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KOMMISSIONEN FOR VIDENSKABELIGE UNDERSØGELSER I GRØNLAND

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THE INVERTEBRATE FAUNAS OF THE  
BATHONIAN-CALLOVIAN DEPOSITS OF  
JAMESON LAND (EAST GREENLAND)

BY

L. F. SPATH

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WITH 26 PLATES AND 14 TEXT-FIGURES

KØBENHAVN

C. A. REITZELS FORLAG

BIANCO LUNOS BOGTRYKKERI A/S

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## A. INTRODUCTION

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The great majority of the fossils described in the following pages were collected by Mr. A. Rosenkrantz and (on Cathedral Mtn. only) by Dr. T. M. Harris, as members of the Danish State Expedition to East Greenland in 1926—27, under the leadership of Dr. Lauge Koch. These fossils came from the shores of Hurry Inlet and the adjoining parts of Jameson Land, as mentioned in the detailed discussion of the localities in a later chapter (C, pp. 124 to 137), and Mr. Rosenkrantz has already given a short account of his work and of the fossils collected in Dr. Koch's *Geology of East Greenland*<sup>1</sup>). I have also before me a small suite of fossils from Antarctic Harbour in Davy Sound, farther north, collected by Mr. J. M. Wordie's Cambridge Expedition of 1929. These specimens were first submitted to me after the return of the latter expedition in 1929, and were briefly mentioned in a paper by Mr. Parkinson and Dr. Whittard<sup>2</sup>); but they were then forwarded to Mr. Rosenkrantz, partly because he had much larger Jurassic collections and had already begun work on them, and partly because I myself was to describe the Triassic material from East Greenland<sup>3</sup>). Recently, however, with the ready consent of Mr. Rosenkrantz, the description of the "Callovian" material has been entrusted to me and I gratefully acknowledge my indebtedness to all the gentlemen mentioned for enabling me to work out these very interesting collections.

On first seeing the ammonites in this collection, I was glad to realise their importance as representatives of the Arctic Bathonian, hitherto unrecognised; but misgivings soon followed when I saw that my reading of the affinities and stratigraphical succession of the faunas was in direct contradiction to the results published by Mr. Rosenkrantz. For not

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<sup>1</sup>) *Meddelelser om Grønland*. Vol. LXXIII, 1929, pp. 145—47.

<sup>2</sup>) *The Geological Work of the Cambridge Expedition to East Greenland in 1929*. *Quart. Journ. Geol. Soc.* Vol. LXXXVIII, p. 653.

<sup>3</sup>) *The Eotriassic Invertebrate Fauna of East Greenland*. *Meddelelser om Grønland*. Vol. LXXXIII, 1930, pp. 1—90, pls. I—XII.

## B. SPECIFIC DESCRIPTIONS

### I. *Phylum Mollusca.*

#### a. Class *Cephalopoda.*

##### 1. Order *Ammonoidea.*

##### Family *Macrocephalitidae*, Buckman 1922 emend.

The East Greenland species of this family belong mostly to the two groups of *Arctocephalites arcticus* and *A. pompeckji*, briefly discussed when the various genera of *Macrocephalitidae* were reviewed in 1928<sup>1</sup>), but now separated as independent groups. The further evidence, since come to light, makes it possible to give a more precise definition of these Arctic stocks for, although recognised as distinct, they were not at that time either accurately dated or else sufficiently well known for detailed comparison with other *Macrocephalitids*. They can now for the first time be more clearly differentiated from their allies in the European province and the region of the Tethys. A detailed description of these two principal genera represented from East Greenland is given below; here it is intended merely to discuss the bearing of the new discoveries on the classification of the family *Macrocephalitidae* as well as of the ancestral *Stephanoceratids*.

The evidence, of course, is not nearly complete enough to permit of a final genealogy, but the continuity from *Sphaeroceras*, in the wider sense (with *Emileia*) to *Macrocephalites*, previously accepted, seems to be confirmed. Since, however, such *Stephanoceratid* groups as *Tulites*, Buckman (including '*Tulophorites*' and '*Madarites*', Buckman) and *Rugiferites*, Buckman (including '*Pleurophorites*' and '*Sphaeromorphites*', Buckman) are closely connected not only with the contemporary Lower Bathonian *Sphaeroceratids*, but also with the *Macrocephalitids*, and the *Cadoceratids*, it would be absurd to select any one species of *Sphaeroceras* (or any other genus) as the root-form of all *Macrocephalitids*. The trans-

<sup>1</sup>) "Revision of the Jurassic Cephalopod Fauna of Kachh (Cutch)". Mem. Geol. Surv. India, Pal. Indica, N. S. vol. IX, Mem. No. 2, pt. 3, pp. 166 et seq.

only would the fauna with '*Macrocephalites pompeckji*' be much earlier than the beds with *Kepplerites tychonis*, instead of later, but the position of the Vardekloft Formation would be above, instead of below, the Fossil Mountain Formation. Some months later, however, and after the description of the Macrocephalitids had been completed, I received, by the kindness of Mr. Rosenkrantz, the manuscript sections on which the text-figures 10—14 on pp. 126—33 are based and I was glad to find that there was an obvious explanation of the difficulty of interpretation, as mentioned below. The faunas being largely new, this confirmation of my reading was doubly acceptable; for the Arctic Macrocephalitids have always been considered to be late, catagenetic forms.

As in the case of the Eotriassic fauna, I have included the descriptions of fossils of other groups, partly because they are not abundant or well preserved enough to be dealt with by specialists, partly because, dissociated from the principal elements of the faunas, the ammonites, detailed descriptions of the other invertebrates, mostly of long ranges, would be of little value and disturb the balance of treatment.

My acknowledgments are again due to the Keeper of the Geology Department of the British Museum (Natural History) for giving me all facilities in connexion with the working out of the collections. Prof. J. P. J. Ravn of the University of Copenhagen has been kind enough to send me the ammonites from localities 1 and 2 on Fossil Mountain, referred to by Madsen, and Dr. F. L. Kitchin of the Geological Survey of England enabled me to examine comparable material in the collections under his charge, while Miss Wood, Mr. L. R. Cox and Mr. T. H. Withers of the British Museum (Nat. Hist.) gave advice on certain invertebrates, as mentioned in the descriptions. To these and to all the other geologists who have helped me I tender my sincere thanks and to Mr. A. Rosenkrantz I am particularly indebted for so generously placing his sections and stratigraphical information at my disposal and for handing the material over to me.

As in previous publications I have attempted to facilitate reference to the plates and figures by differentiating those in the present work with capitals (Plate XVI) as compared with small Roman figures (pl. xvi) when plates in other publications are cited. The letters B.M. and M.P.G. indicate specimens preserved either in the British Museum (Natural History) or in the Museum of Practical Geology, London.



formation of all these Stephanoceratids and Sphaeroceratids from the Bajocian ancestors, through their Lower and Upper Bathonian derivatives, to the later Macrocephalitids and Cadoceratids took place in the 'broad stream of development' by a great variety of different, and significant if often trifling, changes. This is reflected in our complex nomenclature, but the essential unity of the whole group is obvious, whether its members are referred to distinct families or to only four genera.

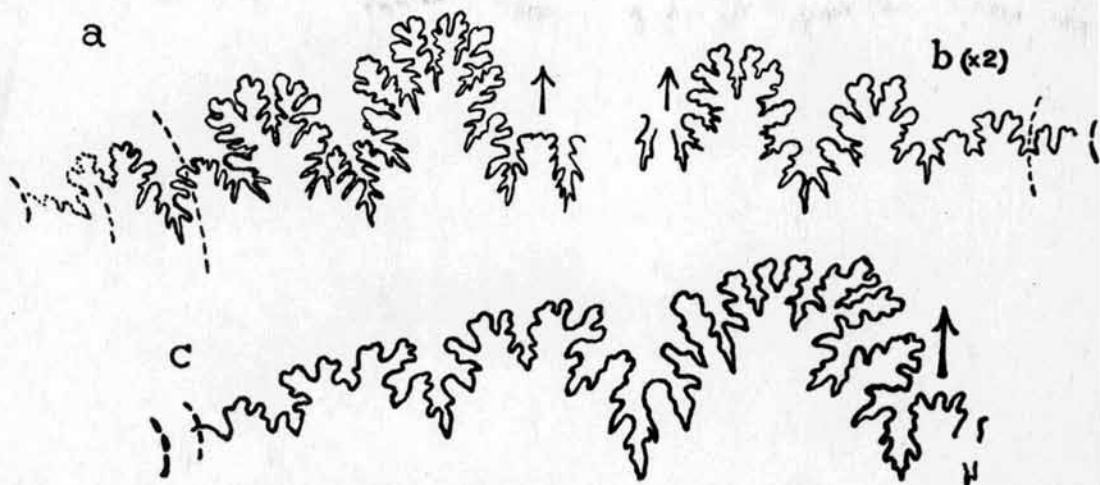
It may be remarked at once that the 'evidence' of recapitulation does not help in the inquiry, but that the time factor is the most important for a natural classification. One form of *Morrisiceras* may have inner whorls, that, if found isolated, would without hesitation be referred to *Cadoceras*; others are so similar to certain forms of *Tulites* that Buckman<sup>1)</sup> included the obviously Macrocephalitic genus *Morrisiceras* in his family Tulitidae. *Tulites cadus* itself is almost a *Cadoceras*, as mentioned below. *Bullatimorphites* (e.g. *B. eszterense*, Boeckh sp.) again are at first indistinguishable from contemporary (early) Macrocephalitids; others (*B. ymir*, Oppel sp.) retain the typical *Sphaeroceras*-characters of the genus. Here again, the nomenclaturist has been ahead of the investigator; and the long-standing differences of interpretation of e.g. such 'series' as that from *Teloceras* and *Tulites* to *Cadoceras*, on the one hand, and from *Sphaeroceras* to *Macrocephalites* on the other, lose much of their meaning if we take the broader view. But in the present state of our knowledge it is clearly preferable to use independent generic names for these groups, overlapping one another in time, and not to link them up into hypothetical 'lineages'. For in my opinion, like the peculiar Arctic Macrocephalitids, the various Bathonian stocks known so far are merely isolated and local off-shoots of the Stephanoceratid root-stock, persisting itself with indifferent and conservative types in the Southern Province and supplying waves of "cryptogenetic" elements, characteristic of more northern seas.

Now as the Tulitids and the Lower Bathonian genera *Morrisiceras* (including '*Morrisites*') and *Bullatimorphites* are important connecting links between the ancestral Stephanoceratidae and the Macrocephalitids in Europe, so *Defonticeras* (including '*Saxitoniceras*', McLearn) seemed to me at first to connect the Arctic groups with the same root-stock. The differences between this genus *Defonticeras* and the Greenland *Cranocephalites*, however, are fundamental. No doubt there will yet be discovered intermediate faunas in Canada that reduce the obvious gap between these genera; for Warren<sup>2)</sup> now records *Defonticeras* definitely

<sup>1)</sup> Type Ammonites, vol. III, 1921, p. 47.

<sup>2)</sup> "A New Pelecypod Fauna from the Fernie Formation, Alberta". Trans. Roy. Soc. Canada (3), vol. xxvi, sect. 4, 1932, p. 3.

together with true *Stephanoceratids*. If not actually Middle Bajocian, *Defonticeras*, thus, is probably not later than Upper Bajocian, although *Stephanoceras* of the *rectelobatum* type range up at least as high as the *subcontractus* zone of the Bathonian. But the resemblance of *Defonticeras* to certain *Bullatimorphites* is striking, e. g. Roemer's<sup>1)</sup> *Sphaeroceras suevicum* or Roman's *Sphaeroceras* sp.<sup>2)</sup>; and Quenstedt's *Amm. bullatus*



Text-fig. 1. External suture-lines of (a) *Tulites modiolaris* (Smith) from the Fuller's Earth Rock (Lower Bathonian) of Laycock, Somerset (M. P. G. No. 28221). (b) *Defonticeras* aff. *ellsii*, McLearn. From the Lower Fernie Shales of Alberta, Canada (B. M. No. C. 35800). (c) *Macrocephalites* aff. *madagascariensis*, Lemoine. From Upper Bathonian bed 22 (*triangularis* subzone) of Jumara, Kachh, India (Raj Nath Colln.).

*latecentratus*<sup>3)</sup> seems to differ from some *Cranocephalites* here figured merely in size.

While this external similarity may be held to be deceptive, the evidence of the suture-lines is still less conclusive. I have seen too many septal edges to attach much value to the comparison of individual lines, but I am now figuring the suture-lines of a typical *Defonticeras* (Text-fig. 1b), a *Tulites* ('*Madarites*', Text-fig. 1a) and of a *Morrisiceras* (Plate IV, fig. 6) for comparison with that of a true *Macrocephalites* (Text-fig. 1c) and the various *Cranocephalites* suture-lines figured in Plates I, III, V. The most obvious difference is in the second lateral lobe, which is narrow and trifid in *Macrocephalites* and wide and irregularly bifid in the earlier groups. I thought this difference of importance,

<sup>1)</sup> "Die Fauna der Aspidoides-Schichten von Lechstedt bei Hildesheim". Inaug. Dissert. Göttingen, 1911, p. 43, pl. VII, figs. 19—20.

<sup>2)</sup> "Céphalopodes du Lias et du Jurassique Moyen etc." in 'Région d'Oudjda', Paléontologie. Protect. Maroc, Notes et Mémoires, 1930, p. 17, pl. VIII, fig. 2.

<sup>3)</sup> "Ammoniten des Schwäbischen Jura", vol. II, 1887, p. 658, pl. LXXVII, fig. 6.

and Schlippe's<sup>1)</sup> figure being diagrammatic and Buckman's photographs not very clear, I examined abundant original material. Of course, it might appear that this difference is merely a result of the differences in coiling, for in *Tulites* ('*Tulophorites*') the leaflet subdividing the second lateral lobe happens to be on the coronate margin<sup>2)</sup>, in *Morrisiceras morrisi*, with small umbilicus, this lobe is well beyond, on the whorl-side, as in *Macrocephalites*. Thus both this genus and *Morrisiceras* (Plate IV, fig. 6) have more trifid lobes. But in *Defonticeras* and *Bullatimorphites*, without umbilical edge, the elements beyond the first lateral saddle are also low and irregular, though a similar arrangement is found again in Callovian forms of *Kheraiceras*. Likewise the degeneration of a suture-line in a scaphitoid branch or in the individual is no criterion for dating the forms. All adult Macrocephalitids simplify their final suture-lines and in the *madagascariensis-cannizzaroii* group, to which the example of text-fig. 1c belongs, the earlier lobes and saddles are long and slender<sup>3)</sup>. Since these forms are of pre-Cornbrash age a similar degeneration in the Arctic species here recorded is thus not necessarily an indication of a late age.

It is probably just the presumed Callovian age of '*Amm. ishmae*' and its reputed allies that has stood in the way of a more general recognition of the importance of this boreal group. But it may be recalled in this connexion that R. Douvillé<sup>4)</sup> stated in 1912 that while there were no older forms to which the Macrocephalitids could be attached yet in the Arctic regions the group of *Amm. ishmae* showed features intermediate between *Macrocephalites* and *Cadoceras*. These he considered to be ancestral characters, and he concluded that the origin of the family Cardioceratidae (in Douvillé's sense) would have to be looked for in the boreal regions. And Douvillé, although a believer in recapitulation and despite the fact that his '*ishmae*-group' resembled *Cadoceras* in the young and *Macrocephalites* in the adult only, thought it tempting to regard this *ishmae*-group as a direct and unmodified descendant of the common Bathonian ancestor of both these genera. This view, of course, is untenable (see p. 52) and it is shown that the earliest East Greenland Macrocephalitids are *Cranocephalites* which have few *Cadoceras* characters. But it is matter for regret that at present it is impossible

<sup>1)</sup> "Die Fauna des Bathonien im Oberrheinischen Tieflande". Abhand. Geol. Spez. Karte v. Els.-Lothr. vol. IV, Heft 4, 1888, p. 197, text-fig. 3.

<sup>2)</sup> See S. Buckman: "Type Ammonites", vol. IV, 1923, pl. CCCLXVIII.

<sup>3)</sup> See Spath, *loc. cit.* (Pal. Indica), 1928, pl. XXIV, fig. 2a; also Boeckh, J.: "Adatok a Mecsekhegység és Dombvidéke etc. II. Pal. Rész." Ertekezések a Természett. Köréből (Budapest), vol. XI, 1881, pl. VII, fig. 2.

<sup>4)</sup> "Etude sur les Cardioceratidés de Dives etc." Mém. Soc. géol. France, Paléont., vol. XIX, fasc. 2, 1912, p. 13.

to link up *Cranocephalites* more definitely with some earlier Arctic ammonite assemblage.

In a paper written in 1921 and revised in 1924, but not published till 1929, Buckman<sup>1)</sup> stated that the feebleness of the ribbing in the Tutilidae was against that family being regarded as the direct ancestor of the Macrocephalitidae. He suggested that a form like *Tulites cadus*, S. Buckman, with ribs much stronger and running straight, not curved, across the venter, might be expected as the ancestral form of the Macrocephalitidae. To me, this suggests a narrowness of outlook, especially since Buckman himself pointed out that the fossil forms so far known could be only a small percentage of those that did exist. But Buckman, of course, assumed that Macrocephalitids only appeared in the Uppermost Bathonian, and that they were separated from the Tutilids by a long time-interval; moreover he accepted as recapitulational 'evidence' the ribbing on the inner whorls of Blake's Upper Cornbrash species which are not at all primitive forms. This applies not only to the straight ribbing of *Dolikephalites typicus* but also to the whorl-shape of *Kamptokephalites terebratus*<sup>2)</sup>, which was said to come very near to the "cadicone coronate" that Buckman's theory postulated. Now in what I consider a primitive type of Macrocephalitid, the ribbing would be as flexiradiate as in Boehm's *Sphaeroceras godohense*<sup>3)</sup>, only a step removed from *Indocephalites diadematus*, Waagen sp., and this type of costation is found also in *Rugiferites* (including '*Pleurophorites*' and '*Sphaeromorphites*', Buckman). Rectiradiate ribbing, in fact, must be rare, if not unknown, even in loosely-coiled ammonites; Waagen's '*rectecostati*' always have curved ribs in the young<sup>4)</sup>, and I have previously directed attention to the difficulty of appraising the "straightness" of the ribbing in the involute Macrocephalitids. To expose the fallacy of the division of these forms into 'flexiradiata' and 'rectiradiata' it is only necessary to squeeze a strip of plasticine all round the whorl of a form like *Macrocephalites macrocephalus* (Blake, pars, cited by Buckman as an example of very straight ribbing), to compare the impression with that of a more 'curvicostate' species, and to note the difference at different sizes.

Now it is important to mention that when Buckman described certain young Canadian examples of *Arctocephalites* (as '*Miccocephalites*' and '*Metacephalites*') he considered them to be not only late forms, but to be related closely to the "*Cadoceras grewingki* series" which he

<sup>1)</sup> "Jurassic Ammonoidea" in "Mesozoic Palaeontology of Blairmore Region, Alberta". Nat. Mus. Canada, Bull. No. 58 (Geol. Ser. no. 50), 1929, p. 7.

<sup>2)</sup> *Loc. cit.* (1905), pl. III, fig. 2b and pl. III, fig. 4 ("*M. macrocephalus*").

<sup>3)</sup> "Beiträge zur Geologie von Niederländisch-Indien. I, pt. 4, Unterer Callovien", Palaeontographica. Suppl. IV, Lief. 3, 1912, p. 151, pl. xxxv, fig. I.

<sup>4)</sup> See Pompeckj, *loc. cit.* (Jurassic Fauna of Cape Flora), 1899, p. 74.

suggested, were not Cadoceratids but Macrocephalitids. Crickmay<sup>1)</sup> disagreed with Buckman and "suspected strongly that the latter had no material from Alaska, but judged only from published illustrations". But he also accepted the 'Proplanulitan' age of the boreal Macrocephalitids and considered them late and catagenetic forms. Knowing their succession in time from the Greenland material here described, it is, of course, easy to criticise Buckman's chronology; but I have on various occasions pointed out that if he constantly found 'biological order' and geological date to be in conflict it must be his methods that were to blame. That is to say, the recapitulational evidence of the inner whorls of ammonites has again and again been proved to be misleading, instead of helpful, and the futility of such tables and graphs as were given by Buckman to illustrate the development of *Cadoceras* and '*Paracephalites*' is too obvious. For in spite of the pseudo-scientific accuracy of the treatment, the genus *Paracephalites*, or rather the two execrably preserved ammonites described by Buckman, remain indeterminable Macrocephalitids.

Crickmay's genera *Lilloettia* and *Buckmaniceras* are scarcely more definite. The former was described as differing from other Macrocephalitids in its early smoothness and narrow umbilicus but *Arctocephalites arcticus* and especially the smooth variety referred to below are very similar. The more inflated *Buckmaniceras*, differing very slightly in suture-line (of a single individual), has an *Arctocephalites* outer whorl, but the greatly depressed earlier volutions are different from those of any Greenland species. The somewhat naive dating of these "genera" as slightly later than most Macrocephalitids and corresponding in age to '*Catacephalites*' (also based on a single, imperfect, individual of a *Cadoceras*) is in the best Buckmanian tradition.

#### Genus *CRANOCEPHALITES*, gen. nov.

Genotype:— *C. vulgaris*, sp. nov., p. 20, pl. I, fig. 4.

As mentioned below (p. 32), this genus is taken to include those *Arctocephalites* in which the body-chamber develops rather coarse and often interrupted ribbing, but does not become smooth. Since there are various transitional forms, e.g. *Arctocephalites ornatus*, with recrudescence of ribbing near the mouth-border, or some varieties of ribbed *Cranocephalites*, with almost smooth body-chambers, separation was prompted chiefly by their difference of horizon, for in the beds with *Arctocephalites nudus*, only 20 metres above the *pompeckji*-horizon, there is not a single

<sup>1)</sup> "Jurassic History of North America: Its Bearing on the Development of Continental Structure". Proc. Amer. Philos. Soc. vol. LXX, No. 1, 1931, p. 41.

<sup>2)</sup> *Loc. cit.* (1929), pp. 18—19.

*Cranocephalites*; and this genus also has not been found in the *arcticus*-beds of Cape Flora. Yet the inner whorls are almost indistinguishable and a formal diagnosis might run:— "Like *Arctocephalites*, but with scaphitoid body-chamber, little or no loss of ornamentation, and suture-line tending to simplify."

Since the inner whorls resemble those of the later *Cadoceras* and of *Macrocephalites*, whereas those of *Defonticeras* are sphaeroceratid, the resemblance in the ribbing on the uncoiling body-chamber and in the presence of a constricted mouth-border is probably not due to close affinity of the two stocks; but at present there is no other Stephano-



Text-fig. 2. *Morrisiceras irregulare*, sp. nov. Side and peripheral views of holotype (with outer whorl all body-chamber) from the Great Oolite of Pinfarthings, near Minchinhampton (Museum of Practical Geology, London, No. 44060).

ceratid known from the Boreal Province that could have given rise to *Cranocephalites*. On the other hand, the *bullati* of the Great Oolite and the associated first Macrocephalitids (*Morrisiceras*) are distinctly less remote in the ancestral\* stock. Large specimens of *Morrisiceras comma*, Buckman, show a contracting body-chamber and a rejuvenescence of the ventral ribbing, much like later Macrocephalitids.

In the young *Morrisiceras* the ribs are also more continuous and flexuous across the umbilical slope, as in *Eurycephalites*, and the larger example figured in text-fig. 2 also shows that bundling of the fine inner ribs into primaries is not unknown in *Morrisiceras*, yet there is no obvious affinity, even if the sharpness of the ribbing of the inner whorls in *Cranocephalites* be taken to be a cœnogenetic feature. Here it may

be recalled that *Eurycephalites vergarensis* (Burekhardt)<sup>1)</sup>, with simplified suture-line, has also been considered to be a derivative of *Morrisiceras*, although Stehn<sup>2)</sup> found it together with later ammonites. Such Macrocephalitids, however, as those figured by Stehn<sup>3)</sup> as varieties of *Eurycephalites rotundus* (Tornquist) are probably closer to the *Cranocephalites* root-stock, and one Andine form<sup>4)</sup> may even be an *Arctocephalites*. The inner whorls of *E. latecostatus* (Stehn) show sharp ribbing with distinct primaries, and it seems to me that both *Eurycephalites* and the Arctic forms must be attached to the true *Macrocephalites*, the first members of which Rehbinder<sup>5)</sup> has found to occur together with a Stephanoceratid referred to *St. deslongchampsii*, i.e. well below the Cornbrash. *Cranocephalites*, then is a derivative of an early Macrocephalid stock, characterized by degeneration in coiling and suture-line. The same stock gave rise to the equally reduced *Arctocephalites* and *Arcticoceras* before the similarly modified Macrocephalid derivatives in more southern areas, like '*Macrocephalicerias*' or *Nothocephalites*, appeared. The convergence of certain *Cranocephalites* towards *Kamptokephalites* is due to their common derivation from the true *Macrocephalites*.

#### 1. *Cranocephalites pompeckji* (Madsen).

(Plate III, fig. 3; Pl. IV, figs. 8—10; Pl. V, figs. 3, 6—8; Pl. IX, fig. 4; Pl. XIII, figs. 1 a. b).

1904. *Macrocephalites pompeckji*, Madsen; "Jurassic Fossils from East Greenland", *loc. cit.*, p. 189, pl. VIII, figs. 5, 6.
- — — — — Skeat: "Jurassic Rocks of East Greenland". *Proceed. Geol. Assoc.*, vol. XVIII, pt. 7, p. 345.
1910. — — — — — Lemoine: "Ammonites du Jurassique supérieur du cercle d'Analalava (Madagascar). *Pal. Madag. VIII, Ann. Paléont.*, Paris, vol. v, p. 166.

<sup>1)</sup> "Beiträge zur Kenntnis der Jura- und Kreideformation der Kordillere". *Palaeontogr.* vol. 50, 1903, p. 21, pl. II, figs. 18—20.

<sup>2)</sup> "Beiträge zur Kenntnis des Bathonien und Callovien in Südamerika". In Steinmann "Beitr. z. Geol. und Palaeont. v. S. Amerika". *N. Jb. f. Min. etc.*, Beil. Bd. 49, 1923 (1924), p. 149.

<sup>3)</sup> *Ibid.* pl. VIII, figs. 2—3.

<sup>4)</sup> *Ibid.* pl. VIII, fig. 1.

<sup>5)</sup> Argiles médio-jurassiques à minerai de fer le long du côté S.O. des hauteurs entre Cracovie et Wielun. *Mém. Comm. Géol.*, N. S., vol. 74, 1912, p. 198.

