theory, several attempts had been made to find Zechstein *in situ* between the *Martinia* limestone and the *Glyptophiceras* beds on Spath Plateau, not least after Frebold in 1931 found Zechstein *in situ* on Wollaston Foreland.

This Zechstein consisted, at least in part, of red sandstones. Koch (1931, p. 29) believed he observed the *Productus* limestone at Rivers 1 and 2 to be overlain by red sandstones, which, in analogy with conditions on Wollaston Foreland, were probably referable to the Zechstein.

Personally, however, I have investigated both of Koch's localities without finding red sandstone *in situ*. In both localities the boundary between the Lower Permian and the superjacent beds was concealed by débris; at River 2, however, conditions were so clear that a bed of red sandstones could hardly be overlooked.

However, the moraine material overlying the sediments in both localities as well as by Ekstraelv south of River 1 contains numerous loose blocks of a red, loose sandstone, which often crumbles on weathering and lends to the moraine material a reddish tint.

These red sandstones are also frequent in places where the moraine occurs above the Devonian or the lower portions of the Lower Permian, as well as above the *Glyptophiceras* beds.

During my work in the field I therefore arrived at the conclusion that Zechstein is not represented by Rivers 1 and 2, and that the record of it was due to a confusion of it with the red sandstone blocks in the moraine, originating from the Upper Devonian sandstones.

KOCH and FREBOLD, both of whom have made investigations in the localities in question, have later informed me that the red Devonian sandstone at the coast differs petrographically from the sandstone blocks that were supposed to indicate the presence of the Zechstein sandstone.

Consequently we should be dealing here with a sandstone from which no fossils are known, but whose age should be intermediate between the *Productus* limestone and the *Glyptophiceras* beds, and probably correspond to the Zechstein sandstone on Wollaston Foreland.

If so, Rivers 1 and 2 are the only localities on Spath Plateau where Zechstein is represented; both to the south, at Ekstraelv, and to the west, in all the localities in which the upper boundary of the Lower Permian can be observed, it is directly overlain by *Glyptophiceras* beds.

The lowermost zone of the *Glyptophiceras* beds consists in many localities along the north side of Spath Plateau of red sandstones, and similarly the uppermost part of the *Martinia* limestone may be sandy and of a reddish colour.

Trias.

In 1926 J. M. WORDIE's expedition to Northeast Greenland made the interesting discovery that Eotriassic sediments occurred both south and east of Cape Stosch.

Since KOCH, independently of WORDIE's investigations, made the same discovery on his expedition in 1926—27, all his later expeditions have been working in the Triassic area. A historical account of the results arrived at before 1931 is given in KOCH's Stratigraphy (1931, pp. 7—16), and I therefore consider it superfluous to deal with these initial investigations, all the more so since all the facts of any importance so far known are mentioned in KOCH's work.

KOCH (1931) and SPATH (1930), on the basis of a few days' work in the field and comparatively incomplete collections respectively, arrived at a stratigraphic table of the sequence of the Triassic sediments (KOCH 1931, p. 78), which has in the main been maintained in spite of our present intimate knowledge of the area. The table is as follows:

Upper *Anodontophora* beds. Type fossil: *Anodontophora fassaensis*, occurring in great numbers and gathering in several thin zones.

Lower *Anodontophora* beds. Type fossil: *Anodontophora* (breviform), very common in several thick beds.

Proptychites beds. Type fossil: *Proptychites rosenkrantzi*, very common within a fairly thin zone.

Upper *Ophiceras* beds. Type fossils: *Ophiceras transitorium*, *Vishnuites*, *Worthenia*, *Bellerophon borealis*, etc., occurring in numerous, probably fairly thin zones with very varying faunas.

Lower *Ophiceras* beds. Type fossils: *Lytophiceras sakuntala*, *L. ptychodes*, *L. commune*, *L. wordiei; Glyptophiceras gracile* and other species. At the top calciferous sandstone with medium-sized *Ophiceras*, underlain by clay with concretions containing big *Ophiceras* and fish remains. This is probably underlain by calcareous sandstone holding small specimens of *Glyptophiceras* and other ammonites.

Glyptophiceras beds. Type fossils: *Glyptophiceras*, several species, all of them small; *Otoceras*, several species; further *Synocladia* and other species related to Permian faunas.

It has, of course, been necessary to alter various details in this table, but still it forms the framework of the new table, since it has turned out that even though the six large subdivisions may be subdivided into smaller zones, they represent a sound and natural main division in palæontological as well as in petrographical respects.

The table, which has been worked out on the basis of my own investigations of the strata and on the results of SPATH's examination of the invertebrates brought home, is as follows:

Anodontophora fassaensis beds. Sandstone with *Anodontophora fassaensis*.
Stegocephalian horizon with *Myalina kochi*.

Anodontophora (breviform) beds. Possibly two subzones.

Proptychites beds. Upper *Proptychites* zone with *P. rosenkrantzi*.
(?Lower *Proptychites* zone with *Koninckites*? sp. nov.?)

Vishnuites beds. Upper *Vishnuites* zone with *Ophiceras* sp. nov.
Middle *Vishnuites* zone with *V. wordiei*.
Lower *Vishnuites* zone with *V.* sp. nov.

Otoceras beds. *Ophiceras* cf. "*sakuntala*" zone.
Ophiceras sp. nov. zone.
Upper *Glyptophiceras* zone.
Lower *Glyptophiceras* zone.

Otoceras beds correspond to the *Glyptophiceras* and the Lower *Ophiceras* beds of the old table, and *Vishnuites* beds correspond to the Upper *Ophiceras* beds of the old table.

In a letter of October 10, 1934, Dr. *Spath* informs me that very likely the subdivision of the *Proptychites* beds cannot be maintained. Hence troughout this paper the *Koninckites?* sp. nov. zone. is placed in parenthesis, since the beds referred to it form probably part of the *Proptychites rosenkrantzi* zone.

The boundary between the *Otoceras* and the *Vishnuites* beds is drawn immediately above the uppermost *Otoceras*-bearing zone, even if other ammonites from the *Ophiceras* cf. "*sakuntala*" zone continue into the superjacent, not *Otoceras*-bearing beds.

The fossiliferous zones are often interstratified with unfossiliferous sandstones or conglomerates varying in thickness from place to place and frequently wedging out and disappearing.

This fact in connection with the varying thickness and character of the fossiliferous deposits render it very difficult to recognise a fossil zone known from a certain area even in adjacent areas.

The work is further impeded by solifluction, which plays a great part on the mountain slopes built up of loose sediments.

An observation on the solifluction should possibly be mentioned here, since it may be of a certain practical importance to later investigators of the area. It is a fact that the west sides of the small ridges separated by rivulets on the northern slope of Spath Plateau are better exposed than the east slopes, where the solifluction is always very conspicuous.

The reason of this is that in the spring the west sides are blown free of snow before the snow begins to melt, while the east sides, which are sheltered from the prevalent winds, are covered by immense snow masses. When the melting of the snow sets in, nearly all the melt-water is formed on the east sides, which are converted into an impracticable slush, whereas the west sides relatively quickly become dry and practicable.

Just as the Triassic sediments vary in character horizontally, they vary in a vertical direction, too, often even from metre to metre or from centimetre to centimetre. The bulk of the series is made up of loose, sandy beds of greatly varying fineness and frequently argillaceous, occasionally even replaced by more or less thick clay beds. Interstratified with these loose sediments are harder sandstone bands of varying thickness, as a rule 1—5 cm thick, and if so, occurring in a number of from two to five in a metre. However, their thickness may increase to 0.5—1 m or more, in some rare cases even to 30 or 40 m. These sandstone bands are very variable, being sometimes calcareous, sometimes uncalcareous, micaceous, conglomeratic, coarse-grained or fine-grained and of highly different colour. Ripple-marks are rather frequently seen on their surface, which may on the whole be very irregular. Less frequent are actual limestone bands, which especially occur in the clayey zones and attain a thickness of up to about half a metre. Within some few zones the loose sand beds contain big balls instead of bands of sandstone. Gypsum and dolomite beds play a very subordinate part in the Triassic sediments.

While the few ammonite-bearing zones exhibit but a slight vertical

distribution, the stratigraphically rather unimportant fossils as *Claraia*, *Spirorbis*, etc., occur throughout the *Otoceras*, *Vishnuites*, and *Proptychites* beds. The fairly thick series of strata intervening between the ammonite zones are thus as a rule fossiliferous. In the thick conglomerate beds (see p. 72) and steep, coarse-grained sandstone walls, however, even these fossils are absent. The fossiliferous ammonite zones nearly always consist of comparatively fine-grained, often clayey sandstones or clay beds containing concretions or limestone bands.

While several invertebrates are not restricted to the ammonite-bearing zones of the Triassic sediments, the vertebrates occur in relatively thin zones, representing, or in close association with, the ammonite zones.

The fish zones are nearly always clayey, and the vertebrate fossils mostly occur in concretions, but may be found in both sandstone and limestone.

The Otoceras beds.

Ophiceras cf. *"sakuntala" zone*	One or perhaps several limestone or sandstone bands with numerous fossils.	
	Clay bed, the upper part especially rich in big *Ophiceras* in concretions. Concretions with fishes and ammonites occur throughout the clay zone.	Fish zone 2.
Ophiceras sp. nov. zone	The clay becomes more sandy downwards and contain mainly *Glyptophiceras* and fishes embedded in sandy concretions of a diameter of up to half a metre.	
Unfossiliferous beds	Loose, coarse, unfossiliferous sandy beds, interstratified with hard, coarse, sandstone bands, in the eastern part of Spath Plateau with a gypsiferous band up to half a metre thick.	
	Conglomerate III Loose, sandy beds with sandstone bands	Only in the western part of Spath Plateau.
	Conglomerate II (to the east replaced by a coarse, hard sandstone).	
	Loose, sandy beds with sandstone bands Conglomerate I	Only in the western part of Spath Plateau.
Upper *Glyptophiceras* zone	Loose or compact, arenaceous sediments, occasionally somewhat conglomeratic, only few fossils; *Claraia* and *Glyptophiceras* in small concretions or in sandstone.	
Lower *Glyptophiceras* zone	Arenaceous beds with limestone bands rich in fossils, *Otoceras*, small *Glyptophiceras* species, fishes, etc.	Fish zone 1.
	The lowermost part of the zone further contains rolled Bryozoans and Brachiopods (probably Lower Permian). The zone only found in the south-western part of Spath Plateau.	

I. *The Lower and Upper Glyptophiceras Zones.*

The fossiliferous lower *Glyptophiceras* zone has but a slight horizontal distribution, occurring in the southwestern part of Spath Plateau only, where it is exposed partly in the northern wall of River 1 and partly at the somewhat more southerly river, Ekstraelv.

In both localities fossiliferous limestone bands occur in loose, sandy beds. In addition to several *Glyptophiceras* species, *Otoceras*, fishes (among others *Bobasatrania*) and other Triassic fossils, Bryozoans and Brachiopods occur in both localities, especially in the lower part of the zone, which is no doubt built up of material originating from similar Lower Permian deposits to those found *in situ* below the Triassic series throughout Spath Plateau.

For the broad features of the sequence of strata at River 1 the reader is referred to KOCH (1931, p. 28), who discovered this interesting exposure. Some few features should, however, be mentioned here.

The lower boundary towards the Permian is not observable (see p. 23), but may be estimated to occur at about 130—135 m altitude. Somewhat farther east the lowermost part of the *Glyptophiceras* series is exposed in the river bed, at about 145—155 m. As here the series dips a couple of degrees towards the east, a Permian sandstone (Zechstein) bed may theoretically occur between the Lower Permian, which is exposed farther west, and the *Glyptophiceras* zone (see p. 23). However, no trace of such a deposit was observed.

The lower *Glyptophiceras* zone proper consists of grey, loose or more compact sandstones with occasional fossils, and interbedded in the sandstone are numerous limestone bands very rich in fossils.

The lower in the series the limestone bands occur, the more fish remains do they seem to contain (see p. 100); but since the lowest limestone bands on account of the loose consistency of the sandstones are the most poorly exposed, it is necessary to search in the loose blocks in the river bed in order to collect a fairly sufficient number of fish remains to get an idea of the fauna.

How many limestone bands the lowermost part of the *Glyptophiceras* sandstone contains, could not be made out. However, a little farther east, where the section is better exposed, the somewhat higher-lying beds could be very thoroughly investigated.

The bottom of the river bed is here at an altitude of 186 m. Between 186 and 198 m the grey *Glyptophiceras* sandstone is seen to contain several limestone bands, varying in thickness from 2 or 3 up to 10 cm. These bands contain numerous fossils, *Glyptophiceras*, *Claraia*, and fish remains (the latter, however, are comparatively rare), and in addition indeterminable plant remains, which do not occur on the same bedding planes as the animal remains. The plants were repeatedly observed

to be restricted to a certain zone of the particular limestone band, and if so, the zone was more arenaceous than the remaining part of the band.

In addition to the limestone bands there occur at the same altitude calcareous concretions, ranging in diameter from some few to more than 20 cm. The concretions contain fossils similar to those found in the bands, though sparser.

Above 198 m altitude no *Glyptophiceras* occur. Between 198 and

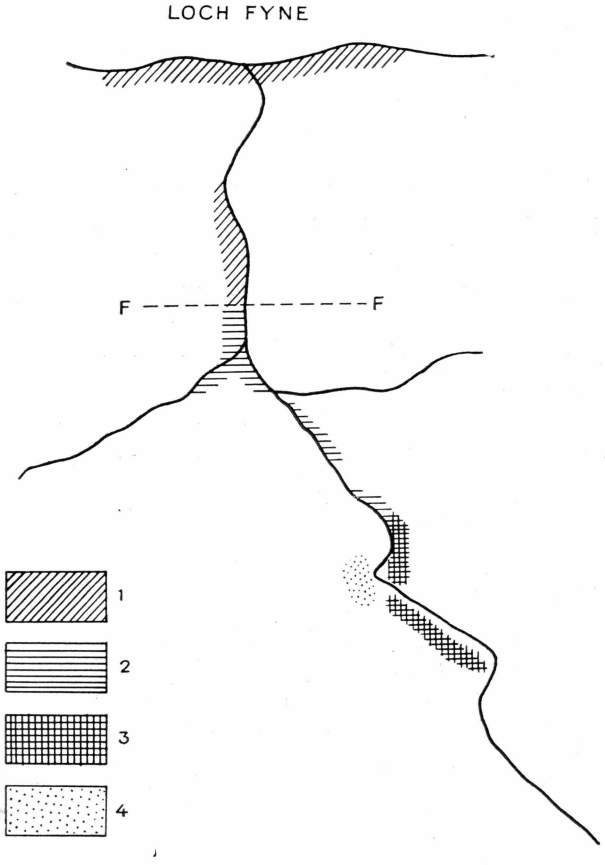


Fig. 13 Ekstraelv. F—F = the fault between Devonian(?) and Permian. 1 = Devonian sandstone; 2 = *Martinia* limestone with an interbedded band of *Productus* limestone; 3 = Lower *Glyptophiceras* zone; 4 = basalt.

203.5 m coarse, grey sandstones are found. At 203.5 m there is a calcareous sandstone band with *Claraia*, which is overlain by looser, grey sandstones. Between 205 and 208 m the latter contain three fairly thick, hard sandstone bands. Thinner bands of a similar, calcareous, micaceous sandstone is met with in several places between 208 and 219 m altitude, the top of the section. The uppermost 15—16 m are almost unfossili-

ferous, only occasionally are plant remains found in the sandstone bands.

The other locality of the fossiliferous lower *Glyptophiceras* zone is situated a couple of kilometres farther south in the northern bank of the first large river south of River 1, Ekstraelv.

The possibility of finding *Glyptophiceras* beds here was pointed out to me by KOCH, who in the summer of 1932 from airplane noticed the extraordinary depth of the river bed. I visited Ekstraelv for the first time in September, 1932, but on account of the new-fallen snow I failed to find the beds overlying the *Martinia* limestone.

It was not till June, 1933, that I succeeded in finding such large snow-free areas in the river-bed that the sequence of strata could be ascertained.

In the south bank of the river-bed of Ekstraelv the fault between the Devonian and the Permian is seen at an altitude of 92 m.

The Devonian beds consist of sandstone similar to that building up the coast cliffs by Rivers 2 and 1 and still farther south.

Neither conglomerates, gypsum, nor dolomite are seen east of the fault, as was the case by River 1. The Devonian is immediately adjacent to the *Martinia* limestone.

At 103 m a small tributary very rich in water joins the river from the south, and at 103.5 m in the eastern bank of this tributary a *Productus* limestone band, about 20 cm thick, is exposed.

Some few metres higher up the river the exposure of the south bank ceases, but almost at the same time an exposure of the beds in the northern bank commences. Here the *Martinia* limestone rises as a nearly inaccessible wall, which a little farther east is overlain, at 162 m, by the lower *Glyptophiceras* zone.

The lowermost 5—6 m of the lower *Glyptophiceras* zone are made up of loose, grey sandstones interstratified with harder, calcareous sandstone bands teeming with Bryozoans, Brachiopods, *Glyptophiceras*, etc. A little higher up the Bryozoans and the Brachiopods which have possibly been worked up from the underlying rocks, decrease in number.

Only the lowermost part of the *Glyptophiceras* zone is exposed in the northern bank, and none of the fish-bearing limestone bands known from River 1 are found *in situ*, although their presence is indicated by loose blocks in the river-bed.

Almost opposite this exposure in the northern bank of Ekstraelv the southern bank exhibits a basalt bed, and somewhat east of this an exposure of the *Glyptophiceras* series, which is here no longer visible in the northern bank.

In this part of the *Glyptophiceras* zone, which no doubt corresponds to the beds by River 1 described in p. 29, only some few *Claraia* were

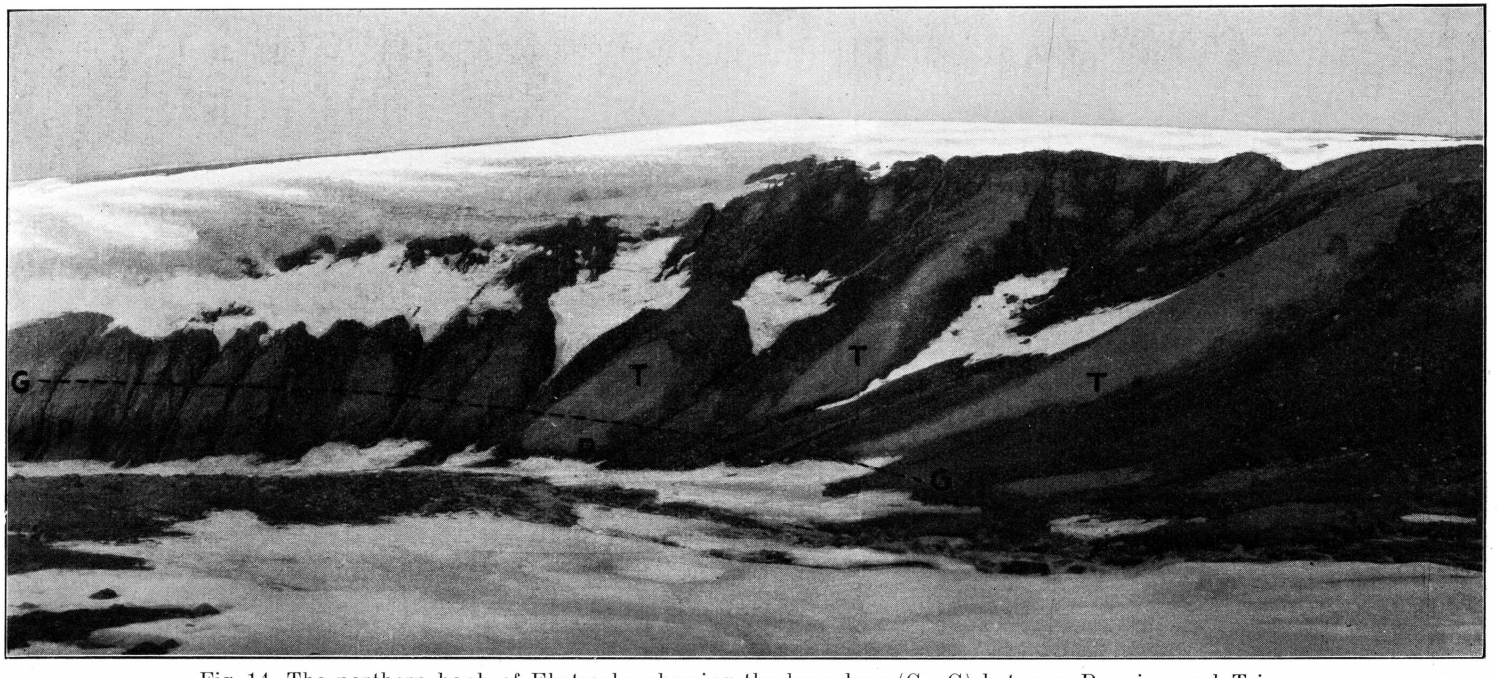


Fig. 14. The northern bank of Ekstraelv, showing the boundary (G—G) between Permian and Trias;
P = *Martinia* limestone; T = *Lower Glyptophiceras* zone.

found. The sequence of strata was exposed up to 198 m altitude, above which the section was covered with loose soil or vegetation.

The area south of River 1 forms part of a comparatively low plain, sloping towards Loch Fyne and covered with a fairly rich vegetation. This plain continues south of the great heights of Spath Plateau as far as the valley of Blue River. Within this large area, which is otherwise covered with vegetation, fixed beds are only exposed in the banks of Ekstraelv.

South of Ekstraelv the land is continuously flat and covered with vegetation, until some distance farther south the basalt becomes the dominant factor in the landscape.

The possibility of finding exposures of the Permian and Triassic beds within this area is very small, as far as can be judged from conditions in Loch Fyne. Farther south, on a sledge journey from Loch Fyne to Tobias Valley, I made some excursions from a camp a few kilometres east of Loch Fyne near the pass leading to Tobias Valley. Here the basalt dominates, and of sediments only loose blocks of grey and red sandstones were observed. However, a heavy snow-covering impeded investigations to some extent.

Between River 1 and Cape Stosch the *Glyptophiceras* beds are much covered with débris, and no exposures of the lower *Glyptophiceras* zone are known. On the north coast of Spath Plateau, however, the sediments overlying the Lower Permian beds are exposed in many places, which enables us to establish that the lower *Glyptophiceras* zone is not represented anywhere on the north coast.

Lower Permian is here overlain by very sparsely fossiliferous, arenaceous sediments like those which crop out at River 1 between the lower *Glyptophiceras* zone and the two uppermost zones of the *Otoceras* beds (KOCH 1931, p. 29).

Claraia and indeterminable *Glyptophiceras* fragments occur, though rarely, even in the lowermost part of these beds, and at a higher level a zone somewhat richer in fossils, the upper *Glyptophiceras* zone, was ascertained.

Here, as at Ekstraelv and River 1, the sediments resting immediately on the Lower Permian beds contain Bryozoan and Brachiopod remains, which probably originate from the older beds.

In the *Glyptophiceras* beds, like everywhere within the Triassic series, the sediments often change their character from place to place. Without discussing more closely these rather unimportant changes, I shall confine myself to giving the conditions in some of the best exposed localities, viz. Rivers 9, 13, and 16 (Blue River).

In the western wall of Immacradal the boundary between the Lower Permian and the Trias occurs at about 270—275 m altitude.

The direct contact is concealed by loose material, but it appears from loose-lying blocks that the *Martinia* limestone is overlain by red sandstones holding badly preserved fossils. Above 291 m there follow greyish, loose sandy beds alternating with more compact sandstones, on the surface of which, between 296 and 304 m altitude, there are accumulations of small limestone concretions, 2—5 cm in diameter, containing *Claraia* and indeterminable fish fragments.

The greyish, arenaceous beds on the surface of which loose sandstone blocks with *Glyptophiceras* are found in many places, terminate at 406 m altitude, when they are overlain by conglomerate II (see p. 78).

The eastern wall of Neviatiakdal (see fig. 19) exhibits a beautiful exposure of the *Glyptophiceras* beds. The boundary between the Lower Permian and the Trias intersects the bottom of the valley at 184 m altitude. The *Martinia* limestone is here overlain by grey sandstones, from the lower part of which a poorly preserved ammonite impression was collected a little farther east.

At 189 m there occurs a fixed bed of a coarse, hard, grey sandstone with reddish felspar grains. The sandstone is slightly conglomeratic, containing pebbles of a diameter of up to 1 cm and in addition occasional Bryozoans.

From 189 to 198 m the beds are made up of loose, grey, micaceous sandstones interbedded with harder bands of a compact sandstone. A few thin, argillaceous zones are seen in the loose sandstone beds.

Similar beds continue up to 207 m altitude, where they are overlain by a conglomeratic zone half a metre thick. The largest pebbles of the conglomerate have a diameter of about 1 cm.

Above 207 m the beds, which have so far been of a greyish colour, assume a reddish colour, and still higher in the series reddish, dark greyish, and grey beds alternate.

Up to 298 m altitude (the base of conglomerate II, see p. 79) loose and hard sandstone bands still alternate. At 272 m there is a thin conglomeratic band. From about 280 to 298 m small loose-lying limestone concretions with *Claraia* and ammonites are fairly frequent.

The section given above from the lower part of the east side of Neviatiakdal may be supplemented by the following observations from the lower part of the ridge that extends in between Øst- and Vestlokaliteten in Neviatiakdal (see the map pl. 1).

From 233 to 256 m loose, grey, sandy beds alternate with hard, grey sandstone bands.

At 256 m there occurs a conglomeratic band, about half a metre thick and with pebbles up to 5 cm in diameter. Above the conglomerate the arenaceous sediments assume a faint reddish coulour, and above 259 m they become somewhat argillaceous.

The numerous sandstone bands occurring in the argillaceous sand beds present a thickness of up to 10 cm, but are generally thinner.

From 271 to 276 m numerous badly preserved ammonites occur in two or three of the sandstone bands. Several similar bands occur somewhat higher up the slope, the uppermost at 285 m. At this altitude further a fairly great number of limestone concretions with *Claraia* were found. At 292 m is the base of conglomerate II which here contains plant remains (see p. 79).

To the east, a few hundred metres west of Wordie Creek, the *Glyptophiceras* beds change their character, appearing here as a steep slope built up of fairly hard, yellowish sandstones. Below Hjørnepunktet the Lower Permian-Triassic boundary occurs at 410 m altitude. The *Glyptophiceras* beds here are yellowish, and consist of alternating fine- and coarse-grained beds, sometimes conglomeratic, with pebbles several centimetres in diameter. In the lowermost half score metres occasional Productids and Bryozoan fragments are found, probably originating from the older beds. Above 426 m the sandstone is reddish and more fine-grained. At 453 m there is a grey, shaly sandstone bed with badly preserved plant remains. Above this altitude the sandstone is again yellowish. An ammonite impression was found at 453 m in a small loose-lying concretion. The steep wall of Hjørnepunktet terminates at 551 m altitude; the upper part of the wall doubtless corresponds to conglomerate II in Neviatiakdal, but cannot be distinguished from the subjacent *Glyptophiceras* sandstone.

Conditions somewhat similar to those described above from Immacradal, Neviatiakdal, or Hjørnepunktet, can be observed along the whole north coast of Spath Plateau, and justifies the maintenance of an upper *Glyptophiceras* zone within these sediments, which correspond to the sandstones poor in fossils overlying the *Glyptophiceras* zone at River 1.