1913. *Macrocephalites pompeckji*, Madsen; Sokolov: "Fossiles blocs erratiques Novaja Zemlia." Trav. Mus. Géol. Pierre le Grand etc., vol. VII, pt. 2, p. 61, (non pl. 1, figs. 1, 2).
1928. — — — Spath: "Revision of the Jurassic Cephalopod Fauna of Kachh", *loc. cit.*, p. 174.
1929. — — — Rosenkrantz (in Lauge Koch, Geology of East Greenland), *loc. cit.*, p. 146.
1930. — — — Frebald: "Verbreitung und Ausbildung des Mesozoikums in Spitzbergen". *Loc. cit.*, p. 111.

The nature of the original material did not allow of a complete description of this species, the suture-line not being distinctly shown in the types and the length of the body-chamber and shape of the aperture being unknown. Sokolov subsequently figured some suture-lines, but the simplified lobes represented in his text-figs. 1a (p. 62) and fig. 2 of pl. I were badly drawn although it is now seen that there is general agreement with the suture-lines of *C. vulgaris* figured in Plate I, fig. 6. Sokolov's almost unrecognisable first example (pl. I, fig. 1), moreover, may belong to a form different from his second specimen (fig. 2), which itself is closer to the species described below, e.g. the example figured in Plate I, fig. 4; and his measurements do not bear out the diagrammatic sections given in his text-figs. 2 and 3 (p. 64).

Unfortunately among the abundant new material now before me, there is not a single example that shows perfect agreement with the type, i.e. the original of Madsen's fig. 6. There are several specimens, however, corresponding to the inner whorls of the paratype (Madsen's fig. 5) and since Madsen himself mentioned that his original material included examples in which the ornamentation of the last whorl had almost disappeared, it is yet possible to interpret the species sufficiently widely to include individuals like that represented in Plate V, fig. 3, although at first sight this would seem to be closer to certain varieties of *C. vulgaris*, described below, than to the present species.

At a diameter of about 13 mm, the last half-whorl shows 20 peripheral ribs, and since most of them result from bifurcation, there are probably 10 primaries, but the inner whorls (on the back of the example figured in Plate III, fig. 3) are incompletely exposed. The whorl, however, is then comparatively narrow and the umbilicus is open. At about



30 mm diameter, the whorl-section is about as high as it is wide, but in the examples represented in Plate IV, figs. 9b and 10, owing to crushing, the proportions are misleading. The measurements of the type and various examples compare as follows:—

	Diameter in mm	Height %	Thickness %	Umbilicus %
1. Madsen, p. 189 (a) . . . . .	70	47	46	13
2. — — (b) . . . . . (at)	62	50	48	11
3. Sokolov, p. 61 (No. 655/1) . .	80	49	49	15
4. — — ( — ) . . (at)	59	52	52	10
5. — — ( — ) . . (at)	33	57	49	16
6. — — (No. 654/1) . .	66	44	45	(?)
7. — — ( — ) . . (at)	50	51	46	12
8. — — ( — ) . . (at)	38	51	50	11
9. Plate V, fig. 3 (var. <i>laevis</i> ) .	89	42	(?)	27
10. — — ( — ) .	62	50	53	17
11. Plate IV, fig. 9 (var. <i>rustica</i> )	57	48	44(?)	15
12. No. 396 (var. <i>rustica</i> ) . . . . .	90 (75)	43	44	18
13. Plate V, fig. 7 (var. <i>intermedia</i> )	65	48	54	15
14. Plate XIII, fig. 1 (trans- itional to var. <i>costata</i> ) . . .	53	50	50	16
15. Plate V, fig. 6 (var. <i>costata</i> ) .	81	44	49	20

These indicate that the thickness is rather variable; and since the body-chamber is always contracting the umbilicus naturally opens out at larger sizes. The body-chamber occupies nearly three-quarters of the last whorl and the helmet-shaped apertural margin is preceded by a shallow but wide constriction, as in *C. vulgaris*.

The suture-line is complex in the young (Plate V, fig. 8) but tends to become simplified towards the end. That figured in Plate IV, fig. 8 was taken from a complete example of the var. *rustica* (No. 396) at the beginning of the body-chamber; and although somewhat corroded, it shows ascending lobes towards the umbilical suture, a feature reminiscent of degenerate Macrocephalitids of higher horizons. In the immature example of the var. *laevis*, figured in Plate IX, fig. 4, the suture-line can be seen to be almost as complicated as that figured in Plate III, fig. 5.

This small example agrees with the inner whorls of the specimen represented in Plate V, fig. 3 (the type of the var. *laevis*) characterised by, first, closer ribbing than in the typical *C. pompeckji*, and, then, more or less complete loss of the ribbing on the body-chamber. This decline of ornamentation, however, may also occur in the var. *rustica*

(Plate IV, fig. 9), with stronger and more distant ribs on the septate whorls and a more robust and more inflated body-chamber, as in the original of Plate II, fig. 1 (which, however, is referred to *C. vulgaris* on account of its bluntly-ribbed earlier whorls).

The small specimen figured in Plate IV, fig. 10 is intermediate in the closeness of its costation between the coarser var. *rustica* and the more delicately-ribbed inner whorls of the var. *laevis*. It may be considered an average young, but cannot be separated from the earlier volutions of the example represented in Plate V, fig. 7. In this, however, the ribs become very strongly curved, especially on the umbilical slope, though to judge by other specimens (e.g. No. 402) this may be an individual peculiarity. Since this variety leads to yet another form (var. *costata*) described below, it may be given a distinct name (var. *intermedia*, nov.); but the costation declines on the body-chamber and does not increase in strength as it does in the var. *costata*. The last suture-line of the figured example of this var. *intermedia* is represented in Plate V, fig. 7b, and it shows not only considerable asymmetry but the usual broadening of the saddles at the beginning of the body-chamber.

In the var. *costata* (Plate V, figs. 6a, b) the sharp ribbing, retained on the body-chamber, has a marked backward bend on the inner half of the whorl-side and peripheral projection of the secondaries. All the costae are prominent laterally, but the secondaries disappear on the periphery. This tends to cause some irregularities in the spacing of the ribs on opposite sides; but towards the end of the type specimen (the mouth-border of which is not preserved) the ribs are again continuous across the venter and exactly opposite one another. The inner whorls of this var. *costata* (Plate XIII, figs. 1a, b) differ so little from corresponding examples of the var. *rustica* (Plate IV, fig. 9) that specific separation of these costate forms is impossible. The right hand side of the smaller example of the var. *costata* is somewhat worn, but the height is about equal to the thickness.

In addition to the bifurcating ribs there are, at this stage, some trifurcating costae and the secondaries are intercalated rather than distinctly branched off. In spite of the fact that the innermost whorls (Plate III, fig. 3) seem more closely costate than the smaller example of the var. *costata*? (Plate XIII, fig. 1) both have about 26 secondaries and 10 primaries to the half-whorl.

The differences between *C. pompeckji* on the one hand and *C. vulgaris* and its varieties on the other, are referred to below. The other species seem less closely comparable, yet as mentioned below, there are transitions to most of them.

Horizon and Localities:— *Pompeckji* horizon. Mt. Hjørnefjæld, locality 6, 740 m, 22 specimens; locality 2b, 740 m, 9 specimens, some

doubtful; locality 2(?), 760 m, 1 specimen. Nodular Ironstone (vi) at 1500 ft., Antarctic Harbour, ridge B, 2 doubtful fragments (45a, 46).

2. *Cranocephalites vulgaris*, sp. nov.

(Plate I, figs. 2—4, 6; Pl. II, figs. 1, 4; Pl. III, fig. 5; Pl. IV, figs. 1, 3; Pl. V, figs. 1a, b; Pl. VIII, figs. 1a, b; Pl. X, figs. 3a, b).

This species was at first united with the last (*C. pompeckji*) but if I now consider it a separate form, having its own varieties, it is done chiefly because there are certain slight though constant differences that on the discovery of better material of both groups in the same section will probably be shown to be of stratigraphical import. Yet it must be added that the two assemblages being preserved in different matrixes (and from localities about 25 miles apart) the slight differences in ribbing may have been accentuated sufficiently by the usual corrosion to cause a different appearance in the two types of rock. Interpreting the species in a still narrower sense, however, it could easily be demonstrated that the example now taken as the holotype of the present species (Plate I, fig. 4) differs from the typical *C. pompeckji* in its wide whorl-section with flattened venter, the smoothness of the periphery, the bluntness and closeness of the ribbing of the earlier whorls, the forward inclination of the ribs, the roundness of the umbilical slope, and of course, the general measurements, although these, in a variable form like the present, are not considered to be of any diagnostic value.

These measurements are as follows:—

	Diameter in mm	Height %	Thickness %	Umbilicus %
1. Holotype (Plate I, fig. 4)....	78	41	46	23
2. No. 416 (Plate IV, fig. 3)....	59	46	44(?)	14
3. No. 415 (Plate I, fig. 2)..... (at)	60	50	50	10
4. No. 422 (Plate V, fig. 1) (var. <i>compressa</i> ).....	74	45	35	23
5. No. 414 (between typus and var. <i>compressa</i> ).....	87	41	41	22
6. No. 418 (Plate IV, fig. 1 var. <i>densicostata</i> ).....	70	40	45	24
7. No. 417 (Plate II, fig. 1 var. <i>robusta</i> ).....	80	44	48	21
8. No. 433 (Plate VIII, fig. 1 var. <i>inflata</i> ).....	70	44	48	21

With regard to example (3) it may be mentioned that since it is septate to a larger diameter than the holotype and retains only a small

part of the body-chamber, its umbilicus is still narrow. This specimen, at the beginning of the outer whorl, shows a portion of the test; and the ribbing, there, is seen to be much sharper than on the internal cast. In the casts referred to *C. pompeckji* the ribbing is as distinct as it is on the test of this specimen No. 415, and there does not appear to be the difference between the costation of the cast and the test as in *C. vulgaris*.

The body-chamber, from just over half to three quarters of a whorl in length, is always contracting, so that the umbilicus suddenly opens out, and the whorl-height becomes less. Since, at the same time, there is a tendency to form a more or less wide constriction just before the aperture, and since the peristome may be either flared, e. g. trumpet-shaped (Plate VIII, fig. 1a), or else rounded off or bent back (Plate I, fig. 4a), there result a variety of differing measurements of various individuals according to the different states of preservation of the final portion where the measurements are taken. Thus, the whorl-height is typically less than the thickness, except in the young (Plate X, fig. 3) or in the var. *compressa*; for in such a complete example as that figured in Plate IV, fig. 1 the final constriction and consequently a wide umbilicus account for the low whorl-height (40 %). The whorl-section varies accordingly and the umbilical wall tends to be overhanging on the contracted body-chamber, although this feature may be conspicuous only on internal casts.

At 8 mm diameter, the ribbing is already strong and at 11.5 mm diameter there are twenty ribs on the venter per half-whorl. These ribs are flexuous, have a sinus forward on the periphery, and mostly arise in pairs (but irregularly) from a very short primary rib which passes over the comparatively high and distinct umbilical wall. At 22 mm, the lateral flexuosity has increased, the ribs are rather irregular and owing to the periphero-lateral edges being somewhat marked, the sinuosity of the secondary costation on the flattened venter is very conspicuous. At 33 mm, the ribbing again is changed. The primary portion now is a third of the length of the whole-rib or more, and the peripheral projection is gone. In the ventral view (Plate I, fig. 3b) the ribs appear straight. The whorl-height is still equal to the thickness (16 mm at 33 mm, 6 mm at 11.5 mm diameter); but after about 40 mm, the whorl gains slowly in thickness. In the typical septate whorls figured in Plate IV, figs. 3a, b, the proportions, as indicated in the above table (No. 2), are misleading, the end being badly worn.

While in the var. *compressa* and in the transitional example (5) listed above, the septate whorls are essentially like those here figured, in the var. *inflata* they are slightly thicker (see Plate I, figs. 3a, b), and in the var. *densicostata* the ribbing is considerably finer and closer. On

the other hand, the var. *robusta* has more bluntly and sparsely-ribbed inner whorls and even on its body-chamber the distantly spaced primaries and short secondary forks are conspicuous. In this variety as in the typical forms the ribbing of the venter may completely disappear on the body-chamber, but in the other three varieties (*compressa*, *densicostata*, and *inflata*) the secondary costation may persist only slightly weakened on the periphery or, after having been feeble or absent on the earlier part of the body-chamber, it may reappear near the aperture.

The suture-line is very variable, chiefly because there is a tendency to simplify the elements so that the lobes become very short and the saddles wide and plump. This is especially noticeable in the last few suture-lines, at the end of the septate part (Plate IV, fig. 3a, considerably worn), but the holotype from which were taken the lobes represented in Plate III, fig. 5 has a deep first lateral lobe and finely divided saddles to the end, as also have less typical, i.e. less inflated examples (e.g. No. 420). In at least some of the specimens, therefore, the simplified suture-lines are the result of corrosion of the surface.

The immature example represented in Plate II, fig. 4 differs from the typical specimens in being slightly more inflated and in having more prominent primary ribs; the other small specimen figured in Plate I, fig. 3 may be attached to the var. *inflata* and leads by various transitional forms to such still more inflated examples as the young *C. maculatus* represented in Plate II, fig. 3

One example (No. 333) of the general aspect of the specimen figured in Plate I, fig. 2, but somewhat transitional to the more inflated *C. subbullatus* (e.g. Plate VII, fig. 1) is interesting on account of its resemblance to *Arctocephalites nudus*, var. *magna* (Plate XII, fig. 4). In the absence of the body-chamber separation of average specimens may indeed be impossible.

Horizon and Localities:— Ammonite horizon on Cathedral Mountain, 370 m, 21 examples, including two doubtful fragments; *Pompeckji* horizon on Mt. Hjørnefjæld, locality 2b, 1 example; locality 6, 1 example.

### 3. *Cranoecephalites gracilis*, sp. nov.

(Plate II, figs. 6a, b; Pl. III, figs. 1a, b.)

As type of this species may be taken the example figured in Plate III, figs. 1a, b, because it is intermediate between the compressed and inflated varieties, not only in shape but also in ornamentation. The dimensions of the holotype and three of these varieties compare as follows:—

1. Holotype (Plate III, figs. 1a, b)	90	38	38	30?
2. transitional form (No. 403)....	84	..	40	..
— — (at)	75	..	48	..
3. var. <i>ornata</i> (Plate II, figs. 6a, b)	80	40	45	26
4. var. <i>rotunda</i> (No. 404) .....	94	..	48	..

The transitional form here listed (No. 2) is interesting because it is intermediate not only to the more strongly ornamented variety No. 3 (var. *ornata*) but also to the more inflated var. *rotunda* with a whorl-thickness of 48 % of the diameter, instead of only 45 % as in the holotype. On the other hand, in this var. *rotunda* the ribbing is almost obliterated on the body-chamber and only oblique folds, as in the (much thinner) var. *laevis* of *C. pompeckji* (Plate V, fig. 3) remain. Since these primary folds, however, are also more distantly spaced in this var. *rotunda* than in the type or in the var. *ornata*, it could equally well have been considered to be an extreme, inflated, individual of the var. *laevis* of Madsen's species; but the intermediate example above listed and other individuals are more transitional to the typical, costate, specimens of *C. gracilis*.

The inner whorls are not preserved in any of the typical specimens, but in a passage-form to the var. *compressa* of *C. vulgaris* (No. 445) they are slightly more closely-ribbed than in the young example figured in Plate IV, fig. 3, so that the closeness of the costation may be looked upon as the most characteristic feature of this species. In the more distinctly ribbed var. *ornata*, the secondary costation across the periphery is preserved on the whole of the body-chamber but in all of the other examples the venter is smooth on the outer whorl except just near the mouth-border where there is rejuvenation of the peripheral ribbing. This var. *ornata* is also connected by transitions directly with *C. maculatus*, as mentioned below.

The small example figured in Plate III, fig. 4, seems to show the type of ribbing characteristic of *Dolikephalites*, but the peripheral sinus forward is becoming less pronounced at the end of the outer whorl, which is all body-chamber. Its reference to the present species is provisional but is prompted by the occurrence of a passage-form (No. 430) with coarser ribbing which is lost on the venter, towards the end. This second example may be attached to the var. *ornata*, but as both are small body-chambers, definite identification is difficult. The resemblance to young *Arctocephalites* (see p. 39) is, however, of considerable interest.

Horizon and Locality:— Ammonite horizon on Cathedral Mountain, 370 m, 9 examples.

4. *Cranocephalites maculatus*, sp. nov.

(Plate I, fig. 1; Pl. II, fig. 3; Pl. III, fig. 6; Pl. IV, fig. 2.)

Although connected by transitional forms with the two species last described, *C. maculatus* can easily be distinguished by its comparatively coarse costation. This is projected forward on the side; and on the outer whorl of the holotype (three-quarters of which are body-chamber) there are about twenty primary ribs, branching at the middle of the side into about 48 secondaries, i.e. there are some trifurcating ribs in addition to a slightly larger number of bifurcating costae. These ribs cease to pass across the periphery soon after the beginning of the body-chamber, but near the aperture they are once more continuous. A slight contraction precedes the mouth-border which in at least one example (No. 440) shows a comparatively large and smooth ventral lappet, bent down more than in the specimen figured in Plate X, fig. 1.

The dimensions are as follows:—

	Diameter in mm	Height %	Thickness %	Umbilicus %
Holotype (Plate I, fig. 1) . . . . .	87	34	53	29
Holotype (at 84 mm diameter) . . . . .	..	..	57	..
Compressed variety (No. 438) . . . . .	..	..	48—50	..
var. <i>transitoria</i> (Plate III, fig. 6). . . . .	87	44	46?	25
var. <i>tenuis</i> (Plate IV, fig. 2) . . . . .	77	43	42	23

The compressed variety here listed leads to the var. *tenuis* which, however, differs from the type also in ribbing, this being more rectiradiate. The difference in the coarseness of the costae and the apparent feebleness of the secondaries in the holotype are due to corrosion, as can be seen on comparing the two sides in fig. 1b (Plate I), although the left-hand side is covered with a thin crust of sinter.

In the var. *transitoria*, on the other hand, the costation is distinctly coarser than on the (far more inflated) holotype; and the secondaries are continuous across the periphery up to the final constriction and the smooth ventral lappet. This, however, is not complete and the mouth-border itself is damaged.

The inner whorls are more coarsely ribbed and less compressed than those of *C. vulgaris*, but the figured example (Plate II, figs. 3a, b) is slightly worn at the end. It well shows the suture-line, with the external lobe as deep as the first lateral and the external saddle less constricted in the middle than that of fig. 5 on Plate III. These inner whorls, however, probably belonged to one of the less inflated varieties, for in a more typical large example (No. 436) the inner whorls can be seen

to be even more inflated, showing a thickness of 73 % at 55 mm diameter, as against 60 % in the figured specimen, at the same size. These inner whorls then are still more like the inner whorls of *Bullatimorphites* or of *Defonticeras* than the example represented in Plate II, fig. 3.

One example (no. 432), with distinctly closer ribbing than the type, connects up directly with the var. *ornata* of *C. gracilis*. Another nearly related species is *C. subbullatus* which, however, is still more inflated and has more flexuous ribbing, at least in the case of the holotype. The two paratypes, mentioned on p. 28 on the other hand, are only slightly thicker than the present form and have very similar ribbing.

Horizon and Localities:— Ammonite Horizon, 370 m, Cathedral Mountain, 10 examples; *pompeckji* horizon, Mt. Hjørnefjæld, locality 6, 740 m, 1 example.

5. *Cranocephalites inversus*, sp. nov.

(Plate V, figs. 2a, b. Plate VI, figs. 7a, b).

This species could be considered merely a coarse and inflated edition of the var. *costata* of *C. pompeckji*, above described, but it differs also in the bluntness of the ribbing and in having sphaeroconic inner whorls, comparable to those of *C. inconstans*; and since it comes from a different bed and locality and is associated with a dissimilar fauna, it seems safer to give it a distinct name, even if the material at present available is poorly preserved. The holotype (Plate VI, figs. 7a, b) has the following dimensions:—

	Whorl-height	Thickness	Umbilicus
	%	%	%
At 93 mm diameter .....	45	54	20
At 48 mm diameter .....	..	60	..

The inner whorls of the holotype are exposed only in section, and the ironstone-matrix does not allow of preparation; but they are apparently comparable to the example figured in Plate V, figs. 2a, b. This, however, at the same diameter, shows a thickness of only 54 % (with a whorl-height of 50 % and an umbilical width of 12 %) so that it probably belonged to one of the less inflated varieties of the present species which, unfortunately, are all represented by very fragmentary, crushed, and corroded specimens.

The coarse and sharp, generally bifurcating costae are only slightly inclined forward on these inner whorls and they are continuous across the periphery, although they may become weakened in the siphonal line. On the body-chamber, the inclination forward of the blunt, lateral ribs is the most conspicuous feature. Combined with the very high umbilical slope, and the irregularity of the secondaries on the wide



periphery, this gives the body-chamber an appearance quite distinct from that of any of the other species of *Cranocephalites* here described.

The mouth-border is damaged, but the broad constriction preceding it is well shown in the side-view (Plate VI, fig. 7a). The suture-line is not visible in the holotype but in two very doubtful septate examples (Nos. 38c and 44b), although much corroded, it can be seen to have had an external saddle and general complication like that figured in Plate III, fig. 5.

While at least one of the more compressed specimens (No. 42) doubtfully attached to the present species, resembles (the body-chamber of) *C. vulgaris*, var. *robusta* (Plate II, fig. 1), three others (39, 44c, 45c) may perhaps be considered transitional to the var. *costata* of *C. pompeckji*. They differ among themselves, however, and in the absence of much of the inner whorls or even of uncrushed material, it is impossible to state whether the resemblance is merely superficial. In the case of the former variety mentioned, in any case, the inner whorls appear to be quite different.

*C. inconstans*, with similar early volutions, has closer costation, with a very distinctive peripheral aspect. *C. furcatus* is more compressed and flexicostate, but one of its varieties (No. 390) greatly resembles a crushed example (No. 44c) provisionally attached to the present species.

Horizon and Locality:—Nodular Ironstone (v1), ridges A and B, Hills east of Antarctic Harbour, 8 specimens.

#### 6. *Cranocephalites inconstans*, sp. nov.

(Plate VII, figs. 8a, b; Pl. VIII, figs. 5a, b).

The holotype of this species consists only of about half of the septate whorls and a portion of the body-chamber, but the former are well-shown in natural section and the latter has such a distinctive peripheral aspect that it must be kept apart from the other species of *Cranocephalites* here described. The dimensions of the holotype at two diameters and of the inner whorls figured in Plate VIII, figs. 5a, b are as follows:—

	Diameter in mm	Whorl-height %	Thickness %	Umbilicus %
Holotype (Plate VII, fig. 8)	75	48	55	21
— — — — —	57	56	60	14
No. 45b (Plate VIII, fig. 5)	44	48	55	18

The inner whorls, with their strong, inclined primaries on the high and rounded umbilical slope, have a distinctly Sphaeroceratid aspect, recalling the earlier volutions of *Bullatimorphites* or *Defonticeras*. The ribs are bi- or trifurcating and continuous across the widely-arched

periphery, the secondary branches, unlike the primaries, being almost radial or straight. On the body-chamber, the forward inclination of the blunt and low secondaries is distinct and they cease abruptly near the siphonal line. The median smooth band separating the costae of the two sides (not opposite to one another) is perhaps the most distinctive feature of the body-chamber of the present species. The primary ribs on the outer whorl (not visible in the figure, Plate VII, fig. 8a) resemble those of *C. inversus* but are much feebler. It is, of course, possible that if abundant and well preserved material had been available, this species would have been reduced to the status of a variety of this more robust *C. inversus*.

Horizon and Locality:— Nodular Ironstone (vi), Hills east of Antarctic Harbour, 2 examples.

#### 7. *Cranocephalites* sp. ind.

(Plate VII, fig. 2).

The specimen here figured is so badly preserved as to be almost unrecognisable, but it is one of four or five examples that cannot be attached to any of the other forms of *Cranocephalites* now described. In the figured specimen, the only features remaining are the sphaerocone whorl-shape and comparatively close, bifurcating costation, irregular and interrupted on the wide periphery as in *C. inversus*. This smoothness of the ventral area distinguishes the form under discussion from *C. subbullatus*. In another example (No. 47), similar but less deformed, sphaeroconerid inner whorls are combined with a crushed body-chamber, so that the resemblance to certain *Bullatimorphites* is considerable. The ventral smoothness is lost again on the last half-whorl which has 27 secondaries. This specimen, at 108 mm diameter, has three-quarters of the outer whorl belonging to the body-chamber and the apertural margin (imperfectly preserved) is smooth and strongly bent down. The general resemblance to *Bullatimorphites bullatus* (d'Orbigny)<sup>1</sup>, however, is probably accidental and apart from the peripheral smoothness of the present form, its distinct primary costae link it with the other species of *Cranocephalites*. There is no suture-line visible on any of the specimens.

In another example (No. 44a) there is enough remaining of the outer whorl to show that it probably belonged to the same species as the last; but this body-chamber portion is crushed on to inner whorls that (at about 50 mm diameter) have thicker and blunter ribs than any of the other species, also a comparatively open umbilicus, though this may be due to accidental deformation. Since the ribbing on these inner whorls is even coarser and much blunter than that of the immature

<sup>1</sup> Paléont. Française, Terr. Jurass. vol. I (1846), p. 412, pl. CXLII, figs. 1—2.

*C. cf. inversus* figured in Plate V, figs. 2a, b, the change to a comparatively finely-ribbed body-chamber is particularly striking. A fourth fragmentary specimen (No. 37b) is still more doubtful and a smaller fifth example (No. 38e) might perhaps equally well be attached to *C. inversus* or *C. inconstans*.

Horizon and Locality:— Nodular Ironstone (v1), Hills east of Antarctic Harbour, 5 examples.

#### 8. *Cranocephalites subbullatus*, sp. nov.

(Plate VI, fig. 6; Pl. VII, figs. 1, 5).