Between the upper *Glyptophiceras* zone and the *Ophiceras* sp. nov. zone (see the table in pl. 1) there is an unfossiliferous, at times conglomeratic, zone of varying thickness. As regards this zone, reference is made to the chapter on the conglomerates (p. 72).

The Ophiceras sp. nov. and the Ophiceras cf. "*sakuntala*" *zones.*

The two uppermost zones of the *Otoceras* beds were previously included under the name "Lower *Ophiceras* beds", and in most places are hardly distinguishable from one another on account of the intense solifluction in the loose sediments. The strata of these two zones are rarely well exposed, but still in so many places that their structure can be traced with no greater variations from one end of Spath Plateau to the other.

The upper part of the *Otoceras* zone between Rivers 1 and 4 were

examined by KOCH (1931, p. 28). South of River 1 this as well as all the higher Triassic zones are absent. It is traceable all along the north side of Spath Plateau as also in a great part of the valley of Blue River, but east of this it has not been observed.

About the two upper zones of the *Otoceras* beds in the western part of Spath Plateau KOCH (1931, p. 34) writes that judging from the conditions at Rivers 2 and 3 they (KOCH's *Ophiceras commune* beds) occur about 300 m above the base of the Trias and about 80 m above conglomerate II (= conglomerate III, see p. 76).

KOCH's classical "lower Ophiceras" fish locality, whence the greater number of the fishes described by STENSIÖ 1932 are derived, is situated within this area. KOCH describes the locality as follows (1931, p. 32): Below a thin ammonite-bearing limestone band (probably 10—15 cm thick) there follows a bed, about 10 m thick, of clay or clayey sandstone with concretions, about one third of which contains fishes, one third ammonites (or *Claraia*), and one third is unfossiliferous.

According to KOCH's observations in all the "lower Ophiceras" localities known up to 1931, the structure of the beds is as follows (KOCH 1931): At the top a thin, but extremely fossiliferous zone resting on a fairly thick bed of clay or clay shale with concretions, from which the fishes are derived, and which in addition contains *Claraia* and ammonites, the same species as occur in the limestone band, but usually bigger specimens. Below follows a fairly thin calciferous or clayey zone, i. a. containing *Glyptophiceras*. *Otoceras* is confined to the much lower-lying beds below conglomerate I and are not found in the "lower Ophiceras zone".

Considering that the above results are based on investigations in the small intricate area round Cape Stosch, they are astonishingly correct. In spite of various alterations, the structure of the two upper *Otoceras* zones has proved to agree in broad features with KOCH's observations.

To gain an idea of conditions within the two uppermost *Otoceras*-bearing zones I shall give some of the most important exposures.

Above the hard sandstone forming the upper boundary of conglomerate III (see p. 77) there follow, on Stegocephalryggen, about 29 m of loose, sandy beds interbedded with numerous thin sandstone bands without fossils. As far as can be made out despite the solifluction, these beds are overlain by 14 m of clay, containing concretions with ammonites, fishes, etc. The lowermost part of this bed is too poorly exposed to enable us to ascertain the position of the *Ophiceras* sp. nov. zone. Fish-bearing concretions seem to increase in frequency downwards, while conversely the invertebrates are most numerous in the upper part of the clay bed.

The surface of the uppermost bed of the clay zone, which is exposed over a considerable area along the ridge of Stegocephalryggen, is covered by a vast number of concretions, which form almost a continuous pavement. These concretions chiefly contain big specimens of *Ophiceras*, also fish remains occur, but sparsely, and the only Stegocephalian remain known from the *Otoceras* beds was found here, viz. the beautiful cranium of *Lyrocephalus kochi* SÄVE-SÖDERBERGH (SÄVE-SÖDERBERGH 1934, p. 150 et seq.), after which the Stegocephalryggen has been

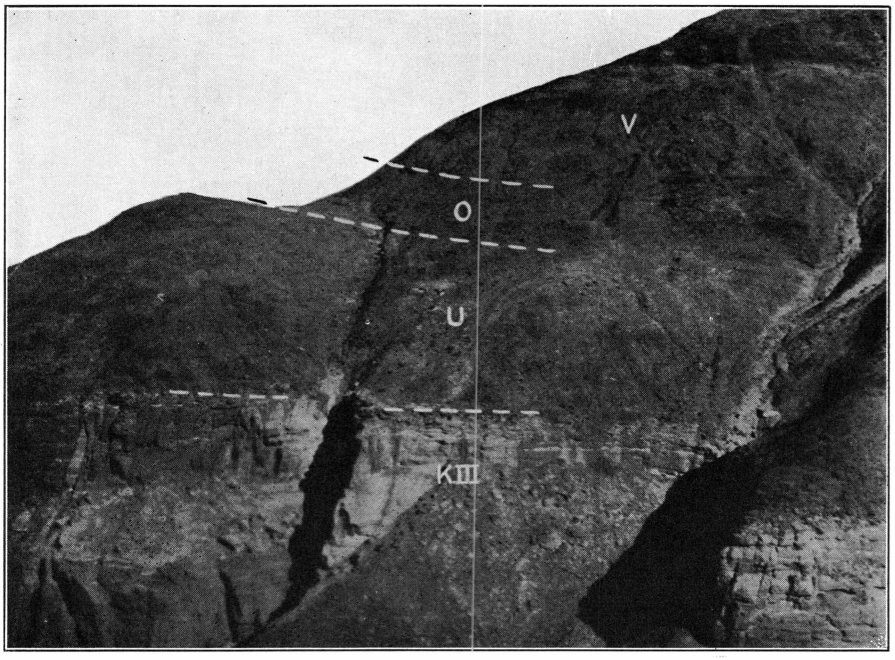


Fig. 15. The rich fish locality (O) on the west side of Fiskeplateauet. KIII = The hard sandstone, terminating conglomerate III upwards; O = the two upper zones of the *Otoceras* beds; U = unfossiliferous sand and sandstone beds; V = *Vishnuites* beds.

named. In addition to *Ophiceras*, the concretions contain *Glyptophiceras* and *Otoceras*.

Some few centimetres above the fish-bearing clay there occurs a band, about 2 cm thick, of grey sandstone, brownish-red on the surface. The occurrence of loose blocks indicate the presence of a calcareous band, 2—3 cm thick, with *Claraia* and ammonite fragments, also but slightly above the fish-bearing clay. About 1.5 m above the latter there is a calciferous band, about 8 cm thick, containing numerous *Claraia* fragments.

Despite the beautiful exposure, no trace of the ammonite-bearing

limestone band mentioned by KOCH (see above), which farther west on Spath Plateau overlies the fish-bearing clay, was observed.

In the western wall of Fiskeplateauet situated immediately east of Stegocephalryggen the strata are not so well exposed either that the *Ophiceras* sp. nov. zone can be distinguished from the *Ophiceras* cf. "*sakuntala*" zone. However, along a stretch of more than 100 m the upper part of the *Otoceras* beds is so well exposed that in 1932 one of the richest fish localities was found here (see p. 101).

Above the hard sandstone terminating conglomerate III (p. 77) there follows a series, about 34 m thick, of loose sand beds with intermediate thin, hard sandstone bands. The latter frequently exhibit ripple-marks, but are unfossiliferous. Above follow about 12 m (estimated) of clay with concretions, which were mostly collected loose on the surface, often broken on account of regelation. Here too, as on Stegocephalryggen, a comparatively large number of concretions with ammonites were found in the upper part of the clay. By the regelation the concretions have shown a tendency to splitting perpendicularly to the bedding planes into several small fragments, while the fish-bearing concretions mostly split parallel to the bedding plane on which the fish rests. By an examination of the concretions collected from the whole series I found several of them to be very big, 30—40 cm in diameter or even more, and more sandy than the smaller concretions. Often the big concretions contain several fishes, or both fishes and ammonites, in the same concretion, on one or several bedding planes.

Big, sandy concretions of this kind are known from several eastern exposures, for instance in Neviatiakdal (p. 44), where they occur in the lowermost, sandy part of the clay zone belonging to the *Ophiceras* sp. nov. zone, often in great numbers.

Hence it is very probable that on Fiskeplateauet, too, they originate from the *Ophiceras* sp. nov. zone, even if this was not ascertained during the work in the field.

Judging from the numerous loose blocks the clay bed are immediately overlain by thin limestone bands carrying fragments of *Claraia*, similar to those described from Stegocephalryggen. Some of these indicate the occurrence here of the ammonite-bearing limestone band mentioned in p. 35, although it was nowhere found *in situ*.

East of the locality in the west side of Fiskeplateauet the upper part of the *Otoceras* beds is traceable to the fault in Immacradal (see the map pl. 1), but along the whole stretch it is poorly exposed, and it is difficult to localise it in the landscape. However, some few fishes were collected here, mostly from the north side of Fiskeplateauet, but also some few from the east side as well as from Borgen and Pyramiden.

However, the two upper zones of the *Otoceras* beds are even more poorly exposed west of Stegocephalryggen, on Knolden, which is bounded on the east by the western branch of River 7, and on the west by the eastern branch of River 6. On the small ridge between Blokken and the Vestplateauet neither the *Otoceras* nor the *Vishnuites* beds were investigated; this ridge may possibly yield a number of fish-bearing concretions.

Vestplateauet west of this ridge was very carefully investigated, and since here the upper part of the *Otoceras* beds are fairly well exposed in several places, a number of fossils were collected from them. The best exposure was met with in a small ravine in the north side of the plateau, some few hundred metres west of the western branch of River 6. About 44 m above the hard sandstone overlying conglomerate III (p. 77) a small exposure of the clay beds of the *Ophiceras* sp. nov. and the *Ophiceras* cf. "*sakuntala*" zones begins. The clay bed is exposed in a thickness of 8 m, and contains concretions with fishes, ammonites, etc. Neither the upper nor the lower boundaries of the bed are exposed. About 5 m below the lowermost exposed part of the clay a band, about 1 m thick, of a grey, micaceous, unfossiliferous sandstone is seen.

At the eastern corner of Vestplateauet the upper boundary of the hard sandstones forming the upper boundary of conglomerate III (p. 77) occurs at 245 m altitude. Eight metres higher up the slope an exposure was observed in the overlying looser sand beds, which are of a light-grey colour and contain some few hard sandstone bands. Six metres higher up the concretions with fishes and ammonites from the fish clay were met with, and about 17 m higher occurred the uppermost concretions from the fish clay. The strata are so badly exposed that it is impossible to distinguish between the two upper zones of the *Otoceras* beds. Lying loose on the surface of the upper part of the clay zone are numerous limestone blocks containing *Ophiceras*, *Otoceras*, *Glyptophiceras*, etc., evidently originating from an ammonite-bearing limestone band superjacent to the fish clay, as stated by KOCH (see p. 35) from the western part of Spath Plateau. The uppermost blocks of the limestone band occur about 1 m above the uppermost concretions of the clay zone.

During his investigations KOCH discovered the most westerly exposure of the upper part of the *Otoceras* beds so far known from the north side of Spath Plateau, viz. the locality west of the delta of River 5, at about 100 m altitude (KOCH 1931, p. 37). Later I visited the locality, but at that time it was entirely covered with scree, so it was impossible to obtain any information of the sequence of strata.

East of the fault of Immacradal the upper part of the *Otoceras* beds is well exposed in many places, and here most of the observations of the sequence of strata were made.

West of Immacradal it was possible everywhere to localise the fossiliferous zones in the upper part of the *Otoceras* beds by computing their distance from the upper surface of the hard sandstone overlying conglomerate III, but some few hundred metres east of Rævekløft conglomerate III disappears, and the hard sandstone is replaced by looser beds of sand and sandstone. Conglomerate II, it is true, continues even to Blue River as a yellow, hard, non-conglomeratic sandstone zone, but it is but little prominent, and on account of its greater distance from the fossil zones less suited as a means of localising the latter during the work in the field.

East of Otocerasdal the best exposures were found in Rævekløft, in the valley of the western River 11, in Neviatiakdal, on Smalleryg, in the valleys of Rivers 14 and 15, in Otocerasdal, in Blokdal, in Rødedal, and in the east and west sides of the valley of Blue River, whereas the Nebalopokryggene are so poorly exposed that merely the presence of the *Otoceras* zones can be ascertained, and it is hardly possible to collect one single fish here.

Conditions in the upper part of the *Otoceras* beds in the eastern bank of Blue River between Gaffeldal and Stribedal east of the Blue River fault differ somewhat from those of Spath Plateau, the *Ophiceras* sp. nov. zone being here extraordinarily well developed, whereas the *Ophiceras* cf. "*sakuntala*" zone plays a subordinate part.

At the place where the zone was investigated (fig. 16) the bottom of the valley lies at 205 m altitude. The lowermost one metre is built up of argillaceous sand, interbedded at short intervals with grey sandstone bands, from a few centimetres up to about 20 cm thick. Possibly this zone, a greater thickness of which is exposed farther north in the river bed, corresponds to part of the conglomerate II sandstone in the eastern part of Spath Plateau (see p. 77 et seq.).

Immediately above the grey sandstone the strata are somewhat concealed by scree. At 229 m altitude there is an exposure of loose, micaceous, greyish sandstones.

At 232 m limestone concretions with *Claraia* make their appearance. Above this altitude the beds are made up of loose sand interbedded with harder sandstone bands containing impressions of *Glyptophiceras*.

At about 235 m loose blocks of a grey sandstone containing *Otoceras*, *Glyptophiceras*, and *Claraia* are of frequent occurrence. Some few metres higher up the sandy beds become more clayey, and the sandstone bands become less dominant, while the concretions increase in frequency. In addition to fishes they especially contain *Glyptophiceras* and *Otoceras*. The greater number of fishes were collected at about 245 m. At about 265 m the uppermost concretions were met with; both *Glyptophiceras*

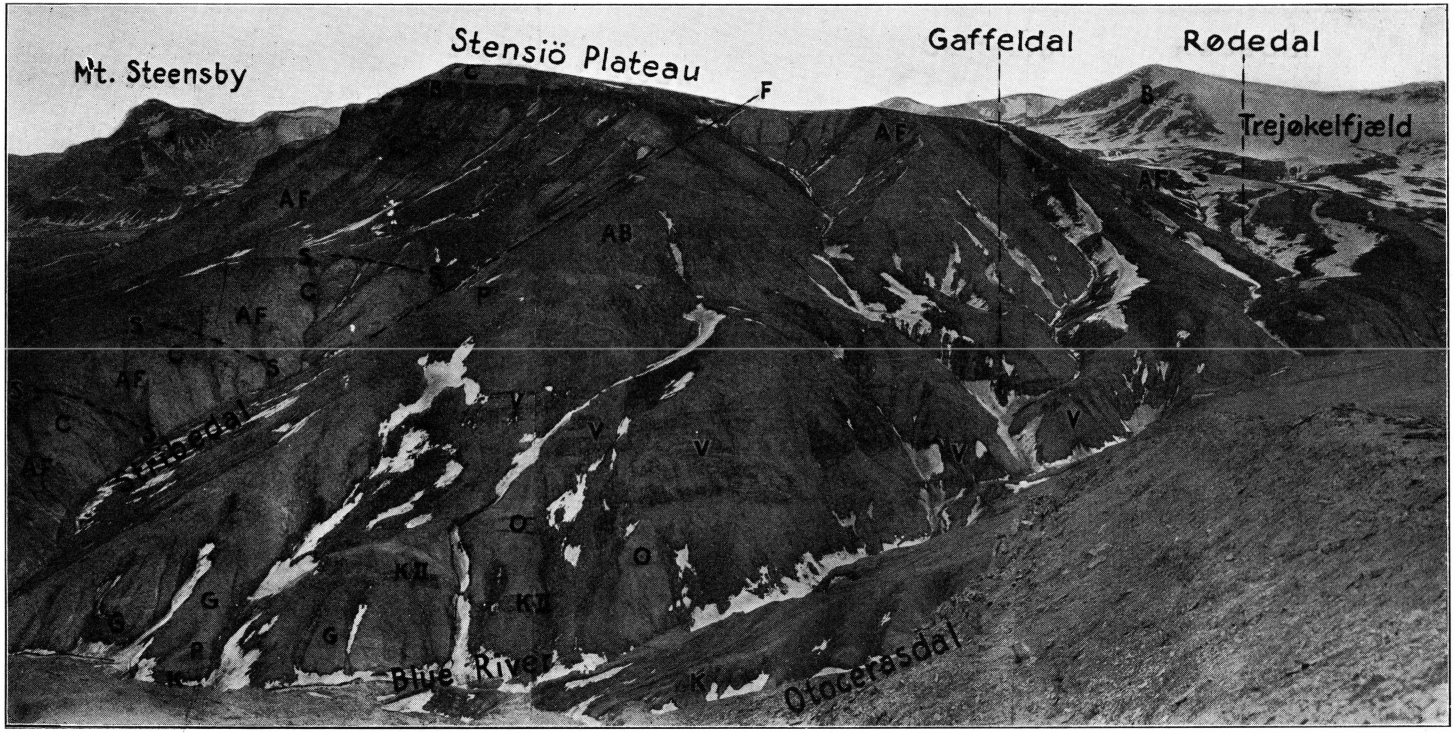


Fig. 16. The east side of Blue River valley. AB = *Anodontophora* (breviform) beds; AF = *Anodontophora fassaensis* beds; B = basalt; C = Cretaceous; F = fault; G = upper *Glyptophiceras* zone; K = Carboniferous conglomerate; K II = conglomerate II sandstone; O = the two upper zones of the *Otoceras* beds; P = *Proptychites* beds; S—S = slip; V = *Vishnuites* beds.

and *Otoceras* occur at this altitude, but the loose, argillaceous beds containing occasional thin sandstone bands continue up to 272 m altitude, where they are overlain by an immense series of reddish and greyish sandstones, probably the lower part of the *Vishnuites* beds (p. 53).

In a ridge immediately south of Stribedal the fish zone with *Glyptophiceras*, *Ophiceras*, *Otoceras*, *Claraia*, and fishes occurs at an altitude of 280 m. In this locality loose blocks of a limestone band, about 10 cm thick and rich in ammonites, were found.

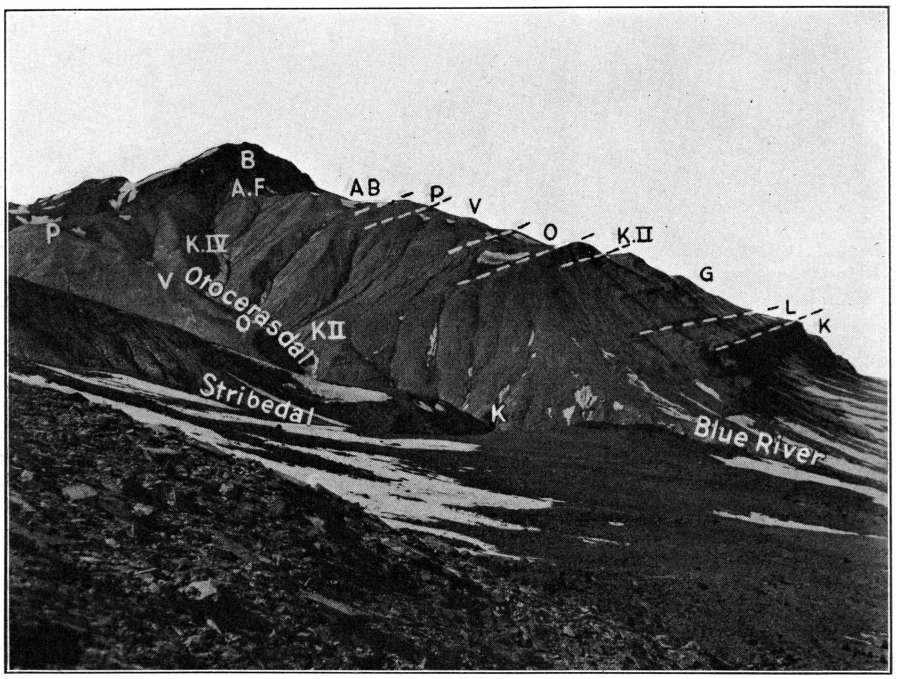


Fig. 17. The eastern part of Spath Plateau seen from the western part of Stensiö Plateau. AB = *Anodontophora* (breviform) beds; AF = *A. fassaensis* beds; B = basalt; G = Upper *Glyptophiceras* zone; K = Carboniferous conglomerate; K II = conglomerate II sandstone; K IV = congl. IV; L = Permian; O = the two upper zones of the *Otoceras* beds; P = *Proptychites* beds; V = *Vishnuites* beds.

These two localities are interesting on account of their mainly sandy development of the fish zone. The great number of *Glyptophiceras* and *Otoceras* occurring here indicates that chiefly the next-highest zone of the *Otoceras* beds is represented, while the uppermost zone, known from the more westerly localities, is less prominent. In many respects conditions here recall those of the Hird Bay area (see p. 90).

The southern wall of Otocerasdal exhibits a beautiful exposure of the upper part of the *Otoceras* beds (see the map in pl. 1).

At 452 m the sandstone of conglomerate II (p. 77) is overlain by

loose or more compact, greyish, unfossiliferous sandstones. They are followed at 465 m by a clay bed, arenaceous below, holding numerous concretions. The upper boundary of the clay bed is at about 488 m. Loose blocks found at this altitude indicate the occurrence *in situ* of a richly ammonite-bearing limestone band and an ammonite-bearing red sandstone band not far above the clay bed. On account of solifluction it is difficult to draw the boundary between the *Otoceras* and the *Vishnuites* beds, nor is it possible to distinguish between the *Ophiceras* sp. nov., and the *Ophiceras* cf. "*sakuntala*" zones in this locality.

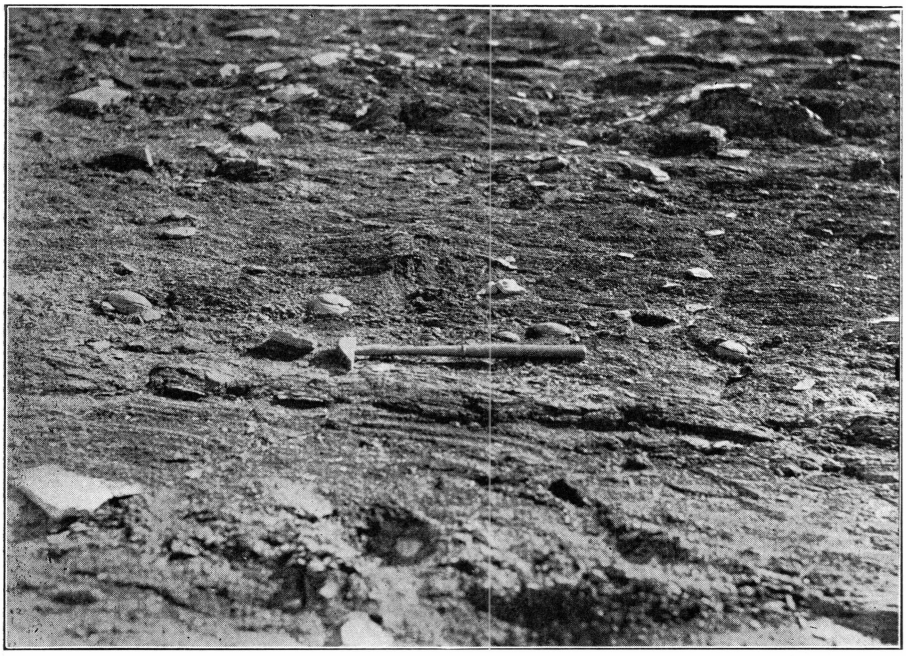


Fig. 18. Ammonite-bearing concretions *in situ* in the clay beds of fish zone II. Exposure in the eastern bank of River 14.

The remaining exposures of the upper part of the *Otoceras* beds in the Blue River area, viz. in Blokdal, Rødedal, and the western slope of Blue River between Otocerasdal and Blokdal, present no features of particular interest. Nor is there any reason to enter further into the development of these beds at Wordie Creek, whereas in the following I shall describe conditions in the valley of River 14.

In the eastern wall of this river the conglomerate II sandstone is overlain at an altitude of 384 m by loose sand beds with more compact sandstone bands. Let us examine conditions some distance farther south, where the bottom of the valley lies at 423 m altitude. Here the lowermost part of the valley side is made up of loose sand beds with

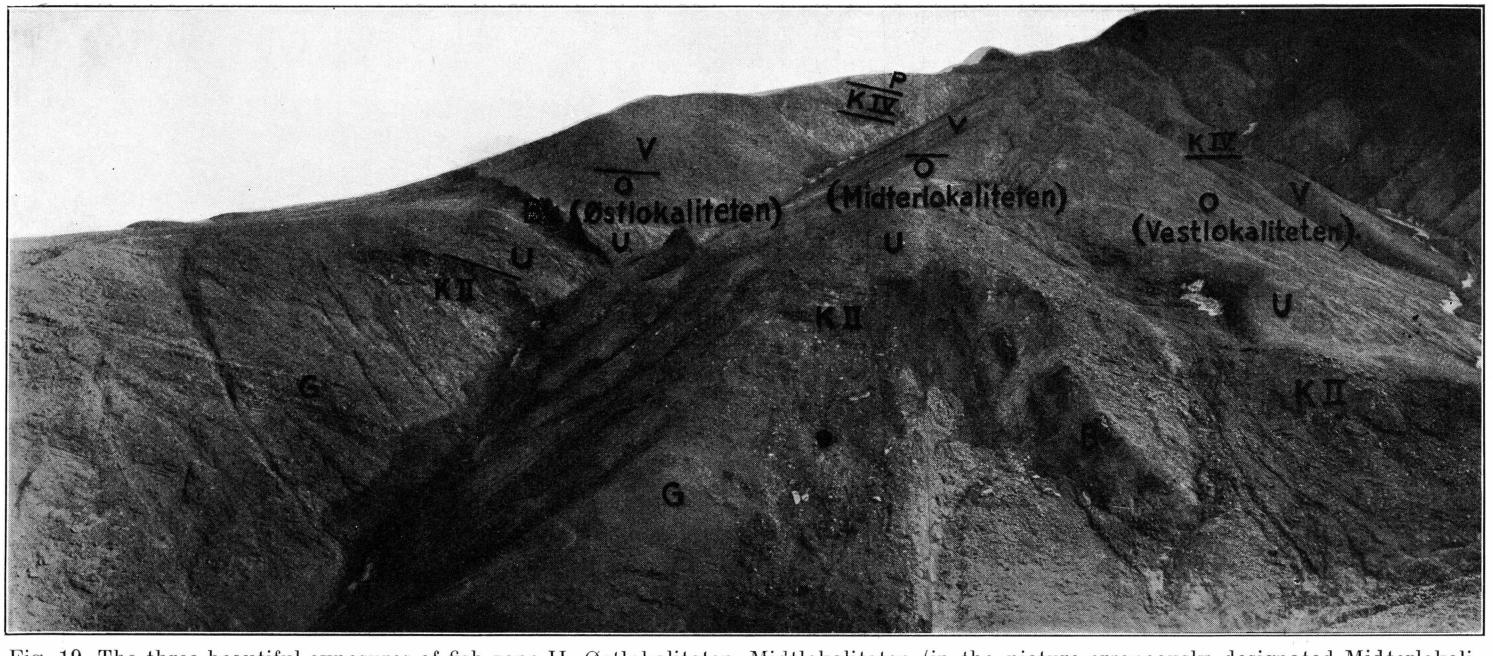


Fig. 19. The three beautiful exposures of fish zone II, Østlokaliteten, Midtlokaliteten (in the picture erroneously designated Midterlokaliteten), and Vestlokaliteten. B = basalt dyke; G = upper *Glyptophiceras* zone; K II = conglomerate II; K IV = conglomerate IV; O = the two upper zones of the *Otoceras* beds; P = *Proptychites* beds; U = unfossiliferous sand and sandstone beds overlying conglomerate II sandstone; V = *Vishnuites* beds.

interstratified sandstone bands. From 432 to 439 m concretions holding *Glyptophiceras pascoei*, *minor* and *gracile*, *Ophiceras subdemissum*, *Claraia* and fishes, begin to appear in the arenaceous clay beds.