It is not certain that the more favourably preserved examples figured in Plate VI, fig. 6 and Plate VII, fig. 1 are absolutely identical with the largest specimen (Plate VII, fig. 5), but since this includes a portion of the body-chamber, it is now taken as the holotype, notwithstanding its fragmentary preservation. The proportions of the three specimens are:—

	Diameter in mm	Whorl-height %	Thickness %	Umbilicus %
Holotype (Plate VII, fig. 5).	70	50	63	15
No. 391 (Plate VII, fig. 1) . .	58	50	66(?)	20
No. 392 (Plate VI, fig. 6) . .	60	50	70	23

Since the holotype, at 66 mm, also shows a thickness of 70 % of the diameter, it is clear that the differences in the table are of no import, the second specimen also being crushed obliquely which accounts for the ribs appearing unusually rigid or even rursiradiate in the photograph (Plate VII, fig. 1). In the holotype, the bi- and trifurcating ribs are distinctly flexicostate, with the primaries crescent-shaped, as in *Indocephalites chrysoolithicus* (Waagen)<sup>1</sup> and the secondaries slightly curved back. But the lateral ribbing at a diameter corresponding to that of the smaller example (Plate VII, fig. 1) is not preserved in the holotype. On its body-chamber which begins apparently at the upper end of the cavity (filled with crystalline calcite) visible in Plate VII, fig. 5, the primary ribs are more thickened and slightly farther apart, so that the lateral aspect then is somewhat intermediate between that of *Sphaeroceras extremum*, Tornquist<sup>2</sup>, and *Stephanoceras submicrostoma*, Gottsche<sup>3</sup>, the latter of which, moreover, shows a somewhat similar if more con-

<sup>1</sup> See Pal. Indica, N. S. vol. IX, Mem. No. 2, pt. 3, 1928, pl. xx1, fig. 6a.

<sup>2</sup> "Der Dogger am Espinazito Pass &c.". Palaeont. Abhand. N. S. vol. IV, 1898, p. 179, pl. xix (v1), fig. 5.

<sup>3</sup> "Über Jurassische Versteinerungen aus der Argentinischen Cordillere", in Beiträge z. Geol. & Palaeont. d. Argentin. Republik. II, Pal.; pt. III, Palaeontographica, Suppl. III, Lief. II, Heft. 2, 1878, p. 15, pl. III, fig. 3.

spicuous narrowing of the outer whorl. The comparison to these two species, however, is misleading, for the inner whorls of these two forms (*Eurycephalites* and *Emileia* respectively) are very different. In the present species, at about 33 mm diameter, the umbilicus is comparatively open and the ribbing is coarse, the general aspect then being that of the young of *C. inversus* (Plate V, fig. 2a). The anterior part of the body-chamber is unknown but was probably slowly contracting as in other *Cranocephalites*, not rapidly, as in *Bullatimorphites*, or as might be inferred from the above measurements. The suture-line is indistinctly visible in the example figured in Plate VI, fig. 6, which has the lateral aspect of a worn *Kamptocephalites herveyi* (J. Sowerby)<sup>1</sup> rather than of an *Indocephalites*, on account of its stronger ribbing.

Whereas in addition to the two figured examples there are at least two more (Nos. 394—95) that may be justifiably attached to the species represented by the unique holotype, others are more crushed and therefore still less easy to identify. In one (No. 393) the remains of the smooth and rounded umbilical wall of the body-chamber (attached to the inner whorls, septate to about 65 mm diameter) suggest a transition to *C. vulgaris*, but in this species the inner whorls are much more delicately ribbed.

Horizon and Localities:— Nodular Ironstone (v<sub>1</sub>), hills east of Antarctic Harbour, holotype and one doubtful fragment; *pompeckji* horizon, Mt. Hjørnefjæld, locality 2b, 740 m, 6 examples.

. 9. *Cranocephalites* sp. nov.

(Plate VII, figs. 3a, b).

This is another form that although very incompletely known may yet be separately discussed since it obviously differs from the other species of *Cranocephalites* here described, not only in its more sphaeroceratid shape, with very small umbilicus, but in its swollen primaries and fine secondary ribs. The dimensions of the figured specimen and a smaller doubtful example are the following:—

	Diameter in mm	Whorl-height %	Thickness %	Umbilicus %
Plate VII, fig. 3 . . . . .	56	50	66	11
— — . . . . . (at)	45	52	68	12
No. 38b (45 mm) . . . . . (at)	32	50	66	14

Since the larger example is still septate and since the inner whorls are not strikingly different from those of the other species from Antarctic Harbour, the lateral aspect at over 50 mm diameter is taken as

<sup>1</sup>) Mineral Conchology, vol. II, 1818, p. 215, pl. cxcv.

typical of the species. It is seen, there, that the thickened primary ribs (continued in a sharp extension down to the umbilical suture) may give rise at the middle of the side to three or four, fine secondaries, slightly inclined forward and continuous across the widely arched periphery. This is the ornamentation characteristic of the Bajocian *Emileia*, except that in this genus the primaries are shorter and the secondaries still finer. The whorl-section is depressed, almost semi-lunar, with high and rounded umbilical slope. The suture-line is not distinctly shown but in the smaller example can be seen to consist of three saddles as in other *Cranocephalites* of which only the external and first lateral saddles are outside the umbilical slope. The bifid second lateral (really first auxiliary) saddle and the remaining small elements seem to be comparable to their equivalents in *C. maculatus* (Plate II, fig. 3a).

Horizon and Locality:— Nodular Ironstone (VI), Hills east of Antarctic Harbour, 3 examples.

10. *Cranocephalites furcatus*, sp. nov.

(Plate VI, figs. 1; 2a, b).

There are about a dozen fragmentary examples of this species but they show considerable variation so that it is again necessary to base the description only on the holotype (Plate VI, fig. 1) although this, itself, is rather incomplete. The dimensions and those of a variety are:—

	Diameter in mm	Whorl-height %	Thickness %	Umbilicus %
Plate VI, fig. 1 (holotype) . . . .	88	42	(?)	23
— fig. 2 (var. <i>pygmaeus</i> )	66	40	35(?)	27(?)

The outer whorl of the holotype is all body-chamber (so far as it is preserved) and since its posterior part is crushed and the anterior end worn away on the side not figured, it is impossible to determine the whorl-thickness. But in most of the fragments the height is greater than the thickness, as in the var. *pygmaeus*, while in only one or two deformed examples height and thickness are approximately equal. The rounded and smooth umbilical wall is comparatively high. The characteristic feature of the present species is the ornamentation, consisting of bifurcating flexicostae, with an occasional secondary rib intercalated, and in the coarseness of this biplicate ribbing already on the inner whorls. There are about 20 thickened primaries to the whorl, crescentic as in *C. inversus*, and with secondary branches slightly prorsiradiate. On the periphery of the holotype the ribs are somewhat weakened but in some of the fragments they are almost as strong on the venter as on the side. The var. *pygmaeus*, with a still larger umbilicus, is characterised by its

daries are feebler and very strongly projected, especially near the aperture. The periphery is smooth, also the high and steep umbilical wall. Unfortunately the cast consists entirely of sandstone matrix so that the dorsal area cannot be exposed. The restored whorl-section, (fig. 4c), is based on the reconstruction. There is also, of course, no trace of the suture-line.

The resemblance of the present species to *Sphaeroceras extremum* Tornquist<sup>1)</sup> has already been stated to be purely superficial. *C. inversus*, on the other hand, differs merely in whorl-shape so that the generic reference is scarcely doubtful, in spite of the fragmentary condition of this unique form.

Horizon and Locality:— Ammonite horizon, 370 m, Cathedral Mountain, 1 example.

#### Genus *ARCTOCEPHALITES*, Spath.

1928. Revision of the Jurassic Cephalopod Fauna of Kachh (Cutch). Pal. Indica, N. S. vol. ix, No. 2, pt. 3, p. 174.

This genus was proposed for a boreal group of Macrocephalitids of which *A. arcticus* (= '*Amm. ishmae*, var. *arcticus*', Newton, in Newton and Teall<sup>2)</sup>) was selected as the genotype. The example in the British Museum (No. C. 7249), cited as representing Newton's species (the holotype not being available), is now figured to illustrate the characteristic change from sharp to blunt ribbing, involute whorl-shape, smooth outer volution at a comparatively small diameter, and deeply divided and interlocking suture-lines. These were stated to be simplified in some species, e.g. the discoidal *A. pompeckji*, Madsen sp., but this is now separated generically (see under *Cranoccephalites*, p. 14). It will be seen that Newton's type-figure was not unsuccessful, and at least one of Whitfield's<sup>3)</sup> illustrations also clearly represents the same form, even in the narrowest interpretation.

It may now be added to the generic diagnosis that after the smooth body-chamber stage there may be a return to strongly prorsiradiate costation, but only quite near the mouth-border. This may modify the final constriction, which in its typical form was already figured by Whiteaves<sup>4)</sup>. In a similar fragment with constricted mouth-border

<sup>1)</sup> *Loc. cit.* (Dogger v. Espinazito), 1898, p. 47, pl. vi, figs. 5—6.

<sup>2)</sup> "Notes on a Collection of Rocks and Fossils from Franz Josef Land, made by the Jackson-Harmsworth Expedition during 1894—1896." *Quart. Jour. Geol. Soc.*, vol. LIII, 1897, p. 500, pl. XL, figs. 1, 1a only.

<sup>3)</sup> "Notes on some Jurassic Fossils from Franz Josef Land, brought by a Member of the Ziegler Exploring Expedition." *Bull. Amer. Mus. Nat. Hist.*, vol. XXII, 1906, p. 131, pl. XVIII, fig. 2.

<sup>4)</sup> *Ibid.*, fig. 1.

before me from the Windy Gully Shoulder at Cape Flora (B.M. no. C. 7251b) the impressed dorsal area shows that a whole whorl previously the ribbing had almost disappeared. This example, therefore, probably belongs to the "smooth variety", i.e. *A. koettlitzii* (Pompeckj)<sup>1</sup>) and my interpretation of this species is based on another such example (No. C. 7253) from the same locality. On account of the occurrence of similar constricted peristomes in other Macrocephalitids, however, and the great variability of these large body-chamber fragments, they are difficult to classify with precision, especially if they come from unknown beds. In the genus *Arcticoceras* described below, there is corresponding variability.

Excentrumbilication is scarcely apparent in the *arcticus* group and this is one reason why I am now separating from it the *pompeckji* group, although the inner whorls are very similar, both having the sharp ribbing, laminate or merely raised, of "*Miccocephalites*" and "*Metacephalites*", Buckman<sup>2</sup>). Such nuclei of Macrocephalitids are again almost impossible to identify. These two genera therefore cannot stand. Even the well-preserved *Macrocephalites ishmae* (non Keyserling) figured by Salfeld and Frebold<sup>3</sup>) from Novaya Zemlya, which shows already great resemblance to immature *Dolikephalites* of the *typicus* group is not adult enough to be definitely classified, although it certainly is not an *Arcticoceras*, like Keyserling's species.

Likewise the finely-ribbed Franz Josef Land form (*A. ellipticus* sp. nov.) represented in Plate XIII, figs. 6a, b superficially resembles certain immature *Pleurocephalites*, recognised by the delicate costation of their inner whorls, while Newton's 'inflated variety', with coarser more triplicate ribbing (now renamed *A. pilaeformis* nom. nov.) was wrongly identified by Pompeckj with '*Macrocephalites*' *pila*, Nikitin. The resemblance of other examples to *Kamptokephalites* and *Indocephalites* is mentioned repeatedly in the descriptions below, but with the exception of the fragment figured in Plate XI, figs. 7a, b, the similarity ends at an early stage.

'*Macrocephalites*' *cadoceroides*, Burckhardt<sup>4</sup>) which was also compared to *A. pilaeformis* and which shows some resemblance to the earlier

<sup>1</sup>) "Jurassic Fauna of Cape Flora, Franz Josef Land". Norweg. N. Polar Exp. 1893—96. Scient. Res. II, 1899, p. 70, pl. II, figs. 12a—c = 'smooth variety of *A. arcticus*' in Newton (*loc. cit.*, pl. XI, fig. 3). Buckman (*loc. cit.*, 1929, p. 11) found differences but overlooked the fact that, as Pompeckj had pointed out, the section is 'not in the plane of the greatest diameter.

<sup>2</sup>) *Lqc. cit.* (1929), pls. I—III.

<sup>3</sup>) Jura- und Kreidefossilien von Nowaya Zemlya. Rep. Scient. Res. Norweg. Exp. Nowaya Zemlya, 1921, No. 23; 1924, p. 4, pl. I, fig. 1.

<sup>4</sup>) "Cefalopodos del Jurásico Medio de Oaxaca y Guerrero". Inst. Geol. Mexico, Bol. No. 47, 1927, p. 29, pl. XIV, figs. 1—7.

whorls of *A. sphaericus*, described below, is probably a *Pleurocephalites* of the *polyptychus*-group.

1. *Arctocephalites greenlandicus*, sp. nov.

(Plate IX, figs. 1a, b; Pl. X, fig. 1).

Although represented by only a single example with crushed inner whorls, this species must be kept distinct from *A. arcticus* (Newton), for apart from the fact that it almost certainly represents a far more compressed form, it differs also in its slightly stronger and more prolonged costate stage and the shape of the mouth-border. The dimensions at two different sizes are:—

Diameter in mm	Height %	Thickness %	Umbilicus %
130	49	30	14
80	52	(?)	9

These show that the body-chamber (three-quarters of a whorl in length) contracts slightly towards the aperture; and the smooth and comparatively high umbilical slope of this contracting outer whorl is well shown on the (unfigured) half, removed from the side represented in Plate IX, in order to expose the inner whorls. These are costate to a diameter of 90 mm, but whereas in the straightness of the ribbing and the (irregular) bifurcation there is close resemblance to the typical *A. arcticus*, the primary ribs remain distinct, instead of disappearing first. In the restored outline-section (Plate IX, fig. 1b) the inner whorl may be shown as too compressed, and the umbilical slope of the outer whorl may have been higher; yet the thickness of the body-chamber is probably correctly represented. The peripheral view near the aperture resembles that of *Arcticoceras kochi*, figured in Plate XIII, fig. 5, but the folds show only a very slight sinus forward.

After the costate air-chambers there is an almost completely smooth stage, comprising half a whorl of body-chamber; but the extremely faint concave striae of growth, that may be seen in two or three places on this smooth portion, are later bundled into about nine coarse folds. These are not symmetrical on the two sides and while there is only one distinct constriction on one side (between the second and third folds) on the side here figured there are three constrictions of which the one between the fourth and fifth folds is the most distinct. Both folds and constrictions die away on the inner whorl-side and the umbilical slope is smooth. The peristome, unfortunately, is damaged, but what remains of the ventral lappet at the end is turned down. The suture-line is visible on the flattened inner whorl, but on account of the preservation (in a



coarse sandstone) too indistinct for delineation. The lobes are trifid but wider than in *A. arcticus* (Plate III, fig. 7); the general aspect and the complication are about the same.

Compared with the adult example of *A. arcticus* figured by Whitceaves<sup>1)</sup>, the difference in the final portion is striking; for the deep constriction that precedes the flared peristome in Newton's species continues down to the umbilical wall and is far more projected peripherally. *Arcticoceras ishmae*, as figured by Sokolov<sup>2)</sup>, has a more comparable final portion but its inner whorls have different ribbing.

The largest of the three examples of *Macrocephalites ishmae* (non Keyserling) figured by Madsen<sup>3)</sup> shows some resemblance to the present form, but is an *Arcticoceras*. The other two fragments (figs. 8—9) are more doubtful; the last could even be a portion of a *Cadoceras* of the *freboldi* group. It is only fair to add that in his interpretation of Keyserling's species, Madsen followed previous authors and was misled by the poor figures of the Petchora type and the smaller examples figured by Eichwald<sup>4)</sup>. On the other hand, as mentioned on p. 55, some of Madsen's specimens probably belong to *Arcticoceras kochi*, known to occur at Vardekløft.

Horizon and Locality:— Cathedral Mountain, with numerous *Cranocephalites*, but in a different matrix and probably from a higher horizon. (1 example).

## 2. *Arctocephalites nudus*, sp. nov.

(Plate IX, figs. 3a, b; Pl. XI, figs. 1a, b, 7a, b; Pl. XII, figs. 4a, b; Pl. XV, figs. 2a, b).

This species appears to be as closely related to *A. koettlitzii* as the form last described is to *A. arcticus*, but it is now separated specifically from the Franz Josef Land form, on account of the differences in the inner whorls and the primary ribs. These, as in all the forms from Mt. Hjørnefjæld, are more distinctly bundled and therefore more prominent than in the Franz Josef Land examples in which the ribs (rather coarse in the young) tend to persist on the outer whorl-side, after the umbilical slope has become smooth. As holotype may be taken the example figured in Plate XI, fig. 1; for although it does not well show the earlier whorls, it retains the complete body-chamber with the mouth-border. Its dimensions and those of four other examples are:—

<sup>1)</sup> *Loc. cit.* (1906), pl. xviii, fig. 1.

<sup>2)</sup> "Zur Ammoniten Fauna des Petschoraschen Jura". *Mém. Com. Géol. N. S.* livr. 76, 1912, pl. 1, fig. 1.

<sup>3)</sup> *Loc. cit.* (1904), pl. viii, fig. 7.

<sup>4)</sup> *Geognostisch-Paläontologische Bemerkungen über die Halbinsel Mangischlak und die Aleutischen Inseln*. St. Petersburg, 1871, p. 146, pl. viii, figs. 4—5, pl. ix, fig. 5, pl. x, figs. 3—7.

	Diameter in mm	Whorl-height %	Thickness %	Umbilicus %
Holotype (Pl. XI, fig. 1) . . . . .	(at)68	52	59	10
var. <i>magna</i> (Pl. XII, fig. 4) . . . . .	(at)67	54	60	12
No. 382 (var. <i>magna</i> ) . . . . .	81	52	56	11
No. 383 (var. <i>magna</i> ) . . . . .	99	..	53	..
No. 384 (coarsely-ribbed variety)	73	..	50	..

The finely-ribbed inner whorls figured in Plate IX, figs. 3a, b, were broken out of a typical example with a smooth body-chamber, like the holotype, so that other immature specimens (e. g. Plate XV, figs. 2a, b) may definitely be referred to the present species. Compared with the similar immature *Macrocephalites ishmae* (non Keyserling) figured by Salfeld and Frebold<sup>1</sup>) the present species is distinguished by its longer secondary ribs, sharper primaries and a more cadoceratid whorl-shape. In young *Dolikephalites typicus* from the Yorkshire Cornbrash (e.g. Blake's originals in the British Museum) the ribbing again is like that of the Novaya Zemlya form, but, as already mentioned, in those immature *Arctocephalites* that were figured by Buckman as '*Miccocephalites*' and '*Metacephalites*', similar sharp costation is found, the primaries, at the point of greatest whorl-thickness especially forming prominent, sharp, edges. '*Miccocephalites concinnus*, Buckman, in fact, seems to differ from the young of the present species merely in compression. Later, the rib-bundles become more rounded and in at least one example (Plate XI, figs. 7a, b), referred to the var. *magna*, but crushed obliquely, there is a superficial resemblance to *Emileia*. This type of ribbing seems different from that of *A. arcticus*; but in an example of *A. pilaeformis* from Franz Josef Land (B. M. No. C. 7251) the ribbing is similar and differs only on account of difference of whorl-shape, i.e. the configuration of the high umbilical slope. In the more typical examples, however, the primary ribs are only slightly more prominent than in *A. arcticus* and differ chiefly in being trifid more often than bifid. On the other hand, these primaries may persist, as obscure folds, after the peripheral ribs have disappeared, but there may be an occasional indistinct constriction or a faint bulge (as in *Ptychophylloceras*) on the smooth body-chamber. The mouth-border, in the holotype, is preceded by a very oblique and deep furrow, far more conspicuous than that figured by G. Boehm<sup>2</sup>) for *Macrocephalites keeuwensis*, but with a similar lip. There is a muscle-scar

<sup>1</sup>) *Loc. cit.* (Rep. Sci. Res. Norweg. Exped. Novaya Zemlya, 1921), 1924, pl. I, fig. 1.

<sup>2</sup>) *Loc. cit.* (Palaeontographica, Suppl. IV) 1912, pls. XXXVII and XLII.

on the figured side, comparable to that of the Mombasa *Aspidoceras* recorded by Crick<sup>1</sup>).

Only the terminations of the three saddles of the last suture-line are visible in the holotype and another example might almost be the original of Stehn's *Macrocephalites rotundus* (Tornquist) var. *eurystoma*<sup>2</sup>), since it has the last septal edge similarly weathered out and a comparable smooth body-chamber, with a constriction at the end. These final suture-lines are always simplified (as in Plate IV, fig. 8) but at earlier stages the suture-line is fairly complex (see Plate XI, fig. 7b).

The example (No. 384) of the coarsely-ribbed variety, above listed, is almost indistinguishable from the true *A. arcticus*, figured in Plate XII, fig. 2, and they are separated merely because the inner whorls, in the Franz Josef Land material before me, are also more distantly-ribbed. The Spitsbergen examples, figured by Frebold<sup>3</sup>) are correspondingly less comparable. His largest example and Pavlov's<sup>4</sup>) Siberian "*Macrocephalites ishmae*, var. *arcticus*", are probably closer to *A. pilaeformis* than to the restricted *A. arcticus*; for both retain the primary ribbing to a fairly large size. The other two examples figured by Frebold are more doubtful; one (fig. 2) resembles the variety of *Arctioceras kochi* represented in Plate XV, fig. 5, but only at the posterior end; and judging by the peripheral ribbing at the larger end, it is a form of *Arctocephalites*. Frebold's smallest example (fig. 1), by its smooth periphery, suggests a transition between *Arctocephalites* and *Cranoccephalites*. Frebold was probably right in stating that his examples might not only belong to different species but might be derived from different horizons.

Horizon and Localities:—*Arctocephalites* beds, Mt. Hjørnefjæld, loc. 2, 760 m (23 examples, including doubtful fragments); loc. 1, 700 m (3 examples).

### 3. *Arctocephalites elegans*, sp. nov.

(Plate X, figs. 4a, b).

This form is distinguished from the last by its compression and the more delicate ribbing, with three secondaries to each primary, persisting on the early part of the body-chamber. The dimensions of the holotype are:—

Diameter	Whorl-height	Thickness	Umbilicus
in mm	%	%	%
85	53	37	7

<sup>1</sup>) "On the Muscular Attachment of the Animal to its Shell in some Fossil Cephalopoda (Ammonoidea)". Trans. Linn. Soc. London (2) VII, 4, 1898, p. 103, pl. XIX, figs. 6—7.

<sup>2</sup>) *Loc. cit.* (1924), pl. XIII, fig. 1.

<sup>3</sup>) *Loc. cit.* (Mesozoikum in Spitzbergen), 1930, p. 71, pl. XXIII, figs. 1—3.

<sup>4</sup>) *Loc. cit.* (Result. scient. expéd. pol. Russe), 1914, pl. XVIII, fig. 2.

The inner whorls are like those of *A. nudus*, but they are not shown in the holotype, though they could be exposed in a slightly deformed (crushed) paratype (No. 372). There are several examples apparently intermediate between the present species and the other forms here discussed, and it might be thought that they all have similar inner whorls. In some of them, however, the early volutions are comparatively evolute and strongly ribbed. Thus the specimen figured in Plate III, fig. 4, is separated generically from the present species (see p. 23), although there is a considerable resemblance, whereas another small specimen here figured (Plate VI, fig. 4) while it cannot be attached to any definite species and while it appears to be rather different, may yet be closely allied to the present species.

At about 50 to 60 mm diameter, the tripartite ribbing is most typically developed, but the primary ribs have become lengthened while the secondaries are shorter, being only three-fifths of the length of the whole rib, whereas in the young the secondaries are more than two-thirds. This, however, is largely due to the umbilicus narrowing (from 18% to 7%) with increase in size and to the gentle rounding of the umbilical slope. The periphery is evenly arched, but the body-chamber shows a wide and shallow constriction in the middle and a smaller (on the ventral part only) just before the constricted peristome. The body-chamber occupies about two-thirds of the outer whorl.

The suture-line cannot be distinctly seen in the holotype but in the paratype already referred to it is as complex as that of the more inflated example figured in Plate XI, fig. 7, or in *A. ellipticus* (Plate XIII, fig. 6). The latter is very close to the form here described also in the ribbing, but it has a relatively broader and more flattened periphery and presumably the more globose inner whorls of the other Franz Josef Land species. There is also resemblance, in the ribbed stage, to various other Macrocephalitids, e.g. *Nothocephalites semilaevis*, Waagen<sup>1)</sup> sp., but the resemblance is found to be superficial when actual specimens are compared, the combination of characters never being the same. In an example transitional to *A. nudus*, however, the likeness to Burckhardt's<sup>2)</sup> *Macrocephalites andinus* is striking although the suture-lines are very different in the two stocks.

Horizon and Locality:— *Arctocephalites* beds, Mt. Hjørnefjæld, loc. 2,760 m (3 examples).

<sup>1)</sup> Jurassic Fauna of Kutch. I. Cephalopoda. Mem. Geol. Surv. India, Pal. Indica, ser. IX, no 1, 1875, p. 119, pl. xxviii, fig. 3.

<sup>2)</sup> Beiträge zur Kenntniss der Jura- und Kreideformation etc., Palaeontogr. vol. 50, 1903, p. 33, pl. III, figs. 10—12.

small size and the bifurcation of most of its ribs. In the most typical example of this variety here figured, both the last septal edge and the final constriction can be seen and the body-chamber occupies only about half a whorl. In the holotype it is three-quarters of a whorl in length, without the aperture, and in another example (No. 192) intermediate between the type and the variety *pygmaeus*, the smooth lip of the peristome is shown, bent downwards and with a wide constriction preceding it, as in a specimen of *Defonticeras* before me (B.M. no. C. 35800). The suture-line is not discernable in any of the examples.

There are transitions between this species and *C. vulgaris* (e.g. No. 110) with merely a wider umbilicus than certain specimens attached to the var. *compressa* of that species, also to *C. inversus* (e.g. 331) or at least to some of the compressed specimens (44c) doubtfully referred to that form.

Horizon and Localities:— *Pompeckji* horizon, Mt. Hjørnefjæld, locality 2b, 740 m, 11 examples; locality 6, 740 m, 2 examples.

#### 11. *Cranocephalites subextremus*, sp. nov.

(Plate IX, figs. 5a—c).

This species is represented only by the body-chamber fragment represented in Plate IX, fig. 5, which may not seem sufficient for the creation of a new name; but since this form is so obviously merely an extreme development of the same stock that produced *C. furcatus* and *C. maculatus*, with a more depressed whorl-section, it is possible to reconstruct its earlier volutions. The contraction of the portion of body-chamber that is preserved alone shows that the umbilicus opened out on the last whorl, as in the other species here described, the whorl-height decreasing from 30 mm to 27 while the diameter still increases. Taking the diameter of the complete specimen to have been about 93 mm, the dimensions at the end would have been approximately:—

Whorl-height .....	30 %	of the diameter
Whorl-thickness .....	62 %	— —
Umbilicus .....	35 %	— . —

With regard to the thickness it may be mentioned that as the ventral view (fig. 4b) shows, there is only a very slight decrease in thickness of the body-chamber towards the constricted mouth-border, but the rim of this itself is somewhat flared, so that the maximum thickness of the shell is at the extreme end. At a diameter of about 60 mm, i.e. approximately at the end of the septate portion, the whorl-height was probably about 50 % and the umbilicus only 15 % of the diameter.

The ribbing is essentially like that of the last species but the secon-

4. *Arctocephalites* sp. ind.

(Plate VI, fig. 4).

The body-chamber fragment here figured is somewhat worn but the ribbing seems unusually flexiradiate, as in *Dolikephalites*. This specimen, however, would not have been separated from various fragments of the other finely-ribbed and compressed species of *Arctocephalites* here described, if it were not distinctly transitional to another body-chamber example in the collection (Plate III, fig. 4) which has a comparatively small umbilicus and is itself connected by a passage form with *Cranocephalites gracilis* (see p. 23). The ribbing is of the same character as that of the young *A. nudus* figured in Plate IX, fig. 3, but distinctly coarser at first, although becoming finer at the end. The only species of *Arctocephalites* here named that has a similar wide umbilicus in the young is *A. sphaericus*, but its costation is still coarser and the whorls are more inflated. In the example here discussed the thickness is slightly less than the whorl-height.

Horizon and Locality:— *Arctocephalites* beds, Mt. Hjørnefjæld, locality 2, 760 m (1 example).

5. *Arctocephalites ornatus*, sp. nov.

(Plate VIII, fig. 3; Pl. XI, fig. 5).

The specimen figured in Plate VIII, fig. 3, is selected as type of this form because on the side not figured the impression of parts of the earlier whorls is retained, showing these to be as finely-ribbed as the young *A. nudus* represented in Plate XV, fig. 2. Similarly fine ribbing is shown in the dorsal area of a smaller paratype, already with half a whorl of body-chamber, and this forms a transition to the more strongly ribbed variety (var. *pleurophorus*) figured in Plate XI, fig. 5, in which the dorsal area (at 60 mm diameter) shows the impress of a few strong costae. The dimensions of these three specimens are:—

	Diameter in mm	Whorl- height %	Thickness %	Umbilicus %
Holotype (Plate VIII, fig. 3) . . . .	95	48	54	17
Paratype (No. 371) . . . . .	67	50?	54	16?
var. <i>pleurophorus</i> (Plate XI, fig. 5)	85	48	52	18

The thicknesses, in the case of the two figured examples, are based on the reconstructed outlines, as shown; for since the opposite sides are largely worn away, the specimens appear much thinner. The wide ventral area, however, and the general whorl-shape agree with the

corresponding features in *A. nudus*. The distinctive character of the present species is the persistence of comma-shaped primary ribs after the secondaries have first weakened and then disappeared entirely, on the earlier part of the body-chamber, also in the rejuvenescence of the costation on the anterior part of the body-chamber. Since there is, at the same time, more distinct excentrumbilication than in the other species of *Arctocephalites*, the form here described may be considered somewhat transitional to *Cranocephalites*.

The strongly inclined terminal furrow with its apertural lip is well shown in the var. *pleurophorus* (Plate XI, fig. 5) but is incompletely preserved in the holotype. This, on the other hand, shows a constriction, three ribs away from the final furrow, and other irregularities; and the costation of the small paratype is still more irregular, so that the species must be interpreted rather comprehensively, so far as the material now available is concerned. Another example (No. 370) might be considered a passage-form to *A. nudus*, having lost almost all ribbing except the crescentic primaries on the first half of the body-chamber which is all that remains. But the recrudescence of the ribbing after the smooth stage shows this form to be more appropriately attached to the present species. In the typical example, at the same diameter (between 60 and 70 mm) the costation is comparable to that of the var. *magna* of *A. nudus* (Plate XII, fig. 4a) but the paratype, at the same size, is already renewing the original strength of its ribbing. These irregularities, of course, make it impossible to refer every fragment in the collection before me to its proper 'species', but when more perfect material becomes available the various forms now included in the present species can easily be separated.

The suture-line is not visible in any of the examples, but even in its absence it is almost impossible to confuse this species with any other described Macrocephalitid.

Horizon and Locality:— *Arctocephalites* beds, Mt. Hjørnefjæld, locality 2, 760 m (4 examples and one doubtful fragment).

#### 6. *Arctocephalites sphæericus*, sp. nov.

(Plate VI, fig. 3; Pl. VIII, fig. 2; Pl. XVI, fig. 5; Pl. XVII, fig. 1; Pl. XIX, fig. 4).

The holotype of this species (Plate XVII, figs. 1a, b) is poorly preserved, but it has an almost complete body-chamber and there are other smaller examples that allow of sufficient reconstruction of the species to give it a new name. The dimensions are as follows:—

	Diameter in mm	Whorl-height %	Thickness %	Umbilicus %
Holotype (Plate XVII, fig. 1)	120	48	65	20
Paratype (Plate XVI, fig. 5)	56	48	66	12
Compressed variety (No. 376) (at)	56	52(?)	60(?)	10(?)

The inner whorls of the holotype are scarcely recognisable but apparently have coarse ribs and a comparatively open umbilicus. The immature specimens, represented in Plate VI, fig. 3, and Plate VIII, fig. 2, show this type of inner whorl even if they cannot definitely be assigned to the present species. The still smaller fragment figured in Plate XIX, figs. 4a, b, also shows a similar early biplicate stage with sharp costae. In the larger fragment (Plate VI, fig. 3) and in the paratype (Plate XVI, fig. 5) triplicate ribs have already appeared and the ribbing at a later stage becomes blunt and less distinct. In the holotype, at 80 to 90 mm diameter, the costation has all but disappeared and only a few umbilical bulges remain. In the compressed variety, above listed, differing merely in its less sphaeroidal whorl-shape, the degeneration of the ribs is more distinctly shown, but unfortunately this example retains only a portion of the body-chamber. This occupies about two-thirds of the outer whorl in the holotype, but the aperture is not preserved.

An example (No. 329) which is somewhat intermediate in whorl-shape between the holotype and the compressed variety above listed, also shows a portion of the body-chamber (originally three-quarters of the outer whorl in length) and it can be seen that this is almost exactly like that of *A. nudus*, with a final, oblique, constriction. In the holotype the accidental absence of the inner whorls on the figured side wrongly suggests a very deep, cadoceratid umbilicus. The suture-line is not distinctly shown in any example.

The present form, at the stage represented by the paratype (Plate XVI, fig. 5) is much like certain *Kamptokephalites*, e.g. *K. hudlestoni*, Blake sp.<sup>1</sup>) or *K. subpila*, Spath<sup>2</sup>). The former is far less globose and the latter has a more cadoceratid umbilical wall than the form here described; and in complete examples, the differences are, of course, considerable, the sharp ribbing persisting to the mouth-border in *Kamptokephalites*.

Horizon and Locality:— *Arctocephalites* beds, Mt. Hjørnefjæld, loc. 2,760 m (13 examples including doubtful fragments).

<sup>1</sup>) Fauna of the Cornbrash: Mon. Pal. Soc. 1905, p. 47, pl. iv, fig. 3.

<sup>2</sup>) *Loc. cit.* (Kachh, 3), 1928, p. 173.



7. *Arctocephalites* sp. nov.

(Plate IV, figs. 7a—c; Pl. VII, fig. 7; Pl. XVI, figs. 1a, b).

This species is distinct enough from the similarly sphaeroconic *A. sphaericus* to be given a separate name, yet I hesitate to increase the number of forms from the Hjørnefjæld assemblage since all the specimens available are incomplete. The (slightly crushed) example figured in Plate XVI has the following dimensions:—

Diameter in mm .....	71
Whorl-height (in % of diameter) .....	50
Thickness (in % of diameter) .....	66
Umbilicus (in % of diameter) .....	14

In the side-view (fig. 1a) part of the outer whorl has been removed to show the earlier evolution. In the peripheral view (1b) the missing piece is added, showing the sphaeroidal shape of the shell, with its extremely depressed whorls. The high and steep umbilical wall is well rounded and the edge is not abrupt, as it is in *Cadoceras*. The example is entirely septate and the umbilicus remains small. The distinctive feature, again, is the costation which is unusually sharp and lamellar on the test, the internal cast having much lower and more rounded ribs. The decline of the costation towards the end of the specimen, seen in the figure, is only apparent, and due to the presence of firmly adhering matrix, in between the prominent ribs. These are bi- and trifurcating and in the young do not differ from those of the more compressed *A. nudus*. The ribs are radial across the periphery at about 45—50 mm diameter, but later the peripheral sinus forward, seen on the earliest whorls of a second specimen (Plate IV, figs. 7a—b), is more developed. The ribbing, thus, altogether shows a remarkable resemblance to that of *Indocephalites*. The suture-line is only indistinctly visible in the larger specimen, but is clearly shown on the inner whorls. It is then characterised by its deep external lobe (Plate IV, fig. 7c).

An example (No. 364) that may be discussed here differs from the figured specimen in having still finer ribbing, comparable to the trifid costation of *A. elegans*, but persisting to a larger diameter (72 mm) and comprising half a whorl of body-chamber. While this example thus represents a passage-form between the two species, its inflated whorl-shape brings it closer to the form here discussed. A fragment (No. 367) of probably a similar finely-ribbed species shows septal surfaces (Plate VII, fig. 7) that may be compared with those of typical Macrocephalitids figured by Quenstedt<sup>1)</sup>; but the vertical umbilical wall has almost

<sup>1)</sup> Ammoniten des Schwäbischen Jura, vol. II, 1887, pl. LXXVI.

*Cadoceras*-like ribs (although with a rounded edge), as in (the far more distantly-ribbed) *Indocephalites diadematus* (Waagen)<sup>1</sup>), which itself had been included in *Cadoceras*. The innermost whorls are more evolute than the next three volutions and the umbilical cast (Plate VII, fig. 7b) is much like that of an involute *Cadoceras* of the *orbis* group (see p. 61).

Another example (No. 365) with only the beginning of the body-chamber at 70 mm diameter, is slightly less inflated than the larger figured specimen, but also costate throughout. It may be considered a passage-form to the more compressed varieties of *A. sphaericus*, recorded on p. 41, or to the var. *magna* of *A. nudus* (Plate XII, fig. 4), but it differs considerably from the former species in the fineness of its ribbing and from the latter in retaining the ribbing on at least part of the body-chamber.

Horizon and Locality:— *Arctocephalites* beds, Mt. Hjørnefjæld, locality 2, 760 m (5 examples).

8. *Arctocephalites* (?) *platynotus*, sp. nov.

(Plate XI, figs. 6a, b).

Although this form is represented only by a body-chamber fragment, it is worthy of being given a new name; for it is not only clearly different from any described species, but shows the last septal edge at one end and part of the peristome at the other. It thus differs from the associated *Arctocephalites* in the extreme shortness of the body-chamber as well as in retaining the costation unimpaired. The dimensions cannot be accurately determined but at a diameter of about 75 mm, the whorl-thickness must have been at least 87 % and probably more at the flared peristome. The height, however, decreased from about 53 % to 44 % near the aperture, so that the originally small umbilicus opened out at the end. There is no trace of the earlier whorls visible in the micaceous sandstone matrix and the last suture-line only shows the indistinct terminations of the two external saddles and of one lateral saddle.

The ribbing is radial; the blunt primaries pass over the rounded umbilical slope with a slight curve forward, but the two or three secondaries are almost rursiradiate and the strong inclination forward shown in the figure (6a) is due to the photograph not being taken at right angles to the plane of coiling. This is important; for comparing the present form with its nearest ally, *Sphaeroceras extremum*, Tornquist<sup>2</sup>), it is seen at once that there is no essential difference in the ribbing, even if the Andine form is drawn with distinctly rursiradiate secondaries. The

<sup>1</sup>) See Spath: Revision of the Jurassic Cephalopod Fauna of Kachh, *loc. cit.*, pt. 3, 1928, p. 188, pl. XXI, fig. 7.

<sup>2</sup>) *Loc. cit.* (Dogger v. Espinazito), 1898, p. 47, pl. VI figs. 5—6.

blunter primaries in the present species and the greater length of the secondaries are merely specific differences, but the proportions of Tornquist's holotype (79—.57—.96—.08) are also different. Since this author does not mention the length of the body-chamber in his larger example (which may be complete, judging by the smoothness at the end) and since the inner whorls of the present form are unknown, the comparison cannot be carried any further for the present.

Horizon and Locality:— *Arctocephalites* beds, Mt. Hjørnefjæld, locality 2, 760 m (1 example).

Genus *XENOCEPHALITES*, Spath, 1928.

*Xenocephalites borealis*, sp. nov.

(Plate XIV, figs. 4a—d).

The unique example here figured has the following dimensions:—

Diameter . . . . .	24 mm		
Whorl-height . . . . .	50 % of the diameter.		
Thickness . . . . .	67 %	—	—
Umbilicus . . . . .	10 %	—	—

It is merely the internal cast of the septate nucleus of a larger form, but its ribbing is so different from that of any other Greenland species here described that it undoubtedly represents a distinct form. The ribs are characterised by a distinct backward curve on the rounded umbilical wall and again near the periphery, but a pronounced inclination forward on the inner whorl-side, also by their extreme thickening towards the venter. At the same time there is a distinct flattening of the tops of the ventral ribs and this flattened surface slopes gently towards the back, so that the forward face of the ribs is higher than the backward, giving the ribbing a curious, scaly, appearance. This can be seen in fig. 4b on the last rib but one. On the earlier half of the outer whorl the ribs bifurcate, still below the middle of the side and yet unusually high up, compared with the forms of *Cranocephalites* and *Arctocephalites*, here described. Later the secondaries are merely intercalated and towards the end all the ribs show a slight ventral sinus forward. This causes a biconcavity of the ribs between the umbilical suture and the siphonal line, but the outer concavity is less marked than the inner. The whorl-section is greatly depressed, with a wide ventral area, but it is regularly rounded, laterally as well as ventrally.

The suture-line (fig. 4d) is simple at first (12 mm diameter) but seems to become more complicated later, with the termination of the first lateral lobe well below the level of the external lobe, not above, as in the earlier stages. The trifid second lateral lobe also is much deeper

and more individualised at the end, and the succeeding bifid saddle (already the first auxiliary) is in the region of the greatest whorl-thickness.

The only species with which the new Greenland form can be compared is *X. neuquensis* (Stehn)<sup>1)</sup> showing similar ribbing, but apparently stronger primaries. Since this form, however, has its body-chamber almost complete, whereas the species here described consists only of septate inner whorls, comparison is not easy. The opening out of the umbilicus in the Andine species and the differences in the dimensions are due to the difference in size, but the alternation of the ribs is identical. '*Macrocephalites*' *nikitini*, Burckhardt<sup>2)</sup>, if correctly interpreted by its author, is not closely related.

The small ammonite fragment collected by Nordenskjöld at his fossil locality I and recorded (but not determined) by Madsen<sup>3)</sup> shows some resemblance to the present species, also to *X. neuquensis*, in the smooth collar-band terminating the body-chamber (at 25 mm diameter). The presence of this body-chamber may account for the decrease in thickness and the open umbilicus, compared with *X. borealis*, but the periphery is almost smooth on the earlier part of the body-chamber (which occupied about three-quarters of the final whorl). There is no species of *Cranocephalites* that shows rejuvenescence of the ribbing near the peristome to such an extent, even if it only affected the last three or four ribs. Moreover, the slight peripheral sinus in these ribs is directed backward, not forward, as in *X. borealis*. On the other hand, the small example collected by Nordenskjöld has a similarly prolonged, smooth, early stage and the ribs of its septate whorls (visible to 13 mm diameter) are equally blunt (striated on the test, as in the entirely unrelated *Epicephalites epigonus*, Burckhardt sp.<sup>4)</sup>) but finer and more closely spaced than those of *X. borealis*. Being too incomplete, this probable second species of *Xenocephalites* from East Greenland unfortunately cannot be definitely identified and the suture-line also could not be developed.

Horizon and Locality:— Mt. Hjørnefjæld, loose, with one example of *Cranocephalites pompeckji*. (Holotype specimen).

<sup>1)</sup> Beiträge zur Kenntnis des Bathonien und Callovien in Südamerika". In Steinmann: Beitr. z. Geol. & Pal. v. S. Am. XXV, N. Jb. f. Min. &c. Beil. Bd. XLIX, 1923, p. 86, pl. 1, fig. 3 (1924).

<sup>2)</sup> "Cefalopodos del Jurasico Medio de Oaxaca y Guerrero". Inst. Geol. Mexico, Bol. no. 47, 1927, p. 34, pl. xvi, figs. 4—9.

<sup>3)</sup> *Loc. cit.*, 1909, p. 198.

<sup>4)</sup> "La Faune Jurassique de Mazapil." Bol. Inst. Geol. Mexico, No. 23, 1906, p. 20, pl. iii, fig. 9 (last portion).

Genus *PLEUROCEPHALITES*, Buckman, 1922.*Pleurocephalites* (?) sp. ind.

(Plate XIX, fig. 5).

Although represented only by the cast of two air-chambers, somewhat crushed obliquely, this form must be discussed separately since it indicates the presence of yet another group of *Macrocephalites* in the Greenland Jurassic. The ribbing is fairly close, since there are six ribs on the venter in a distance of 21 mm, and they are comparatively sharp, especially the primary portions. These project most at the point of greatest whorl-thickness, but pass over the high and rounded umbilical wall. The angularity of the umbilical edge shown in the figure is not natural, and there is no suggestion of a cadoceratid whorl-shape, despite the extreme depression. The ribs were apparently bi- and trifurcating; the primary portion is crescentic, the secondaries are radial. On the dorsal area the costation is obliterated. The suture-line cannot be distinctly seen.

While there is a general resemblance to *Indocephalites diadematus* (Waagen), the more projecting primary ribs suggest a form still closer to *Cadoceras*. I have previously pointed out that the Indian species has nothing to do with *C. sublaeve* or *C. 'modiolaris'*, as Waagen<sup>1)</sup> held, nor can it be placed between *C. elatmae* and *C. sublaeve*, as Nikitin<sup>2)</sup> suggested. In all these Cadocerates the secondary ribs have become reduced or are entirely lost at a similar diameter.

In some of the Greenland species of *Cadoceras* on the other hand, the costation persists to a large diameter, but there is either a sharp umbilical rim, as in *C. calyx*, or blunt ribbing, as in *C. crassum* and *C. frebaldi*. On the whole, then, the reference of the fragment to a Macrocephalitid rather than to a Cadoceratid seems justified, and the most appropriate genus is *Pleurocephalites*, although some depressed *Kamptokephalites*, like *K. terebratus* (Phillips)<sup>3)</sup> or *K. herveyi* (J. Sowerby)<sup>4)</sup> could also produce a similar whorl-portion, if distorted. In the absence of the earlier whorls and the body-chamber<sup>5)</sup>, definite identification, of course, is impossible, but in *Kamptokephalites* the ribbing is rather

1) *Loc. cit.* (Jurassic Fauna of Kutch), 1875, p. 131.

2) *Loc. cit.* (Elatma, II), 1885, p. 56.

3) See Blake, *loc. cit.* (Fauna of the Cornbrash), 1905, pl. III, fig. 6 only; also Spath, *loc. cit.* (Kachh Revision, III) 1928, p. 172).

4) Mineral Conchology, vol. II, p. 215, 1818, pl. cxcv.

5) The large *Pleurocephalites* that develop a smooth final stage, like *P. polyptychus*, Spath sp. (= *Amm. tumidus*, d'Orbigny, Pal. Française, Terr. Jurass. vol. I, 1846, pl. CLXXI), form the group for which I previously accepted Buckman's name *Macrocephalicerat* (1928, p. 174).

coarser, at this stage, while in the true *Macrocephalites* it is finer, without the strong and sharp primaries. *Indocephalites* which differs from *Pleurocephalites* chiefly in retaining its ribbing to the end and in developing from coarse to fine, instead of from very fine to coarse, and then to smooth, is probably a less likely stock since *Pleurocephalites* of the *pila* and *krylowi* group (see p. 72) have been found together with *Arcticoceras ishmae* also in the Petchora Basin. Since the whorl-shape, on account of the crushing, is not original, detailed comparison with the forms of this group is not necessary.

Horizon and Locality:— *Arcticoceras* beds, 545—570 m, Mt. Mikael (1 example).

### Family *Cardioceratidae*, Hyatt, 1892, emend.

#### Sub-Family *Cadoceratinae*, Hyatt, 1900, emend.

The large number of genera established for members of the original *Cardioceratidae* makes it advisable to split it up into the sub-families *Cadoceratinae* and *Cardioceratinae*, the latter to include those post-*Quenstedioceras* developments in which a cordate whorl-section and a serrated keel are conspicuous at all stages. This excludes from *Cardioceratinae* the genus *Chamoussetia* which is merely a keeled *Cadoceratid*, but in the case of some transitional forms (e.g. *Goliathiceras*, Buckman 1919) reference to *Cardioceratinae* rather than *Cadoceratinae* becomes arbitrary. The latter sub-family then is taken to include the following genera:—

*Cadoceras*, Fischer, 1882.

*Arcticoceras*, Spath, 1924.

*Paracadoceras*, Crickmay, 1930.

*Chamoussetia*, R. Douvillé, 1911

*Pseudocadoceras*, Buckman, 1919.

*Quenstedioceras*, Hyatt, 1876 (synonyms:— *Prorsiceras*, Buckman, 1918, *Bourkelamberticeras*, Buckman, 1920, *Weissermeliceras*, Buckman, 1920).

s. g. *Longaeviceras*, Buckman, 1919.

s. g. *Vertumniceras*, Buckman, 1918.

s. g. *Eboraciceras*, Buckman, 1918, (synonyms:— *Eichwaldiceras*, Buckman, 1920, and *Sutherlandiceras*, Buckman, 1922).

s. g. *Pavloviceras*, Buckman, 1920.

The first three of these, occurring in East Greenland, are discussed below in some detail. No member of the *Cardioceratinae* is represented in the material before me, and another *Cadoceratid* offshoot, the *Pachyceratinae*, is quite unknown from the boreal province.

*Chamoussetia* which also has not yet been found north of Yorkshire

and Russia, is a well-defined and universally accepted group, characteristic of the lower *Cadoceras*-bearing beds; the later genus *Quenstedioceras* similarly is not represented in the Greenland material before me, but must be briefly reviewed, chiefly on account of the resemblance between *Longaeviceras* and *Arcticoceras* on the one hand and between *Eboraciceras* and *Cadoceras* on the other. Both *Longaeviceras* and *Eboraciceras*, however, are connected with the other groups of *Quenstedioceras* by so many transitions, that it is advisable to consider them merely subgenera.

Concerning the name *Quenstedioceras*, it ought to be pointed out that Nikitin's description of 1884 settles the spelling. Moreover, as Crickmay pointed out, Hyatt himself used the spelling *Quenstedioceras* still in 1892 so that the original form must be retained, whether right or wrong. The type is *Q. leachi*, not *Q. lamberti*, as Nikitin held, but Sowerby's view that the former was possibly only a variety of the latter might be endorsed even at the present day, the tendency to inflation being perhaps not even a specific character. The coarseness of the ribbing is scarcely more important, but *Vertumniceras* may perhaps be retained for the strongly ribbed forms, just as *Eboraciceras* can be used for the inflated forms that return to a cadoceratid outer whorl. The resemblance of some of the Yorkshire forms to true *Cadoceras* is often most baffling.

The attainment of carination, again, is so variable a feature that it can be used for systematic purposes only in a very general way. If *Quenstedioceras* is derived from *Cadoceras*, and *Cardioceras* again from *Quenstedioceras*, then there must be transitions between them. And since the change did not take place in only a single line but in the general course of development of all the varied groups (in the present case the tendency was towards carination) there are so many possibilities of a more or less successful attempt in one direction being combined with more or less failure in others that almost every species could be taken to represent a distinct lineage and be given a generic name.

Thus the pronouncement of Crickmay<sup>1)</sup> that among the species described by Reeside there were a dozen or so generic groups is merely emulating the methods of the late S. S. Buckman. In Britain there is a continuous succession, often of enormous numbers, of all the types of *Quenstedioceras* and *Cardioceras*, from the Kellaways Clay to the Kimmeridge Clay, and a similar general overlapping of the genera in Russia has been illustrated by Smorodine<sup>2)</sup>. It would be a hindrance instead

<sup>1)</sup> *Loc. cit.* (Nat. Mus. Canada, Bull. 63), 1930, p. 55.

<sup>2)</sup> "Etude sur les relations génétiques des ammonites de la famille des Cardioceratidés." Bull. Ass. Réch. Sci., Fac. Sci., I<sup>re</sup> Univ. Moscou. vol. I, 1926, pp. 97—114, pl. 1.

of a help to science to restrict these two genera to small groups within them, as was done by Buckman, and to accept his new genera as of equal rank, thus removing from *Quenstedioceras* and *Cardioceras* many of the most typical species. The essential homogeneity of the family *Cardioceratidae* is obvious although the genera are all polyphyletic. For I agree with Smorodine that the different forms of *Quenstedioceras* were derived independently from various species of *Cadoceras*, and the different *Cardiocerates* again from various *Quenstediocerates*. The new Greenland material here described enables us to trace the *Cadoceratid* stock back at least two more stages, and to show that even *Cadoceras* and *Chamoussetia* have a separate origin.

While *Quenstedioceras* (*Eboraciceras*) *mologae* and *Q. rybinskianum* (Nikitin)<sup>1</sup> still retain ancestral *Cadoceras* features, a member of yet another *Cadoceratid* offshoot, i.e. the *Pachyceratinae*, has actually been mistaken for *C. sublaeve*, the genotype of *Cadoceras*. This curious form is *Pachyceras jarryi* (Eudes-Deslongchamps MS.) R. Douvillé<sup>2</sup>, first described as *Amm. (Stephanoceras) sublaevis* by Damon<sup>3</sup> in 1860 and by Eudes-Deslongchamps<sup>4</sup> in 1889, and named again (1913) by Buckman<sup>5</sup> who pointed out that even Pompeckj had failed to see that it was not a *Cadoceras*. Such cases of resemblance are to be expected in a homogeneous stock and the fact that Buckman's own '*Catacephalites*' now turned out to be a *Cadoceras* shows that our complex modern nomenclature represents but little real advance. The inclusion of Bruguière's *Amm. coronatus* in the *macrocephali* instead of the *coronarii*, hundred years ago, was a master stroke; the petty question as to whether this species is to be referred to *Cadoceras* (Model), *Pachyceras* (Haug), or *Erymnoceras* (Hyatt) matters most to those who place a fictitious chronological value on these genera.

<sup>1</sup> "Die Jura-Ablagerungen zwischen Rybinsk, Mologa und Myschkin an der oberen Wolga." Mém. Acad. Imp. Sci. St. Pétersb. (VII) vol. xxviii, No. 5, 1881, p. 50, pl. 1, figs. 8—12.