A similar fauna was found in the concretions of the superjacent arenaceous clay beds, where I attempted to ascertain variations in the fauna by collecting fossils at a few metres' interval up the slope. *Otoceras* is represented in all the collections except the lowermost one, which is no doubt due to a mere accident, and the whole exposure, terminating at 463 m altitude, exhibits a very uniform fauna. This arenaceous clay zone belongs to the *Ophiceras* sp. nov. zone. The *Ophiceras* cf. "*sakuntala*" zone is covered with scree, the lowermost part of Kilen, however, seems to be referable to this zone (see p. 49).

On Smalleryg the conglomerate II sandstone (p. 77) is overlain by looser sands with sandstone bands at 358 m. At about 375 m occurs a clay zone with concretions containing fishes and an ammonite fauna, which shows that we are here dealing with the next-highest zone of the *Otoceras* beds. Fortunately this zone is separated from the *Ophiceras* cf. "*sakuntala*" zone by the basalt dyke running from Hjørnepunktet to Nebalopokryggene, which dyke, appearing in the form of a wall several metres high, prevents a mixing of the fossils of the two zones (fig. 6). The basalt dyke intersects Smalleryg at 395 m altitude. The clay zone continues south of the basalt wall, still containing numerous concretions with fishes and ammonites, etc., belonging to the *Ophiceras* cf. "*sakuntala*" zone (which, however, is possibly represented immediately north of the basalt dyke).

At a height of about 400 m, there occurs, judging from loose blocks, a limestone band with ammonites, about 25 cm thick, which forms the upper termination of the *Otoceras* beds.

In Neviatiakdal the largest and most beautifully exposed localities for the upper zones of the *Otoceras* beds in Spath Plateau (fig. 19 and the map pl. 1), the Øst-, Midt-, and Vestlokaliteten, occur. It will suffice here to give the succession of strata of Midtlokaliteten, since the two other localities differ but slightly from this locality.

In the ridge separating the Øst- and the Vestlokaliteten the upper boundary of the conglomerate II sandstone (p. 77) is at 306 m. About 10 m farther west the sandstone is intersected by the above-mentioned basalt dyke from Hjørnepunktet. The sandstone is followed upwards by badly exposed loose sands with thin sandstone bands without fossils. At 353 m there is a gypsiferous bed, 10—20 cm thick, which is overlain by unfossiliferous sand and sandstone beds. From 362 to 378 m there follows a clay zone, the lowermost arenaceous part of which belongs to the *Ophiceras* sp. nov. zone, and contains occasional, very big, arenaceous concretions, while the upper part belongs to the *Ophiceras*

cf. "*sakuntala*" zone. *Otoceras* occur in both zones. In addition to fossiliferous concretions the uppermost 5—6 m of the clay zone contain thin, irregular limestone bands, or rather intergrown concretions, holding ammonites, *Claraia* and other fossils.

The richly ammonite-bearing limestone band superjacent to the clay zone and known from several localities, seems to be absent here, whereas it appears from loose blocks that a limestone band with *Claraia* fragments similar to that known for instance from Stegocephalryggen occurs not very far above the clay zone, and probably indicates the approximate boundary between the *Otoceras* and the *Vishnuites* beds.

The only locality between Neviatiakdal and Rævekløft worthy of mention is the eastern bank of the western River 11. The upper boundary of the conglomerate II sandstone (p. 77) is here at 318 m. In the overlying alternating sands and sandstones a gypsiferous bed about half a metre thick was observed at an altitude of 335 m. Between 353 and 378 m the two upper *Otoceras* zones occur, which cannot be distinguished from one another on account of solifluction.

Summing up the results of our investigations of the part of the *Otoceras* beds occurring west of Rævekløft above conglomerate III and east of Rævekløft above the hard sandstone corresponding to conglomerate II, we find, at the base, a fairly thick series of sands and sandstones without fossils. To the east, where conglomerate III is absent, this series is thicker than to the west, and may contain a fairly thick gypsiferous bed. This zone is succeeded upwards by an arenaceous clay zone with limestone concretions, partly of the same size as those of the superjacent zone, partly very big, sandy concretions of a diameter of 30—40 cm or even more. In the lower part of this zone ammonite-bearing sandstone bands may be found. The ammonite fauna of the sandstones and the concretions is mainly composed of *Glyptophiceras* species and *Otoceras*, while *Ophiceras* is less frequent. On the basis of the fossil contents of the beds Spath (1934) refers them to a special zone, the *Ophiceras* sp. nov. zone. The content of sand in the clay zone decreases upwards, and the very big sandy concretions disappear. This upper part of the clay is distinguished by its richness in concretions, of which a particularly large number occur in the uppermost zone of the clay, at any rate in certain localities. These uppermost concretions are fairly big, and more frequently contain big specimens of *Ophiceras* than the concretions of the lower beds. Closely above the clay zone an ammonite-bearing limestone band holding the same ammonite fauna as that of the upper part of the clay zone is rather frequently found; in addition, also near the clay zone, there occur one or several thin limestone or sandstone bands with *Claraia* fragments and other fossils.

Otoceras is represented throughout the zone, and its uppermost occurrence marks the upper boundary of the *Otoceras* beds.

The upper, less arenaceous, part of the clay zone with its limestone and sandstone bands differs from the *Ophiceras* sp. nov. zone characterised by *Glyptophiceras* in that *Glyptophiceras* is less dominant, while *Ophiceras* species become the dominant element of the ammonite fauna. This uppermost zone of the *Otoceras* beds is termed by SPATH the *Ophiceras* cf. "*sakuntala*" zone.

The two upper *Otoceras* zones contain fishes embedded in concretions, but on account of the difficulty in separating the two zones within the greater part of the area, the collections from them were not kept distinct (p. 27).

Vishnuites Beds.

	Conglomerate IV.
	Coarse sandy beds with bands of sandstone, sometimes with sandstone balls, and if so, now and then conglomeratic.
Upper *Vishnuites* zone (with *Ophiceras* sp. nov.)	Argillaceous, fine-grained sands with compact sandstone bands and concretions. Fossils: ammonites, mussels, gastropods, fishes, etc. { Fish zone 4.
	Coarser sand beds with bands of sandstone or sandstone balls, sometimes (in the eastern part of Spath Plateau) with conglomeratic zones.
Middle *Vishnuites* zone (with *Vishnuites wordiei*)	Clayey, fine-grained sand beds with dense sandstone bands, sometimes with concretions and a highly fossiliferous limestone band with *Vishnuites wordiei*, *decipiens*, *Ophiceras transitorium*, etc.
	Predominantly coarse sandy beds with sandstone bands. (Possibly absent from the western part of the area).
Lower *Vishnuites* zone (with *Vishnuites* sp. nov.)	Argillaceous, fine-grained sand beds with compact sandstone bands and one, two, or three limestone bands with ammonites etc. *Bellerophon* is of frequent occurrence in this zone. Clay zone with small concretions with fishes. (Only in the eastern part of the area). { Fish zone 3*). Loose, coarse-grained sandy beds with sandstone bands. In the eastern localities, however, somewhat argillaceous and with concretions. In these localities the concretions as well as one or several sandstone bands contain an ammonite fauna closely related to that of the *Ophiceras* cf. "*sakuntala*" zone, but without *Otoceras*.

*) Regarding fish zone 3, see p. 53.

The *Vishnuites* beds, the series intermediate between the *Otoceras* and the *Proptychites* beds, comprise the beds termed "Upper *Ophiceras* beds" by KOCH in 1931. Both the Cambridge Expedition 1926 and the Danish expeditions prior to 1931 brought back fossils from the *Vishnuites* beds in Spath Plateau (KOCH 1931, pp. 83—84, SPATH 1930, p. 67 et seq.). However, on account of the very incomplete collections from the débris-covered sections and the difficulty in localising the localities (KOCH 1931, p. 42) without a map of the area, it was impossible to make out the stratigraphical conditions at the time when KOCH's paper was published.

KOCH writes as follows (1931, p. 83): "Several fossil horizons occur between the Lower *Ophiceras* beds and the *Proptychites* beds, but our knowledge of them is so far only slight. They seem to be restricted everywhere to fairly thin zones. In most of the localities in the vicinity of Cape Stosch a thin zone of calcareous, fossiliferous sandstone was met with, in which, however, ammonites were rare, the fossils being chiefly *Bellerophon* and various pelecypods. Future investigations may, no doubt, greatly enlarge our knowledge of the Upper *Ophiceras* beds. When I establish this horizon here, it is because these beds have yielded a fauna differing decidedly from that of the Lower *Ophiceras* beds."

That several thin fossiliferous zones occur in the *Vishnuites* beds has been confirmed by the investigations in 1932—33.

The sediments of the *Vishnuites* beds are mainly loose sand and clay beds with numerous bands of harder sandstones, rarely limestone. The bands range in thickness from some few centimetres to several metres. (Regarding conglomeratic zones in the *Vishnuites* beds, see p. 52).

The highly débris-covered sections in connection with the frequently very thin fossiliferous zones render the investigation of this part of the Triassic series more difficult than any other zone within the area, and only by combining the observations from the best exposures of the numerous sections investigated is it possible to form an idea of the conditions.

I shall commence the description of the *Vishnuites* beds by giving three important sections, which together have supplied most of the facts of any importance. Subsequently I shall discuss the deviating conditions observed in various places within the area.

Fiskeplateauet and Stegocephalryggen. The structure of the *Vishnuites* beds on Fiskeplateauet and Stegocephalryggen described in the following pages may be regarded as typical of the whole part of the north side of Mt. Frebold, situated west of Immacradal. It much resembles the section described by KOCH (1931, p. 36) from the northwestern corner of Spath Plateau, to which the reader is referred for information about the much obscured area near Cape Stosch.

Stegocephalryggen is a long, narrow ridge situated immediately west of Fiskeplateauet (see the map); the section extends from some distance down the *Otoceras* beds up through the *Vishnuites* and *Proptychites* beds, to be concealed some distance up the *Anodontophora* (breviform) beds below the basalt scree originating from the steep wall of Mt. Frebold.

The beds are best exposed in the ridge itself. Here the *Vishnuites* zone was thoroughly investigated, but it was not very rich in fossils. The section is as follows:

476—464 m. Conglomerate IV. A steep sandstone wall, with subordinate conglomeratic bands (see p. 79).

464—373 m. Grey, loose sand beds with numerous hard sandstone bands up to 5—8 cm thick. The loose sandy beds often contain well rounded sandstone balls. *Spirorbis* and mussels occur (i. a. *Anodontophora* ?), but no ammonites.

373—365 m. Grey, loose, sandy beds with harder sandstone bands, as in the series above 373 m. At 373 m *Claraia* and *Ophiceras* n. sp. were found loose, doubtless originating from a fixed bed in the neighbourhood; the latter species indicates the presence of the upper *Vishnuites* zone.

365—349 m. Loose sand beds with numerous thin sandstone bands, easily distinguishable from the superjacent series on account of a dark reddish-brown colour of the weathered surface of the sandstone beds. The loose sand beds are finer-grained, occasionally slightly argillaceous, and the sandstone bands are finer-grained and more compact than in the overlying lighter series.

In addition to lamellibranchs and some few other fossils of no stratigraphical value, *Ophiceras transitorium* and *Vishnuites* sp. were collected at 358 m, so the lower and middle *Vishnuites* zones cannot be localised with certainty. The boundary towards the *Otoceras* beds is at 347 m. The investigation of the rather poorly exposed *Vishnuites* zone in the west side of Fiskeplateauet supplements to some extent our knowledge of conditions at River 7. Here the series is built up as follows:

The lower boundary of conglomerate IV is at 517 m. At 377 m occurs the upper boundary of the *Otoceras* beds in the western side of Fiskeplateauet. The upper part of the series, from 517 to about 450 m, resembles the corresponding zone in the Stegocephalryggen, being built up of coarse, loose, sandy beds with numerous intermediate sandstone bands and occasional sandstone balls. The fauna, too, is equally poor and of little stratigraphical value.

Between 450 and 377 m the much obscured beds are more fine-grained and argillaceous, and at the same time evidently more fossiliferous. From the fossils collected it seems (according to information by SPATH) that the upper *Vishnuites* beds are represented between 416 and 436 m, while middle *Vishnuites* beds occur from 406 to 415 m altitude. Owing to obscuration by débris it is difficult to form an idea of the series between the middle *Vishnuites* zone and the *Otoceras* beds, but judging from the loose blocks, this part of the *Vishnuites* beds contains ammonite-bearing bands, indicating the presence of a lower *Vishnuites* zone.

The most conspicuous feature of Fiskeplateauet and Stegocephalryggen considered as a whole is the presence between conglomerate IV and the *Vishnuites* zone of an immense series very poor in fossils, while on the other hand the upper *Vishnuites* zone on Fiskeplateauet occurs but some 40—50 m above the *Otoceras* beds and in Stegocephalryggen still lower. (The very few fossils from the upper *Vishnuites* zone in Stegocephalryggen may, however, have slid down from an upper *Vishnuites* zone occurring at about the same distance from the *Otoceras* beds as in Fiskeplateauet).

In Vestplateauet, Blokken, Borgen, and Pyramiden the *Vishnuites* beds are poorly exposed, but to all appearance they are in all essentials built up in the same manner as near River 7.

East of the fault of Immacradal the fossil zones of the *Vishnuites* beds are better developed, i. e. richer in fossils and hence less easily overlooked. In several places the *Vishnuites* beds are exceptionally beautifully exposed, so that fairly minute collections could be made.

The most complete and best exposed section through the *Vishnuites* beds (fig. 20) was investigated in the small ridge, Kilen, situated between the two branches of River 14.

Coming from the north through the long valley of River 14, we note the upper part of the *Otoceras* beds (see p. 44) in the eastern wall immediately before reaching the northern point of Kilen. The lowermost part of Kilen is somewhat covered with débris, but probably consists of the upper part of the *Ophiceras* cf. "*sakuntala*" zone, which is overlain by the *Vishnuites* series but a few metres up the slope.

Here the beds dip about 12° to the south and 1° or 2° to the west.

Between 458 and 460 m several blocks of a greyish, about 6 cm thick, sandstone band, i. a. containing *Glyptophiceras pascoei*, indicate that the band occurs *in situ* about this level. (Similar blocks were not found above this altitude).

Limestone concretions with ammonites and in rare cases fish remains are fairly common on the surface of the slope between 458 and

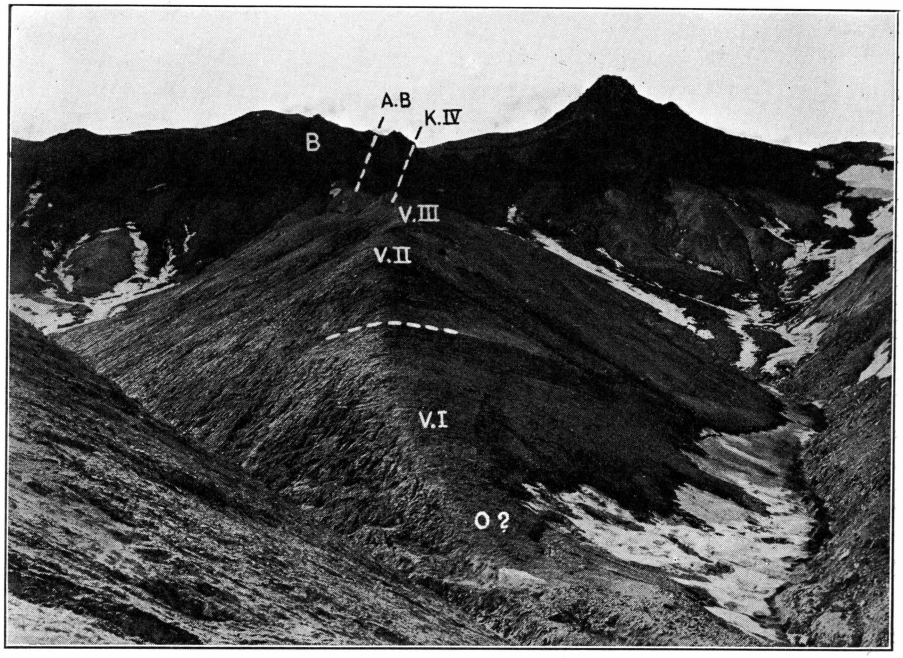


Fig. 20. Kilen. AB = *Anodontophora* (breviform) beds; B = basalt; K IV = conglomerate IV; O? = probably obscured upper part of uppermost zone of *Otoceras* beds; V. I, V. II, V. III = Lower, middle, and upper zones of *Vishnuites* beds. The broken line in the middle of the picture corresponds to A- - - - -A in fig. 21.

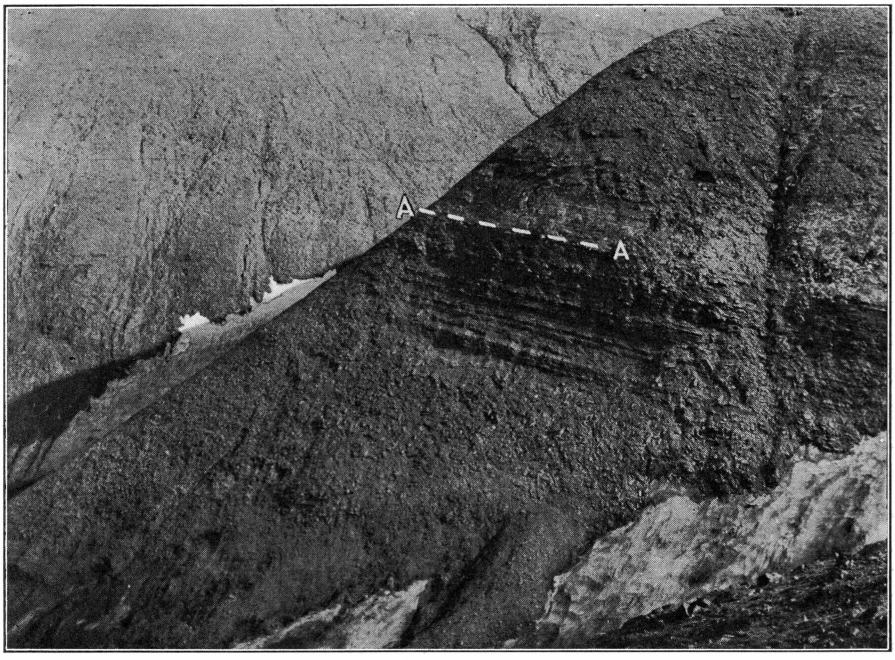


Fig. 21. Detail picture from Kilen; A- - - - - A = the upper boundary of the extraordinarily beautifully exposed lower *Vishnuites* zone.

460 m. Ammonites embedded in concretions may still be found a couple of metres farther up the slope, but at 462 m they are very rare.

At the same time loose blocks of fossiliferous limestones make their appearance, evidently originating from a fixed limestone band exposed at 464 m altitude. This limestone band varies in thickness from 3 to about 20 cm. It rests directly on loose, argillaceous sand beds with numerous thin sandstone bands. Some few hundred metres farther east, in the east side of River 14, the corresponding loose, clayey sand beds contain fish remains embedded in concretions; in both localities the bed possibly (see p. 53) corresponds to fish zone 3 (see p. 102), which is so beautifully developed in Neviatiakdal. In this valley fish zone 3 occurs about 20 m above the upper boundary of the *Otoceras* series, and the intermediate beds are poor in fossils and coarsely arenaceous, alternately loose or compact, beds. On Kilen, however, the fauna of the ammonite-bearing concretions is closely related to the fauna of the uppermost zone of the *Otoceras* beds, only *Otoceras* being absent. And since the boundary between the *Otoceras* and the *Vishnuites* beds has been drawn at the upper limit of *Otoceras*, I am inclined to refer the concretion-bearing zone on Kilen between 458 and 462 m to the lower *Vishnuites* beds (see the table in p. 46).

Above the limestone band, whose ammonite fauna also indicates a very low position within the *Vishnuites* beds, there occur argillaceous sand beds with intercalated thin sandstone bands without ammonites, but with occasional specimens of *Myalina*, *Claraia*, and *Spirorbis*, which occur throughout the *Vishnuites* beds. At 469 m there is a limestone band 2—7 m thick, containing some few species of *Ophiceras*, further *Claraia*, *Myalina*, and *Naticopsis*. Again, at 472 m, there occurs a limestone band of about the same thickness as the preceding one, but it has only yielded *Claraia* and a fish fragment. Both these upper limestone bands present so many points of similarity to the lower band that it is natural to refer them, too, to the lower *Vishnuites* beds.

On either side of the uppermost limestone band the section is beautifully exposed over some few metres (fig. 21), and the beds are seen to consist of arenaceous clay with numerous argillaceous, compact sandstone bands, on the upper and under sides of which specimens of *Spirorbis* often occur. The bands vary in thickness from 1 or 2 to 8 or 10 cm.

Above 478 m the beds change their character, being coarsely arenaceous and containing thin, coarse-grained sandstone bands. Between 482 and 483 m the sand beds are again argillaceous, and contain a *Claraia*-bearing sandstone band. From 483 to 484.5 m the coarsely arenaceous facies is again present, and from 484.5 to 507 m the argillaceous facies with the fine-grained sandstone bands, occasionally con-

taining mussels, etc., occurs. At 494 m this zone contains a friable limestone band with *Vishnuites wordiei*, *V. decipiens*, *Naticopsis*, etc., that is, a typical middle *Vishnuites* fauna. The beds immediately below the limestone band contains small limestone concretions, either unfossiliferous or with *Naticopsis* (see p. 53).

The coarsely arenaceous facies is found again between 507 and 529 m, between 524 and 525 m it is even conglomeratic with pebbles up to 6—8 cm in diameter. The argillaceous facies is again present between 529 and 549 m. In addition to numerous sandstone bands it contains limestone concretions with *Ophiceras*, *Claraia*, *Naticopsis*, fishes, etc. Ammonites are fairly rare, and most frequent in the lower part of the zone, while the mussels are most numerous in the upper part. The fauna differs from the middle *Vishnuites* fauna i. a. in its lack of *Vishnuites wordiei* and *V. decipiens*, and according to SPATH's investigations represents a special zone, the upper *Vishnuites* zone, which includes fish zone 4.

Above 549 m there occur coarse-grained, arenaceous, loose beds with well rounded sandstone balls. On splitting the central part these balls will frequently be found to consist of a pebble, and since this bed is directly overlain by conglomerate IV, which is here developed as a greyish-green, hard sandstone (p. 79), it seems natural to assume that also the pebble-bearing zone corresponds to part of conglomerate IV farther west.

I have given this section in such great detail because it represents the best exposure through the *Vishnuites* beds on Spath Plateau.

The remaining part of the area between Immacradal and River 16 agrees in all essentials with this section, even though numerous deviations from conditions on Kilen may be met with from place to place; now an extra ammonite-bearing limestone or sandstone band is intercalated, now one of the small fossil zones is absent (or is overlooked on account of solifluction). However, it would take us too far afield to discuss all these minor deviations here.

In Neviatiakdal the *Otoceras* beds are overlain by sandy beds poor in fossils and of a thickness of 15—20 m, which according to their position should correspond to the zone on Kilen underlying the lowermost limestone band in the *Vishnuites* beds and containing concretions with ammonites. In Neviatiakdal this zone contains no concretions. The series becomes clayey upwards and here contain several small concretions with very beautifully preserved fishes, sometimes Stegocephalian remains. This clayey zone, the thickness of which ranges from 5 to 8 m, fish zone 3, possibly corresponds to fish zone 3 at River 14, but instead of being overlain by limestone bands belonging to the lower *Vishnuites* beds there follow, about 5 m above it, middle *Vishnuites* beds with *Vishnuites*

wordiei and *V. decipiens*, and other fossils, which farther east lie at a considerably higher level in relation to fish zone 3.

This may be explained in two ways. Either fish zone 3 in Neviatiakdal corresponds, as indicated in the table p. 46, to fish zone 3 on Kilen, and the lower *Vishnuites* zone is poor in fossils and badly developed in Neviatiakdal; or we are here concerned with two fish zones, one, fish zone 3a, on Kilen situated within the lower *Vishnuites* beds and in Neviatiakdal possibly below the sandy, sparsely fossiliferous beds 15—20 m thick, but concealed by loose scree, and a fish zone 3 b, in Neviatiakdal occurring in close association with the middle *Vishnuites* beds and possibly corresponding to the concretionary part of the middle *Vishnuites* beds on Kilen (see p. 52). Whether one or the other explanation is the right one, can hardly be decided on the basis of our present knowledge of the area, since fish zones have nowhere been observed in both the lower and the middle *Vishnuites* beds within the same section.

Stensiö Plateau. A considerable part of the *Vishnuites* series is exposed in the north slope of Stensiö Plateau (see the map pl. 1) from ridge 6 to ridge 12. West of ridge 6 the *Vishnuites* beds lie on a lower level than the surface of the vegetation-covered coast land, and east of ridge 12 the sediments are concealed by a cover of loose basalt blocks.

The investigations recorded below were made in ridge 9 issuing almost from the middle of the plateau. As the beds dip towards the west, the lower parts of the *Vishnuites* beds are exposed farther east in the plateau. The reason why I prefer to describe ridge 9 is that the beds are best exposed here. The *Otoceras* beds are absent from the north side of the plateau, the most easterly locality whence they are recorded is the area bounded by faults east of River 16, where they are overlain by a considerable series of hard sandstones (p. 41), constituting the lowermost part of the *Vishnuites* series.

Below the lowermost fossiliferous zone on Stensiö Plateau, the middle *Vishnuites* zone, there is a thick series of hard sandstones, which probably corresponds to the sandstones overlying the *Otoceras* beds a little farther west.

At 137 m occurs the lowermost exposure in ridge 9. From this point up to 150 m the slope is built up of hard, yellow sandstones (some distance farther east the lower portions of this sandstone zone are exposed).

Between 150 and 171 m loose, greyish sand beds with unfossiliferous concretions are found. At this height a loose sandstone block with *Bellerophon* and *Myalina* was collected.

Above follows a bed of grey sandstone, 3 m thick, succeeded up to 203 m by loose, somewhat clayey sand beds with numerous thin sand-

stone bands. On a small ledge at an altitude of 173 m within this zone there occurs, in addition to several loose sandstone blocks with mussels, a very thin zone (about 1 m of the surface of the slope) covered with hundreds of ammonites and other fossils. The fauna has been determined by SPATH, and includes the following forms:

Vishnuites wordiei.
— *decipiens*
— *decipiens var. spiniseptata*
Acanthophiceras cf. gibbosum.
Ophiceras transitorium.
— sp. nov.?
Naticopsis arctica.
Claraia sp.
Anodontophora sp.