<sup>2</sup> "Etude sur les *Cardioceratidés* de Dives, Villers-sur-Mer, et quelques autres gisements." Mém. Soc. Géol. France, Paléont., vol. XIX, fasc. 2, 1912, p. 37.

<sup>3</sup> "Handbook to the Geology of Weymouth and the Island of Portland." London, p. 28, fig. 14.

<sup>4</sup> "Rapport sur les Fossiles Oxfordiens de la Collection Jarry." Bull. Soc. Linn. Normandie, vol. II, 1889, p. 26.

<sup>5</sup> "The 'Kelloway Rock' of Scarborough". Quart. Journ. Geol. Soc. vol. LXIX, 1913, p. 163.



Genus *ARCTICOCERAS*, Spath, 1924<sup>1)</sup>.

Genotype:— *Amm. ishmae*, Keyserling, in Keyserling and Krusenstern: "Wissenschaftliche Beobachtungen auf einer Reise in das Petchora-Land im Jahre 1843." St. Petersburg. 1846, p. 331, pl. xx, figs. 8—10.

The genotype species has been misinterpreted by most authors, including perhaps authorities like Pavlow<sup>2)</sup>, so that I am now refiguring a typical small Petchora specimen (Plate XV, figs. 7a, b) to show the characteristic sharp costation, the narrow venter and the small umbilicus, without rim. A much larger Petchora specimen in the British Museum (No. C. 6603) septate to the end (over 110 mm diameter) is still essentially the same, the strongly projected ribs only just beginning to disappear and bifurcating at about the middle of the side, but the primary portion forming less of a prominent crest than it did before. This agrees with the observations of Pompeckj<sup>3)</sup> and Sokolov<sup>4)</sup>, the latter of whom described the characters of the adult. I previously stated that this genus was related to *Pseudocadoceras*, Buckman, but did not comprise *Amm. ishmae*, var. *arcticus*, Newton, which is discussed above under *Arctocephalites*. The reference of the genus *Arcticoceras* to the Cadoceratinae in 1924 and again in 1928<sup>5)</sup> contrary to Lemoine<sup>6)</sup>, may be held to be open to objection, since in the adult it returns to a Macrocephalid stage, but this reference has now received impartial support by Rosenkrantz's first record of the East Greenland species here described as "big Cardioceratids, closely related to the forms described by Reeside under the name of *Quenstedticeras?* from Lower Oxfordian of North America."

The new forms now described seem to form an interesting group of transitions between *Arctocephalites* on the one hand and *Chamoussetia* on the other. *Arcticoceras michaelis* is the most Macrocephalid of the Greenland species but shows also resemblance to *Cadoceras pseudishmae*, in spite of its rounded umbilical border. The strongly ornamented

<sup>1)</sup> "On the Blake Collection of Ammonites from Kachh, India". Mem. Geol. Survey, India, Pal. Indica, N. S., vol. ix, no. 1, 1924, p. 7.

<sup>2)</sup> "Cephalopoda etc." in Result. Sci. Expéd. Polaire Russe 1900—03 sous la direction du Baron E. Toll". Mém. Acad. Imp. Sci. St. Pétersb. (VIII), vol. XXI, no. 4 (Classe Phys.-Math.) 1914, p. 62. The figured example (Plate XVIII, fig. 2) is poor but does not show an *Arcticoceras* periphery.

<sup>3)</sup> *Loc. cit.* (Cape Flora), 1899, p. 72.

<sup>4)</sup> *Loc. cit.* (Petschorascher Jura), 1912, pp. 15 and 49.

<sup>5)</sup> *Loc. cit.* (Pal. Indica, N. S. vol. 1, no. 2, pt. III), 1928, p. 174.

<sup>6)</sup> "Ammonites du Jurassique supérieur du cercle d'Analalava". Paléont. de Madagascar, VIII. Ann. Pal. vol. v, 1910, p. 20.

*A. kochi* is closer to the true *A. ishmae*; and its var. *pseudolamberti* is very similar to an example figured as belonging to *Chamoussetia stuckenbergi* (Lahusen)<sup>1</sup>). Yet the genus *Chamoussetia*, R. Douvillé<sup>2</sup>), is founded on a Savoy species (*Amm. chamusseti*, d'Orbigny<sup>3</sup>) = *Amm. lenticularis*, Phillips<sup>4</sup>), non Young and Bird) and has not been recorded from the Arctic Province. Moreover, there are species like *Cadoceras hyperbolicum* (Simpson MS.) Leckenby sp. and an allied new form (B.M. No. 21006) which connect the more acute *Chamoussetia* with *Cadoceras subpatruum*, Nikitin, so that in spite of the resemblance to *Arcticoceras* in ribbing and in suture line, *Chamoussetia* is not considered its immediate descendent, but merely a development of the same parent stock.

In connection with the absence from the Arctic areas of this genus *Chamoussetia*, it is interesting to record that in dissecting an English example of *C. chamusseti* (B.M. no. 37500), I came upon two *Placunopsis* valves attached to one side of the venter of the septate whorls (at about 80 mm diameter) and subsequently covered by the next outer whorl which in the same radius (at about 140 mm diameter) included only the beginning of the body-chamber<sup>5</sup>). This means that as in the case of the ceratite, recorded by Philippi<sup>6</sup>), or the *Lytoceras* (with *Discina*) figured by Dumortier<sup>7</sup>), the *Placunopsis* must have attached themselves to the living ammonite and grown to a fair size before becoming sealed up by the further growth of the shell. I agree with Benecke<sup>8</sup>) that in the case of a form swimming in an upright position, the peripheral attachment of a parasitic organism may not indicate a benthonic mode of life. I may mention in this connection that keeled shells like *Chamoussetia* have been considered to be well adapted for an actively swimming mode of life. Oxytote forms of *Platylenticeras* of the Valanginian with similar shape but constantly asymmetrical suture-lines and the siphuncle

<sup>1</sup>) In Stuckenberg "Otchet geolog. etc." Mat. Geol. Russia, St. Petersburg. Imper. Mineral. Soc. vol. VI, 1875, p. 115, pl. v, fig. 3 (not identical with *C. chamusseti*).

<sup>2</sup>) *Loc. cit.* (Cardioceratidés), 1912, p. 19. The inclusion of *Quenstedioceras* (*Longaeviceras*) *funiferum*, Phillips sp. 1829 (= *Amm. galdrinus*, d'Orbigny, 1846 = *Amm. galdrinus*, 1847) in *Chamoussetia* is not here accepted.

<sup>3</sup>) Pal. Française, Terr. Jurass., vol. I, 1847, p. 437, pl. clv. (The original spelling must be adhered to, although the species was named after the Savoy geologist Chamusset).

<sup>4</sup>) *Loc. cit.* (Geology of Yorkshire), vol. I, 1829, p. 142, pl. vi, fig. 25.

<sup>5</sup>) Over half a whorl in length in large examples (175 mm diameter) but not showing the peristome (with a ventral rostrum according to Nikitin).

<sup>6</sup>) "Über ein interessantes Vorkommen von *Placunopsis ostracina*, Schl. sp." Zeitschr. Deutsch. Geol. Ges. vol. LI, 1899, Verhandl. p. 67.

<sup>7</sup>) "Études paléontologiques sur les dépôts jurassiques du Bassin du Rhône". IV. Lias supér., 1874, p. 217, pl. XLVII, fig. 1.

<sup>8</sup>) "Versteinerungen der Eisenerz-Formation von Deutsch-Lothringen und Luxemburg". Abhand. Geol. Spez. Karte v. Els.-Lothr. N. F. Heft VI, 1905, p. 550.

always on one side, seem to me, however, to have been mainly benthonic crawlers, even if capable of swimming well when necessity arose. The rather coarse sandstone matrix of the Greenland forms here described and the associated other invertebrates certainly indicate shallow water; and I take all the Macrocephalitids and Cadoceratids to have had a mode of life similar to that of the recent *Nautilus*<sup>1</sup>).

In the description of *A. kochi* below it is mentioned that the suture-line of a young example resembles that of d'Orbigny's "*Amm. galdrinus*" (which is a synonym of *Quenstedioceras (Longaeviceras) juniferum*, Phillips sp.)<sup>2</sup>) on account of the increased number of umbilical elements. In fact even the external aspect of these Quenstediocerates is similar to that of the more crushed examples of *Arcticoceras*, here described, so that their first record (in Rosenkrantz) as *Quenstedioceras* is easily understood. The keeled inner whorls of *Q. (Longaeviceras) juniferum*, however, are decisive, and as in the case of the less specialised, common *Q. (Longaeviceras) placenta* (Simpson [Bean?] MS.) Leckenby sp.<sup>3</sup>) (= *Q. keyserlingi*, Sokolov<sup>4</sup>) I take it to be a development parallel with the group of *Cadoceras nikitini*, Sokolov<sup>5</sup>), the inner whorls of which foreshadow the keeled *Quenstedioceras*. For a new form of *Longaeviceras* occurs already in the Kellaways Rock (B.M. no. C. 13029).

While *Arcticoceras*, thus, is not intimately connected with either *Cadoceras* or *Chamoussetia*, not to mention *Quenstedioceras*, and while the development is entirely different from that of *Pseudocadoceras*, the genus is undoubtedly closer to *Arctocephalites*. Apart from the constant inclusion of *A. arcticus*, as a variety, in *Arcticoceras ishmae* and the consequent reference to '*Macrocephalites*', the involute whorl-shape, absence of a definite umbilical rim, and the smooth final stage, are also Macrocephalitid rather than Cadoceratid features. Here, again, then, it is the appearance of compression and projected costation in the young of *Arctocephalites*, foreshadowing the earliest *Arcticoceras*, that are taken

<sup>1</sup>) See Spath, Notes on Ammonites. Geol. Mag. vol. LVI, 1919, p. 32.

<sup>2</sup>) See Pal. Française, Terr. Jurass. I, 1847, pl. CLVI, fig. 3; also R. Douvillé, *loc. cit.* (Cardioceratidés), 1912, pl. III (IX), fig. 6, text-figs. 16—17, p. 22.

<sup>3</sup>) "On the Kellaways Rock of the Yorkshire Coast". Quart. Journ. Geol. Soc. vol. xv, 1859, p. 10, pl. II, fig. 1, refigured in Buckman: Type Ammonites, vol. III, 1920, pl. CXLVIII. A large Scarborough specimen (B. M. no. C. 1076) of over 140 mm diameter (with nearly a whole whorl of body-chamber) returns to a rounded periphery after the keeled stage, and in a Petersborough specimen (no. C. 19340) the rounding begins before the end of the septate stage.

<sup>4</sup>) "Zur Ammoniten-Fauna des Petschoraschen Jura". Mém. Com. Géol. St. Pétersb. N. S. livr. 76, 1912, p. 53, pl. II, fig. 2.

<sup>5</sup>) *Ibid.*, p. 53, pl. I, figs. 3a—d.

to afford the clue to the interpretation of the latter as an early *Cadoceras* offshoot of the *Macrocephalitid* root-stock, independent of *Cadoceras* itself.

1. *Arcticoceras kochi*, sp. nov.

(Plate XII, fig. 1; Pl. XIII, figs. 4—5; Pl. XIV, figs. 1—3; Pl. XV, figs. 1, 4—6).

None of the numerous examples and fragments is perfect enough to serve as the sole basis of a new species, yet piecing together the evidence of all, this form may be considered to be the most characteristic and best known of the species of the Greenland *Arcticoceras* beds. The measurements of some of the examples are as follows:—

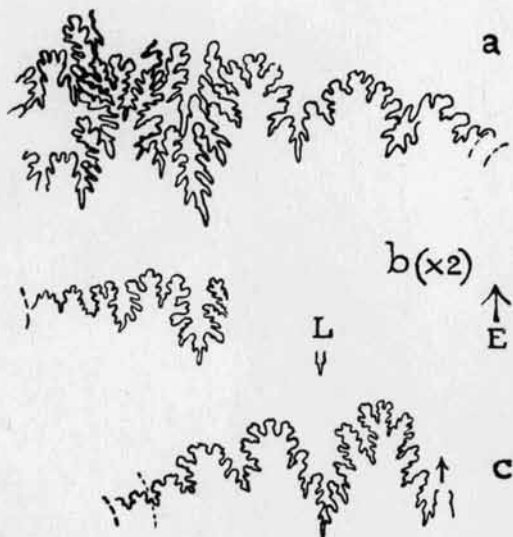
	Diameter in mm	Whorl-height %	Thickness %	Umbilicus %
Holotype (Plate XV, fig. 1) . . .	115	51	(?)	15
Paratype I (Plate XII, fig. 1) .	105	48	42	17
— II (Plate XIV, fig. 1) .	160	50	(?)	10
No. 354 (suture-line, text-fig. 3)	132	49	(?)	10
Inner whorls (Plate XV, fig. 4) .	55	44	39	26

This species can be best described by calling it an extremely close ally of *A. ishmae*, differing chiefly in greater inflation, more robust ornamentation and a more decided forward sweep of the ribs. The young is similar to the early whorls of *Cadoceras*, like *C. stenolobum*, or of *Pseudocadoceras*, like *P. nanseni*, and comparatively evolute, the width of the umbilicus amounting to as much as 27% of the diameter at about 40 mm, on an impression in one body-chamber (354). The fine and close ribs are strongly inclined on the low and rounded umbilical slope, become radial on the innermost portion of the lateral area, and then at once strongly inclined forward towards the periphery. The sinus on the perfectly rounded ventral area is pronounced at all stages.

The young example of which the measurements are given above (Plate XV, fig. 4) was not found together with the larger examples, but may be assumed to belong, if not to the same species, at least to a very close ally. It is as yet essentially like *A. ishmae* at the same diameter. The next stage is represented by the squeeze of the dorsal area of the paratype I figured in Plate XII, fig. 1c. The ventral costation then is only slightly coarser than that of *A. ishmae* (Plate XV, fig. 7b), but on the next outer whorl, i.e. at about 100 mm diameter, the ribbing has become distinctly coarser and far more projected than in Keyserling's species.

The succeeding stage is not well shown in the holotype (Plate XV, fig. 1), on account of defective preservation, but the primary ribs rapidly

disappear, the whorl-sides become smooth, and only the peripheral ribs persist for a time. Later, i.e. on the body-chamber, the arched ventral area also is quite smooth. The larger example figured in Plate XIII, fig. 4 is crushed and the sharpness of the periphery is quite accidental; its side view (Plate XIV, fig. 1) shows it to lose even the ventral ribbing at an earlier stage than the holotype. But another fragment (Plate XIII, fig. 5) and body-chamber examples (Nos. 354, 358) show that the periphery remained broadly arched to the end where there may be rejuvenation of the ribbing.



Text-fig. 3. (a) *Artioceras kochi*, sp. nov. External suture-line (composite) of an example (No. 354) from Mt. Mikael (545—70 m), at a diameter of about 90 mm. (b) Umbilical elements of young example figured in Plate XV, fig. 4 (enlarged  $\times 2$ ) from same locality but at 600 m (L = lateral lobe, E = external lobe, i.e. siphonal line). (c) Suture-line of the fragment (No. 340) of *Artioceras* sp. ind. from Vardelkloft, referred to on p. 56.

nation of the ribbing. The final stage is rather irregular; there may be a few coarse pleats or more numerous, but indistinct folds, or a preliminary constriction on a perfectly smooth, final portion. The deep constriction immediately preceding the peristome (with a long ventral lappet) is strongly inclined forward and as in the case of the complete example of *A. ishmae* figured by Sokolov<sup>1</sup>), the excentrumbilication is very slight. In the large specimen of *Macrocephalites* aff. *madagascariensis* from which was taken the suture-line figured in Text-fig. 1c, there is a similar smooth body-chamber and a shallow constriction, but the radial folds of the venter and the more pronounced uncoiling of the final

<sup>1</sup>) *Loc. cit.* (Petschorascher Jura), 1912, pl. 1, fig. 1 (reduced  $\times \frac{1}{4}$ ).

portion give these *Macrocephalites*-body-chambers a distinctive appearance.

The suture-line (Text-fig. 3) could be exposed in an example of 160 mm diameter, with the mouth-border complete, and just over half a whorl of body-chamber. The drawing, however, is composite, the second lateral saddle and the umbilical elements having been added from later septal edges than the rest. It differs from the suture-line of *A. ishmae*, as figured by Sokolov<sup>1</sup>), in only small details, such as a more narrowly-stemmed external saddle or a less deeply-cleft second lateral saddle. In the young example figured in Plate XV, fig. 4 the elements from the "second lateral" lobe down to the umbilical suture are shown (Text-fig. 3b) and they suggest comparison with the suture-line of d'Orbigny's *Amm. 'galdrinus'* as mentioned in the generic discussion.

The more finely-ribbed (crushed) fragment figured in Plate XV, fig. 5 connects the holotype of the present species with some densicostate examples, three of which are now figured (Plate XIV, figs. 2, 3; Pl. XV, fig. 6). I at first thought of giving these a separate name; for although there are transitions, the extremes of the two forms could be kept distinct. The preservation of most of the fragments, however, is so poor that accurate description of the more densely ribbed form is impossible, and it is now included in the present species merely as a variety (var. *pseudolamberti*, nov.). The originals of Plate XIV, fig. 3 and Pl. XV, figs. 5 and 6 are body-chamber fragments, but a transitional specimen to the typical *A. kochi* (no. 361) has equally finely costate inner whorls. In the case of a large, smooth example like that figured in Plate XIV, fig. 1, where the ribbing of the earlier whorls is not seen, reference to this var. *pseudolamberti* rather than to the type is suggested.

The Greenland '*Macrocephalites*' *ishmae* figured by Madsen seem to be only partly referable to the genus *Arcticoceras*. They have already been referred to under *Arctocephalites greenlandicus* (p. 35), but the presence of bad fragments of the present species in the material from Vardekløft (Locality B) makes it probable that at least some of Madsen's examples may have belonged to *A. kochi*, though not to *A. ishmae*. On the other hand, three of the fragments before me seem to agree with the largest example figured by Madsen and they probably belong to a new species, distinguished from the associated *A. kochi* by less projected and less prominent ribbing. The inner whorls, preserved in two of them, could not be distinguished from those of the var. *pseudolamberti*, but later the difference in the ribbing, as shown in Madsen's figure, is considerable. Moreover, there is then apparently a perpendicular umbilical wall, not seen in the young or in the associated *A. kochi*, but

<sup>1</sup>) *Loc. cit.* (Petschorascher Jura), 1912, pl. III, fig. 12.

the three fragments are all septate and crushed. One of them, larger than Madsen's example (also septate) shows that this presumably new form must have reached a considerable size. The suture-line of one of the fragments (No. 340), reproduced in Text-fig. 3c, differs from that of *A. kochi* in its less subdivided external saddle, but the siphonal half of this is worn.

Horizon and Localities:— *Arcticoceras* beds, 545—570 m, Mt. Mikael (20 examples and fragments, and many small); 600 m (3 examples); Vardekloft, loose at locality B (10 examples).

## 2. *Arcticoceras michaelis*, sp. nov.

(Plate XIII, figs. 3a, b).

The holotype of this species, with three-quarters of the outer whorl belonging to the body-chamber, has the following dimensions:—

Diameter in mm.....	62
Whorl-height (in % of the diameter) .....	45
Whorl-thickness (in % of the diameter).....	53
Umbilicus (in % of the diameter) .....	26

The inner whorls are not visible and the septate portion is corroded, but the general aspect is that of *A. kochi*. At a diameter of 45 mm, however, the thickness is already 53 %, giving the whorl a depressed, reniform section, with comparatively high but rounded umbilical wall and a subtrigonal, arched, periphery. The ribs, bifurcating and single, as in the (flatter) young *A. kochi*, represented in Plate XV, fig. 4a, are sharp and strongly projected on the lateral area, after being first reflexed on the umbilical wall, but the ventral sinus is far less conspicuous than in *A. kochi* or *A. ishmae*. In having an open umbilicus and in the breadth of the periphery, the present species, thus, differs from the typical *Arcticoceras* and approaches to *Cadoceras*. The suture-line is unknown and there is no trace of the mouth-border, although the body-chamber is probably nearly complete.

The sharp ribbing suggests comparison of this species with *Kamptokephalites*, especially the forms of the *dimerus-lamellosus* group in which there is a forward sinus in the peripheral ribbing. The inner whorls, however, are different in the two stocks and there is no projection of the ventral ribs in *Kamptokephalites* at early stages.

Although as yet incompletely known, the present form is of interest as connecting several of the boreal groups, like *Cadoceras pseudishmae* or the probably new *Arcticoceras* represented in Plate XI, fig. 3, and discussed below (p. 58).

Horizon and Locality:— *Arcticoceras* beds, 600 m, Mt. Mikael (holotype).

3. *Arcticoceras* sp. juv. ind.

(Plate III, fig. 2; Pl. VIII, fig. 4; Pl. IX, fig. 6; Pl. XI, fig. 2; Pl. XV, fig. 3).

Associated with smooth body-chambers of undoubted *Arctocephalites* there were found large numbers of small ammonites which although showing considerable variation, at first sight seem to resemble immature *Pseudocadoceras*, like *P. nanseni*, Pompeckj sp. (See Plate IX, figs. 2a, b; Pl. XI, fig. 4). They are smooth to a diameter of 5 or 6 mm, and have a depressed-circular whorl-section, with a small but not closed umbilicus. The ribs first appear as faint folds on the periphery where they are only slightly curved forward (Plate IX, fig. 6) but slender primaries follow almost immediately and the connecting lateral ribs are slightly flexuous. The irregularly biplicate ribbing up to a diameter of about 15 mm, at least in the more densely ribbed examples (Nos. 353a, b) is closely similar to that of the young *Arctocephalites* figured in Plate IX, fig. 3. Most of the specimens, however, are more distantly ribbed (Plate XV, fig. 3) and cannot be separated from certain young *Cadoceras* by the costation alone, although the later species of this genus and especially immature *Pseudocadoceras* are likely to show their advanced nature already then, either in the sharp ventral sinus, in the greater strength of the primaries compared with the secondaries, or in their looser coiling.

The body-chamber fragment represented in Plate XI, fig. 2 is one of the largest and shows general agreement with the species last described (*A. michaelis*) except in its compression, the whorls being slightly higher than thick. The ribs are then mainly single, closely spaced and strongly inclined forward, and much finer than the ribbing of the inner whorls shown in the dorsal area. This is the reverse of what occurs in *Pseudocadoceras*, where the ribs become suddenly coarse on the body-chamber. On the other hand some immature *Arcticoceras* from Mt. Mikael, also including fine and coarse varieties, and presumed to belong to the var. *pseudolamberti* of *A. kochi* which occurs in crushed impressions (e.g. No. 352) near the same horizon, are essentially similar in the external features that can be compared. Owing to the coarse sandstone matrix or the ochreous infilling of the septate whorls, the suture-lines are generally destroyed in the young examples from Mt. Hjørnefjæld or, when recognisable, they are too immature to be of any help.

The small example figured in Plate VIII, fig. 4, deserves separate mention because its costation is unusually rursiradiate. The last half-whorl shown is already body-chamber but the earlier part is badly preserved. The primary ribs are radial, after the initial backward bend on the rounded umbilical slope, and only the secondary branches (two or three to each primary) show the pronounced inclination backward. The peripheral sinus forward of the last 14 ribs is very slight; the earlier



ribs run straight across the venter. The example shows the greatest resemblance to young *Quenstedioceras* such as the group that was figured by R. Douvillé<sup>1</sup>) as *Q. henrici* var. *carinatum* (Eichwald). In these, however, the ribbing is weakest in the siphonal line, not strongest, and, no doubt, if complete examples were available, the resemblance would be shown to be merely superficial.

The septate fragment figured in Plate XI, fig. 3, is the only larger example from the lowest *Arcticoceras* beds of Mt. Mikael and although its ribbing is much less projected than it is in typical *Arcticoceras* yet it must be referred to this genus on account of its sharpened periphery and distinct forward sinus of the ventral ribbing. It is especially interesting since it seems to connect with *Cadoceras pseudishmae* as well as with the earlier *Arctocephalites*, but in view of its fragmentary nature, it cannot at present be described as more than probably another new species of *Arcticoceras*.

Horizon and Localities:— *Arcticoceras* beds, Mt. Hjørnefjæld, locality 1, 700 m (many small); lowest *Arcticoceras* beds, 500 m, Mt. Mikael (1 fragment and three small).

#### Genus *CADOCERAS*, Fischer, 1882.

*Genotype*:—*A. sublaevis*, J. Sowerby, 1814, Mineral Conchology, vol. 1, p. 117, pl. LIV (large figure) = *Nautilites modiolaris*, Lhuyd, 1699.

This genus has often been discussed but there is some uncertainty yet, even about the genotype. Fischer's diagnosis makes it perfectly clear that his '*C. modiolare*' must be a form with ventrally projected ribs in the young. This fits the true *Nautilites modiolaris* of Lhuyd<sup>2</sup>), but as this author, even in his second edition of 1760 did not use binomial nomenclature, Sowerby's name of 1814 must be employed for this form. Cox<sup>3</sup>) pointed out that the first post-Linnean description of an *Amm. modiolaris* was W. Smith's (1817) but this is a *Tulites* of the Fuller's Earth Rock, and in my opinion is identical with Buckman's *T.* ("*Madarites*") *mударus*, var. *parvus*<sup>4</sup>). There is no doubt, to my mind, about Lhuyd's form being identical with *C. sublaeve*; the sharp, plain edge and the perfectly conical umbilical cast alone show that other *modiolaris*-like species occurring in the Kellaways Rock cannot come into

<sup>1</sup>) *Loc. cit.* (Cardioceratidés), 1912, pl. iv (x), figs. 50—52.

<sup>2</sup>) Lhuyd (Lhwyd, Luidius), Edward: "Lithophylacii Britannici Ichnographia etc." (1st ed.) 8vo. Londini et Lipsiae, 1699, p. 18, pl. vi, No. 292.

<sup>3</sup>) "On British Fossils named by William Smith". Ann. Mag. Nat. Hist. ser. 10, vol. vi, 1930, p. 301.

<sup>4</sup>) Type Ammonites, vol. III, 1921, p. 46; vol. IV, 1922, pl. CCLXXI A, B. (S. S. Buckman coll. in B. M. No. 1921).

consideration. But it cannot be insisted on too much that the ventral projection of the ribs in the young is extremely variable. As a rule the more compressed individuals show this feature more distinctly than the inflated examples, and in these the ventral sinus forward may be so slight that it can scarcely be observed, even in a straightened-out plasticine squeeze. In other words, the projection is a character of the 'prophetic phase' (Pavlov), foreshadowing later derivatives of the stock, and it is very unequally developed at first, and only in the young.