The fauna is a typical middle *Vishnuites* fauna, evidently originating from a very thin, richly fossiliferous bed.

At 185 m a stegocephalian cranium was found in company with a single specimen of *Vishnuites cf. wordiei*, *Myalina*, and *Claraia*.

From 203 to 209 m a reddish-grey, fine-grained, unfossiliferous sandstone was observed.

At 211 m a fossiliferous zone was met with, viz. a knolly, greyish-brown, dolomitic band of a few centimetres' thickness, containing:

Ophiceras sp.
Vishnuites sp.
a new ammonite.

The following year *Ophiceras transitorium*, *Myalina*, and *Naticopsis* were collected in the same place.

This fauna represents the upper *Vishnuites* zone, which does not evidently contain fishes here.

Above an altitude of 211 m the sandstones become coarser, and at 219 m a greyish sandstone bed is seen of a thickness of about half a metre. The overlying beds carry large balls of a coarse-grained sandstone in addition to thin sandstone bands up to an altitude of 227 m, where they are overlain by a bed of coarse-grained, grey sandstone about 4 m thick, possibly corresponding to the zone with sandstone balls, conglomerate IV, farther west.

The lower *Vishnuites* zone.

If we sum up the various observations on the lower *Vishnuites* zone, the lower boundary of which is determined by the upper limit of the

Otoceras, it will be seen that in part of the area at any rate it commences with an ammonite-bearing zone, whose fauna shows close relationship with the fauna of the uppermost zone of the *Otoceras* series, but lacks *Otoceras*. This zone, whose thickness may possibly be up to 10 m, is made up of loose, clayey sand beds with thin, compact sandstone bands, which sometimes contain ammonites; however, the greater part of the fauna of this zone was found in concretions.

The same development of the lower part of the lower *Vishnuites* zone seems to occur in the eastern part of Spath Plateau, while the western part of the plateau is made up of mainly sandy beds poor in fossils and with no concretions. As regards conditions in Neviatiakdal, see p. 52.

East of River 9 this lowermost lower *Vishnuites* zone is overlain by fish zone 3 (possibly 3 a, see p. 53), a series, 5—8 m thick, of loose, clayey sand beds with thin, compact sandstone bands and very small concretions with fishes or stegocephalians. With the exception of mussels and *Spirorbis*, invertebrates are fairly rare in this zone. (As regards the best exposures of the zone, see p. 102).

East of River 9 this zone is followed upwards by loose, clayey sand beds with sandstone bands, which may contain ammonites, and with up to three limestone bands with a fairly rich lower *Vishnuites* fauna. On Kilen this zone has a thickness of about 16 m, while in Neviatiakdal it is either almost absent or covered by scree (see p. 53).

West of River 9, where a division of the lower *Vishnuites* beds is very difficult on account of their poor development and bad exposures, there is every reason to assume that their upper part is made up of loose, somewhat clayey sand beds, interbedded with sandstone bands with ammonites and one or several fossiliferous limestone bands.

Between the lower and the middle *Vishnuites* zones there mostly occurs a coarse-grained, sandy series of strata poor in fossils and ranging from an inconsiderable thickness to about 30—40 m.

The Middle *Vishnuites* Zone.

On Kilen (p. 52) the middle *Vishnuites* zone is represented by a clayey sand bed, about 20 m thick, with thin sandstone bands, some few small concretions, and a single crumbling limestone band containing the ammonites typical of the middle *Vishnuites* zone, viz. *Vishnuites wordiei* and *V. decipiens*, in addition to other fossils. The zone is all the more conspicuous, since it is bounded both upwards and downwards by coarse-grained beds poor in fossils. The zone is equally conspicuous in Otocerasdal, Wordie Creek, and on Stensiö Plateau.

In Neviatiakdal, however, the middle *Vishnuites* beds occur only some few metres above fish zone 3, which does not possibly correspond

to fish zone 3 at River 14 (p. 53), and if so, it should be termed fish zone 3b in distinction from fish zone 3a in Kilen (p. 53).

The middle *Vishnuites* zone west of Immacradal was ascertained in several places (p. 49), but the beds are so highly obscured by débris everywhere that it is difficult to obtain an idea of their thickness and of the stratigraphical details.

The Upper *Vishnuites* Zone.

This zone, which is best exposed on Stensiö Plateau and in the area between Rivers 13 and 16, was ascertained along the north side of the whole Spath Plateau and part of Stensiö Plateau. East of River 12 its concretions were found to contain vertebrate remains (fish zone 4).

Where the zone is best developed, it has a thickness of about 20 m and is built up of loose, clayey sand beds with numerous compact sandstone bands, yielding mussels, occasional poorly preserved ammonites, etc., further limestone concretions with ammonites, other invertebrates and fishes, in some cases stegocephalian remains. The ammonites are most frequent in the lower part, the mussels in the upper part of the zone.

Immediately superjacent to the zone are deposits closely resembling conglomerate IV (p. 52). Limestone bands are rare in this zone, only in a single place, at 643 m altitude west of Wordie Creek, a fairly thick limestone band rich in fossils was found, the position of which within the upper *Vishnuites* zone has not yet been established.

While in the area east of River 12 the upper *Vishnuites* zone occurs rather close below conglomerate IV and about 50 m below the *Proptychites rosenkrantzi* zone, farther west, in the area round the Fiskeplateauet and Stegocephalryggen, it has a lower position in relation to the *Otoceras* beds and occurs about 100 m below the *Proptychites rosenkrantzi* zone, an immense series of coarse-grained sandy sediments poor in fossils, occurring here between conglomerate IV and the upper *Vishnuites* zone.

For the sake of completeness it should possibly be attempted to insert the scattered observations of the previous expeditions in the stratigraphical table.

The sandstone rich in ammonites occuring from 244 m altitude on the slope west of River 5 (KOCH, 1931, p. 41) (Coll. C. St. loc. 7), which according to SPATH (in a letter cited by KOCH 1931, p. 41) belongs to a low "Upper *Ophiceras*" horizon, should of course be placed within the lower *Vishnuites* zone of the new division.

The loose block found in 1927 by KOCH within the area of River 5 and containing a very interesting fauna (SPATH 1930, p. 65, and KOCH 1931, pp. 40 and 83), i. a. *Otoceras?*, was placed by KOCH in the "Upper *Ophiceras* beds". At that time *Otoceras* gave no clue as to the age of

the fauna, having not yet been found in "Lower *Ophiceras* beds". The block further contained a peculiar specimen of *Ophiceras* (SPATH 1930, Pl. VIII, figs. 11—12). SPATH has informed me that this *Ophiceras* has been found in two other blocks collected on the surface of fish zone 2 of Fiskeplateauet, and since *Otoceras* further proved to occur throughout the zone formerly termed the "Lower *Ophiceras* beds", but has never been found in younger beds, I am inclined to assume that the block originates from the upper part of the uppermost zone of the *Otoceras* beds, possibly even from an arenaceous development of the limestone band mentioned in p. 35.

A typical middle *Vishnuites* fauna was collected by WORDIE 16 km east of Cape Stosch (Colln. Sp. IX) (KOCH 1931, pp. 47 and 84, SPATH 1930, p. 68). However, the fauna list also comprises ammonites from lower horizons.

Another mixed fauna is Colln. Sp. VIII (KOCH 1931, pp. 44 and 84, SPATH 1930, p. 67), which seems to include forms from the *Vishnuites* as well as from the *Proptychites* beds.

Apart from those mentioned above, the previous collections from the *Vishnuites* beds are small, stratigraphically but little important, faunas, in which the molluscs are especially dominant.

Proptychites Beds.

Proptychites rosenkrantzi zone	Well developed clay zone with concretions and sandstone bands with fossils. The zone is more sandy in the lower than in the upper part. In the eastern part of Spath Plateau the clay zone is of subordinate importance, and the fossiliferous part often highly conglomeratic, occasionally with dolomite bands.	Fish zone 4.
	In certain localities, at any rate, unfossiliferous, sandy, looser or more compact beds.	
Koninckites? sp. nov.? zone?*)	Loose, rather sandy clay beds with sandstone bands and concretions, possibly with a single limestone band.	
	In the western part of Spath Plateau conglomeratic beds (conglomerate IV), which to the east are probably replaced by hard sandstones, possibly overlying slightly conglomeratic, loose sand beds with sandstone balls.	

* See the footnote p. 25.

This zone was discovered in 1926 by WORDIE (SPATH 1930, p. 66), and additional collections were made by the Danish expeditions in 1929 and 1930 (SPATH 1930, p. 67, KOCH 1931, pp. 35, 39, 51, and 84). On the basis of the collections from "locality 4" (KOCH 1931, p. 44), where *Proptychites rosenkrantzi* were found in company with *Ophiceras transitorium* and *O. aff. greenlandicum* (SPATH 1930, p. 68), SPATH assumed that "the so-called *Proptychites* horizon" was only a subzone

of the "*Ophiceras* beds". KOCH (1931, p. 84) disagreed with this view, since according to his investigations "the *Proptychites* beds represent one of the most certain stratigraphic horizons". The recent investigations have supported KOCH's view; there can be no doubt that SPATH's material from "locality 4" represents mixed faunas.

The *Proptychites* beds, which are of a much smaller thickness than the underlying *Vishnuites* beds, have been observed along the greater part of the north sides of Stensiö Plateau and Spath Plateau and further on Mt. Steensby and in the Mt. Diener area.

The lowermost part of the *Proptychites* beds, or the unfossiliferous series of strata intervening between the *Vishnuites* and the *Proptychites* beds, is built up of coarse sand beds or sandstones (p. 57), the latter often forming a steep wall. Especially in the western part of Spath Plateau this series is often conglomeratic, and in the present paper is termed conglomerate IV (see p. 77), which designation is also applied to the series farther east, where it is not, or but partially, developed as a conglomerate (see p. 79).

Conglomerate IV is succeeded by the fossiliferous part of the *Proptychites* beds, which are usually badly exposed, and the petrographical character of which changes from place to place.

On the basis of the material collected 1932—33 SPATH at first thought it possible to divide the *Proptychites* beds into two zones, the lowermost of which is perhaps characterised by the presence of *Koninckites?* sp. nov.? and the upper by *Proptychites rosenkrantzi*[1]).

Almost everywhere within the area the beds were so highly obscured by débris that I was unably to distinguish the two zones during the work in the field, for which reason the collections from both zones were usually mixed. This, for instance, is the case with many of the fishes collected, which, it is true, were most frequent in the upper part of the *Proptychites* beds, but also occurred in the lower part. During the work in the field fishes from both zones (fish zone 5) were uniformly labelled.

In Stegocephalryggen (p. 48), the sequence of strata was as follows:

The upper boundary of conglomerate IV is at 476 m, and from this altitude to 489 m loose sand beds with thin, hard, unfossiliferous sandstone bands were observed. Beyond the latter altitude the loose sand beds become somewhat clayey and contain occasional concretions and (several?) calcareous sandstone bands holding a fauna which might indicate the presence of the doubtful *Koninckites?* zone.

From about 490 m to 497 m loose sand beds with thin, hard, unfossiliferous sandstone bands are found. Above, up to 501 m, the beds become more clayey again and contain concretions with fishes and invertebrates, indicating the presence of the *Proptychites rosenkrantzi* zone.

[1]) Regarding this altered view, see the footnote p. 25.

Above 501 m occurs the *Anodontophora* (breviform) series, which is poor in fossils.

West of Stegocephalryggen the *Proptychites* beds are poorly exposed, but hardly differ essentially from those on Stegocephalryggen. At the northwestern corner of Spath Plateau some few collections were made from the *Proptychites* beds.

Between Immacradal and Fiskeplateauet the *Proptychites rosenkrantzi* zone is interbedded with a concretionary clay bed of a considerable thickness, which at River 8 was measured to be about 20 m.

The lowermost, comparatively sandy part of the clay zone in addition to concretions contains thin sandstone bands. Vertebrate remains are most frequent in the upper part of the clay, while *Proptychites* as a rule occurs in the lower part. No information can be given about the doubtful lower *Proptychites* zone.

On Falkeryggen, where the beds are comparatively well exposed, part of the *Proptychites* beds was ascertained. Here the sequence of strata was as follows:

The upper boundary of conglomerate IV (p. 79) occurs at 409 m. It is directly overlain by a clay bed containing small concretions and thin, calcareous sandstone bands with *Spirorbis*, *Claraia*, *Naticopsis*, and coproliths. Above follows a somewhat more sandy zone with thin, unfossiliferous sandstone bands.

Beyond 416 m the beds are somewhat clayey and contain small concretions with mussels and fishes. Within this zone, at an altitude of 422 m, a limestone band 10—20 cm thick with mussel fragments, etc., occurs. In the superjacent beds several calcareous sandstone bands, 1—2 cm thick, with *Spirorbis* were observed. At about 242 m the clayey sand beds are replaced by purely sandy beds, beginning with an unfossiliferous, grey sandstone band 3 cm thick with a brownish weathered surface.

From 430 to 431 m there again occur clayey sand beds with concretions, which in addition to fishes contain ammonites and mussels. The succeeding beds are poorly exposed, for which reason it is impossible to determine the upper boundary of the *Proptychites* series.

In the eastern part of Spath Plateau, in the area between Nasutdal and the valley of Blue River as well as in the upper part of the latter, the *Proptychites rosenkrantzi* zone is exposed in numerous places and everywhere occurs considerably above the upper boundary of conglomerate IV. It is often separated from conglomerate IV by a fairly thick series, in which the lower *Proptychites* zone, if present, must be searched for. So far it has not been observed within the area, from which it may be inferred with some degree of certainty that it must be very poor in fossils here.

Within the area in question the *Proptychites rosenkrantzi* zone

occurs about 40—60 m above the upper *Vishnuites* zone, and has a thickness of about 10 m. It is, in the main, sandy, and fossils are present in concretions. (For the conglomerates occurring in this zone, see p. 83).

On Stensiö Plateau all the ridges in which the *Proptychites rosenkrantzi* zone (or part of it) is exposed, are numbered from west to east.

In the following I shall describe a section through the zone in the same ridge in which the section through the *Vishnuites* beds (mentioned p. 49) was measured. It should be premised, however, that even if both the lower and upper *Proptychites* zones are represented in the collections brought back from Stensiö Plateau, I am unable to draw the boundary between them.[1])

The following is known about the section in ridge 9:

The upper boundary of the series, which probably corresponds to conglomerate IV (see p. 54), is at 231 m altitude. Above follow, up to 276 m, loose, sandy or clayey beds with numerous greyish-brown sandstone bands, 1—2 cm thick, and, very rarely, small concretions with fishes and other fossils. (At 253 m altitude a stegocephalian cranium was found lying loose, possibly derived from a fixed bed in the neighbourhood or slid down from the clay beds of the *Proptychites rosenkrantzi* zone.) Of invertebrates, *Claraia*, *Spirorbis*, and others were found in the sandstone bands and in the concretions.

Part of this series, or possibly the whole series, probably belongs to the doubtful lower *Proptychites* zone. The upper part is comparatively coarse-grained and poor in fossils.

Above 276 m the loose sand beds are again clayey, and contain thin sandstone bands with *Claraia*, *Spirorbis*, *Myalina*, etc. Gradually the loose sandy clay beds increase, while the sandstone bands decrease, and the zone terminates upwards with a fairly thick clay zone with very few sandstone bands but rather numerous concretions with fishes and invertebrates, in some cases stegocephalians. At 314 m the zone, which represents the upper part of the *Proptychites* beds, terminates with hard, unfossiliferous sandstones, which commence the *Anodontophora* (breviform) series. (For the *Proptychites* beds in Mt. Steensby and the Mt. Diener area, see p. 70).)

When it is borne in mind how greatly the character and thickness of the beds within the *Proptychites* zone vary from place to place, and how incomplete are the exposures that have escaped solifluction, it will be understood that there is a possibility that the table in p. 57, even though it includes our present knowledge, does not give all the details of the portions of the *Proptychites* beds which are at present inaccessible.

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[1]) Regarding the altered view, see the footnote p. 25.

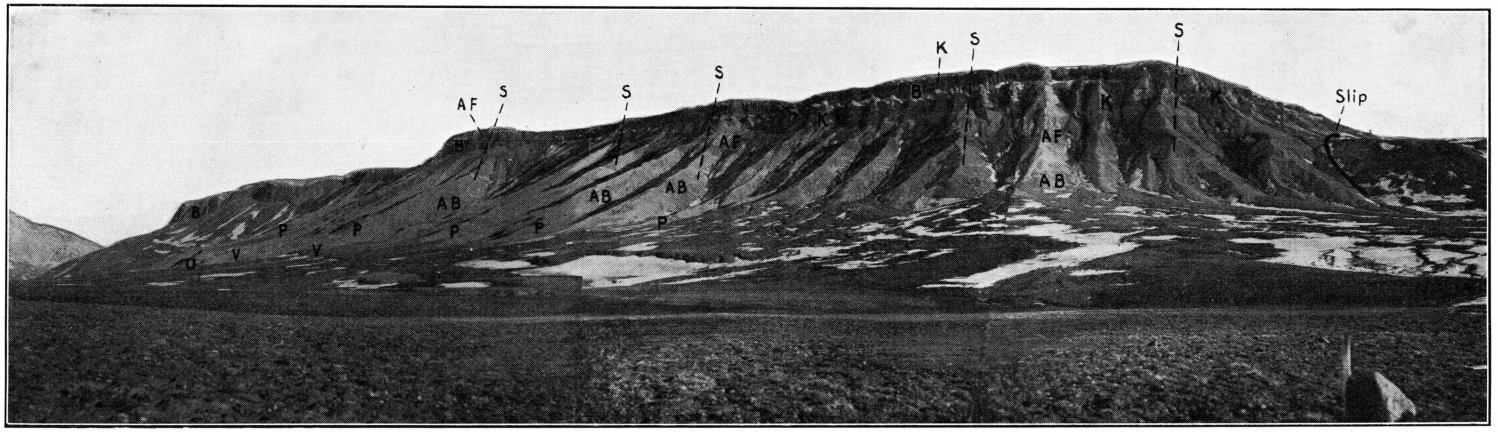


Fig. 22. North side of Stensiö Plateau. AB = *Anodontophora* (breviform) beds; AF = *Anodontophora fassaensis* beds; B = basalt; K = Cretaceous P = *Proptychites* beds; S = Stegocephalian zone. Immediately below the latter the light-coloured sandstone forming the upward termination of the *A.* (breviform) beds. U = unfossiliferous sandstone below the middle *Vishnuites* zone. V = middle and upper *Vishnuites* zones.

Anodontophora (breviform) beds.

This immense series intervening between the *Proptychites* beds and the *Anodontophora fassaensis* beds is almost exclusively built up of loose or compact sandstones, occasionally sand. On account of the loose consistency of the beds, which often causes an obscuration of the stratigraphical sections, and on account of the lack of stratigraphical guides, as for instance conglomerates and hard, steep sandstone walls, the *Anodontophora* (breviform) beds are very difficult to subdivide; whether a division into subzones will be possible, depends on the results of SPATH's investigation of the material collected.

As mentioned by KOCH (1931, p. 50), there is a very considerable difference in the development of this series in the eastern and the western parts of the area, *Anodontophora* (breviform) being extremely abundant in the western part, even in beds several metres thick, while it is rare between Nasutdal and Blue River, and much rarer still on Stensiö Plateau and in the eastern area.

As regards the western part of the area it would seem that KOCH is right in his statement (1931, p. 93) that "slightly above the *Proptychites* beds the sandstones become coarser and the next 80—90 m of the slope are made up of thick bands of such sandstones which particularly in the upper part may be almost conglomeratic, and between these there occur thick beds teeming with *Anodontophora* sp. (breviform)"

Moreover the *Anodontophora* (breviform) beds in the northwestern part of Spath Plateau contain a conglomerate, conglomerate V, which possibly in part corresponds to an immense wall of hard sandstone (see p. 80) occurring a little farther east, near River 5.

The upper boundary towards the *Anodontophora fassaensis* beds should possibly be drawn somewhat below the *Anodontophora* (breviform) conglomerate mentioned by KOCH (1931, p. 36), but it can hardly be drawn with certainty west of River 16, since it was defined (see below) on the basis of the sequence of strata on Stensiö Plateau, between fossil zones that are less conspicuous to the west.

On Stensiö Plateau the apparently almost unfossiliferous *Anodontophora* (breviform) beds terminate with a light greyish sandstone, 6—8 m thick, which forms a steep wall. This sandstone has yielded an *Anodontophora* sp. (longer than *A.* (breviform)), and underlies the stegocephalian horizon with *Myalina kochi* (see p. 65), which occurs again about 50 m below the lowermost *Anodontophora fassaensis*-bearing beds. Here the boundary between the *A.* (breviform) and the *A. fassaensis* beds has been drawn between the hard sandstone and the horizon with stegocephalians.

Even from a distance of several kilometres the hard sandstone is visible as a conspicuous light-coloured line running along the northern slope of Stensiö Plateau (see fig. 22).

West of Blue River the beds higher than and including the youngest part of the *A.* (breviform) beds are rarely represented; only in Otocerasdal, Immacradal, and, as ascertained by Koch (1931, p. 40), at the northwestern corner of Spath Plateau the lowermost part of the *A. fassaensis* beds are preserved. All these three exposures have a fairly inconsiderable horizontal distribution, and this is possibly the reason why the stegocephalian horizon has not yet been definitely determined.

In Immacradal and at the northwestern corner of Spath Plateau

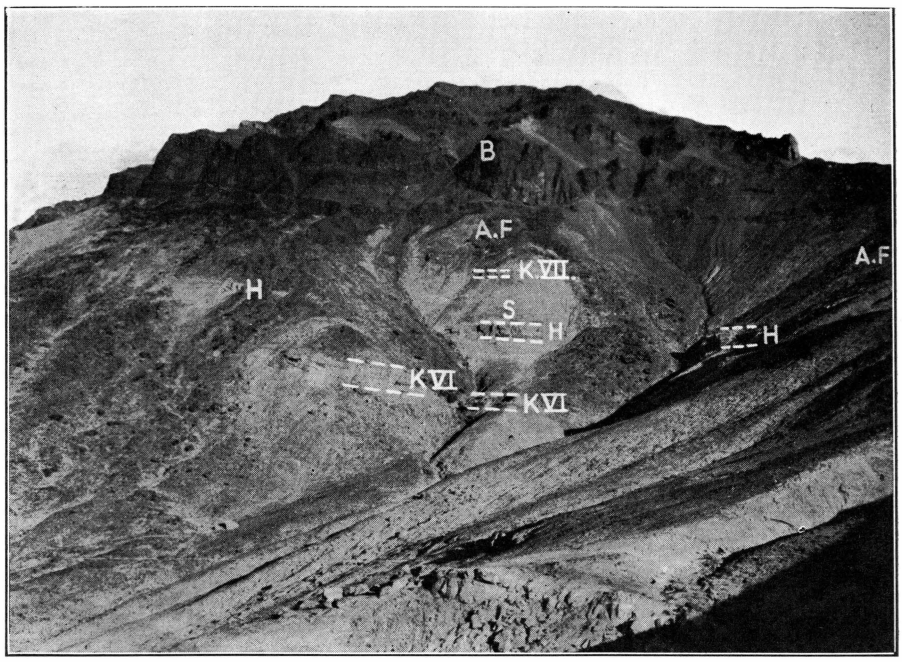


Fig. 23. Northwestern corner of Spath Plateau. A.F = *Anodontophora fassaensis*-bearing beds. B = basalt; H = hard sandstone, immediately subjacent to the supposed stegocephalian zone; K VI = conglomerate VI; K VII = *Anodontophora* (breviform) conglomerate; S = presumed stegocephalian zone.

a light-coloured, hard sandstone occurs in the youngest part of the *A.* (breviform) beds, forming a small wall and containing poorly preserved impressions of mussels. Its position in relation to the lowermost *A. fassaensis*-bearing beds agrees fairly well with its supposed correspondence to the light-coloured sandstone underlying the stegocephalian horizon on Stensiö Plateau, and hence it is hardly too audacious to draw the boundary between the *A.* (breviform) and the *A. fassaensis* beds immediately above this sandstone. Thus conglomerate VII, the *A.* (breviform) conglomerate, is placed in the lowermost part of the *A. fassaensis* series.

As the constant alternation of sand and sandstone types represented in the immense *A.* (breviform) zone is of but little interest, I shall confine myself to recording one of the best exposed sections through the series, viz. the section on Falkeryggen (see p. 59), situated so far towards the west that the beds still contain fairly well preserved mussels (se above).

As mentioned in p. 59, the lower *Proptychites* zone is exposed in Falkeryggen up to 431 m altitude, while the upper *Proptychites* zone has not been observed. From 431 to 544 m the section is concealed by scree, with the exception of a small exposure at 512 m altitude in a ravine cutting through grey sandstones with plant remains in the west side of the ridge. From 544 to 592 m loose sand beds with sandstone balls predominate, highly reminiscent of those observed in the upper part of the *Vishnuites* beds on Stegocephalryggen (see p. 48). Above 592 m the sandstone balls of the loose sand beds, which have here a greenish hue, are replaced by thin sandstone bands.

At about 655 m the surface of the ridge is strewn with numerous blocks with specimens of *Anodontophora* shorter and higher than the actual breviform type.

At about 678 m and again at 682 m the sandstones contain *Anodontophora* n. sp.? At 707 m is the upper boundary of a greenish-grey sandstone bed, 6—8 m thick, which is here fairly loose and contains harder sandstone balls, whereas farther west it forms a steep wall. This bed possibly (see above) marks the upper boundary of the *A.* (breviform) series.

From 712 to 722 m *A.* (breviform) occurs in some peculiar hard blocks of the form of cylinders split lengthwise. These blocks probably originate from the *A.* (breviform) conglomerate (conglomerate VII), which in Immacradal, some few hundred metres farther west, is 0.5 to 1 m thick and occurs about 5 m above the above-mentioned steep sandstone wall.

From 727 to 759 m the slope is built up of loose sands interbedded with thin, unfossiliferous sandstone bands.

From 759 to 772 m *Anodontophora fassaensis* occurs in the typical red and grey, fine-grained sandstones. Some few metres higher the section is covered by basalt and basalt débris.

An investigation of *Anodontophora* (breviform) beds in other places west of Blue River will show that *Anodontophora*, sometimes *Myalina*, occur here and there, now in a low, now in a high zone of the series, but judging from their varying occurrence from place to place, these fossil zones have but a slight horizontal distribution.

With the exception of a couple of loose blocks I did not find any fossils in the *A.* (breviform) zone on Stensiö Plateau below the light-coloured sandstone forming the upvard termination of the *A.* (breviform) beds.

As regards the *A.* (breviform) beds on Mt. Steensby and Mt. Diener, see p. 69.

Anodontophora fassaensis beds.

	Moderately coarse-grained sandstones. Unfossiliferous red and grey fine-grained sandstones
A. fassaensis zone	Red and grey, fine-grained sandstones, certain bedding-planes covered with *A. fassaensis*, occasional *Myalina*, and serpulids. Alternating with the fossiliferous beds are beds of a similar aspect but with no fossils. The lowermost part of this zone may be slightly conglomeratic and occasionally oolitic.
	Unfossiliferous, sandy, grey sediments. (Perhaps *A.* (breviform) conglomerate).
Stegocephalian horizon or *Myalina kochi* zone	Clay zone with calcareous sandstone bands, the lowermost of which is the thickest and situated immediately above the lower boundary of the *A. fassaensis* beds. The sandstone bands contain *Myalina kochi*, serpulids, and stegocephalians.

On Stensiö Plateau, where the *Anodontophora* (breviform) beds terminate upwards with the steep, light-coloured sandstone wall (p. 62), a calcareaous, sandy band, 10—20 cm thick, containing numerous specimens of *Myalina kochi* and further *Serpula* sp. nov.?, both determined by SPATH, occurs immediately above the sandstone, as the lowermost part of the *A. fassaensis* beds.

In ridge 8—9, where the section through this zone was investigated, there further occurred a large number of stegocephalian remains (p. 105) and occasional fishes. Above the calcareous band there follow débris-covered, looser, clayey beds, possibly with several thin bands containing *Myalina*, stegocephalians, and other fossils. Here the zone occurs from 538 to 543 m.

From 543 to 575 m the beds are covered by scree, however, at 557 m a band of unfossiliferous greyish-green sandstone, about 1 m thick, is exposed.

At 615 m the series of alternating red and grey, very fine-grained sandstones begins, whose bedding planes are covered with *Anodontophora fassaensis*. These beds continue upwards to 669 m, when the basalt rises as an inaccessible wall for at least 50 m, and beyond this the *A. fassaensis* beds continue to the top of the slope.

The lowermost zone of the *A. fassaensis* beds, the stegocephalian horizon or the *Myalina kochi* zone, can be traced along the greater part of the north side of Stensiö Plateau (see the map). Apart from ridge 8—9, stegocephalian remains were only collected on the ridge west of ridge 8—9 and on ridge 3; by far the greater number of the finds

were made on ridge 8—9, although the stegocephalian zone in several of the other ridges is exposed to the same extent. Ridge 3 is interesting in that it exhibits the sequence of strata within the lowermost part of the *A. fassaensis* beds in a more beatiful exposure than in any other place on the slope of the plateau. In ridge 3 the upper boundary of the light-coloured sandstone wall is at 475 m, about 1 m higher the sandstone band about 15 cm thick with *Myalina kochi* is seen, from which at any rate part of the stegocephalians from ridge 8—9 are derived.

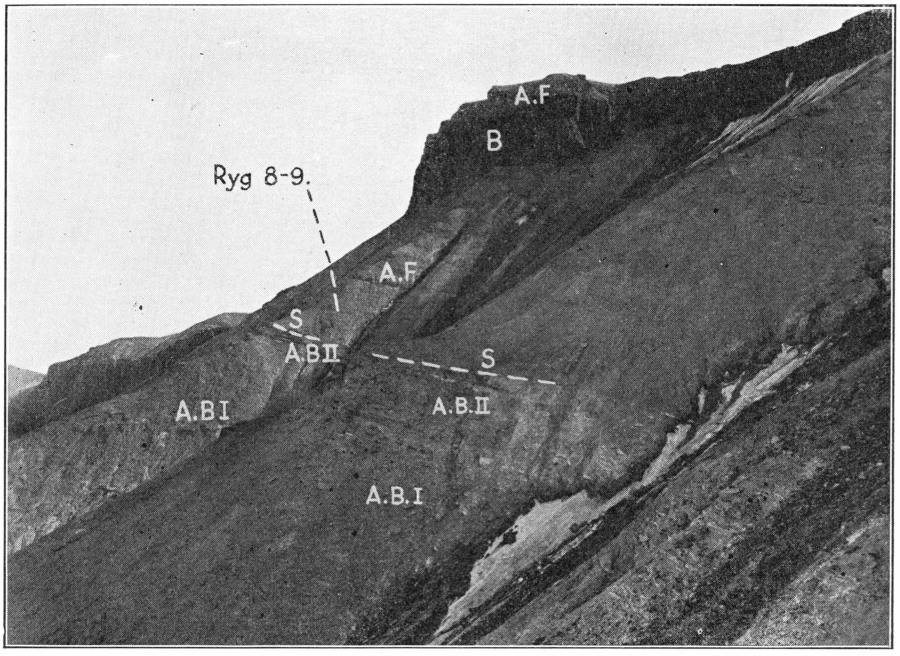


Fig. 24. Detail picture of the stegocephalian zone on the north side of Stensiö Plateau. A.B I = *Anodontophora* (breviform) zone (unfossiliferous sandstone); A.B II = light-coloured sandstone terminating the *A.* (breviform) zone upwards; A.F = *Anodontophora fassaensis*-bearing beds; B = basalt; S = zone with stegocephalians.

Above follow clay beds, on the surface of which occasional stegocephalian remains are found, possibly originating from the thin sandstone band with *Myalina* occurring in the clay zone at 485 m altitude. The upper boundary of the clay zone, which contains several thin sandstone bands, is at 496 m, where it is overlain by shaly, micaceous, grey sandstones. The uppermost *Myalina*-bearing sandstone band occurs at 492 m.

Both on Mt. Steensby and in the Mt. Diener area a *Myalina kochi* horizon is found somewhat below the *A. fassaensis*-bearing beds, in which horizon no stegocephalians were found. As already mentioned

(p. 63), there occurs in several places on Spath Plateau a hard, light-coloured sandstone which possibly corresponds to the light-coloured sandstone on Stensiö Plateau. Since the *A.* (breviform) block conglomerate (VI, p. 76) mentioned by Koch (1931, p. 36) is situated above this sandstone, it belongs to the lower part of the *A. fassaensis* zone. (Regarding the distribution of this bed, see p. 81).

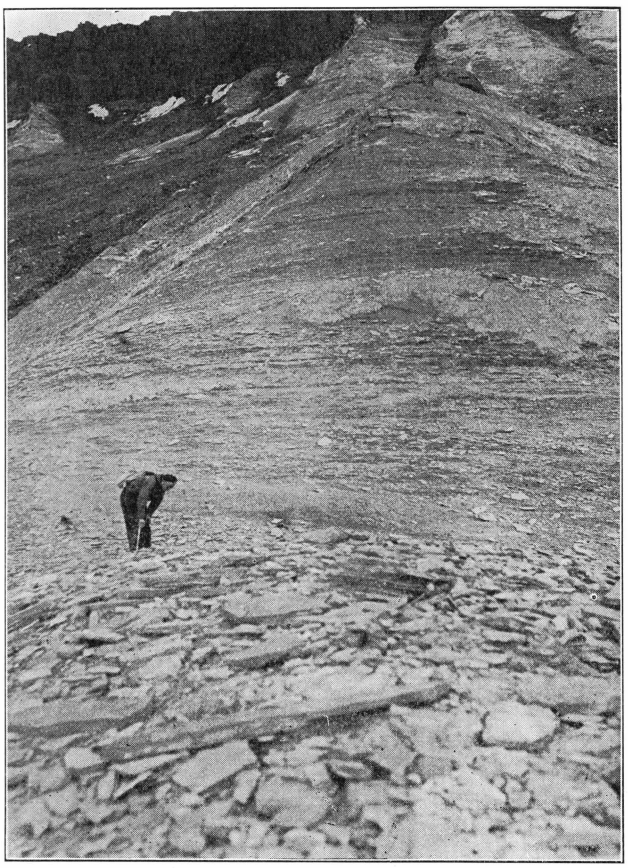


Fig. 25. Detail picture of the stegocephalian zone on Stensiö Plateau, ridge 3. In the foreground the lowermost thick band with *Myalina kochi* and stegocephalians; above, clay beds with thin bands containing *Myalina kochi* and stegocephalians.

Between the *A. fassaensis*-bearing beds and the light-coloured sandstone at the northwestern corner of Spath Plateau Koch (1931, p. 40) found beds with *Myalina kochi.*

In the western part of the north side of Stensiö Plateau the Cretaceous series overlies the *A. fassaensis* beds. Thus there is here a possibility of investigating a more complete series of *A. fassaensis* beds than in any other place west of Yellow River.

Here the boundary between the *A.* (breviform) and the *A. fassaensis* beds is at about 336 m. The stegocephalian horizon was poorly exposed, only some few *Myalina kochi* were visible.

From 374 to 377 m more or less loose sandstones with *Myalina* occur. At 384 m there is a band, about 20 cm thick, of a conglomeratic, red, oolitic sandstone with numerous *Serpula* tubes. It is overlain by

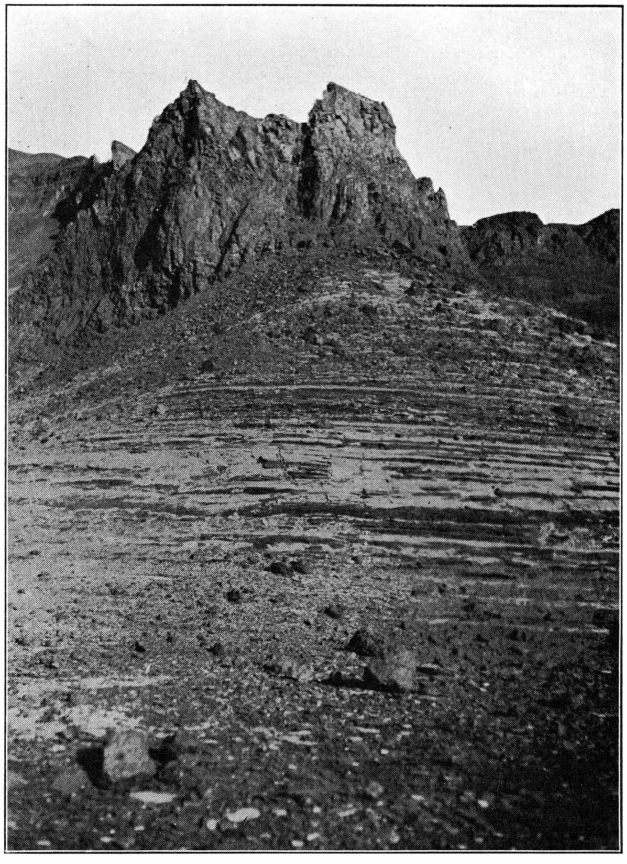


Fig. 26. Detail picture of typical red and grey *Anodontophora fassaensis*-bearing bands, overlain by clay beds interstratified with thin beds carrying *Myalina kochi* and stegocephalians.

typical red *A. fassaensis* beds. Whether such beds also occur below the conglomeratic band, could not be decided on account of obscuration by débris.

About 2—3 m above the first conglomerate bed there occurs another conglomerate of the same appearance but only 2—3 cm thick. It is overlain by typical red and grey *A. fassaensis*-bearing beds alternating with beds of a similar aspect, but unfossiliferous. At an altitude

of about 420 m numerous sandy unfossiliferous concretions of the size of a hazel-nut occur.

Up to this point fossiliferous and unfossiliferous beds have alternated several times. The series now becomes entirely devoid of fossils, and at the same time the sandstone becomes coarser. It is therefore difficult to draw the boundary between the Triassic and the Cretaceous series, though it seems to be at 530 m, above which altitude the beds clearly change their character, being made up of hard, yellow sandstones.

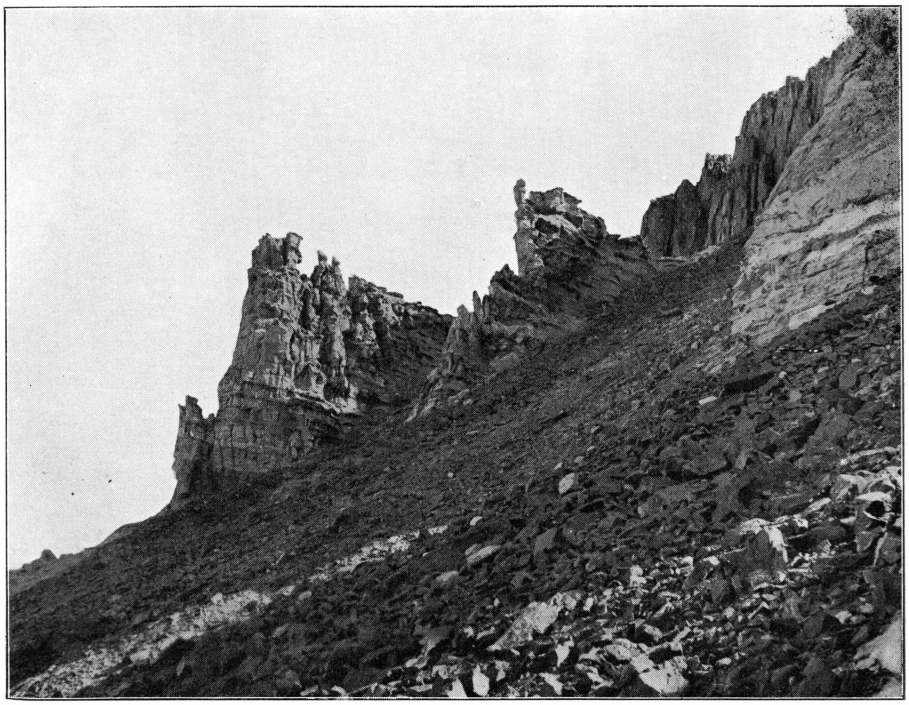


Fig. 27. Cretaceous coulisses on Stensiö Plateau. At the top right, basalt.

Mt. Steensby and the Mt. Diener area.

The whole stretch between Yellow River and River 23, comprising the Mt. Steensby and Mt. Diener areas, is of a very uniform geological structure. The Triassic sediments are almost exclusively represented by sand and sandstone beds belonging to the *Anodontophora* (breviform) and the *A. fassaensis* beds. The overlying Cretaceous beds are very conspicuous, forming nearly perpendicular walls of an enormous thickness. The basalt, too, plays an important part along this stretch.

Immediately east of the fault at River 23 (see pl. 1) the *Anodontophora fassaensis* beds are still exposed, but a little farther east the basalt becomes dominant and sedimentary beds do not appear again till east

of River 25. According to FREBOLD (1934) these sediments are of Upper Cretaceous age, and thus considerably younger than the Cretaceous sediments present in several places between Cape Stosch and River 23, which, judging from their ammonite fauna, belong to the Aptian (KOCH 1931, p. 98).

Immediately west of River 23 KOCH (1931, p. 51) found the *Proptychites rosenkrantzi* zone exposed at 40—50 m altitude. Later I visited the locality and found the zone exposed from 27—37 m. The beds dip 20° towards the west, and a little farther west the fossiliferous zone

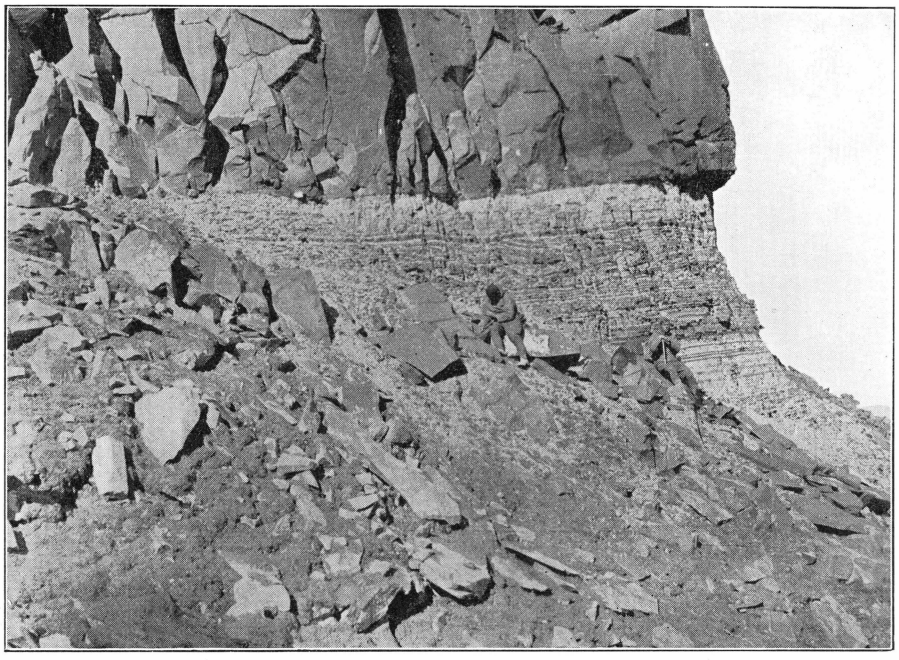


Fig. 28. Triassic sediments below the lower basalt zone on the north side of Mt. Steensby between Rivers 22 and 23.

therefore lies below the surface of the low coast-land. The zone is built up of sandy clay beds, containing several, about 2 cm thick, clay bands and small concretions. In addition to *Naticopsis*, *Myalina*, *Claraia*, *Spirorbis*, and *Proptychites* some few fish remains and coproliths were observed (cf. also KOCH 1931, p. 51). The *Proptychites* zone is overlain by unfossiliferous sand and sandstones.

West of the fault running through the delta of Red River (pl. 1) the *Proptychites rosenkrantzi* zone was again observed. Since on this side of the fault the beds dip but a few degrees to the west, the zone is traceable over a distance of several hundred metres. The altitude of the lower boundary of the zone about midway between Diener River and

Red River was measured to be 102 m and the thickness of the zone to about 17 m. The fossiliferous beds are of the same type as at River 23 (see above), and several well preserved fishes were collected from the small concretions. In the area west of Red River, the *Proptychites* beds are concealed by scree and vegetation farthest east, on the north side of Mt. Steensby. But in the middle part of Mt. Steensby, near River 21,

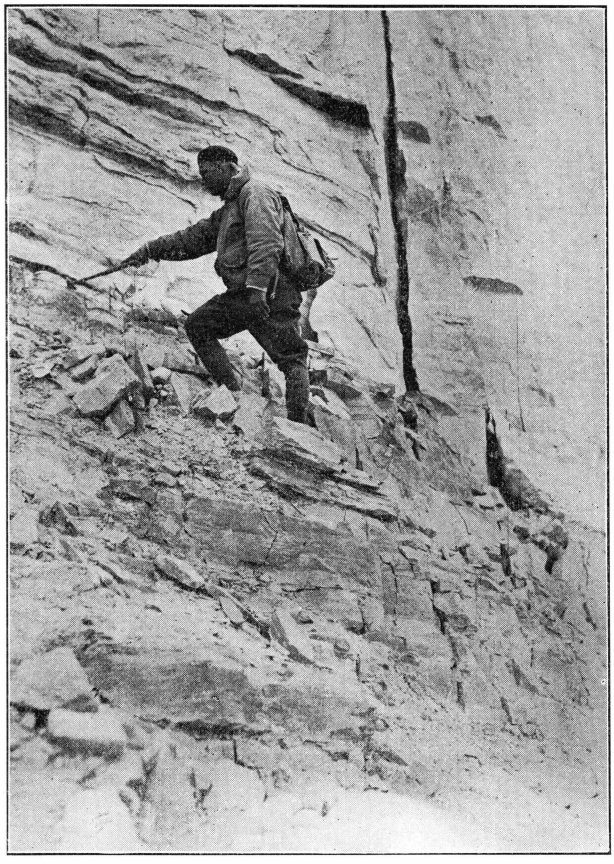


Fig. 29. The boundary (at the point of the hammer) between the *Anodontophora fassaensis* beds and the Cretaceous beds on the north side of Mt. Steensby.

the zone appears again between 95 and 106 m altitude, not far below the thick lowermost basalt zone. Thus along the greater part of the north side of Mt. Steensby the *Proptychites* zone occurs at a very low altitude, to the east closely above, and to the west immediately below, the basalt zone.

That the *Proptychites* zone occurs at such an inconsiderable altitude on Mt. Steensby is a point of great interest, since it excludes the possibility of finding *Vishnuites* and *Otoceras* beds east of Yellow River, despite

the doubtful locality of *Ophiceras cf. demissum* and *O. wordiei* reported by Norwegian trappers as mentioned by KOCH (1931, p. 51).

KOCH states (1931, pp. 48—49) that he observed a small exposure of Cretaceous sandstone partially enclosed in the low-lying basalt occurring near the shore in the north side of Mt. Steensby. However, after my investigation of the beds I feel certain that they are built up of Triassic sediments.

The very uniform *Anodontophora* zones were investigated in several places on Mt. Diener and Mt. Steensby. A single section will give a sufficiently clear picture of the sequence of strata, for instance that measured in the eastern third of the north side of Mt. Steensby. The base of the section was at 197 m, south of the plateau above the low basalt zone. (The basalt dips considerably towards the south and hence occurs below the base of the section). From 197 to 424 m loose or compact sandstones alternate with sand beds without fossils. This uniform zone no doubt corresponds to the *Anodontophora* (breviform) beds farther west. At an altitude of 424 m the *A. fassaensis* beds begin with the *Myalina kochi* zone (the stegocephalian zone), which in the place where the section was measured is penetrated by a basalt dyke about 2.5 m thick and running parallel to the sandstone beds.

Neither on Mt. Steensby nor in the Mt. Diener area were vertebrates met with in the *Myalina kochi* zone. At 467 m the red and grey *Anodontophora fassaensis*-bearing, fine-grained sandstones begin, alternating up to 541 m with unfossiliferous sandstones of a similar aspect. Between 541 and 601 m fine-grained, alternately red and grey, unfossiliferous sandstones occur. The *A. fassaensis* beds terminate upwards with hard, coarser-grained, grey sandstones, which are overlain at 607 m by yellow, hard, Cretaceous sediments (see fig. 29).

The other sections measured through the *Anodontophora* beds on Mt. Steensby and Mt. Diener correspond to those recorded above, and will not therefore be discussed in detail here.

Regarding the numerous faults and slips found within the area, reference is made to pp. 9—10 and the map in pl. 1.

The Conglomerates.

The western part of the north side of Spath Plateau exhibits a peculiar aspect on account of a number of steep, almost perpendicular, walls, which break the uniformity of the northern slope of Mt. Frebold. Even from a long distance the inaccessibility of these yellow walls is evident, and this is perhaps one of the reasons why earlier investigators chose to work in the more easily accessible west side of the plateau even though the beds are more poorly exposed there than on the north side.

Most difficult of access is the area between Immacradal and River 5,

where the steep walls are intersected by narrow canyons or rugged ravines, at the highly sloping bottom of which the snow forms a several metres thick fan, which does not melt even in warm summers. The way up through Tusindtrinskløften to the rich vertebrate localities of Fiskeplateauet and Stegocephalryggen leads across such a steep, icy snow-fan, where each step must be cut in the ice. We also went up through the ravine of River 8, laboriously cutting steps in the ice until we found an easier way below the ice, in the tunnel formed by River 8. More difficult still is it to climb the rock walls, as one has to cut steps in the hard rock.

The steep walls of the ravines are partly built up of conglomerates, partly of hard sandstones. The conglomerates early attracted the attention of explorers on account of their content of blocks containing fossils of Zechstein age, on which basis they were referred to the Permian until ROSENKRANTZ, finding Triassic fossils in the beds intermediate between the conglomerates (1930, p. 356), established their Triassic age.

KOCH visited the Cape Stosch area for the first time in April, 1927, and in spite of unfavourable working conditions due to snow-covering discovered that the conglomerates contained pebbles of Zechstein age. On account of the intricate stratigraphical conditions no definite determination of the age could be made, but KOCH mentions (1929, p. 117) that there was some reason to assume that the conglomerates and the superjacent limestone were actually of Permian age.

In his stratigraphical table KOCH (1930, p. 118) placed *Ophiceras* and *Proptychites* beds of an estimated thickness of 100 m, between the basalt and the presumed Permian series.

On the Danish expedition in 1929 a party of geologists under the leadership of ROSENKRANTZ made investigations in the Cape Stosch area, and in addition to securing considerable collections of fossiliferous blocks from the conglomerates they succeeded in ascertaining the presence of Eotriassic zones between the conglomerates carrying blocks of Zechstein age (ROSENKRANTZ 1930, pp. 361 and 365, KOCH 1931, p. 13).

This changed the conception of the age of the conglomerates, which was now regarded as Eotriassic, and ROSENKRANTZ transferred the name Cape Stosch Formation, proposed by KOCH to include the conglomerates as well as their block contents and the beds intercalated between them, to comprise only the blocks carrying Zechstein fossils in the conglomerates (ROSENKRANTZ 1930, p. 356).

KOCH's *Allorisma* bed, which was first assumed to consist of a hard, glauconitic, oolitic limestone (KOCH 1929, p. 117) forming the upper part of the Cape Stosch Formation, according to ROSENKRANTZ's investigations consist of pebbles originating from one of the Eotriasic conglomerates (1930, p. 356).

In the summer of 1929 KULLING made an investigation of the

beds at River 2, and gave a description of the lowermost Triassic conglomerates, which he observed in a thickness of about 60 m about 40 m above the *Productus* limestone (KULLING 1930, p. 344). He described the conglomerates as follows: "about 60 m, conglomerate, yellowish-grey. The boulder material consists of the Caledonian red muscovite-bearing granites, Eleonore Bay limestones, dolomites, and quartzites, gneisses, orange-coloured loose sandstones, boulders of shales, and grey fossiliferous limestones."

As regards the horizontal distribution of the fossiliferous blocks of the conglomerates ROSENKRANTZ ascertained (1930, p. 357) that they occur in a large number slightly east of Cape Stosch in the basal conglomerate of the Wordie Creek Formation, but decrease in number towards the east. Personally I made no attempt to secure further material from these loose blocks, and as regards the division of the block material and the composition of the faunas I shall refer to FREBOLD's papers on these subjects. Blocks with young-Palaeozoic fossils occur in all the conglomerates up to and including conglomerate V, but are increasingly frequent towards the base of the series. (Regarding the conglomerates of the Hird Bay area, see p. 89). According to ROSENKRANTZ, the block content of the basal conglomerate differs from that of the higher-lying conglomerates (1930, p. 358); see further FREBOLD 1933, p. 10.

In the following I shall attempt to give a general view of the horizontal and vertical distribution of the conglomerates, which has not been done quite satisfactorily in earlier papers.

ROSENKRANTZ (1932, p. 10, Pl. 1, fig. 5) gives a sketch showing the distribution of the conglomerates within the sedimentary series, which, in addition to the conglomerate underlying the *Posidonomya* shales, are indicated 1—1, the basal conglomerate of the Triassic series, 2—2 and 3—3, higher-lying Triassic conglomerates, which are seen to wedge out towards the east. However, since ROSENKRANTZ has omitted the fault in Immacradal discovered by himself (1930, p. 360), probably because its presence was doubted by KOCH (1931, p. 45), his sketch is somewhat misleading; moreover the designation «basal conglomerate" is inadequate, since we are now aware that an Eotriassic series more than 100 m thick (see p. 27) occurs below the conglomerates appearing on the north side of Spath Plateau.

ROSENKRANTZ's three conglomerates form the most prominent rock walls in the north side of Spath Plateau; however, ROSENKRANTZ's numbering of them does not correspond to that made by KOCH, who numbered them 1 to 5, but in various places in the text uses different numbers for the same conglomerate. FREBOLD (1933, p. 7) employs one of KOCH's set of numbers.

At River 1 conglomerate I, according to KOCH (1931, p. 29), occurs

at 240 m altitude and conglomerate II at 300 m. The thicknesses of the conglomerates are not given.