A similar feature that suggests an erroneous phylogeny to the recapitulationist is the compression in the young. Thus Buckman spoke of the development in the early genera, for instance, *Cadoceras*, taking place from a platycone stage; but it is only the later forms of this genus that have compressed and rather involute young while the earlier species have rounded or depressed whorls and an open umbilicus. In view of the occurrence of such transitional species between *Arcticoceras* and *Cadoceras* as *C. pseudishmae*, here described, it may seem risky to be dogmatic; but I can see no boreal stock from which *Cadoceras* could be derived. *Arcticoceras*, as mentioned above, slightly resembles *Chamoussetia* like *C. stuckenbergi*; *Arctocephalites* even at Cape Flora, is quite distinct from the local *Cadoceras* and *Pseudocadoceras*-fauna (preserved in another rock), and *Cranocephalites* is a still less likely ancestor. On the other hand, *C. quenstedti*, nom. nov. (for *Amm. sublaevis*, Quenstedt pars<sup>1</sup>), non Sowerby), described by Quenstedt himself as differing in its less conical umbilicus, can scarcely be distinguished from certain *Rugiferites* (e.g. B.M. no. 50146), except by the peripheral sinus and the more bullate umbilical edge. The Cornbrash *C. breve*, Blake, is a still more typical *Cadoceras*, but unfortunately only known in one imperfect example. To my mind the origin of *Cadoceras* is to be looked for in such a southern, not boreal, Stephanoceratid stock as that which also produced *Indocephalites diadematus* and other Macrocephalitids. In such a stock the recurrence of a typical "*Stephanoceras*" (*Erymnoceras coronatum*, Bruguière sp.) at a late date would easily be explained.

There is not a single Greenland *Cadoceras* that could be compared to *C. sublaevis* itself. In the interpretation of this species again, Buckman made unnecessary difficulties. Nikitin<sup>2</sup>), in speaking of Sowerby's original, clearly had in mind the largest specimen. Pompeckj<sup>3</sup>) definitely stated that he confined the name *sublaevis* to that large example. Yet Buckman, after pointing out in 1913 that Eudes-Deslongchamps had

<sup>1</sup>) "Ammoniten des Schwäbischen Jura", vol. II, 1887, p. 672, pl. LXXIX, fig. 7 only.

<sup>2</sup>) *Loc. cit.* (Elatma, II), 1885, p. 57.

<sup>3</sup>) *Loc. cit.* (Cape Flora), 1899, p. 77.

completely misunderstood Sowerby's species, considered in 1922<sup>1</sup>) that Deslongchamps's meaningless synonymy made one of Sowerby's smaller specimens (south-east figure) the lectotype. The 'chorotype' Buckman then figured as *C. sublaeve* is much more coarsely ribbed than either the inner whorls of Sowerby's large example<sup>2</sup>) or the specimen (B.M. no. 43881b) which Crick registered as the probable original of Sowerby's smaller figure. The latter is a transition to the English form of *C. tchefkini*, d'Orbigny sp. (e.g. B.M. No. 50453, 50652) that Nikitin<sup>3</sup>) already had considered to be common, but generally mistaken for *C. sublaeve*; and since the lectotype of the Russian species<sup>4</sup>) is even more finely-ribbed than Sowerby's original, Buckman's example differs very considerably. It would, in fact, have been given a separate name if Buckman had looked at the types in the British Museum, but since it is immature and, at larger diameters, could not be distinguished from other varieties of *C. sublaeve*, it will be sufficient to consider it merely a var. *rugosa* nov. Far commoner is a form in which the whorl-section agrees with that of a Laufen example figured by Quenstedt<sup>5</sup>). This had been called a passage-form between *C. frearsi* (d'Orbigny) and *C. surense*, Nikitin, but these two species have not been found outside Russia to my knowledge and they are high zonal forms. The Wurtemberg example on the other hand, by its nodate and blunt umbilical rim is shown to be even less developed than the variety (var. *communis*, nov.) of *C. sublaeve* which has its compressed whorl-section, but slightly finer ribbing. A typical Chippenham example of this variety (No. 1234 L.F.S.) differs from one of Nikitin's<sup>6</sup>) examples of *C. tchefkini* merely in its wider umbilicus and in retaining the costation to a larger diameter (60 secondaries and 30 primaries at 68 mm). The English examples of *C. tchefkini*, slightly less compressed than a Rybinsk specimen (No. 1235) which I owe to the kindness of M. P. Petitchere, differ from this var. *communis* chiefly in their finer ribbing and more pronounced ventral sinus (e.g. No. 1236).

Still another variety of *C. sublaeve* (e.g. B.M. no. 50652, C. 3385, C. 10209) is more involute than the type, has almost perpendicular

<sup>1</sup>) Type Ammonites, vol. IV, 1922, pl. cclxxv (legend).

<sup>2</sup>) Since Sowerby's figure was engraved, this specimen must have been broken (perhaps accidentally dropped) for it is now composed of a number of pieces glued together that allow of inspection of every detail of the inner whorls.

<sup>3</sup>) "Quelques excursions dans les musées et dans les terrains mésozoïques de l'Europe occidentale etc." Mém. Soc. belge géol. &c. (Bruxelles), vol. III, 1889, p. 34. (Printed in Russian, Bull. Com. Géol. no. 10, December 1888).

<sup>4</sup>) See A. d'Orbigny in Murchison, Verneuil et Keyserling. "Géologie de la Russie d'Europe &c." Vol. II, Terrains Second. Syst. Jurass. Mollusques, 1845, p. 439, pl. xxxv, figs. 13—14.

<sup>5</sup>) *Loc. cit.* (1887), pl. lxxix, fig. 5.

<sup>6</sup>) *Loc. cit.* (Rybinsk, 1881) pl. III, fig. 22, only.

umbilical walls and tends to retain the nodate rim. It is difficult to distinguish, in the smooth stage, from other large *Cadoceras*, e.g. from *C. durum* (Buckman) and *C. orbis*, nom. nov. (= *Amm. modiolaris*, d'Orbigny<sup>1</sup>), non Smith). The former was first described as a Macrocephalitid and given a new generic name ('*Catacephalites*') presumably because erroneous stratigraphical views and bad preservation made it a difficult 'type' to accommodate elsewhere. I myself, after examining the crushed holotype, thought it to be probably a *Kamptokephalites*<sup>2</sup>). Now, however, that the South Cave fauna<sup>3</sup>) has yielded better specimens to the labours of Mr. G. Baker Alexander, a number of examples of *C. durum* are available and they can be matched by specimens from the Wiltshire Kellaways Rock (e.g. B. M. No. 24172, 50758). The species is seen to be close to *C. tolype*, Buckman<sup>4</sup>), and especially to *C. simulans*, nom. nov. (= *Cadoceras modiolare*, Nikitin<sup>5</sup>) non d'Orbigny), both of which, however, are more evolute and have less globose inner whorls.

*C. orbis*, on the other hand, not only lacks the crater-umbilicus of *C. sublaeve*, having a cork-screw like cast, but it has a rounded edge at all stages. It thus resembles the far less globose *C. sysolae*, Khudyaev<sup>6</sup>). The young is finely ribbed and smooth at an early age, like *C. milashevici*, Nikitin<sup>7</sup>), but only in this respect; for the latter has compressed early whorls and a sharp umbilical edge. The only form I know that resembles *C. orbis* in the young is a Popiljany species (B. M. no. 7949) which I have always considered to be new and which was not described by Krenkel<sup>8</sup>). But this form is complete at 60 mm, with three-quarters of a whorl of body-chamber, and it remains in the immature *orbis*-stage, with even greater smoothness and still more rounded umbilical edge. At 60 mm, the young *C. orbis* has a thickness of 80 % and an umbilicus of 18 % of the diameter, but at a larger size the thickness is generally about 100 %, while the umbilicus increases to about 26 or 29 % (B. M. nos. 39885, C. 394).

<sup>1</sup>) Pal. Française, Terr. Jurass. Vol. I, 1847, p. 468, pl. CLXX.

<sup>2</sup>) *Loc. cit.* (Pal. Indica), pt. III, 1928, p. 173.

<sup>3</sup>) See *ibid.*, pt. VI, 1932 (associated with *Cadoceras tchefkini* and *C. sublaeve*, var. *communis*, etc.).

<sup>4</sup>) Type Ammonites, vol. IV, 1923, CDVI.

<sup>5</sup>) *Loc. cit.* (Elatma, II), 1885, pl. IX (XI), figs. 48a, b.

<sup>6</sup>) The Mesozoic Deposits in the Region of the Sysola River (S. part of Petchora-Land). Bull. Com. géol. Leningrad. vol. XLVI, No. 5, 1927, pp. 506, 519, pl. XXVII, figs. 1—2.

<sup>7</sup>) *Loc. cit.* (Rybinsk), 1881, pl. III, fig. 25.

<sup>8</sup>) "Monographie der Kelloway-Fauna von Popilani in Westrussland". Palaeontograph. vol. LXI (1915), pp. 222—25. The *C. "loeschi"*, Krenkel, mentioned there, so far remains a *nomen nudum*.

The Russian *C. milashevici*, *C. compressum*, Nikitin<sup>1)</sup>, *C. nikitini*, Sokolov<sup>2)</sup>, and *C. stenolobum* (Keyserling) Nikitin<sup>3)</sup>, are not before me from the English Kellaways Rock, at least in examples large enough to be definitely identified, but I can confirm Pompeckj's<sup>4)</sup> statement concerning the occurrence of a form which he considered intermediate between *C. sublaeve* and *C. stenolobum*. Now that Keyserling's original has been figured by Sokolov<sup>5)</sup>, the resemblance of the English form (B.M. no. 8175) to *C. stenolobum*, is indeed striking, but as it tends to lose its ventral costation at 65 mm diameter and then returns to a *sublaeve* stage (only more compressed), it must be separated from Keyserling's species and Nikitin's form (the latter renamed var. *densicostata*, nov.).

A large Alaskan example (B.M. no. C. 35783) labelled *C. stenoloboide*, Pompeckj, is another distinct form of the same group, losing its ribbing soon after the end of the septate stage (at 75 mm diameter), but whether this species is identical with Pompeckj's<sup>6)</sup> original *C. stenoloboide* seems doubtful, the small holotype having already half a whorl of body-chamber. The Alaskan example seems closer to the 'flattened variety of *Amm. (Cadoceras) modiolaris*' figured by Newton<sup>7)</sup> except that the nodate umbilical rim is more distinct. Pompeckj considered this form to belong to his *C. nanseni*<sup>8)</sup> and assumed this species to broaden its whorls in the adult, like other *Cadoceras*, but I believe that he confused several species. For the true *C. nanseni*, as represented by Pompeckj's text-figure 16 (p. 87) has a costate body-chamber, with coarsening and often single ribs which, together with the general compression at all stages, shows it to be a form of the genus *Pseudocadoceras*, Buckman. I am now figuring (Plate IX, figs. 2a, b; Pl. XI, fig. 4) a body-chamber and the inner whorls (enlarged  $\times 2$ ) of this common Franz Josef Land species which prove that it belongs to what Buckman called the *gre-wingki* series. This also comprises such species as *Pseudocadoceras cato-stoma*, *P. schmidti*, *P. petelini*, Pompeckj sp.<sup>9)</sup>, in addition to the English forms, and they may be associated with *Cadoceras*, but go higher.

<sup>1)</sup> *Loc. cit.* (Rybinsk) 1881, p. 67, pl. III, figs. 26—27. This was later (1885, Elatma, II, p. 61) included with *C. milashevici*, but according to the Russian material before me, it may well be kept apart, at least as a variety.

<sup>2)</sup> *Loc. cit.* (Petschorascher Jura), 1912, p. 53, pl. I, figs. 3a, b, c, and d.

<sup>3)</sup> *Loc. cit.* (Elatma I), 1881, p. 121, pl. XII, (v), figs. 28—30.

<sup>4)</sup> *Loc. cit.* (Cape Flora), 1899, p. 78.

<sup>5)</sup> *Loc. cit.* (Petschorascher Jura), 1912, p. 52, pl. I, fig. 4.

<sup>6)</sup> "Jura-Fossilien aus Alaska". Verh. Kais. Russ. Min. Ges. St. Petersburg. (2), vol. XXXVIII, 1900, p. 255, pl. VII, figs. 2a—d.

<sup>7)</sup> In Newton and Teall, *loc. cit.*, 1897, pl. XXXIX, fig. 10.

<sup>8)</sup> *Loc. cit.* (Cape Flora), 1899, p. 86, pl. II, figs. 1—3, 5, 6.

<sup>9)</sup> *Loc. cit.* (Alaska), 1900, pp. 258 etc., pls. v—vi.

One of these is the Alaskan *C. wosnessenskii*, Grewingk sp.<sup>1)</sup> which according to a septate example before me (B.M. no. C. 35782) has fine secondary ribbing to at least 75 mm diameter, but instead of losing the umbilical nodes, like *C. stenoloboide*, it develops those comma-shaped bullae at the border that characterise the far more inflated (but badly figured) *C. doroschini*, Eichwald sp.<sup>2)</sup>. To judge by two Alaskan specimens in the British Museum (Nos. 35784—85) this species is more closely related to the common and more coarsely-ribbed *C. elatmae*, which has recently again been the subject of a careful paper by Bodylevsky<sup>3)</sup>. The English Kellaways Clay form which was referred to by NIKITIN<sup>4)</sup> as *C. elatmae* (B.M. no. 24737) is referable to the more inflated *C. tolype* (Buckman) which at large sizes becomes very globose, instead of contracting like *C. doroschini* or *C. elatmae*<sup>5)</sup>, or *C. rubrum*, nom. nov., a large Scarborough example of which (B.M. no. 33591) has inflated inner whorls indistinguishable from Quenstedt's<sup>6)</sup> *Amm. sublaevis macrocephali* (and perhaps Bronn's<sup>7)</sup> "*Amm. modiolaris*, Morris" which must be wrongly drawn) but the constricted body-chamber of which is similar to that found in the large *C. elatmae*, just cited, or in *C. variabile*, nov. from East Greenland. There is, however, a common, more evolute and less inflated variety of *C. tolype*, somewhat transitional to *C. rubrum* in the earlier stages, which differs from the later true *C. sublaeve* merely in retaining the nodate umbilical rim to a larger diameter and in having the inner whorls recti- or even rursiradiate as in *C. elatmae*.

*C. tschernyschewi*, Sokolov<sup>8)</sup>, is again comparable to (the more densely nodate) *C. doroschini* or *C. rubrum* and differs from *C. elatmae* chiefly in being more involute and globose, with less oblique umbilical nodes in the adult.

*C. brooksi*, Crickmay, from the Fernie Shale of British Columbia,

1) "Beitrag zur Kenntniss der orographischen und geognostischen Beschaffenheit der Nord-West-Küste Amerikas mit den anliegenden Inseln". Verh. Russ. Kais. Min. Ges. St. Petersburg. 1848—49 (1850), p. 344, pl. iv, figs. 1a—d.

2) "Geognostisch-Paläontologische Bemerkungen über die Halbinsel Mangschlak und die Aleutischen Inseln". St. Petersburg, 1871, p. 138, pl. vii, fig. 6; pl. viii, figs. 1—2.

3) "The Development of *Cadoceras Elatmae*, Nikitin". Annuaire Soc. Pal. Russie, vol. V, (1925) 1926, pp. 61—94, pls. iv—v.

There are inflated varieties of *C. elatmae* (e.g. No. 115, L. F. S.) which are transitional to the English species.

4) *Loc. cit.* (Bull. Soc. belge Géol.), 1889, p. 34. The second example (No. 21006) is just an ordinary *C. sublaeve*.

5) See Nikitin, *loc. cit.* (Elatma I), 1881, pl. xi (iv), fig. 20.

6) Cephalopoden, 1849, p. 177, pl. xiv, figs. 6a, b.

7) *Lethaea geognostica*, 1850—56, pl. xxiii, figs. 10a, b (said to be reduced  $\times \frac{1}{3}$ ).

8) *Loc. cit.* (Petschorascher Jura), 1912, p. 51, pl. i, figs. 2a, b; pl. ii, fig. 1.

is referred to below (p. 65) in connection with *C. crassum*, but the remaining species of *Cadoceras* need not be discussed here. Like *C. patruum*, Eichwald<sup>1)</sup>, or *C. subpatruum*, Nikitin<sup>2)</sup>, they are extreme forms, not found outside Russia; or like *C. schumarowi*, Nikitin<sup>3)</sup>, and *C. seebachi*, Behrendson (= *Amm. sublaevis*, Seebach<sup>4)</sup>, non Sowerby) they are not definitely identifiable from the figures.

The new Greenland forms here described bring the number of species of *Cadoceras* to over thirty, but I do not think subdivision is necessary. Buckman's 'two series' according to the projection of the ribs in the young certainly are not natural divisions and the extremes that would seem to be excluded by Fischer's diagnosis on account of a wider umbilicus (*C. calyx*), a rounded border (*C. franciscus*) or persistence of the costation (*C. dubium*) are intimately allied with more orthodox species.

### 1. *Cadoceras crassum*, Madsen.

(Plate XVI, figs. 3a, b).

1904. *Cadoceras crassum*, Madsen: "On Jurassic Fossils from East Greenland", *loc. cit.*, p. 193, pl. ix, figs. 1—3, pl. x, fig. 1.

1931. — cf. — — ; Sokolov and Bodylevsky: "Jura und Kreidefaunen von Spitzbergen", *loc. cit.*, p. 78.

Madsen's species is sufficiently characterised by its costation persisting to over 100 mm diameter, by its whorl-thickness being still 70 % (as in the young) at a diameter of 140 mm, and by its evolute inner whorls. The holotype, figured by Madsen, however, is not well preserved, so that the species is difficult to interpret by those who only know the common forms of the *sublaeve*-group. It is also possible that the suture-line figured by Madsen, and taken from another specimen, does not belong to the species as I would restrict it; but the inner whorls here

<sup>1)</sup> Smorodine (*loc. cit.*, *Cardioceratidae*, 1926 p. 112) put this species with *Longaeviceras galdrinum* (d'Orbigny) Nikitin sp. and *Quenstediocerates* into a high horizon, so that the reference to either *Cadoceras* or *Chamoussetia* would seem to be incorrect.

<sup>2)</sup> *Loc. cit.* (Elatma II) 1885, p. 58, pl. XI (XIII), fig. 58. Comparable to *Amm. hyperbolicus* (Simpson MS) Leckenby (refigured and misinterpreted in Buckman: *Yorkshire Type Ammonites*, vol. II, 1914, pl. xcvi) which I have previously included in *Chamoussetia*, but which may equally well be left in *Cadoceras*.

<sup>3)</sup> "Allgemeine Geologische Karte von Russland. Blatt 56". *Mém. Com. géol.* vol. I, No. 2, 1884, p. 68, pl. III, fig. 16 (probably not a *Cadoceras* at all).

<sup>4)</sup> *Hannoverscher Jura*. 1864, p. 151, pl. VIII, figs. 3a, b (perhaps a *Pseudocadoceras*).

figured (Plate XVI, fig. 3) show such perfect agreement in measurements with the holotype, at a corresponding stage, that detailed comparison with the other forms of *Cadoceras* now recognised becomes possible. The dimensions are as follows:—

	Plate XVI, fig. 3	Holotype
Diameter in mm.....	56	57
Whorl-height (% of diameter) .....	43	44
Whorl-thickness (% of diameter).....	68	70
Umbilicus (% of diameter) .....	30	30

The ribs are bi- and trifurcating, as in the young *C. elatmae*, but the secondaries are much more prominent and radial, and the umbilical rim remains rounded. The unusual flexuosity of a few ribs in the figure is due to an injury and is not developed on the opposite side. The suture-line of the example here figured has the median prong in the first lateral lobe longer than shown in Madsen's text-figure 2, but the outer leaflet subdividing this lobe (and interlocking with the terminations of the preceding external saddle) does not seem to have been drawn correctly in this figure.

The differences between *C. crassum* and such allied Greenland species as *C. freboldi* are referred to below. *C. brooksi*, Crickmay<sup>1</sup>), based on a very incomplete specimen, has rounded inner whorls like the Greenland species here discussed, but judging by the enlarged restoration figured by its author, with non-tuberculate umbilical rim, it is entirely different from any *Cadoceras* here described.

Horizon and Locality:— Horizon with calcareous concretions, *Tychonis* beds, Vardekløft, locality A, 560 m (1 example).

## 2. *Cadoceras freboldi*, sp. nov.

(Plate XVIII, figs. 2a, b).

This new species is based on an example of about 100 mm diameter, with the body-chamber just beginning, but the last half-whorl is omitted in the figure. The dimensions at the two sizes are:—

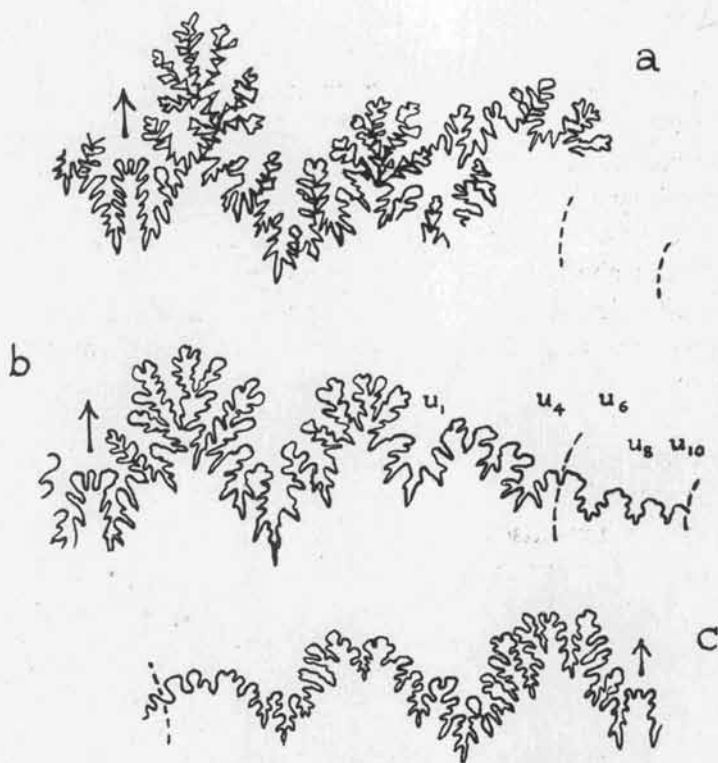
Diameter in mm.....	100	77
Whorl-height (% of diameter) .....	44	40
Whorl-thickness (% of diameter).....	72	65
Umbilicus (% of diameter) .....	24	26

The inner whorls are finely-ribbed, like those of *C. crassum*, but the costation soon becomes coarser and more widely spaced, and the venter

<sup>1</sup>) *Loc. cit.* (Nat. Mus. Canada, Bull. 63), 1930, p. 57, pl. xvi, figs. 3—5.



is highly arched instead of being broad and flat. At 95 mm diameter, i.e. at the beginning of the body-chamber, the costation ceases, the secondaries having been blunt and low in comparison with the prominent primary ribs for nearly half a whorl previously. These crescentic primary ribs are thickened or bullate on the last half-whorl, but they are mere costae, as in *C. crassum*, at earlier stages. They are continuous over the high and vertical umbilical wall except near the end; and at the beginning



Text-fig. 4. (a) *Cadoceras freboldi*, sp. nov. External suture-line of holotype (see Plate XVIII, figs. 2a, b). (b) *C.*(?) sp. ind. Suture-line (slightly worn) of the example referred to on page 71. (The order of the appearance of the umbilical lobes was not observed, but is based on the development of *C. elatmae*, according to Bodylevsky, 1926). (c) *C. victor*, sp. nov. Suture-line of the specimen figured in Plate XXI, fig. 1a. All three specimens are from Vardekloft Formation (*Tychonis* Beds), locality B.

of the smooth body-chamber the edge seems to become more rounded. A distinctive feature of the present species is the slight sinus forward of the ribs on the slightly sharpened periphery; this is scarcely perceptible in the figure, but causes a peculiar resemblance of *C. freboldi* to certain Quenstediocerates (*Eboraciceras*). The final whorl-section differs from that of *C. crassum* in being not only more galeate but also more depressed and wider, with the greatest thickness at the rounded umbilical edge.

The suture-line (Text-fig. 4a) is characterised by very slender saddles and great complexity, rivalling that of *Macrocephalites*. In *C. stenolobum* (Keyserling) Nikitin sp.<sup>1)</sup>, however, and in a large Alaskan example (B.M. No. C. 35783) referred to *C. stenoloboide* (Pompeckj)<sup>2)</sup>, the suture-lines are scarcely less complex, while some specimens of *C. tolype*, from the English Kellaways Clay, and with the lobes more subdivided than Buckman's holotype<sup>3)</sup>, are also comparable. In whorl-shape and inner whorls, of course, all the three species mentioned are entirely different.

While the remaining Greenland species of *Cadoceras* are less comparable to *C. freboldi*, there is distinct resemblance to the forms of the group of *Pleurocephalites pila*, Nikitin, already discussed. The increasing bluntness of the ribbing and the smooth final stage, indeed, are very similar to the corresponding Macrocephalitid development (*P.* ["*Macrocephalicerias*"] *polyptychus*, Spath sp.) but the evolute inner-whorls of the present species alone prevent separation from the associated Cadoceratids. The group of specimens discussed below under *Cadoceras* (?) sp. ind. includes similar passage forms between the Macrocephalitids and the later true *Cadoceras* of the *sublaeve*-group.

Horizon and Locality:— Horizon with calcareous concretions, *Tychonis* beds, Vardekløft, locality B (1 example).

3. *Cadoceras victor*, sp. nov.

(Plate XVI, figs. 6a—c; Pl. XVII, fig. 5; Pl. XXI, figs. 1a, b).

This form is represented in the collections before me by five typical examples and perhaps the doubtful specimen figured in Plate XVII, fig. 5, which is not well enough preserved for separate description. The dimensions of four of these specimens are as follows:—

	Diameter in mm	Height %	Thickness %	Umbilicus %
1. Holotype (Plate XVI, figs. 6).	85	40	78	33
2. — (inner whorls) . . . . .	55	39	60	31
3. — ( — — ) . . . . .	30	41	59	30
4. Paratype I (No. 362) . . . . .	140	40	82	26
5. — II (Plate XXI, fig. 1b)	170	44	83	26
6. — III (Plate XXI, fig. 1a)	120	42	83	24

The measurements are all somewhat approximate, but they show that while the whorl-height remains fairly constant the umbilicus is relatively narrower in the adult and the thickness increases considerably.

<sup>1)</sup> *Loc. cit.* (Elatma, I), 1881, pl. xii (v), fig. 30.  
<sup>2)</sup> *Loc. cit.* (Jura-Fossilien aus Alaska), 1900, p. 255, pl. vii, figs. 2—3.  
<sup>3)</sup> Type Ammonites. Vol. IV (1923), pl. cvi.

The innermost whorls, after the earliest, smooth, stage, are evolute and finely-ribbed, like the example represented in Plate XXIV, fig. 5, but at a diameter of 12 mm the thickness, greatly in excess of the whorl-height, amounts already to nearly 60 %. The umbilical edge is well rounded in the young and does not tend to become angular until about 50 mm diameter. The ribs then are bi- and trifurcate, with the primary portion (not thickened) inclined forward and getting gradually shorter on the umbilical wall, but with the secondaries perfectly radial. These latter then become weakened, while the comma-shaped primaries are increasingly oblique and blunt, as in *C. elatmae* (Nikitin). At about 80 mm diameter the venter is smooth and on the anterior part of the body-chamber the primary nodes also disappear while the umbilical edge is then as angular as in *C. sublaeve* (Sowerby). The suture-line is that of a typical *Cadoceras*.

While there is no great resemblance to the forms of the *sublaeve* group, except in the globosity of the final smooth stage, the forms of the English Kellaways Clay, like *C. tolype*, Buckman (with a similar suture-line) and *C. rubrum*, nov., are decidedly closer. But they also have less evolute inner whorls than the Greenland forms, which are thus rather distinct from their European allies. The example figured in Plate XVII, fig. 5, however, with a narrower umbilicus, might be considered to come closer to the better known species of *Cadoceras*, but it has unusually long primary ribs and is thus transitional to the group of forms discussed below under *Cadoceras* (?) sp. ind. Unfortunately the body-chamber portion (last third) is worn and very incomplete, but the high umbilical wall and sharp edge stamp the example as an undoubted *Cadoceras*. The inner whorls again are like those of the present species, but the body-chamber may have been more highly-arched.

Horizon and Localities:— Vardekløft, *tychonis* beds, locality B (4 examples); C, 540—50 m (1 example); South of *Goniomya*-Kløft, locality D, 540 m (1 example).

#### 4. *Cadoceras* sp. nov. aff. *victor*, nov.

There is another species among the *Cadoceras* material from East Greenland, distinguished from the last by more coarsely and distantly-ribbed inner whorls and persistence of the costation to a larger diameter. It is not figured or named because the most favourably preserved fragment, still septate at a diameter of about 100 mm, consists only of less than half the ammonite, with the innermost whorls lost in the matrix. The medium-sized whorl is comparable to the young *C. crassum*, figured in Plate XVI, fig. 3, but the whorl-section is more rounded, i.e. the

venter is less broad, the umbilical edge less marked, and the ribbing is coarser and more distant. The whorl-section is reniform, then, but becomes typically cadoceratid, i. e. even more flattened than that represented in Plate XXI, fig. 1b, on the next outer whorl. The forms of the *sublaeve*-group, with similar cadicone whorl-sections, all differ in their inner whorls and are more inflated, the dimensions of the present species being approximately:—

Diameter in mm.....	100	64
Whorl-height (% of diameter) .....	40	38
Whorl-thickness (% of diameter) .....	70	67
Umbilicus (% of diameter) .....	33	30

At 100 mm diameter there are about twelve primary ribs to the half-whorl, less nodate and more elongated than in *C. elatmae*, at the same size, but comparable to the ribs of the young of that species. This, however, even then, is a much more typical *Cadoceras*, and other species with umbilical crescents, e. g. *C. doroschini*, Eichwald sp. (badly figured)<sup>1</sup>) are even less comparable.

The highly indented suture-line is similar to that of *C. victor* except for small details on the umbilical wall which itself is less perpendicular in the present form. This is also closely related to *C. elatmae*, Nikitin<sup>2</sup>), and one of the examples figured by this author in 1881 might almost do for the species now described, if the figure were twice the size, i. e. if costation persisted to at least 90 mm diameter.

Horizon and Locality:— *Tychonis* beds, Vardekløft, locality B (1 example and 3 doubtful fragments).

##### 5. *Cadoceras calyx*, sp. nov.

(Plate XX, figs. 1a, b).

The unique example on which this form is based has the following dimensions:—

Diameter in mm.....	100
Whorl-height (% of diameter).....	37
Whorl-thickness (% of diameter) .....	81
Umbilicus (% of diameter).....	37

It differs from the other Greenland species so far known in its typical *Cadoceras* umbilical wall, so characteristic of the *sublaeve*-group;

<sup>1</sup>) *Loc. cit.* (1871), p. 138, pl. VIII, fig. 2 (= a variety?).

<sup>2</sup>) *Loc. cit.* (*Elatma*, I), pl. XI (IV), fig. 21.

but the umbilicus is very wide and the inner whorls are unusually evolute. The umbilical cast thus is very different from that of *C. sublaeve*, already figured by Lhuyd<sup>1</sup>). Moreover, since the specimen is still septate at over 100 mm diameter, and since the strongly projected ribbing still persists at the end, the form is clearly differentiated from all other species of *Cadoceras*.

This costation is not distinct in the figure, because the last half of the outer whorl is worn, especially on the periphery. The specimen also is crushed obliquely so that the whorl-section (fig. 1b) is restored; but on the side not figured, where the umbilical edge is visible for a short distance, it is less angular. It shows more distinctly that the primary ribs passing over the edge, never form such definite bullae as they do in e.g. *C. elatmae* or *C. tolype*, and that they do not differ so much in strength from the long secondaries as they do in other forms of *Cadoceras*, except at a much smaller size. The secondaries branch off the primary ribs close to the umbilical edge and there are about 59 of the former to 27 of the latter, i.e. trifurcating ribs are comparatively rare.

The complex suture-line is seen on the (worn) venter and has the slender elements of the other species here figured, with the median prong of the lateral lobe well below the external lobe and the second lateral saddle not entirely outside the umbilical edge.

*C. brooksi*, Crickmay<sup>2</sup>), already mentioned, has an open umbilicus and sharp rim, but it is difficult to compare on account of its incomplete state. Crickmay suggested that it probably never reached a large size, but since the present species also attained a cadicone shape at a fairly small diameter, the British Columbian form may well represent merely the inner whorls of a larger species.

Horizon and Locality:— Horizon with calcareous concretions (*Tychonis* beds), Vardekløft Formation, near Point Constable (holotype).

#### 6. *Cadoceras* (?) sp. ind.

(Plate XX, fig. 5; Plate XXII, figs. 3a, b).

Three poorly preserved specimens agree in general aspect, but may not belong to the same species. This, unfortunately, cannot be definitely determined, but the examples are worthy of being discussed separately because they appear to be passage-forms between *Arctocephalites* of the type of *A. sphaericus* and *Cadoceras* of the *freboldi*-group. They are thus of considerable interest from a phylogenetic point of view.

The larger figured example (Plate XX, fig. 5) differs from *C. freboldi* merely in having a less deep and smaller umbilicus (18 %) with

<sup>1</sup>) Lithophylacii Britannici Ichnographia, &c., 1699, pl. iv, fig. 292, p. 18.

<sup>2</sup>) *Loc. cit.* (Nat. Mus. Canada, Bull. 63). 1930. p. 57, pl. xvi, figs. 3—5.

less vertical walls and a more compressed whorl-section; but this may be due partly to corrosion or deformation in the rock, although the specimen is not crushed. The opposite side is entirely worn away and half a whorl (covering the left-hand portion of the figured side from the crack in the middle to the point marked \* has been omitted on account of still more defective preservation. At the end, however, of the complete example, representing a septal surface at about 115 mm diameter, the whorl-section was probably much as restored in fig. 5b, with the greatest thickness (about 65 %) still in the region of the primary ribs which pass over the rounded umbilical edge. At one place on the isolated last half-whorl, however, the umbilical wall is almost perpendicular and quite smooth, so that the roundness of the edge may be at least partly due to the defective preservation. The ribs are increasingly more distant and blunter, with apparently about eight primary ribs on the (unfigured) last half-whorl; but it is impossible to state whether this is followed by a smooth stage, as in the somewhat similar *Arctocephalites sphaericus* (Plate XVII, fig. 1).

The suture-line is only partly shown and seems to resemble that of *C. freboldi*, without, however, being quite so finely subdivided. The ventral portion of the suture-line, unfortunately, is not visible and preparation seems inadvisable, in view of the crumbly condition of the matrix. The small fragment, figured in Plate XXII, figs. 3a, b, however, well shows the suture-line, down to the damaged umbilical wall. The septal surface of an inner whorl, nearly circular, is shown in the matrix of the dorsal side of this fragment, but is displaced by mineralisation. If this example belongs to the same species as the first, the differences from *C. freboldi* consist chiefly in the slightly finer and closer ribbing, the longer primaries; and the less conspicuous umbilical border.

While these two examples, then, might well have been discussed with *C. freboldi*, a third and largest specimen, with still smaller umbilicus, (14 % at 120 mm diameter) may belong to a different species and it can only provisionally be referred to *Cadoceras*. Only its suture-line is figured (Text-fig. 4b, p. 66) and even this has suffered from the general corrosion, though only in details of frilling. It does not differ in any essential from that of the second fragment discussed above. The most conspicuous external differences are the greater obliqueness of the ribbing and the general compression of this third example, but as it is so badly crushed that the median saddle of the external lobe of the suture-line is well below the (accidentally sharpened) periphery on one side, no significance is attached to these differences. The example is entirely septate, but the body-chamber probably started at the present diameter of 120 mm, to judge by the surrounding matrix. Blunt ribs, especially the thickened primaries, still persist almost to the end of the

septate stage, so far as can be seen, and the umbilical wall is comparatively low and rounded. In spite of its more macrocephalitic aspect, the largest example thus probably also represents an early type of *Cadoceras*, transitional to *Arctocephalites*.

The resemblance to *Indocephalites chrysoolithicus* (Waagen)<sup>1)</sup> is interesting in view of Nikitin's inclusion of this Indian form in the genus *Cadoceras*. The decline of ornamentation, while still in the septate stage, however, prevents comparison of the Greenland species with either *Indocephalites* or *Kamptokephalites*, while '*Macrocephalicerus*' (d'Orbigny's *Amm. tumidus*)<sup>2)</sup> is characterised by its inner whorls (of *Pleurocephalites* aspect) and the broad saddles of its suture-line.

The forms here described may also be held to show some resemblance to *Macrocephalites krylowi* (Milachewitch)<sup>3)</sup> and its allies like *M. pila*, Nikitin<sup>4)</sup>. The former had been compared to *Kamptokephalites* (*lamellosus* and *grantanus*) on the one hand and to *Cadoceras wosnessenskii* (Grewingk) on the other, and it is characterised by evolute inner whorls, but increasing inclusion, with overhanging umbilical wall in the adult. According to Sokolov<sup>5)</sup> it occurs together with *Arcticoceras ishmae* and the whorl-section given by the latter author, might well be that of an *Arctocephalites*; but since the original had a large part of the body-chamber, it must be put (with *M. pila*) in the genus *Pleurocephalites*. The inner whorls of the latter species, as figured by Semenow<sup>6)</sup>, and the allied *M. andrussowi*<sup>7)</sup> show that this group is close to *Pleurocephalites folliiformis*, Buckman<sup>8)</sup>, and their finely-ribbed inner whorls and sharp costation on the body-chambers separate them widely from the forms here discussed. If a body-chamber fragment (No. 328) of another large example with blunt ribs also belong to the group here discussed, then the reference to *Cadoceras* rather than to these Macrocephalitics would be open to criticism.

Except for its wider umbilicus and persistence of the ribbing, the third and largest example mentioned might also be compared to the coarsest of Frebold's three Spitsbergen specimens of *Macrocephalites* cf. *ishmae*, var. *arctica*, Newton already referred to (p. 37). This, how-

<sup>1)</sup> See Spath, *loc. cit.*, Pal. Indica, 1928, pt. III, pl. XXI, fig. 6.

<sup>2)</sup> Pal. Française. Terr. Jurass., I, 1848, pl. CLXXI.

<sup>3)</sup> "Études paléontologiques. II. Sur les couches à *Amm. macrocephalus* en Russie". Bull. Soc. Imp. Nat. Moscou, vol. LIV, 1879, no. 3, p. 14, pl. 1, figs. 1a, b and c.

<sup>4)</sup> *Loc. cit.* (Elatma II), 1885, p. 50, pl. (VIII) x, figs. 45—46.

<sup>5)</sup> *Loc. cit.* (Petschorascher Jura), 1912, pp. 14 and 49.

<sup>6)</sup> "Faune des dépôts jurassiques de Mangyschlak et de Tourar-Kyr". Trav. Soc. Nat. St. Pétersb. (Géol. et Min.) vol. XXIV (1896), pl. 11, figs. 2a—d.

<sup>7)</sup> *Ibid.*; figs. 3a—d; p. 130.

<sup>8)</sup> Type Ammonites, vol. IV, 1922, pl. CCCXLVIII.

ever, is still farther removed from *Cadoceras* and is a typical *Arctocephalites*.

Horizon and Localities:— Horizon with calcareous concretions, *tychonis* horizon (and below?) Vardekløft Formation, loose, locality B (3 examples); locality C, 525 m (the doubtful body-chamber fragment).

7. *Cadoceras dubium*, sp. nov.

(Plate XXII, figs. 2a, b).

The holotype of this form consists of little more than the body-chamber, what is left of the inner whorls being replaced by crystalline calcite. The dimensions of the complete shell are:—

Diameter in mm.....	63
Whorl-height (% of the diameter).....	49
Whorl-thickness (% of the diameter).....	49
Umbilicus (% of the diameter).....	18

The inner whorls are more compressed, so far as can be seen, and at 40 mm diameter, the whorl-height is still in excess of the thickness. This is the end of the septate stage and the inflation, slight as it is, is confined to the body-chamber which comprises nearly a whole whorl. The apertural margin, however, is not preserved. The whorl-section is elliptical at first, but the umbilical slope becomes high and abrupt towards the end. The greatest thickness is near the rounded umbilical edge and the whorl-section gradually narrows towards the periphery. The lower portion of fig. 2b thus shows the whorl-shape better than the more defective upper part.

The ribs are mostly biplicate and the point of bifurcation is distinct in general. There are only a few intercalated secondaries and a few single ribs. The costation is prominent, especially on the venter and towards the end, and there is a slight peripheral sinus forward. The suture-line is not visible.

This species, in the gradual coarsening of its ornamentation on the body-chamber, undoubtedly approaches *Pseudocadoceras* rather than *Cadoceras*; which typically has a smooth body-chamber. On the other hand, since the present form only acquires the steep umbilical wall towards the end, without uncoiling at the same time, it is probable that it is merely a compressed *Cadoceras* which, on further growth, would have become more globose. The compression alone distinguishes it from all the other species here described, which, however, on account of a similar type of ribbing, might be difficult to distinguish in the case of crushed individuals. The compressed Russian forms of *Cadoceras*.



like *C. compressum* (Nikitin) and others referred to above (p. 62) all have finer ribbing with far more projection.

Horizon and Locality:— Horizon with calcareous concretions, *Tychonis* Beds, Vardekløft Formation, locality B, (holotype).

8. *Cadoceras franciscus*, sp. nov.

(Plate XX, figs. 2a—c).

This species is based on the example figured in Plate XX, fig. 2, which shows already part of the body-chamber. The dimensions are:—

Diameter in mm.....	62 (56)
Whorl-height (% of diameter).....	46
Whorl-thickness (% of diameter).....	50
Umbilicus (% of diameter).....	23

The inner whorls, as seen in the umbilicus, are typically cadoce-  
ratid, with fine costae, reclined on the steep and high umbilical slope,  
but with a rounded edge, as in young *C. elatmae*, though more com-  
pressed. After 40 mm diameter, the whorl-section becomes circular and  
then subcordate, with the greatest thickness near the umbilical border  
and the periphery highly arched. The umbilical wall then becomes very  
high but it is only slightly steeper than in the young *C. frearsi* (d'Orbigny)  
Nikitin<sup>1</sup>). The ribs are fine and close, and mostly bifurcating, except  
near the end of the septate stage, where the secondaries are first irregular  
and then obsolete. The body-chamber probably was entirely smooth  
anteriorly because the last few primaries seen on the earliest part of  
the body-chamber also seem to weaken. In the somewhat similar *C.*  
*fearsi*, of course, the ribbing is much coarser and the periphery is  
sharpened at all stages. In the present form, the ventral sinus is scarcely  
perceptible.

The suture-line is finely divided and the first lateral lobe is deeper  
than the external lobe. The enlarged fig. 2c (Plate XX) shows the  
elements at about 35 mm diameter and the complex external saddle is  
seen in fig. 2b. It is very similar to that of *C. stenolobum*, Nikitin<sup>2</sup>)  
but this form differs entirely in whorl-shape.

Another example differs from the type in having the ribbing very  
slightly coarser, with the primaries blunter and more distant, also a  
wider umbilicus (30 %), with a higher and steeper wall. The specimen,  
at 66 mm diameter, just shows the beginning of the body-chamber  
and is smooth on the venter. It may be considered a transition to the  
more typical *Cadoceras*, like *C. victor*.

<sup>1</sup>) *Loc. cit.* (Elatma, I), 1881, pl. XI (IV), fig. 22b.

<sup>2</sup>) *Loc. cit.* (Elatma I), 1881, pl. XII (V), fig. 30.

This species shows some resemblance to *C. wosnessenskii* (Grewingk)<sup>1)</sup>, or at least to the diagrammatic original figure, but the high umbilical wall of the Alaskan form and its fine and long secondaries, as figured by Pompeckj<sup>2)</sup>, allow of easy distinction.

Horizon and Localities:— Horizon with calcareous concretions, *Tychonis* beds, Vardekløft Formation, locality B (holotype and 1 doubtful fragment); locality C, 525 m (1 transitional example).

#### 9. *Cadoceras variabile*, sp. nov.

(Plate XVIII, fig. 1; Pl. XIX, figs. 1a—c, 2a, b; Pl. XXIV, figs. 5a, b).

The fragmentary example figured in Plate XIX, fig. 1, is selected as type because its inner whorls are well exposed. The dimensions at various stages are the following:—

	Diameter in mm	Whorl-height %	Thickness %	Umbilicus %
Holotype (Plate XIX, fig. 1) . . . . .	33	40	40	30
— — — . . . . .	74	40	51	29
— (complete) . . . . .	112	38	?	32
Plate XVIII, fig. 1 . . . . .	142	40	50	25
Plate XIX, fig. 2 (var. <i>occlusa</i> ) . . . . .	54	49	50	24

It is not certain whether the inner whorls, figured in Plate XXIV, figs. 5a, b, actually belong to the present species since they were not broken out of a larger example, but found loose. They show, however, the same evolute coiling, circular whorl-section and costation, the latter with the characteristic sinus forward on the periphery. The ribs, then, are sharp, especially in the type which is in a better state of preservation than the isolated inner whorls. They are either single or bifurcating and the branching occurs at about the middle of the side or just below. At 30 mm diameter the umbilical wall begins to take on the typical *Cadoceras* aspect, with the primary ribs showing well at the contact of the whorls, but disappearing on the umbilical slope which tends to become entirely smooth. There is no sharp edge, however, at any stage and even on the smooth body-chamber, the umbilical rim remains rounded.

The irregularly bifurcating ribs, with an occasional intercalated secondary on the medium-sized whorls, are strongly projected; but at 70 mm diameter they become weakened and, on the outer whorl, the secondaries tend to disappear altogether. They may reappear, how-

<sup>1)</sup> *Loc. cit.* (Verh. Russ. K. Min. Ges.) 1850, p. 344, pl. iv, figs. 1a—d.

<sup>2)</sup> *Loc. cit.* (Jurafossilien Alaska), 1900, p. 251, pl. v, fig. 5.

ever, near the deep constriction which precedes the mouth-border, while the oblique primary folds persist more or less distinctly throughout. The whorl-section in the later stages is decidedly inflated and the venter is broadly arched. The mouth-border, with its strongly inclined constriction and projecting rounded lappet, is comparable to that of *C. elatmae*, Nikitin sp.<sup>1)</sup> or of *C. tchernyschewi*, Sokolov<sup>2)</sup>, both of which, however, are different in whorl-section. The body-chamber occupies exactly three-quarters of the outer whorl.

The suture-line is very complex (Plate XIX, fig. 1d) and similar to that of *C. freboldi*. The last few suture-lines of the large example figured in Plate XVIII, fig. 1 are slightly simplified, the external saddle especially acquiring a broader stem.

This large example, on account of its narrower umbilicus, differs somewhat from the holotype, but its inner whorls are poorly preserved. It is possible that it belongs to the var. *occlusa* (Plate XIX, fig. 2) but in this the umbilicus is only 24 % of the diameter already in the young. The ribbing and suture-line are the same as in the type, but in the absence of the outer whorls it is impossible to identify the two examples. This var. *occlusa* somewhat resembles a Russian *Cadoceras* referred by Nikitin<sup>3)</sup> to *C. tchefkini*, but the slower increase in the thickness and the absence of a distinct umbilical edge are sufficient to distinguish the Greenland form.

*Paracadoceras harveyi*, Crickmay<sup>4)</sup> differs not only in size and whorl-shape, but in its simpler suture-line. *Cadoceras breve*, Blake<sup>5)</sup> is much closer and shows similar rejuvenation of the ribbing towards the end of the body-chamber which is just over three-quarters of a whorl in length. The differences are chiefly in size, width of umbilicus and whorl-section; but as the unique Cornbrash type is imperfectly preserved and only its last suture-line is shown, comparison cannot be pushed any further. The umbilical rim, however, of *C. breve* is already very distinct for so early a form. The resemblance of the body-chamber of the holotype to that of a *Cadoceras* figured by Douvillé<sup>6)</sup> as *C. modiolare* is superficial, the earlier whorls being very different in the two forms.

**Horizon and Localities:**— Horizon with calcareous concretions, *Tychonis* beds Vardekløft Formation, Locality A, 560 m (1 example); locality B (2 examples), locality C, 525 m (1 example); south of *Goniomya*-

<sup>1)</sup> *Loc. cit.* (Elatma, I), 1881, pl. xi (iv), fig. 20.

<sup>2)</sup> *Loc. cit.* (Mém. Com. Géol. N. S. 76), 1912, pl. 1, fig. 2.

<sup>3)</sup> *Loc. cit.* (Rybinsk &c., 1881), pl. iii, fig. 22.

<sup>4)</sup> *Loc. cit.* (Nat. Mus. Canada, Bull. 63), 1930, p. 55, pl. xvi, figs. 1—2.

<sup>5)</sup> *Loc. cit.* (Mon. Pal. Soc.), 1905, p. 48, pl. v, fig. 1.

<sup>6)</sup> Céphalopodes calloviens d'Argences. Mém. Soc. Linn. Normandie, vol. XXIII.

kløft, locality D, 540 m (3 examples); Mountain west of Mt. Harris, near Point Constable (1 example).

10. *Cadoceras pseudishmae*, sp. nov.

(Plate VIII, figs. 6a, b).

In the very prominent, lamellar, costation and its projection peripherally this species may be held to show affinities with *Arcticoceras*, but since there is a high and almost perpendicular umbilical wall and inflation towards the end of the only example available, reference to *Cadoceras* becomes necessary. The completely septate holotype has the following dimensions:—

Diameter in mm.....	88
Whorl-height (% of diameter).....	48
Whorl-thickness (% of diameter).....	55
Umbilicus (% of diameter).....	20

The inner whorls are not exposed, but on the side not figured the umbilical wall of the penultimate volution is seen to resemble that of *C. elatmae*, with the closely-set primaries (before they become nodate in the Russian species) forming the characteristic *Cadoceras*-festoon along the umbilical suture. Phillips<sup>1)</sup>, in his drawing of a doubtful *C. sublaeve* seems to have inadvertently put these ribs at the bottom instead of along the top of the umbilical wall. The present form, however, has a similar crater-umbilicus, so far as can be seen, without a trace of steps.

The ribs are irregularly bi- and trifurcating and are distinctly inclined forward, with a pronounced peripheral sinus. This is not seen in the ventral view (fig. 6b) on account of the curvature of the whorl and this aspect is also misleading since it suggests a rounded umbilical edge on the (very defective) last volution. The costation is distinctly weakened towards the end, but as the present termination of the example is a septal surface, the complete specimen must have been of considerable size. The somewhat trigonal section of the whorls, with slightly sharpened venter is suggested only in the lower part of fig. 6b. The suture-line is too indistinct for description.

*C. pseudishmae* has some resemblance to that English species referred to on p. 62 which had been compared to *C. stenolobum* already by Pompeckj. Its ribbing, however, is much closer and less sharp and prominent. Among the Greenland species, *C. frebaldi* is distinguished by its straighter costation, and the inner whorls of *C. variabile* or of its

<sup>1)</sup> Geology of Yorkshire, Vol. II, 1829, pl. vi, fig. 22.

var. *occlusa* are less strongly ribbed. *Arcticoceras simplex* is closer in the style of costation, though it has more numerous ribs, but its rounded umbilical slope, without edge, and the general whorl-shape suggest reference to a different group.

It is tempting to consider the form represented in Plate XI, fig. 3, as not only a forerunner of the present species but also as a passage-form between *Arctocephalites* and *Arcticoceras*. Its very low umbilical wall, however, definitely separates it from the form here described, in spite of a somewhat similar, trigonal whorl-section. It also resembles the forms described above as *Cadoceras* (?) sp. ind., but it is probably an *Arcticoceras*.

Horizon and Locality:— *Arcticoceras* beds, Mt. Mikael, loose, at 600 m (1 example).

Genus *PARACADOCERAS*, Crickmay, 1930.

*Paracadoceras ammon*, sp. nov.

(Plate XXI, figs. 5a, b).

Only the body-chamber of a single example is available but it is so different from any described species that the bestowal of a new name is well justified. The measurements of the holotype are:—

Diameter in mm.....	86
Whorl-height (% of diameter).....	40
Whorl-thickness (% of diameter).....	40 (?)
Umbilicus (% of diameter).....	33

The specimen is slightly deformed which accounts for the elliptical shape; and the measurements are approximate. But the ventral sinus in the fine and close ribbing is original and the plain mouth-border with its peripheral lappet is almost intact. The inner whorls up to the last suture-line are missing; since, however, the dorsal area is much too narrow to accommodate the earlier whorls, even if they were extremely compressed, the example must also have been crushed. The inner whorls may have been similar to the type of *C. franciscus* figured in Plate XX, fig. 2, but the costation persists unchanged and pronouncedly prorsiradiate on the entire body-chamber. It is characterised by the long primaries which pass over a perfectly rounded umbilical slope and subdivide rather irregularly at the middle of the side, but there are in addition intercalated secondaries. The ribs are sharper at first, then tend to become blunt especially on the venter. There is no trace of the suture-line.