A more detailed mention of conditions there is made by KOCH in p. 92: "Conglomerate I is 5—8 m thick, and is overlain by about 10 m of coarse sandstones. Above follows conglomerate II, of a thickness of about 20 m, succeeded by 70—80 m of sandstones, in places rather fine-grained, in other places containing quite thin bands of fine-grained conglomerates. Then follows conglomerate III, varying in thickness from a couple of metres to about 10 m. This conglomerate, which is nowhere particularly hard, is overlain by about 60 m of fine-grained sandstones and clay shales." KOCH figures (1931, p. 31, fig. 7) a section through the 501 m plateau within the western part of Spath Plateau. Here three conglomerates, numbered from I to III, are indicated below the "Lower *Ophiceras*" bed. The conglomerate above the *Proptychites* bed is termed conglomerate V. In the text (1931, p. 35) KOCH terms the latter conglomerate IV, and in the description of the complete section through the sediments round Cape Stosch (1931, pp. 91—93) he terms the *Anodontophora* (breviform) block-conglomerate conglomerate V, although it can hardly correspond to conglomerate V in his fig. 7, since the latter is situated fairly close to the *Proptychites* beds.

About the conditions at Rivers 2 and 3 KOCH states (1931, p. 34) that the *Ophiceras commune* zone occurs about 80 m above conglomerate II, and 120 m above this zone follows conglomerate III, which is overlain by the *Proptychites* beds.

Also in the important section through the northwestern corner of Spath Plateau (KOCH 1931, pp. 36—37) conglomerates are stated to occur below the "lower *Ophiceras*" beds, below the *Proptychites* beds, at 441 m altitude, within the uppermost part of the section, and the interesting Triassic block conglomerate slightly below the *Anodontophora fassaensis*-bearing beds.

The section east of River 5 (KOCH 1931, p. 41) also shows a conglomerate far below the "upper *Ophiceras* zone", another below the *Proptychites* beds, and a third nearly 100 m higher. In the last two sections the conglomerates are not numbered. East of River 5 KOCH (1931, p. 42) mentions a conglomerate I and a conglomerate II below the "lower *Ophiceras*", and a conglomerate III below the *Proptychites* beds.

Thus KOCH's designation of the conglomerates changes from place to place, and ROSENKRANTZ's sketch only shows some of the conglomerates, and as already mentioned (p. 79) is on the whole somewhat misleading.

On account of the great importance of the conglomerates for the location of the fossiliferous zones in the often highly débris-covered

sections, a uniform numbering of the conglomerates in the various sections would, of course, be convenient, and a numbering according to the order in which they occur would seem the most natural.

An ideal section based on observations in the western part of Spath Plateau exhibits no less than seven important conglomerates. Of these Nos. I, II, and III are situated between the *Glyptophiceras* and the *Ophiceras* sp. nov. zones (see pp. 27 and 75), conglomerate IV

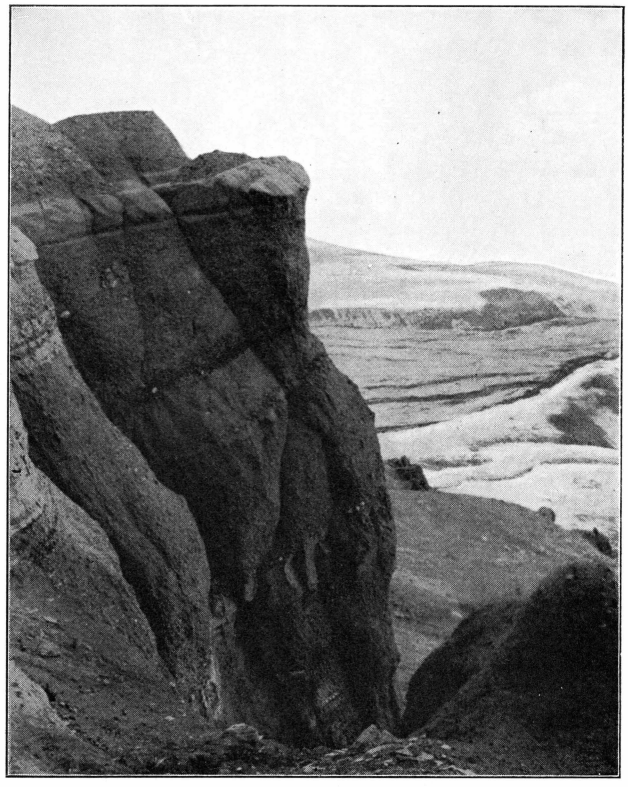


Fig. 30. Details of conglomerate III on Fiskeplateauet.

between the Upper *Vishnuites* zone (p. 46) and the Lower *Proptychites* zone (p. 57 and the footnote p. 25), conglomerate V about 80—100 m above conglomerate IV, and conglomerate VI at a similar distance above conglomerate V. Conglomerate VII is the *Anodontophora* (breviform)-bearing block conglomerate (p. 65) occurring some few metres below the *Anodontophora fassaensis*-bearing beds.

While thus in the area round River 1 three conglomeratic zones occur below the *Ophiceras* sp. nov. zone, only two conglomerates were observed below this zone on the north side of Spath Plateau. The position of these two conglomerates indicate that they correspond to conglome-

rates II and III at River 1. However, we cannot entirely disregard the possibility that the lowermost conglomerate on the north coast corresponds to both conglomerates I and II at River 1. In the following, however, the conglomerates of the north coast will be designated conglomerates II and III, but the possibility cannot be disregarded that conglomerate II may be equivalent to conglomerates I—II at River 1.

The conglomerates below the *Ophiceras* sp. nov. zone are generally of a considerable thickness, notably conglomerate III, which also forms the highest of the inaccessible walls west of Immacradal.

Where conglomerate III is best developed, it occurs in immediate association with a hard sandstone, which forms the uppermost part of the steep rock wall, and the thickness of which may exceed 20 m. Usually this sandstone is unconglomeratic, but may contain thin, tapering, conglomeratic bands. Conglomerates IV, V, and VI are present in thin bands, but they are surrounded, or overlain, by hard sandstones of a considerable thickness, which are as a rule the main component of the steep walls that render the conglomeratic zones so conspicuous. As will be shown in the following, the hard sandstones can in several cases be traced farther eastward than the conglomerate beds proper. For practical reasons the sandstones occurring in association with the western conglomerates will be termed conglomerates, even though in the eastern part of the area the actual conglomerate beds are less prominent. Thus for instance the term conglomerate II from Neviatiakdal merely refers to the hard sandstone zone forming the eastern continuation of the actual conglomerate II occurring west of Nasutdal. And conglomerate V from Vestplateauet designates the actual thin conglomeratic bed as well as the immense beds of hard sandstone occurring in association with it. (Both Koch and Rosenkrantz without further explanation apply the designation conglomerate to prominent steep walls forming the continuations of the more westerly conglomeratic zones but with no conglomeratic beds).

Hard sandstone beds were not observed in association with the peculiar conglomerate VII.

The horizontal distribution of the conglomerates.

If the conglomerate I that occurs in the area of River 1 does not form part of conglomerate II of the north coast (see above), it evidently tapers very rapidly towards the east.

Conglomerates II and III of the north coast, which at Tusindtrinskløft are 20 m apart, form huge rock walls, especially between Rivers 5 and 9. At Tusindtrinskløft the thickness of conglomerate III

(including the associated, overlying hard sandstone) is about 80 m. A similar thickness was measured immediately west of the fault of River 9. Both conglomerates II and III appear again east of Immacradal, but here conglomerate III, though still of a considerable thickness, lacks its uppermost zone of hard sandstone, and is otherwise of a friable, crumbling consistency, so that no steep wall like that farther west occurs here. Some few hundred metres farther east, between Rævekløft and the valley of River 10, conglomerate III is composed of reddish-yellow,



Fig. 31. View towards the west from the upper edge of conglomerate IV, east of Rævekløft. K. II, K. III., and K. IV = conglomerates II, III, and IV; O= the two upper zones of the *Otoceras* beds; P. I. = *Proptychites* beds; V = *Vishnuites* beds; F = the fault of Immacradal.

mouldering, slightly comglomeratic sandstone. In the river-bed of, and east of, River 10 every trace of conglomerate III has disappeared.

At Rævekløft conglomerate II still shows the same development as west of Immacradal, but from Rævekløft towards River 10 the pebbles decrease in number and size.

At the same time as the pebbles decrease in number, conglomerate II continues towards the east as a yellowish sandstone wall, which is traceable as far as the valley of Blue River, even though between Rivers 15 and 16 it is difficult to distinguish from the subjacent *Glyptophiceras* sandstone, which here also consists largely of hard, yellow sandstones (p. 34).

At the western River 11 subordinate conglomeratic beds are still encountered in the sandstone corresponding to conglomerate II. The same is the case at River 13.

At River 11 east and River 12 east and west the thickness of the conglomerate II sandstone is considerable, up to about 50 m, but decreases again farther east.

As regards conglomerate IV, KOCH made the following observations in the western part of Spath Plateau (1931, p. 34). About 120 m above the *Ophiceras commune* zone is the base of conglomerate IV (KOCH's conglomerate III), which is overlain by *Proptychites* beds. The conglomerate increases in thickness towards the southwest. On the north slope leading up to the 501 m point the conglomerate (KOCH 1931, p. 34) resembled a coarse sandstone, which only on a closer investigation could be termed a conglomerate; here it had not by far the same thickness as to the southwest.

The conglomeratic bed of conglomerate IV is of a very inconsiderable thickness along the greater part of the north coast of Spath Plateau. It is, however, interbedded between hard sandstones, which form the steep wall that makes the conglomerate so conspicuous. Similarly to conglomerate II (p. 78), which passed eastward into a hard sandstone with no, or subordinate, conglomeratic beds, the fairly conglomeratic conglomerate IV from the southwestern part of Spath Plateau is replaced on the north side of the plateau by this sandstone with subordinate or no conglomeratic beds.

Conglomerate IV (the steep wall below the *Proptychites* beds even when not conglomeratic) is traceable eastward as far as Blue River (regarding Stensiö Plateau, see p. 54). It is often difficult to measure its thickness, its lower boundary being concealed below material that has slid down from the loose sand and clay beds overlying the conglomerate. The thicknesses given below therefore only refer to the exposed part of the zone.

In Vestplateauet the thickness of the conglomerate was measured to be 14 m, and in a small ridge immediately west of this plateau it was even up to 20—25 m. In Blokken it is exposed as a 14 m high wall. In all these three places it is directly overlain by the *Proptychites* beds. In Stegocephalryggen 12 m of conglomerate IV are exposed, the lowermost metre of which is slightly conglomeratic. The *Proptychites* beds were met with 8 m above its upper boundary (see p. 58).

The top of Fiskeplateauet is made up of conglomerate IV, which is here about 15 m thick. In Pyramiden conglomerate IV is seen to form a 15 m high wall, which is not conglomeratic; here it is directly overlain by the *Proptychites* zone. Immediately east of the fault at River 9 conglomerate IV attains a great thickness, thus in Falkeryg about 45 m,

and has not the character of a conglomerate. Some few metres higher up the slope the *Proptychites* zone occurs (see p. 59). Conglomerate IV is exposed in all the valleys within Nebalopokryggene, but its thickness within this area was not measured.

In Neviatiakdal its thickness is 23 m, and it is underlain by 6 m of coarse sand with sandstone balls, the central part of which often consisted of pebbles.

By Rivers 12 and 13 the exposed part of conglomerate IV is traversed by a fault (see p. 11 and the map in pl. 1).

On Kilen conglomerate IV is of a fairly loose consistency and crumbling, forming here a wall only 5—7 m high, below which loose sand beds occur with similar pebble-carrying sandstone balls to those of Neviatiakdal.

In the eastern bank of River 14 conglomerate IV is but 8 m thick, and round Wordie Creek no hardened sandstone zone occurs below the *Proptychites* beds. However, in a ridge in Otocerasdal a sandstone wall about 15 m high is met with, probably corresponding to conglomerate IV. Conglomerate IV was not found in any other place within the Blue River area.

Conglomerate V is met with at the northwestern corner of Spath Plateau between 300 and 338 m in the form of one (possibly several) thin conglomeratic zones in a hard sandstone wall.

In the same section the upper boundary of conglomerate IV is at 220 m altitude. (The section intersects the large slip mentioned by KOCH (1931, p. 35), and hence the absolute thickness can hardly be determined here). Possibly the conglomeratic boulders mentioned by KOCH (1931, p. 37) found at about 300 m at the northwestern corner of Spath Plateau are derived from this conglomerate; possibly it is also the same conglomerate which was observed by KOCH (1931, p. 35) at the 501 m point in the western part of Spath Plateau.

Farther east, in the valley of River 5 and on Vestplateauet, the hard sandstone representing conglomerate V increases considerably in thickness, so that a huge steep wall, wedging out both to the east and west, is seen in the back wall of the valley south of the large slip (fig. 4). Thus on Vestplateauet the sandstone bed has already decreased considerably, and on Blokken it is merely distinguishable as a thin, light-coloured stripe. The greatest thickness of conglomerate V in the back wall of the River 5 valley must be estimated at considerably more than 50 m; however, since it forms here an absolutely inaccessible wall, I could make no exact measurement. On Vestplateauet the wall formed by conglomerate V is about 28 m high, and apparently unconglomeratic. East of Blokken the sediments above the *Proptychites* zone are covered by basalt scree, and not till on Pyramiden conglomerate V appears again as a

yellow sandstone wall 8—10 m high about 100 m above the upper boundary of conglomerate IV. East of Immacradal, it is true, various hard sandstone zones are met with in the *Anodontophora* (breviform) beds, but none of them can be referred with certainty to conglomerate V. Thus on Kilen a sandstone wall about 10 m high and possibly corresponding to conglomerate V occurs about 80 m above the *Proptychites* beds.

ROSENKRANTZ's Triassic conglomerate 3—3 (1932: pl. 1, fig. 5) marked as a dotted line, bifurcating into an upper and a lower branch at and west of Vestplateauet, no doubt corresponds partly to conglomerate IV and partly to conglomerate V.

KOCH (1931, p. 36) records a conglomerate from 441 m altitude at the northwestern corner of Spath Plateau which I observed later in the same locality as a nearly 7 m high, slightly conglomeratic sandstone wall K VI (fig. 23). On Vestplateauet, where it is no longer conglomeratic, its thickness was about 5 m, and its distance from the upper boundary of conglomerate V was measured to be about 80—90 m.

Slightly above K IV the hard sandstone mentioned in p. 63 is seen (fig. 23 h), which may with some right be taken to correspond to the light-coloured sandstone of a similar thickness which occurs east of Immacradal and on Stensiö Plateau, forming the upward termination of the *A.* (breviform) beds, and which is directly overlain by the *Myalina kochi* zone and the horizon with stegocephalians (see p. 65). (However, every reservation must be taken as regards the connection of the sandstone from these three widely separated localities).

The peculiar conglomerate VII is the *Anodontophora* (breviform) conglomerate discovered by KOCH (1931, pp. 36 and 93) at the northwestern corner of Spath Plateau some few metres below the *A. fassaensis* beds. The same conglomerate occurs on Vestplateauet some 70—80 m above conglomerate VI as a band about 80 cm thick. In addition to blocks very rich in *A.* (breviform) it contains pebbles of widely different origin. Farther east it has only been observed in the area of Immacradal (see p. 64).

After tracing the distribution of these seven conglomerates, it will be evident that the actual conglomeratic zones within these beds thin out very rapidly towards the east and gradually disappear. While conglomerates II and III are conglomeratic nearly as far east as Nasutdal, the actual conglomeratic zones of conglomerates IV, V, and VI have a much less distribution to the east, the smaller the higher in the series of strata the conglomerates occur. The peculiar conglomerate VII, however, has a fairly considerable distribution to the east, occurring, as mentioned above, in Immacradal.

Of considerable interest is a number of fairly thick conglomerates

which occur in the *Vishnuites* and the *Proptychites* beds in the area round Rivers 13—16, but which cannot be directly compared with the more westerly conglomerates. Thus in a section from Neviatiakdal a zone of highly friable conglomerates with pebbles up to 5 cm in diameter was found between the middle and upper *Vishnuites* beds at 381—382 m altitude, and another friable conglomeratic zone with still larger pebbles

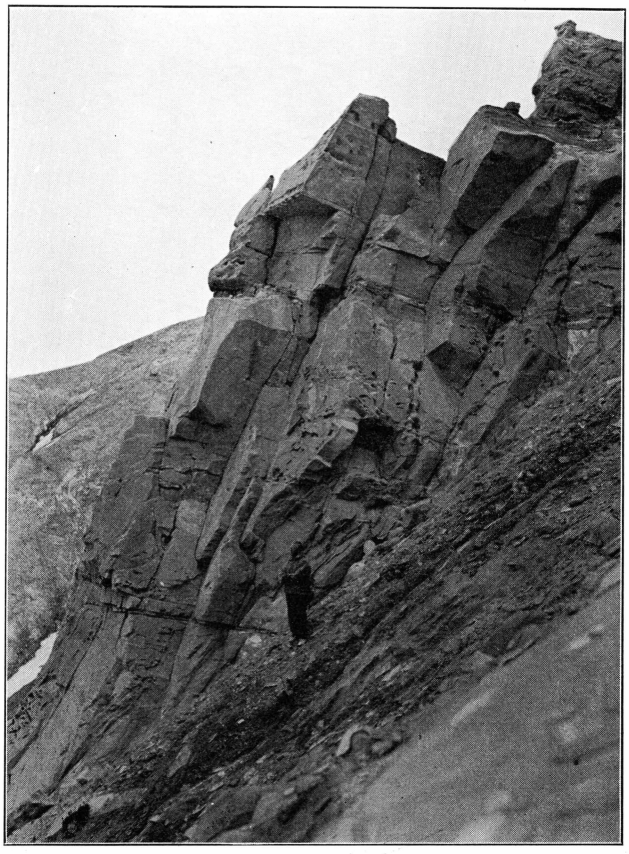


Fig. 32. The hard sandstone of Neviatiakdal, interbedded betweeen the *Vishnuites* and the *Proptychites* beds.

was found between 397 and 398 m altitude. The upper *Vishnuites* zone occurs between 417 and 435 m, and is overlain by a loose, sandy zone, 6 m thick, with pebble-bearing sandstone balls (see p. 56), which again is overlain by conglomerate IV, here about 23 m thick. The *Proptychites rosenkrantzi* zone occurs from 492 to 498 m. Its lowermost part is conglomeratic, with pebbles up to 10—15 cm in diameter.

On Kilen, from 525 to 526 altitude, between the middle and the upper *Vishnuites* zones, there occurs a conglomerate with pebbles of up to 6—8 cm in diameter. From 530 to 550 m the upper *Vishnuites* zone

is met with, and closely associated with the *Proptychites rosenkrantzi* zone occurring from 597 to 607 m is a conglomerate, between 598 and 602 m, with pebbles up to 15 cm in diameter.

Conglomerates seem also to occur in the eastern wall of River 14 below the upper *Vishnuites* zone, and about 10 m above the upper boundary of conglomerate IV there is a friable conglomerate, 2—3 m thick, with pebbles up to 15—20 cm in diameter. The pebbles contain a *Proptychites rosenkrantzi* fauna, which shows that here it is the upper *Proptychites* zone itself that is conglomeratic.

In the area round Wordie Creek the upper *Proptychites* zone is also conglomeratic. Here the conglomeratic zone attains a thickness of about 10 m.

In the description of the conglomerates mention is not made of the fairly fine-grained conglomerates occurring in the lower part of the *Otoceras* beds (see p. 33) on the north coast of Spath Plateau.

As regards the conglomerates known from the northwestern part of Spath Plateau Koch (1931, p. 98) put forward the supposition that they indicate the presence of a steep coast immediately west of Cape Stosch which has repeatedly been subjected to orogenic movements. The conglomerates of the Hird Bay area (p. 89) were also assumed to have been formed near a steep coast cliff. The conglomerates between Rivers 13 and 16, discovered later, also point towards the existence of a steep coast, which must, no doubt, have been situated north of the area. As regards the parallelisation of the individual orogenic movements within these three areas, the conglomerates of the Hird Bay area underlying the next-highest *Otoceras* zone probably correspond to conglomerates I—III in the area near Cape Stosch. Corresponding conglomerates were not found in the area between Rivers 13 and 16, which has possibly been elevated above the surface of the water during part of the period of deposition of the conglomerates (as regards gypsum, see p. 45). The higher-lying conglomerates round Rivers 13 and 16 are more difficult to parallel with the conglomerates to the west. In fact, the conglomerates between the middle and the upper *Vishnuites* zones do not seem to have any parallels in the area round Cape Stosch (it should, however, be borne in mind that the *Vishnuites* beds near Cape Stosch are so poorly exposed that the conglomerates, if present, might easily have been overlooked). The conglomerates occurring above the upper *Vishnuites* zone to and including the upper *Proptychites* zone in the area between Rivers 13 and 16 possibly correspond, at any rate partially, to conglome-

rate IV. From Hird Bay neither *Vishnuites* beds nor *Proptychites* beds are known.

It will be evident from the above that nothing speaks against the supposition that the movements have been almost contemporary within the whole area round Godthaab Gulf. It seems, however, as if the movements have been strongest at the time when the *Otoceras* beds were laid down, and have decreased gradually as the *Vishnuites* beds, the *Proptychites* beds, and the *Anodontophora* (breviform) beds were deposited. KOCH (1931, p. 96) as well as FREBOLD (1933, p. 26) parallel these movements with STILLE's "pfalzische" movements.

The Hird Bay Area.

Mt. Brinkley	**Söderbergh Plateau**	**Cape Stosch*)**
		A. (breviform) beds
		Proptychites beds
		Vishnuites beds
Basalt		
Uppermost zone of *Otoceras* beds	Sandstones of varying consistency, in part conglomeratic, with mussels	Uppermost zone of *Otoceras* beds
Next-highest zone of *Otoceras* beds		Next-highest zone of *Otoceras* beds
	Hiatus	conglomerates
	Uppermost zone of *Otoceras* beds	
Conglomerate	Next-highest zone of *Otoceras* beds	The *Glyptophiceras* zones
	Yellowish hard conglomeratic sandstone	
Greyish sand and sandstone beds	Greyish sands and sandstone beds	
Permian	Permian	Permian

In 1929 the small area of sediments near Hird's Fox Farm on the south coast of Clavering Island attracted the attention of the members of the Danish expedition. Here KULLING, ROSENKRANTZ, POULSEN, and SIGURD HANSEN found *Posidonomya* shales and *Martinia* limestone to

*) It has been attempted to show the proportionate thicknesses in the lower part of the *Otoceras* beds within the three areas, for practical reasons, however, not in the upper part.

be overlain by Eotriassic beds, from which, in addition to invertebrates, i. a. *Otoceras*, beautifully preserved fishes embedded in concretions were collected. Also the finding of *Godthaabites* in the *Martinia* limestone (a loose block) was of considerable interest.

The following year the area was investigated and mapped by KOCH, NOE-NYGAARD, and G. SEIDENFADEN, and in 1931 it was visited by SÄVE-SÖDERBERGH, MALMQVIST, LETH PEDERSEN, LAURSEN, and the present author, on which occasion *Medlicottia* was found in the *Martinia* limestone for the first time. In September, 1932, I again worked in the area, and finally, in the summer of 1933, I further investigated the area together with J. TROELSEN and A. JENSEN.

Although such a large number of geologists have been at work within the area, it can hardly be said to have been investigated in all details, the beds being so highly covered with débris in most places that the sequence of strata can only be studied in small exposures in the walls of the ravines. However, in spite of this the sequence of strata is known in its broad features, and future finds of fossils will hardly present any surprises.

As will appear from the map (pl. 1), the distribution of sediments in the area between Sneugleelv and Fossilelv is not fully known, not because the sediments were especially poorly exposed, but because circumstances prevented me from making a planned excursion to this area in the summer of 1933.

At Hird Bay no trace of a conglomerate corresponding to the Namurian (?) conglomerate at Cape Stosch has been observed. Whereever the beds are fairly well exposed, the crystalline rocks are overlain by limestone or dolomite and gypsum (ROSENKRANTZ 1930. a., pp. 353 and 354, KULLING 1930, p. 345, KOCH 1931, p. 55), succeeded by *Posidonomya* shales. However, in many localities these gypsiferous and dolomitic beds are concealed by scree originating from the *Posidonomya* shales and the *Martinia* limestone. According to ROSENKRANTZ (1932, p. 11), the gneiss in the southern part of Söderbergh Plateau is overlain by quartzite and sandstone, and these again are overlain by veined limestone.

In the southernmost part of Söderbergh Plateau (see the map pl. 1). I observed a bed of dolomite, 4 m thick, above the gneiss, but much thicker beds of dolomite were found farther north on Söderbergh Plateau and Mt. Brinkley Plateau.

As pointed out by ROSENKRANTZ (1930. a., p. 353) the gypsum at Hird Bay does not by far attain the same thickness as at Cape Franklin and in part of the Cape Stosch area. It is exposed in a few places in the southern part of Söderbergh Plateau.

As mentioned in p. 14, it was decided, after a consultation with KOCH and FREBOLD, to draw the boundary between the Carboniferous and

the Permian below the Schwagerina zone. Conditions in the Hird Bay area have highly contributed to this decision.

On Spath Plateau the *Posidonomya* shales are overlain by *Martinia* limestone interbedded with a more or less thick band of *Productus* limestone belonging to the Schwagerina zone. The *Martinia* limestone above and below this band is of exactly the same type and contains the same fauna. Neither on Spath Plateau nor at Cape Franklin did the *Martinia* limestone contain ammonites, although from FREBOLD's table (1932. c., p. 54) one gets the impression that it contains *Godthaabites* and *Medlicottia* in these places. In the said table the *Martinia* limestone at Cape Franklin and at Cape Stosch is indicated as Artinsk, although at Cape Stosch, at any rate, it contains no fossils which are not represented in the Schwagerina *Martinia* limestone underlying the *Productus* limestone.

Cape Stosch	Certain determinations of age	Hird Bay area
Eotrias		Eotrias
Martinia limestone (Schwagerina, possibly Artinsk?)	Artinsk ?	At the top Artinsk *Martinia* limestone with *Medlicottia* and *Godthaabites;* below this, *Martinia* limestone, sometimes alternating with *Posidonomya* shale. Age probably Schwagerina, possibly Artinsk.
Productus limestone (Swagerina).	Schwagerina	
Martinia limestone (Schwagerina)		
Posidonomya shales (Schwagerina)		*Posidonomya* shales, probably Schwagerina; possibly Artinsk.

My conception of the Lower Permian in the coast near Cape Stosch is shown in the table in fig. 8 (see further p. 14 et seq.). At Hird Bay, as will also appear from the above table, we find at the base *Posidonomya* shales and at the top *Martinia* limestone, and, as ascertained by SÄVE-SÖDERBERGH (KOCH 1931, p. 34), these two rocks alternate in the wall of Fossil River. The *Martinia* limestone contains Artinsk ammonites (Frebold 1932. c., p. 54, FREBOLD 1932. b), and personally I succeeded in finding some of these in situ in the *Martinia* limestone. They show that at any rate the upper portion of the *Martinia* limestone is of Artinsk age. Its lower part, similarly as in the coast near Cape Stosch, is probably of Schwagerina age. This supposition was supported by the finding of several loose blocks of *Productus* limestone in the Hird Bay area, which might indicate the presence in the *Martinia* limestone

of a band of *Productus* limestone with a Schwagerina fauna, as is the case on Spath Plateau. However, if these blocks have been transported by the ice from another place, there is, of course, a possibility that the *Martinia* limestone and perhaps also the *Posidonomya* shales at Hird Bay are Artinsk throughout.

As regards the distribution of the Permian in the Hird Bay area there is but little to add to Koch's investigations (Koch 1931, pl. IV). The various minor corrections that have been made will appear from a

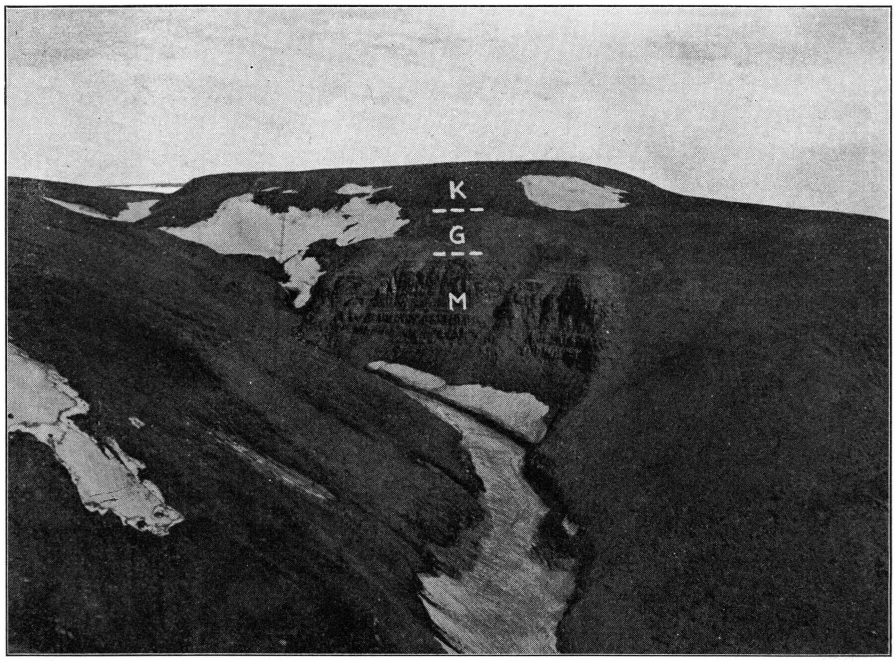


Fig. 33. Sneugleelven. M = *Martinia* limestone; G = grey, sandy sediments; K = hard, yellow sandstone with subordinate conglomeratic bands.

comparison of pl. 1 and Koch's map. It should, however, be pointed out that the *Martinia* limestone does not by far attain a thickness of 200 m, as estimated by Koch (1931, p. 56). Nowhere within the Hird Bay area does the aggregate thickness of the *Posidonomya* shales and the *Martinia* limestone exceed 80—90 m, and in several places it is considerably less.

In 1929 Kulling (1930, p. 345) discovered that the Permian beds at Hird Bay, the thickness of which he estimates at more than 90 m, contained fish remains, notably in the upper portion and in concretions. As already stated, fishes occur on Spath Plateau partly in a zone in the upper part of the *Posidonomya* shales (p. 18), partly in the *Productus* limestone band (p. 23). Loose fragments of concretions containing remains of

elasmobranchs found at Hird Bay indicate that here, too, a concretion-bearing fish zone occurs in the *Posidonomya* shales. But in addition the *Martinia* limestone at Hird Bay contains *Arctacanthus*, *Fadenia*, and other elasmobranchs. From the *Martinia* limestone in the eastern wall of Fossil River a type of shark tooth new to Greenland was collected, which is highly reminiscent of DE KONINCK's European *Campodus* (DE KONINCK 1842—44, p. 617; E. NIELSEN 1932, p. 36). In addition the *Martinia* limestone at Hird Bay contain various plant remains (HALLE 1931, p. 23), which are of interest because of their fairly modern character.

The peculiar hooks discovered by ROSENKRANTZ (1930. a., p. 354) in the Permian at Hird Bay and compared by him to the Triassic *Phragmoteuthis*, occur now and then in great abundance in company with an ortoceratite shell in such a way that their possible association cannot be rejected (according to a discussion with ROSENKRANTZ). From Cape Stosch neither plant nor fish remains are known from the *Martinia* limestone.

As will be evident from the table in p. 84, the Triassic deposits of the Hird Bay area can be paralleled to some extent with those of the coast round Cape Stosch, but they exhibit a far poorer development than the latter. Thus there is a considerable hiatus between the *Otoceras* and the *A.* (breviform) beds, and beds younger than *A.* (breviform) beds are absent, possibly owing to erosion of the sediment area, which is but slightly protected by basalts.

On the Mt. Brinkley Plateau the Triassic deposits are somewhat better exposed than on Söderbergh Plateau, so the stratigraphy of that plateau did not present any very great difficulties. The lowermost part of the Triassic sediments consists of clayey, greyish-green, fairly loose sand beds, alternating with greyish unfossiliferous sandstone bands. The thickness of this zone is very difficult to determine on account of the loose consistency of the beds, which, when the thaw sets in, makes them so plastic that they flow down across the boundary towards the subjacent *Martinia* limestone. However, the thickness can be estimated at between 20 and 60 m. Above follows a conglomeratic zone 80—90 m thick. Neither KULLING, who investigated the southwest side of Mt. Brinkley, nor FREBOLD (1931. b. p. 35) mention the greyish-green clayey sand and sandstone zone. KULLING (1930, p. 345) writes that conglomeratic beds rest disconformably on the Permian *Posidonomya* shales and the *Martinia* limestone. That a disconformity exists between the conglomerates and the substratum is proved, according to KULLING (1930, p. 346), by the fact

that the series of limestones and shales (Permian), which southwest of Mt. Brinkley attains a thickness of about 90 m, one kilometre farther south is but 45 m thick. According to KOCH (1931, p. 59), the *Martinia* limestone on the Mt. Brinkley Plateau is overlain by greenish shales and sandy marls, occasionally interbedded with conglomerates and overlain by coarse conglomerates. The immense Triassic conglomerate, as already pointed out by KULLING, differs in composition from the conglomerates in the coast near Cape Stosch. KULLING states as follows (1930, pp. 345—46): "The conglomerates .... differ from the upper Cape Stosch conglomerates by their more yellowish-brown colour, the generally highly kaolinised condition of their granitic and gneissic boulders, and the somewhat different types of boulders of sedimentary origin. The kaolinised feldspathic rocks are indicative of other conditions of disintegration than those prevailing during the deposition of the upper Cape Stosch conglomerate."

Another point of difference which immediately catches our eyes if we compare the conglomerates from the two localities, is that the size of the pebbles in the conglomerates on the Mt. Brinkley Plateau is as a rule less than those of the Cape Stosch conglomerates.

According to FREBOLD's map of the distribution of young-Palæozoic components in the Eotriassic conglomerates (FREBOLD 1933, p. 51, fig. 1) (see p. 23), the conglomerates in the Hird Bay area do not contain such components (FREBOLD 1930. a. and 1933, p. 41). However, the size of the pebbles is generally less than on Spath Plateau, which may be due i. a. to the fact that the material has been more strongly affected at Hird Bay than on Spath Plateau, and naturally the sedimentary rocks will be more strongly affected than the eruptives, which are generally more resistant. I did not give special attention to these blocks, but from an exposure in the northeastern part of the Mt. Brinkley conglomerate I observed a sample of a lightcoloured limestone containing fossils of young-Palæozoic age. Whether it was of Zechstein age or older, I was unable to decide, but I suppose that a careful investigation of these conglomerates may bring to light interesting fossiliferous blocks. On the southwest, west, north, and northeast sides of Mt. Brinkley the conglomerates do not, as a rule, form steep walls, but are so crumbling, due to weathering, that they form gentle slopes partially covered with scree. Southwest of the basalt top sandstones as well as loose sand beds can be observed between the actual conglomeratic zones, and the whole conglomerate zone has the appearance of a huge staircase with three steps. Southeast and east of the basalt top the conglomerates are more compact and form huge walls in several places. As mentioned by KOCH (1931, pp. 59—60), the conglomeratic zone is overlain by yellowish, clayey sediments with concretions. From these beds a concretion with

an ammonite was collected in 1931 (KOCH 1931, p. 60) which points towards the presence of the uppermost zone of the *Otoceras* beds.

During the investigation in 1933 we found south of the basalt top of the plateau, between 866 and 889 m altitude, a sandy-clayey zone with limestone concretions, which in addition to fishes such as *Bobasatrania*, *Coelacanthids*, *Perleidus*, *Australosomus*, and other species, contained the following forms determined by SPATH: *Otoceras*, *Glyptophiceras pascoei*, *G. gracile*, and other species of *Glyptophiceras*, *Ophiceras*, and *Claraia*. In a letter to me SPATH says about this fauna: "I should put it below the fauna with large *Ophiceras* (your upper zone of clay with concretions)". Thus this fauna should represent the *Ophiceras* sp. nov. zone of the coast near Cape Stosch. Occasional concretions from the same zone were met with northwest of the basalt top, and thus to all appearance this next-highest zone of the *Otoceras* beds, as shown in the map pl. 1, is present above the conglomeratic zone on all sides of Mt. Brinkley. However, on the southeast, west, north, and east sides it is almost entirely concealed below loose soil and down-fallen basalt blocks. The ammonite found in 1931 shows that as on Söderbergh Plateau also the uppermost zone of the *Otoceras* beds is represented on the Mt. Brinkley Plateau, but it is hardly of great thickness. Between the *Otoceras* beds and the basalt, the lower boundary of which southwest of the top of Mt. Brinkley is at about 900 m altitude, some few exposures of unfossiliferous, baked, red and grey sandstones were seen.

The deep ravine of Fossil River (see the map pl. 1) divides the Triassic deposits of Söderbergh Plateau into a small western area between Fossil River and Fish River, and a larger eastern area, which extends rather far towards the north. The greater part of the small western Triassic area is covered by loose soil, but in a few places the beds are so well exposed that it is possible to get an idea of the structure of the plateau. It is of special interest because it has yielded an essential part of the material of Triassic fishes described by STENSIÖ. The fishes were found in two localities, the westernmost of which (fish locality 2), situated near Fish River, was discovered in 1929 by ROSENKRANTZ, and the easternmost (fish locality 1), situated near Fossil River, was discovered in 1930 by KOCH.

According to ROSENKRANTZ (1930. a., p. 360) the sequence of strata at Fish River is as follows: Above the *Martinia* limestone there follow about 20 m of coarse sandstones with subordinate conglomeratic beds (matrix arkose) at the base. The sandstones are overlain by a thin bed of an impure grey limestone with poorly preserved specimens of *Ophiceras*, and this bed is overlain by 25 m of a greasy, brownish clay with

numerous calcareous concretions of clay ironstone. The concretions contain fishes and ammonites, i. a. *Otoceras*. Since ROSENKRANTZ's visit, this fish locality has been visited by KOCH in 1930 (1931 p. 56), by SÄVE-SÖDERBERGH in 1931 (KOCH 1931, p. 56), and by the present author in 1932, but none of us succeeded in finding the ammonite zone below the clay bed. However, a very bad exposure of a similar grey limestone with ammonites can be seen in a single place in the locality, but it seems either to form a band in the clay zone or to overlie it. Otherwise there is nothing to add to ROSENKRANTZ's description except that he has no doubt overestimated the thickness of the clay zone (see below). The quite small exposure has now been so thoroughly investigated that it will hardly be possible to find one single un-examined concretion, and it will take several years before new concretions will be exposed.

The other fish locality (fish locality 1) on the western side of Fossil River was discovered by KOCH in 1930 (KOCH 1931, p. 57). Here, too, clay with fossiliferous concretions is underlain by yellow, hard sandstone with subordinate conglomeratic beds. The thickness of the sandstone is about 20 m, as in fish locality 2 at Fish River, but here it is not directly underlain by *Martinia* limestone, but of a series, 25—50 m thick, of greyish-green loose, clayey sand and sandstone beds. I especially directed my attention to an investigation of corresponding beds at Fish River. At Fish River the lowermost few metres of the Triassic beds are concealed by loose sandstone blocks, and the lowermost exposed beds are made up of the above-mentioned yellowish coarse sandstone with conglomeratic zones, whose upper boundary occurs about 20 m above the *Martinia* limestone. Above the sandstone wall there follow about 2 m of loose, sandy beds, alternating with sandstone bands but few centimetres thick, overlain by a hard unfossiliferous sandstone band, about 40 cm thick, and this again is overlain by about 8 m of clay with concretions, from which ROSENKRANTZ collected the fossils brought back from fish locality 2 (see above). Consequently there is a possibility of the presence here of a bed but few metres thick corresponding to the greyish-green zone at Fossil River below the loose sandstone blocks concealing the base of the series; on the other hand, the yellow, hard sandstone may rest directly on the *Martinia* limestone.

Fish locality 1 has been described by KOCH (1931, p. 57). Above the coarse, yellow sandstones with subordinate conglomeratic beds there follow about 5 m of clay, the lowermost half metre of which contains a large number of concretions with *Claraia*. Higher up in the clay, where *Claraia* is less frequent, ammonites and fishes occur. In addition loose blocks were found, highly reminiscent of the calcareous sandstone of the upper part of the "Lower *Ophiceras* zone« of the coast near Cape Stosch (see p. 27). One of these blocks contained *Ophiceras sakuntala* and *O.*

ptychodes, which might indicate that also the upper parts of the "Lower *Ophiceras*" beds are represented here. The beds above fish locality 1 are much covered with scree, but according to KOCH (1931, p. 57) they have a thickness of about 50 m.

KOCH (1931, p. 80) referred the invertebrate faunas from fish localities 1 and 2 (except the above-mentioned loose blocks) to the "*Glyptophiceras* beds", but to a higher zone than those from the area of Cape Stosch. KOCH's *Glyptophiceras* beds correspond to the lowermost zones of the *Otoceras* beds. The reason why KOCH placed these beds so low in the stratigraphical sequence although their fish fauna agreed fairly well with that of the "Lower *Ophiceras* beds" of the Cape Stosch coast, is no doubt the presence of *Otoceras* in these faunas. It has proved later that *Otoceras* also occurs in KOCH's "Lower *Ophiceras* beds", and accordingly the two faunas, like that mentioned from the Mt. Brinkley Plateau in p. 90, show the greatest agreement with the fauna known from the *Ophiceras* sp. nov. zone on Spath Plateau (see the table in p. 84). Both on the Mt. Brinkley Plateau (see p. 90) and in fish locality 1 (the loose blocks) there are indications that also beds corresponding to the uppermost zone of the *Otoceras* beds on Spath Plateau are represented in the Hird Bay area. However, in the latter area this zone seems to be very poorly developed.

The easternmost Triassic part of Söderbergh Plateau, as will appear from KOCH's map (1931, pl. IV), has a very considerable extension in the direction north-south. The whole of this area, more particularly its southern part, which is most easily accessible from the coast, is so greatly covered by scree that it is extremely difficult to make out the sequence of strata. Hence it will be easily understood that the section measured in 1931 by MALMQVIST and SÄVE-SÖDERBERGH has occasioned a misunderstanding in KOCH's description (1931, p. 58). The section was as follows:

620 m Top of Söderbergh Plateau.
617 m and below. Sandy, argillaceous, grey conglomerate.
544—524 m Grey, shaly, fairly hard sandstones with cross-bedding and conglomerates.
507 m Conglomerate and arkose, interbedded with sandstone containing badly preserved pelycopods, probably *Anodontophora* (breviform);
480 m Arkose.

Break in the section. The measurements were continued a little farther north, where the following section was obtained:

507 m Sandstones with *Anodontophora* (breviform).
477—474 m Thin-bedded arkose and cross-bedded sandstone.

457 m Very hard, yellow sandstone.
450—396 m Yellow sandstone with conglomeratic bands.
397—247 m Débris of green sandstone and clay of a very loose consistency.
247 m *Martinia* limestone.
and below.

From this section KOCH (1931, p. 58) inferred that the greyish green series overlying the *Martinia* limestone here had quite an exceptional thickness compared with the other places within the Hird Bay area in which it is represented. After a thorough investigation of the area I arrived at the conclusion that the greyish-green series here, as for instance west of Fish River (p. 91) and on Mt. Brinkley (p. 88), does not exceed a thickness of 50 m, or not by far the thickness exhibited by the lower zones of the *Otoceras* beds on the coast near Cape Stosch. I measured a section extending from the southern end of the plateau to its top, and from its top to the northern end, and arrived at the result that the lowermost part of the Triassic deposits from the boundary towards the *Martinia* limestone to and including the upper zones of the *Otoceras* beds agreed perfectly in thickness and composition with the beds of fish locality 1 west of Fossil River.

It proved that the southern part of Söderbergh Plateau, where the huge greyish-green débris series of SÄVE-SÖDERBERGH was found, is a much flexured area, and that accordingly the substratum of the Triassic beds, the *Martinia* limestone, here occurs at increasingly higher altitudes towards the north. Thus the upper boundary of the *Martinia* limestone was measured by SÄVE-SÖDERBERGH to be 247 m (see above), while in the place where I measured the section, also in the southern part of the area, it was at about 230—240 m, and near the junction of Sneugleelv and Fish River (fig. 33) I measured it to be 356 m.

In the places in which I investigated the section, the *Martinia* limestone was overlain by débris of greyish-green sandy and clayey beds. However, already between 290 and 293 m (and possibly slightly higher), there occurred a débris-covered zone with numerous ammonites embedded in a calcareous sandstone, according to SPATH almost exclusively *Ophiceras sakuntala*.

This fauna probably corresponds to the fauna known from fish locality 1 (p. 91), found in loose blocks originating from the uppermost zone of the *Otoceras* beds. Consequently the concretionary next-highest zone of the *Otoceras* beds must occur below 290 m, which means that here 60 m at most of Triassic sediments occur between the fish zone and the *Martinia* limestone. The beds are so much covered with débris that no trace could be detected of the hard, yellow, somewhat conglomeratic sandstone occurring below the fish zone west of Fossil River, but since

it occurs some few hundred metres farther north, east of Fossil River, in the vicinity of Sneugleelv, there is hardly any doubt that it also occurs in the southern part of the eastern Triassic area of Söderbergh Plateau. Throughout this area no sediments younger than the above-mentioned ammonite zone are found, and the zone is only preserved in this single place. As a rule both this ammonite zone and possibly the next-highest zone of the *Otoceras* beds and the subjacent yellow, hard sandstone seem to have been removed by erosion throughout the flexured area east of Fossil River, for which reason the surface is almost everywhere made up of débris of the greyish-green series. But the central and northern parts of Söderbergh Plateau exhibit a very simple and undisturbed sequence of strata.

As mentioned above, the upper boundary of the *Martinia* limestone in the eastern wall of the southern part of Sneugleelv occurs at 356 m altitude. Here, too, the *Martinia* limestone is overlain by greyish-green, sandy, fairly loose beds (fig. 33).

About 388 m altitude (possibly slightly lower) is the lower boundary of the hard, yellow sandstone beds with subordinate conglomerate beds, known from the area west of Fossil River. The thickness of this series is here about 38 m. The beds overlying the sandstone were so highly obscured by débris that they could not be closely investigated.

Some distance farther north, where the section continues, the upper boundary of the hard sandstone is at an altitude of about 450 m. Here, too, it was impossible to investigate the beds immediately superjacent to the hard sandstone. However, at 462 m loose sand beds with more compact sandstone bands containing mussel remains were found in situ. To all appearance the two uppermost zones of the *Otoceras* beds lie below these sandstones, but above the yellow, hard sandstones with the subordinate conglomerate beds.

The sequence in the higher-lying part of Söderbergh Plateau agrees with the upper part of SÄVE-SÖDERBERGH's and MALMQVIST's section (see p. 92). It should, however, be noted that remains of mussels (possibly *Anodontophora* (breviform)) are met with over and over again in the beds from 462 m to the top of the plateau and are not restricted to a small part of the series.

The section continues from the top of the plateau at about 600 m down the north side of the plateau. Below the usual mussel-fragment-bearing beds there followed, from 447—to 443 m, a small exposure of clayey sediments with numerous concretions containing a fauna of fishes and invertebrates similar to that known from fish localities 1 and 2 and from the Mt. Brinkley Plateau. This zone was found at an altitude corresponding precisely to that of the beds immediately superjacent to the hard, yellow sandstone on the south side of the central part of

Söderbergh Plateau, and here, too, it is underlain, as might be expected, by hard, yellow sandstones with subordinate conglomeratic beds. The thickness of this sandstone is only about 37 m. It is underlain by clayey, greyish sand beds with occasional grey unfossiliferous sandstone bands, underlain at 371 m by *Martinia* limestone.

The Triassic deposits on Malmqvist Plateau, which, as will appear from the map (pl. 1), is only a portion of Söderbergh Plateau separated from the remaining part of the plateau by a fault, are but slightly distributed horizontally. The beds are much covered with débris, but judging from loose blocks we have here a series corresponding entirely to that of Söderbergh Plateau, even though no fossils were collected from the *Otoceras* beds.

All the larger faults of the Hird Bay area are indicated on the map (pl. 1), which in this respect is a combination of BACKLUND's (1932, pl. I) and KOCH's (1931, pl. IV.) maps with some few additions and alterations in places where the earlier maps were not quite correct. During my work in the field I was unable to verify the existence of faults 1 and 2.

The Vertebrate Zones.

The Permian and Eotriassic deposits at Godthaab Gulf and Gael Hamkes Bay are of particularly great interest on account of their abundance of well preserved fishes and also, as regards the Eotriassic deposits, by their contents of stegocephalian remains.

The vertebrate remains are not uniformly distributed in the immense sedimentary series, but are mostly restricted to fairly thin zones occurring in certain relations to the invertebrate zones that form the basis for the zonal division of the deposits. From the above description of the stratigraphy of the Hird Bay and the Cape Stosch areas the place of the various vertebrate zones in the sequence of strata will be evident.

On the basis of the extremely beautifully preserved and very important material that has been brought back I shall give below, to facilitate the work for future investigators, a summary of the most important exposures of the vertebrate-bearing zones, and at the same time state what is known at present of the vertebrate faunas of the individual zones. As the bulk of the fish material has not yet been worked up, the information about the fish faunas is of course not by far exhaustive, but, as will be shown below, we are able to state that the Eotriassic vertebrate faunas change their composition from zone to zone throughout the whole series of strata.

Before describing the individual vertebrate localities, I shall briefly mention the possibilities for obtaining further material from the localities visited by me. These remarks especially apply to the vertebrate zones of

the Eotriassic beds. The vertebrate remains in these beds occur, as a rule, in concretions (more rarely in sandstone or limestone bands). In a locality in which a concretionary vertebrate zone is exposed, a larger or smaller number of concretions can be seen lying loose on the surface of the slope. Sometimes the concretions are whole, sometimes they have been split up by the frost into a greater or smaller number of fragments (see p. 37), and only exceptionally the concretions are found in their original place in the loose sediments. Most of the localities visited by me were investigated so thoroughly that nearly all the concretions, or fragments of such, lying loose on the surface were examined. It will be expressly stated in the following in which places there are still possibilities for collecting vertebrates from the concretions lying loose on the surface. Additional collections can only be secured in two ways, either by blasting or by digging where conditions render it possible (if either of these modes of procedure may be of any use, it will be stated under the mention of the particular locality), or by postponing further collection until new concretions have been weathered out. However, the latter process is extremely slow, since in the well exposed localities, where the solifluction hardly plays a role of any importance (see p. 26), the surface of the ground as a rule remains quite unchanged from year to year. In several cases tracks of musk-ox or man have been observed to have remained unaltered for one or two years in the clayey sediments. Thus it seems most probable that several years will elapse before so many concretions have been loosened as to make new collecting worth while.

The Permian.

A small number of fish remains are known from loose blocks from the Hird Bay area, probably originating from a fish zone in the *Posidonomya* shale (see p. 87). Some few fish remains have also been collected from the *Martinia* limestone within the same area, and occasional specimens from the *Productus* limestone of Spath Plateau, but by far the greater number of the Permian fish remains have been yielded by the fish zone of the *Posidonomya* shale on Spath Plateau (regarding the structure of the fish zone, see p. 18). The vertebrate material from the latter fish zone collected by the expeditions prior to 1931, in addition to occasional indeterminable Palaeoniscid remains, consisted of elasmobranchs (EIGIL NIELSEN 1932). The following elasmobranchs were found in this material: *Fadenia crenulata*, *Agassizodus groenlandicus*, *Copodus* (?) sp., and an indeterminable fin-spine.

The material collected before 1931 included some blocks which according to our present knowledge of the structure of the Permian can be determined as originating from the *Productus* limestone of Spath

Plateau. They contained the following forms (EIGIL NIELSEN 1932): *Janassa kochi*, *Arctacanthus uncinatus*, and *Cladodus* sp.

Som few elasmobranch remains were also found in the material collected by the expeditions prior to 1931 from the *Martinia* limestone of the Hird Bay area, viz. *Arctacanthus uncinatus* and (according to verbal information by ROSENKRANTZ) teeth of *Fadenia*.

The renewed investigation of the Permian in the Hird Bay area and on Spath Plateau in 1932—33 showed that the fish zone of the *Posido-*

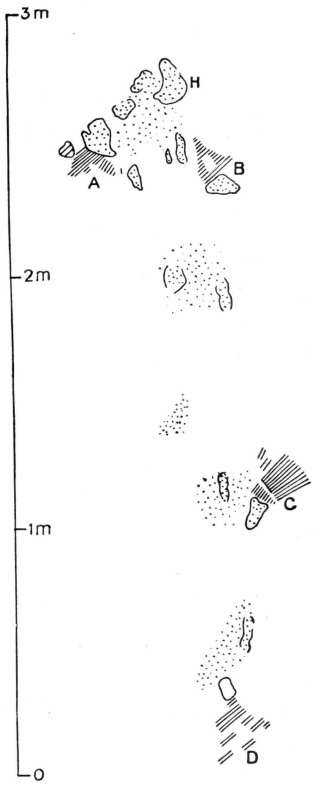


Fig. 34. Remains of *Fadenia* in the fish zone of the *Posidonomya* shale near River 14. A, B, C, D = fin remains; H = teeth and scleral cartilage; other dotted areas = indeterminable cartilage remains.

nomya shale on Spath Plateau in addition to elasmobranchs, among which were several new forms, contained a considerable number of partially very big palaeoniscids.

By a preliminary examination of the elasmobranchs from the fish zone the following forms were found: *Fadenia crenulata*, *Agassizodus groenlandicus*, *Cladodus* sp., and an *Edestus*-like symphysial row of teeth. In addition to teeth, numerous fragments of the cranium and the calcified skeleton of the body not only of these but possibly also of other

elasmobranchs were found; from the fin-remains alone it appears that some of the forms have been very big (fig. 34). Dr. ALDINGER, who is at present working out the palaeoniscids from the same zone, has kindly supplied me with the following fauna list:

Elonichthys punctatus n. sp.
Pygopterus nielseni n. sp.
Pygopterus minor n. sp.
Palaeniscus groenlandicus n. sp.
Palaeoniscus pusillus n. sp.
Acropholis stensiøi n. gen. n. sp.
Plegmolepis kochi n. gen. n. sp.
Boreolepis jenseni n. gen. n. sp.
Platysomus sp.

The fish zone was investigated whereever exposed on Spath Plateau, but as the fishes are mostly very little conspicuous in the dark limestone, some specimens may possibly have been overlooked, so renewed investigations would hardly be quite in vain.

In addition to collecting from loose blocks of the limestone bands and loose concretions, occasional cross-sections of fishes may be discovered when walking along the limestone bands in situ. Often it is extremely difficult to secure such fishes, as the thick limestone bands do not generally split along the planes where the fishes occur. The very few exposures from which the fish material was derived forms but a slight part of the mostly very poorly exposed fish zone.

The classical locality is situated immediately west of River 8 (KOCH's River 7, see p. 8) (KOCH 1931, p. 25). Further collections here will hardly be rewarded with any fossils. The fish zone is also fairly well exposed between Rivers 13 and 14, but here, too, there is but a slight possibility for securing further material. The exposures that have yielded most fossils are situated near the two faults at River 14; by digging in the localities represented in figs. 10 and 12 it may be possible to secure further finds. Another good exposure extends from about 100 m west of Wordie Creek to the corner of the Carboniferous conglomerate west of the valley of Blue River. Some further material may possibly be collected here from the fixed limestone band in the fish zone, however, the area is very difficult to investigate, since the upper edge of the nearly 80 m high, almost perpendicular wall of the Carboniferous conglomerate occurs some few metres below the friable *Posidonomya* shale.

From the area round Hird Bay occasional teeth of *Fadenia crenulata* and *Agassizodus groenlandicus* have been collected during the recent investigations, from blocks probably originating from the fish zone of

the *Posidonomya* shale as well as from the *Martinia* limestone, and from the *Martinia* limestone further teeth of *Arctacanthus uncinatus* and the *Campodus*-like tooth mentioned in p. 88. The fish remains of this area are so scattered, and the exposures so poor that only quite occasional finds may be made here.

The *Martinia* limestone on Spath Plateau contains no fish remains, and the forms from the *Productus* limestone recorded under the mention of the older material are of such rare occurrence that a systematical collecting here will not be worth while.

The Trias.

As will appear from the stratigraphical description of the Cape Stosch area, no less than six vertebrate zones are known from the Eotriassic deposits, viz. fish zones 1—5 and the stegocephalian zone. Of these zones only fish zone 2 is known also from the Hird Bay area. As the petrographical character of the zones and their place within the Trias have already been described, I shall confine myself to mentioning their faunas in so far as they are known, and the exposures that have yielded vertebrate fossils and may possibly yield such fossils in the future.

The material forming the basis of Stensiö's work on the Triassic fishes of Greenland (Stensiö 1932) was collected by the Danish expeditions prior to 1932. With the exception of some few indeterminable fish fragments from the *Proptychites* beds (Koch 1931, p. 51), the material was derived solely from fish zones 1 and 2 on Spath Plateau and from the fish zone (corresponding to the lower portion of fish zone 2 on Spath Plateau) in the Hird Bay area. It comprised the following forms:

I. An exposure of fish zone 1 at River 1.
   Fin-spines of the *Nemacanthus* type.
   Indeterminable Selachian fin-spines.
   Laugia ? n. sp. ?
II. The fish zone of the Hird Bay area.
   Polyacrodus claveringensis.
   Birgeria.
   Glaucolepis arctica.
   Boreosomus ? sp.
   Australosomus kochi.
   Bobasatrania groenlandica.
   Laugia groenlandica.
III. Fish zone 2 of Spath Plateau.
   Birgeria groenlandica.

Glaucolepis arctica.
Australosomus kochi.
Bobasatrania groenlandica.
Laugia groenlandica.
Perleidus stoschiensis.
Ospia whitei.
Broughia perleididoides.
Helmolepis gracilis.

The very large material of Eotriassic vertebrates from East Greenland that has been collected since STENSIÖ's investigations, not only comprises a considerable number of new forms from fish zones 1 and 2, but also numerous new forms from new-discovered vertebrate zones within the Triassic deposits. As, however, the material has not yet been worked out, we can at present only give very sparse information on the faunas of the newly discovered zones.

Fish zone 1.

In addition to elasmobranch fin-spines, which form the most conspicuous element of the fish fauna, this zone contains isolated bones and scales of ganoids; a single bone is identifiable as a teeth-bearing bone of *Bobasatrania*. The fish remains occur partly in limestone bands, partly in concretions (p. 29). Fish zone 1 is only known from two localities, Ekstraelv and River 1. There is hardly any possibility of securing further material from Ekstraelv, whereas such may doubtless be collected from loose blocks in the river-bed of River 1, however, on account of the fragmentary condition of the fish remains, and on account of the uniformity of the fauna, such a material will hardly bring to light essential new facts.

Fish zone 2.

Of all the vertebrate zones fish zone 2 has yielded by far the greater number of fishes. The greater part of the small material treated by STENSIÖ was derived from this zone, and several new forms have since then been collected from it. The fishes occur in concretions (see p. 27), which are mostly much larger than in any of the overlying vertebrate zones. These concretions are less resistant to erosion than those of fish zones 3, 4, and 5, for which reason a smaller percentage of fishes from this than from the higher-lying zones are suitable for anatomical studies.

By far the commonest form of fish zone 2 is *Bobasatrania*, which occurs in all sizes, the specimens varying in length from less than 2 cm to more than 40 cm. The next-commonest form is *Laugia*, and No. 3 is *Australosomus*. Very common are further *Perleidus* and *Birgeria*

(big specimens are rare). Of forms from this zone not previously found in East Greenland may be mentioned *Saurichthys* (very rare), an Edestid (one single symphysial row of teeth), and several big Coelacanthids belonging to other genera than *Laugia*. In addition a large number of new ganoids. A unique find from this zone is the beautiful cranium of *Lyrocephalus kochi* SÄVE-SÖDERBERGH (SÄVE-SÖDERBERGH 1934), after which Stegocephalryggen has been named.

The exposures of the lower portion of fish zone 2 within the Hird Bay area are small and much covered by débris. There is but very little prospect of finding new exposures within this area, and several years will have to elapse before it will be worth while to visit the old exposures. The material from the Hird Bay area has been collected from the following exposures: fish localities 1 and 2 on the southern part of Söderbergh Plateau (see p. 90), a locality on Mt. Brinkley Plateau southwest of the basalt top (see p. 90), and a locality in the northernmost part of Söderbergh Plateau (see p. 94).

The western part of Spath Plateau exhibits only one fairly well exposed locality of fish zone 2, viz. KOCH's classical locality at River 3 (KOCH 1931, p. 32). I never visited this locality, which has been thoroughly investigated by KOCH.

On the north side of Spath Plateau there are a large number of exposures of this zone, which, like all the exposures on the north side of the plateau, occur on the west slopes or the crests of the ridges that have in the course of time been formed by the numerous rivers. The fact that the east slopes are always covered by débris, I have attempted to explain in p. 26.

A couple of small exposures of fish zone 2 occur on Vestplateauet (see p. 38); for the time being there is no prospect of obtaining further material from them. The fish zone has not been investigated on the small ridge between Vestplateauet and Blokken; some material may be secured here.

The exposures of fish zone 2 on the west sides of Stegocephalryggen and Fiskeplateauet together have yielded considerably more than a hundred fishes; however, both these localities have been investigated so carefully that a visit will not be worth while until erosion has laid bare new concretions. In the locality on Stegocephalryggen blasting may possibly be successfully employed.

The next exposure of any importance is situated in Rævekløft (see p. 39). It has yielded several fishes, but is at present entirely exhausted. A less important exposure occurs in the valley of River 11 (see p. 45), but further material cannot be expected from this locality either. The three best localities known from fish zone 2, viz. Østlokaliteten, Midtlokaliteten, and Vestlokaliteten (see p. 44, fig. 19,

and pl. 1) in Neviatiakdal have yielded together at least 500 fishes. Although I was at work in these localities for several weeks, I dare not deny the possibility of collecting a small number of fishes by a zealous search. Midtlokaliteten is so excellently exposed that a digging for concretions may be established. Smalleryg exhibits an excellent exposure of fish zone 2, which is here penetrated by a basalt dyke (see p. 44). A large number of fishes have been brought home from this locality, which at present must be considered as exhausted. Digging or blasting may possibly prove worth while. Another, now emptied, locality is found in the east wall of River 14 (see p. 42), and a third, nearly emptied locality immediately east of Wordie Creek (see p. 39). From the two latter localities a fairly large number of fishes have been brought home. An excellent locality of fish zone 2 is found in Otocerasdal (see p. 41). It has yielded many fishes, but is now entirely emptied. Smaller exposures of fish zone 2 are found west of Blue River between Otocerasdal and Blokdal, further south of Blokdal, at Rødedal east of Blue River, and between Rødedal and Gaffeldal. Only a small number of fishes have been brought home from these small exposures, and further collecting here will hardly be worth while.

An excellent exposure of fish zone 2 occurs east of Blue River, between Gaffeldal and Stribedal (see p. 41, fig. 17). It has yielded several fishes, a fairly large number of which were found in concretions in situ in the clay beds, which are exposed in a very small ravine cutting across the locality. Digging in the south wall of this ravine may possibly bring to light new concretions.

Fish zone 3.

In fish zone 3 the vertebrates occur in small, compact concretions and are, as a rule, very well preserved. On account of the small size of the concretions, they often only contain fragments of fishes, either the cranium (with a larger or smaller part of the body) or the hindmost part of the body including the caudal-fin. In rare cases a larger or smaller part of the body, lacking head as well as caudal-fin, is preserved. In nearly all cases it is possible from the form of the concretions alone to decide whether they contain entire fishes, heads, or caudal regions.

The commonest fish of this zone is *Australosomus*, the remains of which often lie very much disturbed in the small concretions. Small specimens of *Bobasatrania* occur now and then in addition to several other ganoids; fairly common is a big palaeoniscid, of which, as a rule, only the head and the front part of the body are preserved. Further at least two genera of coelacanthids are represented, one of which may be *Laugia*. Some few stegocephalian remains (SÄVE-SÖDERBERGH, 1934) have also been collected from this zone, i. a.

An indeterminable *Lyrocephaline* ? and remains of a vertebrate column, ribs, etc.

The possibility of dividing fish zone 3 into two subzones, one situated in the lower *Vishnuites* zone and the other in the middle *Vishnuites* zone, has been discussed above, and shall not therefore be treated here. All the exposures of fish zone 3 are small, and they have been so carefully investigated that they will hardly yield any material for the next few years.

The westernmost exposure of the zone, which is fairly much obscured by débris, occurs immediately east of Rævekløft. An excellent exposure was encountered a short distance east of River 10 and occasional finds were also made in the valley of River 11. The best exposures are situated in the area round Neviatiakdal (the possible zone 3b, see, p. 52), where one locality was found above Østlokaliteten (p. 44), another above Midt- and Vestlokaliteten (p. 44), and a third in the western valley side. A very small exposure was found on Smalleryg. The easternmost exposures of the zone occur near River 14, partly on Kilen (p. 49) partly in the eastern bank of the eastern branch of River 14 (p. 51).

An interesting find was made on Stensiö Plateau at a somewhat greater altitude than the most richly fossiliferous zone of the middle *Vishnuites* beds (p. 54), viz. a cranium of *Lyrocephalus johansoni* SÄVE-SÖDERBERGH (SÄVE-SÖDERBERGH 1934), the locality of which, however, cannot be located in any of the known vertebrate zones.

Fish zone 4.

The vertebrate remains from this zone, which are mostly well preserved, occur in fairly small, often irregularly formed, concretions or in calcareous sandstone bands with an irregular surface.

At present but very little can be said about the composition of the fauna. Most noteworthy is the absence of *Bobasatrania* and, as far as known, also *Australosomus*. The ganoids dominate, while the coelacanthids are sparse. A single find proves the presence of stegocephalians in this zone (SÄVE-SÖDERBERGH 1934). Fish zone 4 is only known from the easternmost part of Spath Plateau, and the comparatively small exposures have, as a rule, been carefully investigated. The westernmost exposure known is from Neviatiakdal (p. 56), but it has been so carefully investigated that for the time being further investigations will hardly be rewarded with any fossils. The same applies to the small exposure on Kilen (p. 52). The greater part of the material collected is derived from the area between River 14 and Wordie Creek; a careful

investigation of this stretch may possibly bring to light some further material. The easternmost exposure of the zone is situated in the south wall of Otocerasdal; from this locality, too, some further vertebrate remains may be collected.

Fish zone 5.

The zone that has yielded the largest number of vertebrates next to fish zone 2 is fish zone 5. The fossils generally occur in concretions, which are fairly small but contain very beautifully preserved fossils. As in the preceding zone *Bobasatrania* is absent, and if not absent, *Australosomus* is at any rate very rare. Forms like *Perleidus*, *Ospia*, *Broughia*, etc., are very common and also various coelacanthid genera are fairly frequently met with, even though *Laugia* as far as known is entirely absent. *Saurichthys* and *Birgeria* occur, but rarely, as well as a considerable number of new forms, about which nothing can be said as yet. A larger number of stegocephalian remains have been collected from this zone than from any of the underlying vertebrate zones (SÄVE-SÖDERBERGH 1934).

Lyrocephalus rapax SÄVE-SÖDERBERGH (loose on the surface of the lower *Proptychites* beds).
Lyrocephalus sp. and other Lyrocephalinae? from the *Proptychites rosenkrantzi* zone.

With the exception of a small stretch (see below), fish zone 5 has been so thoroughly investigated throughout that no material of importance may be collected in the nearest future. Most likely neither blasting nor digging will be worth while, since the concretions to all appearance are of sparse occurrence in the thick clay beds.

Fish zone 5 is generally fairly well exposed on Vestplateauet (p. 59), on Blokken, and on the small ridge connecting the two. A small number of fishes were collected from these localities. Stegocephalryggen (p. 58) exhibits a small, but beautiful exposure of the zone, which has yielded several fishes. On Borgen and Pyramiden the zone is fairly well exposed (p. 59), and these exposures have yielded a considerable number of vertebrates. Several fishes were further collected in the area between Rivers 9 and 10. From an exposure near Neviatiakdal (p. 59) some few fishes were collected, and a single specimen was obtained from an exposure on Kilen. Between River 14 and Otocerasdal (p. 59) the zone is extremely well exposed in several places, and although a great deal of well preserved fishes were collected along this stretch, there may be a possibility for collecting more material from this area. Some few fishes were collected from minor exposures in the area of Blue River,

but the exposures were so small, and fish zone 5 otherwise so highly covered with débris, that further investigations will serve no purpose. Fish zone 5, however, is extremely beautifully exposed on the ridges numbered 1 to 12 on the north side of Stensiö Plateau (p. 60, and the map pl. 1). The bulk of the material from fish zone 5 is derived from these twelve small ridges, which were very carefully investigated, so for a number of years hardly any material can be collected from them. The easternmost exposure of the zone was met with in the area of Mt. Diener, extending some few hundred metres eastward from Red River (pp. 70 and 71). It was much obscured by débris, and has yielded but few fishes.

The Stegocephalian zone.

The Stegocephalian zone is the uppermost of the six known vertebrate zones. The fossils occur in calcareous, sandy bands (p. 65), and chiefly comprise stegocephalians, of which a fairly large number of cranial fragments were brought home. According to SÄVE-SÖDERBERGH (1934) the fauna comprises the following forms:

Wetlugasaurus groenlandicus SÄVE-SÖDERBERGH.
Stoschiosaurus nielseni SÄVE-SÖDERBERGH.
Stoschiosauras nielseni ?
Stoschiosaurus n. sp. ?
Lyrocephaline ? and several remains of Trematosaurinae?

In addition to stegocephalians the zone contains some few fish remains. The only thing that can be stated after a preliminary examination of the material is that the fish fauna includes at least two ganoid types and a single coelacanthid.

Only on the north side of Stensiö Plateau were vertebrates found in the stegocephalian zone, which is more or less exposed on all the ridges occurring between the northwestern corner of the plateau and the eastern area of the north side of the plateau, which is strewn with basalt blocks (pl. 1).

Nearly all the vertebrate remains are derived from the exposure on ridge 8—9 (see pl. 1). Som few specimens were collected on the ridge west of ridge 8—9 and on ridge 3. The whole zone has been very carefully investigated, so the possibilites for securing further material from it are but small. The only possibility may be digging in the best locality, ridge 8—9.

Remarks on the Vertebrate Faunas.

A. Permian.

Immediately after the publication of my work on the Permian (Permo-Carboniferous) fish material collected prior to 1931 (E. NIELSEN 1932), the "Fish Fauna of the Middle Phosphoria Formation" by C. C. BRANSON (1933) came out. In this paper BRANSON described a new genus, *Dolophonodus*, which presented no essentially different characters from those of the East Greenland genus *Arctacanthus* E. NIELSEN. In a later paper (1934) BRANSON therefore, since *Dolophonodus* must be regarded as a synonym of the genus *Arctacanthus* erected some few months previously, referred the Wyoming species to the East Greenland genus. Curiously enough both species had been described under the specific name *uncinatus*, for which reason BRANSON changed the name of the Wyoming species to *Arctacanthus wyomingensis* BRANSON. The occurrence of this interesting species in two localities so widely apart makes BRANSON embark upon a closer comparison between the fish faunas of the middle portion of the Phosphoria formation and that of the Lower Permian of East Greenland (BRANSON 1934). From BRANSON's fauna lists the unmistakable similarity between the elasmobranch faunas is evident, which is further confirmed by the large collections from East Greenland of recent years.

Phosphoria.	*East Greenland.*
Arctacanthus wyomingensis	*Arctacanthus uncinatus.*
Janassa unguicula.	*Janassa Kochi.*
Agassizodus variabilis.	*Agassizodus groenlandicus.*
Cladodus occidentalis.	*Cladodus* sp.
Hamatus phosphoriensis	*Fadenia crenulata.*
Ancistriodus serratus.	(Ganoids, see p. 98).
Placoid scales	Placoid scales
Ctenacanthus mutabilis.	Indeterminable fin-spine.
C. browni.	*Edestus* (?) sp.
Edestus (?) sp.	and other forms.

C. C. BRANSON is no doubt right when he states that the similarity between the two faunas and the occurrence of *Arctacanthus* indicate a close correlation of the Wyoming and the East Greenland beds in question.

B. Triassic.

Even if the slight number of stegocephalian remains found renders it impossible to draw definite conclusions as to the distribution of the

individual forms, it seems (SÄVE-SØDERBERGH 1934, p. 194) as if the stegocephalian fauna changes its character from the lower vertebrate zones to the upper. *Lyrocephalus*, which has been found in the *Otoceras*, *Vishnuites*, and *Proptychites* beds, plays a very subordinate part in the uppermost vertebrate zone (only a single doubtful Lyrocephaline fragment being known (SÄVE-SÖDERBERGH 1934, p. 195 and 196)) whereas *Wetlugasaurus* and *Stoschiosaurus* have only been found in the uppermost vertebrate zone.

To all appearance the composition of the fish faunas also changes from zone to zone, but since at present the bulk of the material brought home has not yet been determined, only some of the most conspicuous points of difference between the vertebrate zones will be mentioned. Already KOCH (1931, p. 89) was aware that fish zones 1 and 2 contained different fish faunas (p. 100), zone 1 containing fin-spines of selachians which were not found in fish zone 2, while the latter zone merely contained forms which did not appear in fish zone 1. As mentioned in p. 100, I succeeded in ascertaining the presence of *Bobasatrania* among the sparse ganoid remains from fish zone 1, but apart from this no genus common to the two zones is known. Of selachians, *Polyacrodus claveringensis* is known from fish zone 2 (both from the Hird Bay area and from Spath Plateau) and an *Edestus*-like symphysial row of teeth (from Neviatiakdal). Selachians are not known from any of the higher-lying vertebrate zones. As mentioned above, *Bobasatrania* is known from fish zone 3, in addition to fish zones 1 and 2, but not from fish zones 4 and 5 or from the stegocephalian zone. Whether it is represented by various species in the three lowermost fish zones, is unknown. *Australosomus* and *Laugia*, which are of frequent occurrence in fish zones 2 and 3, are absent or very rare in the higher-lying zones. *Birgeria* is known from fish zone 2, but is absent or very rare in the remaining vertebrate zones. *Saurichthys* has only been found in fish zones 2 and 5. These examples of the distribution of some of the most easily recognisable forms is all what can be said at present about the differences between the vertebrate zones. However, when the large material brought home has been worked up, each of the six vertebrate zones may probably prove to have its own peculiar fauna.

STENSIÖ has called attention to the close relationship existing between the Eotriassic fish fauna of East Greenland and the Triassic faunas of Madagascar and Spitsbergen. From our present incomplete knowledge of the new material collected from East Greenland the close relation of the East Greenland fish fauna to that of Spitsbergen is still more evident, *Saurichthys* and big Coelacanthids of similar types to those known from Spitsbergen having now been found in East Green-

land. As regards the variety of forms, the Eotriassic fish faunas of East Greenland seem to surpass those of both Spitsbergen and Madagascar.

According to SÄVE-SÖDERBERGH (1934, p. 196), the stegocephalian fauna from the Eotriassic of East Greenland shows closest affinity to the faunas of Spitsbergen and Northern Russia.

Summary.

1) Lower Permian deposits occur on Spath Plateau and in the Hird Bay area. On Spath Plateau the sequence of strata is as follows: at the base dolomite and limestone with gypsiferous bands of varying thickness. Above follows *Posidonomya* shale with a fish zone in its upper portion. It is succeeded by *Martinia* limestone interstratified by a band of *Productus* limestone. At Hird Bay the sequence is as follows: At the base dolomite, limestone, and gypsum, as on Spath Plateau, overlain by *Posidonomya* shales, which possibly contain a fish zone. The upper part of the *Posidonomya* shales alternate with the lowermost part of the *Martinia* limestone. Above follows an immense zone of *Martinia* limestone, in the upper part of which Artinsk ammonites are found.

2) In both areas the Permian is overlain by Eotriassic sandstone. (The occurrence of Permian sandstone below the Eotriassic beds at Rivers 1 and 2 is very doubtful.)

3) The Eotriassic deposits along the south coast of Godthaab Gulf and Gael Hamkes Bay can be divided into five divisions according to their fossil contents, and several of these may be further subdivided.

4) Six vertebrate zones have been ascertained within the Eotriassic series, all of them containing fish remains, and the five upper zones also stegocephalian remains. Probably the composition of the fish faunas varies from zone to zone. Judging from the rather sparse material of stegocephalians the same seems to be the case with the stegocephalians, whose frequency in proportion to that of the fishes increases upwards from zone to zone.

5) In the western part of Spath Plateau a number of unfossiliferous conglomerate zones occur in the Eotriassic series, which decrease in thickness towards the east, and also some hard sandstone zones are found. On the whole the rule is valid that the older the conglomerate is, the greater is its distribution to the east.

6) Another system of conglomerates occurs in the eastern part of Spath Plateau.

7) The Eotriassic deposits of the Hird Bay area correspond to parts of the complete series of the Cape Stosch area. Thus the conglomerates at Hird Bay correspond to the lower conglomerates at Cape Stosch. Only a single vertebrate zone is known from Hird Bay, which corresponds to the lower portion of the next-lowest vertebrate zone on Spath Plateau.

8) A very considerable vertebrate material was collected from the areas investigated, and a detailed map has been worked out of the north sides of Stensiö Plateau and Spath Plateau, where the largest number and the most yielding vertebrate localities were found.

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Færdig fra Trykkeriet den 22. Februar 1935.

GEOLOGICAL SKETCH MAP OF THE COAST EAST OF C. STOSCH

EAST-GREENLAND

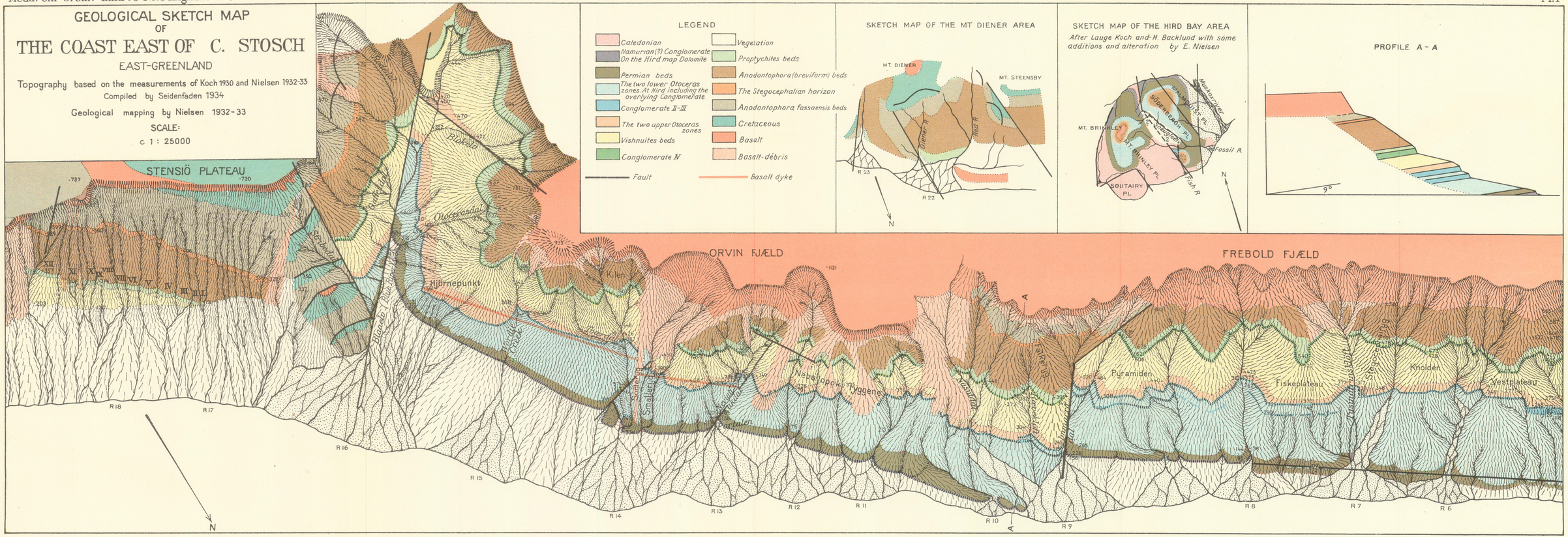
Topography based on the measurements of Koch 1930 and Nielsen 1932-33

Compiled by Seidenfaden 1934

Geological mapping by Nielsen 1932-33

SCALE:

c. 1 : 25000



LEGEND

- Caledonian
- Namurian(?) Conglomerate On the Hird map Dolomite
- Permian beds
- The two lower Otoceras zones. At Hird including the overlying Conglomerate
- Conglomerate II-III
- The two upper Otoceras zones
- Vishnuites beds
- Conglomerate N
- Vegetation
- Proptychites beds
- Anodontophora (breviform) beds
- The Stegocephalian horizon
- Anodontophora fassaensis beds
- Cretaceous
- Basalt
- Basalt-débris
- Fault
- Basalt dyke

SKETCH MAP OF THE MT DIENER AREA

SKETCH MAP OF THE HIRD BAY AREA

After Lauge Koch and H. Backlund with some additions and alteration by E. Nielsen

PROFILE A - A

Reproduceret ved Geodætisk Institut. København 1935.