*P. harveyi*, Crickmay<sup>1)</sup> differs in its smooth body-chamber, with

<sup>1)</sup> *Loc. cit.* (Nat. Mus. Canada, Bull. 63), 1930, p. 55, pl. xvi, figs. 1—2.

primary folds, which are also far more distantly placed. There does not seem to be any other described species with which the present form could be compared, for similarly evolute *Cadoceras* of the early *breve-elatmae* group have a distinct umbilical edge and in the case of Quenstediocerates of the *mologae-rybinskianum* type, the resemblance is only very distant.

Horizon and Localities:— Horizon with calcareous concretions, *Tychonis* Beds, Vardekløft Formation, South of *Goniomya*-Kløft, locality D, 540 m (holotype).

#### Family *Kosmoceratidae*, Hyatt 1900, emend.

This family is now taken to include only the genera *Kepplerites*, Neumayr (with the sub-genus *Seymourites*, Kilian and Reboul, as explained below), *Govericeras*, Buckman, *Sigaloceras*, Hyatt, and *Kosmoceras*, Waagen, the last with the sub-genera *Gulielmiceras*, *Gulielmites*, *Zugokosmokeras*, and *Spinikosmokeras*, Buckman. The subdivision of this homogeneous family into three by Buckman<sup>1)</sup> is unnecessary, and his inclusion of the uncoiled 'Parapatoceratidae' as a fourth is altogether unacceptable. These last i. e. the single genus *Parapatoceras*, is now known to be connected with the earlier *Spirocera* by transitions and must be attached to the Parkinsonidae. The numerous genera created by Buckman for small and often heterogeneous groups of Kosmoceratids within his remaining three families have already been rejected by Brinkmann<sup>2)</sup> who rightly complained that scarcely distinguishable varieties had been referred to different species and even genera. Brinkmann, however, was not justified in altering the spelling of Buckman's names, whether objectionable or not, and he went wrong in the use of '*Anakosmoceras*' (sic) instead of *Gulielmiceras*, dating from 1920.

As regards the derivation of *Kepplerites*, the earliest of the Kosmoceratid genera, I agree with Brinkmann who accepted its Macrocephalitid origin. Contrary to Buckman whose cyclical views and belief in a 'law of earlier inheritance' necessitated the assumption not only of an unknown ancestor in an unknown locality, but an inversion of the "biological order", I see in the appearance of a transient runcinate stage in the earlier forms of Kosmoceratids merely a parallel to the first appearance of the *Cadoceras* and *Cardioceras* characters in the young stages of the other derivatives of the Macrocephalitidae, discussed in this memoir.

With regard to the geographical distribution of the Kosmoceratids,

<sup>1)</sup> Type Ammonites, vol. vi, 1926, p. 20.

<sup>2)</sup> "Monographie der Gattung *Kosmoceras*". Abh. Ges. Wiss. Göttingen, Math.-Nat. Kl., N. F. vol. 111, 4, 1929, p. 8.

Brinkmann stated that only very few lived in the Arctic Jurassic, in spite of its boreal character (*Cadoceras*, &c.); that they became scarce already in the Petchora district; were known from East Greenland in only two examples, and had been recorded in doubtful fragments from Franz Josef Land, Alaska and British Columbia, but not from the North Siberian Jurassic. It seems to me that in view of the scarcity or absence of Upper Callovian and Divesian deposits in these Arctic areas, the rarity of Kosmoceratids is largely accounted for.

Genus *KEPPLERITES*, Neumayr 1892<sup>1</sup>).

Sub-genus *Seymourites*, Kilian and Reboul, 1909.

This genus has recently been discussed by various writers but since there is considerable divergence of opinion, it becomes necessary to review the group of forms to which it belongs. The genotype is *K. keppleri* (Oppel) which was not figured by its author, but which was included by Zittel<sup>2</sup>) in the genus *Macrocephalites*, not in *Kosmoceras* ('*Cosmoceras*'). Comparing the illustrations of one of Oppel's Ehningen syntypes of *K. keppleri* (in Buckman<sup>3</sup>)) with Quenstedt's *Amm. macrocephalus evolutus*<sup>4</sup>), one is, indeed, struck by their similarity. '*Cerericeras*' *ceriale*, S. Buckman<sup>5</sup>), is another form of the same group, notwithstanding Buckman's placing of this 'genus', without the slightest reason, six hemerae earlier than *Kepplerites*, and in spite of apparent slight differences in the suture-lines (of single individuals). Now to my mind, these three forms represent the true *keppleri* group, perhaps even the single species *K. keppleri* itself, and it is taken to be a Macrocephalitid stock, in which runcination of the periphery, transient at first, and appearing on the inner whorls first instead of the outer, wrongly suggests a Parkinsonid ancestry. Neumayr, on the other hand, started off by defining his genus *Kepplerites* as including "Kosmocerates", showing an early *Parkinsonia*-stage. Buckman, in 1926, still accepted this recapitulatorial view of the origin of 'Gowericeratidae'; and apparently not knowing the young stages of the early Kosmoceratids, he was led by his own theorising to make the extraordinary statement that "geological order was, in the main, the inverse of biological order". Brinkmann<sup>6</sup>) was much nearer the mark in stating that Quenstedt's

<sup>1</sup>) In Neumayr and Uhlig: "Über die von H. Abich im Kaukasus gesammelten Jurafossilien". Denkschr. Akad. Wiss., Wien, Math.-Nat. Kl. vol. LIX, 1892, p. 53.

<sup>2</sup>) Handbuch der Paläontologie. Vol. I, Abt. II, Lief. III, Munich, 1884, p. 470.

<sup>3</sup>) Type Ammonites. Vol. IV, (1922), pl. cclxxxix a, b.

<sup>4</sup>) "Ammoniten des Schwäbischen Jura". Vol. II, p. 655, pl. lxxvii, figs. 1—5.

<sup>5</sup>) Type Ammonites, Vol. IV, (1922), pl. cclxxvi.

<sup>6</sup>) "Monographie der Gattung *Kosmoceras*". Abh. Ges. Wiss. Göttingen, Math. Phys. Kl., N. F., vol. XIII, No. 4, 1929, p. 14.

*Amm. macrocephalus evolutus* showed the close affinity that existed between the oldest Kosmoceratids and the Genus *Macrocephalites*, but he erroneously considered Quenstedt's *Amm. macrocephalus evolutus* to represent the fully-grown *Amm. gowerianus*. This, of course, may be due to Quenstedt's inclusion of a small *Gowericeras* (pl. LXXVI, fig. 9), with a tubercle at the middle of the side, in the same species as the large *Keplerites* represented in his pl. LXXVII, figs. 1—5.

It is possible that Neumayr was misled by the same figures when he described the young of *Keplerites* as tuberculate, but in any case he included in his genus three successive assemblages of which the one to which the (Bathonian) genotype *K. kepleri* belongs is almost untuberculate in the young, or at least has only a small tubercle, placed close to the umbilical wall. At larger diameters this is always lost, and there is the characteristic return to a *macrocephalus*-stage. In the *gowerianus* group of the next higher (koenigi) zone, the tubercle is at the middle of the side in the young and persists in this position to the end, the only resemblance to the earlier *kepleri*-group (to which, however, there are many transitions) being the presence of a runcinate stage, which may be equally transient, but which is preceded by a far more distinctly Kosmoceratid stage, i.e. the '*Parkinsonia* stage' of Neumayr. Finally there is the third, and latest *calloviensis* group, already close to *Kosmoceras* (*Gulielmiceras*), in which runcination persists to the end, although tuberculation disappears. There are again many transitions between this (*Sigaloceras*, Hyatt) and the *gowerianus* group (*Gowericeras*, Buckman), and the last survivors of the latter, in the *calloviense* beds especially, figured by Buckman as *Galilæiceras galilæii*, '*Galilæites*' and '*Galilæanus*' are intimately connected with the 'micans' (= true *galilæii*) or *calloviense* group of *Sigaloceras* in which rejuvenation of the ornament results in a few coarse and tuberculated pleats. By including in the synonymy of Sowerby's *Amm. gowerianus* such diverse elements as *Keplerites kepleri*; *Kosmoceras semenowi*, Uhlig; *K. boreale*, Ravn, etc., Brinkmann has only brought confusion into this group, although his attempt to simplify the nomenclature was laudable.

Buckman, before him, had gone to the other extreme, but his names were largely given on the basis of a spurious stratigraphy. If *Gowericeras* (with '*Torricellites*') were as widely separated from '*Galilæiceras*' (with '*Galilæites*' and '*Galilæanus*') as his chronology suggests (with the later '*Catasigaloceras-Gulielmiceras* fauna', wrongly interpolated between the two) then there might be some justification for their generic separation. The same may be said of '*Gulielmina*' as distinct from *Sigaloceras*, *Cerericeras* as compared with *Keplerites*, and so forth, for artificial differences can easily be demonstrated with graphs. But the differences in age are either imaginary or else the exact contrary



of what Buckman had stated; and his tables of the morphic development of the ten "genera" of his family Gowericeratidae are still less evidence of their distinctness, for the cyclical views on which they are based are now discredited.

So far as the known European forms of this group go, then, there is no difficulty in distinguishing the three divisions indicated, in spite of the occurrence of numerous transitions. There is clearly nothing among the Arctic forms here dealt with that could be attached either to *Sigaloceras* or to *Gowericeras*, although Brinkmann thought *Kosmoceras* (*Keplerites*) *loganianum* to be probably identical with *G. gowerianum*. There remains *Keplerites* in the restricted sense, which has the more complex suture-lines and the macrocephalic inner whorls of the boreal forms under discussion; and it has to be seen whether their separation as an independent genus *Seymourites*, was justified. Kilian and Reboul<sup>1)</sup>, in establishing this genus, were, of course, entirely misled; but since they definitely mentioned Whiteaves's *Amm. loganianus*<sup>2)</sup> as the type of their section *Seymourites* (of the genus *Kosmaticeras*, Gros-souvre), this name has to be adopted for the boreal group, if found to be sufficiently distinct from *Keplerites*. Neumayr, himself, although he had already in 1885<sup>3)</sup> compared *Am. loganianus* to Lahusen's *Kosmoceras gowerianum*, did not include it in *Keplerites*, but Martin<sup>4)</sup> quoted *Keplerites*? cf. *K. loganianus* (Whiteaves), together with the closely allied *Stephanoceras* cf. *Amm. astierianus* (Eichwald)<sup>5)</sup>, from his 'Cado-ceras' zone.

Frebold<sup>6)</sup>, as recently as 1930, identified with the Greenland *K. tychonis* his Spitsbergen *Macrocephalites* cf. *evolutus* (Quenstedt) and Sokolov and Bodylevsky<sup>7)</sup> also referred the same forms (as *K. svalbardensis*) to the genus *Keplerites*. But the boreal forms were definitely separated from the European groups when McLearn<sup>8)</sup>, in 1927, created

1) "Les Céphalopodes Néocrétacés des Iles Seymour et Snow Hill". Wiss. Erg. Schwed. Südpol.-Exped. vol. III, pt. 6, 1909, p. 26.

2) Mesozoic Fossils. Vol. 1, pt. 1. "On some Invertebrates from the Coal-Bearing Rocks of the Queen Charlotte Islands". Geol. Surv. Canada, 1876, p. 27, pl. VIII, fig. 2 only.

3) "Die Geographische Verbreitung der Juraformation". Denkschr. Akad. Wiss. Wien, Math. Nat. Cl., vol. 50 (1885), p. 96.

4) The Mesozoic Stratigraphy of Alaska. U. S. Geol. Surv. Bull. 776, 1926, p. 281.

5) Geognostisch-Paläontologische Bemerkungen über die Halbinsel Mangischlak und die Aleutischen Inseln. St. Petersburg, 1871, p. 143, pl. IX, figs. 1—2 (pl. VIII, fig. 3?).

6) "Verbreitung und Ausbildung des Mesozoikums in Spitzbergen". Skrifter om Svalbard og Ishavet. No. 31, 1930, p. 31.

7) *Loc. cit.* (Jura Kreidefaunen Spitzbergen), 1931, p. 80.

8) "Some Canadian Jurassic Faunas". Trans. Roy. Soc. Canada, (3) vol. XXI, sect. IV, 1927, p. 71.

the genera '*Yakounites*' and '*Yakounoceras*' for Whiteaves's *Amm. loganianus* and a close ally of this species. In a later paper<sup>1)</sup> '*Yakounites*', McLearn, was replaced by *Seymourites*, on the writer's pointing out the existence of this genus; and it was stated to differ from *Keplerites* in retaining the single row of lateral tubercles and in having a deeply-cut suture-line. In the case of '*Yakounoceras*', said to differ from '*Yakounites*' merely in details of the simpler suture-line, and in my opinion a synonym, the differences from *Keplerites* were also stated to consist of the retention of the tubercles and the possession of a very different suture-line. Since McLearn's remarks on *Keplerites*, however, were based on Buckman's figure and Quenstedt's suture-line, the differences are largely due to this extremely narrow interpretation adopted, and it will be shown below that in the East Greenland species, it is not only impossible to separate the tuberculate from the untuberculate forms, but the suture-line also may vary very considerably. There remains the difference in the early runcinate stage, but this again is so widely different even in individuals which in later stages cannot be separated specifically that generic distinction seems impossible. Nevertheless there are certain slight differences that make it advisable to retain *Seymourites* for the boreal forms, but only as a subgenus of *Keplerites*; for they are probably only differences of habitat. These are the large size, the tendency of the peristome to become flared, with a preceding shallow constriction, the loss of runcination at an earlier stage than in the Wurtemberg examples, and especially the finer ribbing in the young, the true *Keplerites* (including "*Cerericeras*") being coarser in the septate stage than most of the boreal forms here grouped in *Seymourites*. This separation may also yet be justified from a stratigraphical point of view; for *Seymourites*, being associated with *Cadoceras* and especially a *Gulielmiceras*, probably includes the boreal equivalents of the Callovian *Gowericeras* as well as of the Cornbrash *Keplerites*.

1. *Keplerites* (*Seymourites*) *tychonis* (Ravn).

(Plate XXIII, figs. 1-3; Pl. XXIV, figs. 2, 4, 6; Pl. XXV, figs. 1-3; Pl. XXVI, figs. 3, 6.

?1904. *Macrocephalites* sp. cf. *compressus* (Quenstedt) Madsen: "Jurass. Foss. E. Greenland", *loc. cit.*, p. 192.

1911. *Keplerites tychonis*, Ravn: "Jurass. Cretac. Foss. N. E. Greenland", *loc. cit.*, p. 490, pl. xxxvii, fig. 1.

1929. — — — Rosenkrantz in Lauge Koch: "Geo-

<sup>1)</sup> *Loc. cit.* (Nat. Mus. Canada, Bull. no. 54), 1929, p. 4.

- logy of East Greenland", *loc. cit.*, p. 146.
1929. *Kepplerites tychonis*, Ravn: Frebold: "Ob. Lias. Unt. Callov. Spitzbergen", *loc. cit.*, p. 11.
1929. *Kosmoceras (Kepplerites) tychonis* (Ravn); Brinkmann: "Monographie Gattung *Kosmoceras*". Abh. Ges. Wiss. Göttingen, Math. Phys. Kl., vol. XIII, pt. 4, p. 36.
1930. *Kepplerites tychonis*, Ravn; Frebold: "Verbreit. Ausbild. Mesozoikums Spitzbergen", *loc. cit.*, p. 31.
1931. — . — . — . Sokolov and Bodylevsky: "Jura Krei-defaunen Spitzbergen", *loc. cit.*, p. 80.

There are altogether about 40 examples and fragments referred to this species and it has been possible to study its variability. It should be mentioned, however, that in delimiting the form the ornamentation has (arbitrarily) been taken to be the most important feature, the details of the suture-line varying considerably even on opposite sides of the same specimen. The changes in the whorl-section (in uncrushed specimens) also are not considered to be of significance. As a rule the whorls are slightly higher than broad, after a diameter of about 35 mm, but in the example (467) figured in Plate XXV, fig. 2, the proportions vary as follows:—

	at 117 mm diameter	at 100 mm diameter
Whorl-height (°/o) . . . . .	30	39
Whorl-thickness (°/o) . . . . .	34	39
Umbilicus (°/o) . . . . .	40	35

At a smaller size (75 mm) where the whorl-height = 35 mm, the thickness is 30 mm and the section then resembles that figured by Ravn (pl. xxxvii, fig. 1c); but it must not be assumed from the measurements given that there is a regular increase in whorl-thickness, for in this specimen the aperture is 'flared' i.e. it suddenly opens out, trumpet-wise, after a very noticeable contraction of the whole whorl. In another complete example (472), with the mouth-border as oblique as in the lectotype of *K. svalbardensis*, the constriction is less deep and the labial rim of the aperture is only slightly raised. This second example, however, at 112 mm diameter, has an umbilicus of only 30 °/o. The length of the body-chamber varies from just over half a whorl to nearly three-quarters.

In the example (468) figured in Plate XXIII, fig. 1, the width of the umbilicus is only 25 °/o at 100 mm diameter and at 70 mm it has

decreased to 18 %. This latter represents the adolescent stage that resembles *Macrocephalites*, but the primary ribs tend to show either definite tuberculation or at least are more raised and more bent than in such comparable *Macrocephalites* as *M. (Dolikephalites) flexuosus*, Spath<sup>1)</sup>, or *M. (D.) gracilis*, Spath<sup>2)</sup>.

In other examples the 'macrocephalus-stage' can be traced back to the preceding 'gowerianus-stage' (see Plate XXIII, fig. 3) in which runcination (i.e. truncation of the ventral area, with appearance of ventro-lateral edges) may or may not be apparent. The umbilicus is again wider in the young and dimensions of two examples (including that here figured) compare as follows:—

	No. 465 (at 45 mm diameter)	No. 466 (35 mm diameter)
Height of last whorl (°/o) . . . . .	48	50
Thickness of last whorl (°/o) . . . . .	44	43
Umbilicus (°/o) . . . . .	27	26

There are generally two or three secondary ribs to each primary tubercle in the young, or about 72 ribs to 27 tubercles, but in the example (473) figured in Plate XXIII, fig. 2, there are 84 secondaries to 27 primaries, i.e. it represents already the *macrocephalus* stage. At still smaller diameters, the appearance is that figured by Ravn in his figures 1d, e, but owing to the enlargement and the fact that the umbilicus is covered, the aspect of these inner whorls is somewhat misleading. In fact I believe that the immature examples described by Ravn<sup>3)</sup> as "*Kosmoceras boreale*" are merely the young of the present species or its closer allies. Ravn himself compared them to *Kepplerites lahuseni*, Parona and Bonarelli<sup>4)</sup>, which is close to *Sigaloceras quinqueplicatum* (Buckman)<sup>5)</sup>, and Brinkmann<sup>6)</sup> included *Kosmoceras boreale* in the synonymy of his (far too comprehensive) *Kepplerites gowerianus*. But Ravn's examples do not differ in any essential feature from the three immature examples here figured in Plate XXIII, fig. 3, Pl. XXIV, fig. 4, and Pl. XXVI, fig. 3, and the suture-line of the inner whorls of another example (No. 465) figured in Plate XXV, fig. 3, shows the same general plan.

<sup>1)</sup> Revision of the Jurassic Fauna of Kachh. Pt. 3. Pal. Indica, N. S. vol. IX, Mem. No. 2, pl. xxxii, fig. 4.

<sup>2)</sup> *Ibid.*, p. 173 (= *Macrocephalites 'canizzaro'*, Couffon non Gemmellaro).

<sup>3)</sup> *Loc. cit.* (Jurassic and Cretaceous Fossils from N.E. Greenland), 1912, p. 489, pl. xxxvi, figs. 5—6.

<sup>4)</sup> "Sur la Faune du Callovien inférieur (Chanasien) de Savoie". Mém. Acad. Savoie, (IV) vol. VI, 1895, p. 138, based on one of Lahusen's examples of '*Cosmoceras gowerianum*' (*loc. cit.*, 1883, pl. vi, fig. 8 only).

<sup>5)</sup> See below p. 95.

<sup>6)</sup> *Loc. cit.* (*Kosmoceras* Monographie), 1930, p. 25.

Part of the external suture-line of the adult was figured by Ravn and it agrees with that of *K. (S.) svalbardensis* which, in fact, may be based only on crushed examples of the present species, for the only distinguishing feature, namely the bundling of the primaries in the Spitsbergen form, may be due to the deformation in the rock. There are three more saddles in the external suture-line (Plate XXV, fig. 2a) and in the more involute varieties and on the macrocephalitoid earlier whorls, only the first auxiliary saddle may be on the lateral area, whereas later even the second auxiliary saddle may lie outside the rounded umbilical edge. There is, however, considerable variability and simplification of all the elements towards the end of the septate stage.

In an involute variety (e.g. nos. 351, 346) the umbilicus is only 23% at a diameter of 95 mm, but as this is still in the septate stage, the difference is of not more than varietal value. As there are several more, typical, examples of this narrowly umbilicate variety (e.g. nos. 349—50) it may be named var. *involuta*. In the example figured in Plate XXV, fig. 1, the umbilicus is also narrow, but this is partly due to crushing, for the overhanging umbilical wall of the figured side is flattened on the other. This example, however, is rather more coarsely ribbed than the typical specimens or especially the var. *involuta* which, in this respect, is comparable to the larger type of *K. (S.) svalbardensis*, but only its septate stage. The original of Plate XXV, fig. 1, may then be considered to be transitional to a more coarsely-ribbed form of *Seymourites*, like *K. (S.) antiquus*, described below. The two smaller examples figured in Plate XXIII, fig. 2, and Plate XXVI, fig. 4 also develop rather more distantly-spaced ribbing towards the end and may be the young of the same transitional form, although they could equally well be attached to some of the examples included in *K. (S.) svalbardensis*, or to *K. (S.) peramplus*, nov. There is also an inflated variety, but as it is represented only by a single fragmentary example (no. 348) it cannot at present be more accurately described than by stating that the thickness, at 105 mm diameter, is 43%, the umbilical wall being unusually high.

The specimen figured in Plate XXVI, fig. 6, on account of its bundled ribs, has a very distinctive appearance, but as it also is before me in only a single example it is provisionally attached to the present species as a var. *fasciculata*. The inner whorls are indistinguishable from those of other examples (compare e.g. fig. 4 of the same plate) but the break shown in the photograph marks the last septal edge and the fasciculate ribs are most typically developed on the body-chamber. There are four or five secondaries to each primary rib, but towards the end they become less regular and the primaries are more closely spaced. It is the character of the costation on the whole of the

body-chamber (compare Plate XXIII, fig. 1) that may be looked upon as one of the most distinctive features of the typical *K. (S.) tychonis*. In *K. (S.) svalbardensis*, discussed below, the ribbing is taken to be as bundled and as persistent as in this var. *fasciculata* of *K. (S.) tychonis*, but in the absence of the body-chamber, differentiation would seem to be impossible.

What is probably yet a different form is represented by half an ammonite (completely septate) of 85 mm diameter (No. 334), with round, *gowerianus*-like, inner whorls. Its outer volution is only slightly more inflated than a corresponding whorl of *K. (S.) tychonis* and would not be separable even as a variety; but the distant (although untuberculate) primaries of the evolute earlier whorls give this form a very distinctive appearance. The inflated variety, mentioned above, differs in having the typical macrocephalitid inner whorls.

Horizon and Localities:— Horizon with calcareous concretions, Upper Vardekloft Formation, Localities A (560 m), B and C Vardekloft, and D (540 m) south of *Goniomya* Kløft (40 specimens). Mt. Mikael, at 620 m (1 specimen).

2. *Keplerites (Seymourites) svalbardensis*, Sokolov and Bodylevsky.

1929. *Macrocephalites cf. evolutus* (Quenstedt) Frebold: "Oberer Lias und Unteres Callovien in Spitzbergen", *loc. cit.*, pp. 10, 12, pl. II, figs. 1 (2 and 3?).

1930. *Keplerites tychonis*, Ravn; Frebold: "Verbreitung und Ausbildung des Mesozoikums in Spitzbergen", *loc. cit.*, pp. 19, 31, pars, non pl. VII, fig. 1.

1930. *Keplerites svalbardensis*, Sokolov and Bodylevsky: "Jura- und Kreidafaunen v. Spitzbergen", *loc. cit.*, p. 79, pl. v, fig. 1 only.

Since the Spitsbergen material attached to this species may include more than one form, I am basing my interpretation on Sokolov and Bodylevsky's larger example which appears to belong to the same species as Frebold's Botneheia fragment (pl. II, fig. 1). This form is represented by three crushed examples from Mt. Mikael, associated with a body-chamber fragment of *K. (S.) tychonis*, and it is possible that Frebold's smallest fragment (pl. II, fig. 4) also belongs to the latter species. The other three specimens figured by Frebold, however, and perhaps even Sokolov and Bodylevsky's paratype are still more doubtful and may belong to yet another species of *Keplerites*.

In the restricted interpretation, the present species differs from *K. (S.) tychonis* merely in having the primary ribs thickened where they branch. It is doubtful, of course, whether the greater length and the prominence of the fasciculate primaries in the Spitsbergen lectotype may not be due to the crushing; for Sokolov and Bodylevsky's smaller fragment does not differ from the inner whorls of *K. (S.) peramplus* at the same diameter. Since the three Greenland examples that I am now referring to *K. (S.) svalbardensis* have also suffered from deformation in the rock, and are moreover fragmentary, they cannot be taken to substantiate the validity of this species. On the other hand, it is just the bundling of the ribs on the body-chamber that prompted the creation of a var. *fasciculata* of *K. (S.) tychonis* for the unique specimen figured in Plate XXVI, fig. 6, which may thus be provisionally considered to represent a passage-form between the typical *K. (S.) tychonis* and *K. (S.) svalbardensis*.

The Canadian species that superficially resemble the species here described, have lateral tubercles, and *K. (S.) antiquus*, with similarly bundled ribs, is more distantly costate on the inner whorls and of different dimensions.

Horizon and Locality:— *Tychonis* horizon, Mt. Mikael, at 605—620 m (3 specimens).

### 3. *Kepplerites (Seymourites) peramplus*, sp. nov.

(Plate XXIV, figs. 1a, b).

The large example here figured shows some resemblance to certain Canadian species of *Kepplerites (Seymourites)* of equal size but it is more nearly related to *K. (S.) tychonis* from which it differs chiefly in dimensions. These are as follows:—

Diameter in mm . . . . .	115	210
Whorl-height (in % of diameter) . . . . .	50	38
Whorl-thickness (in % of diameter) . . . . .	50	35
Umbilicus (in % of diameter) . . . . .	17	34

From these measurements it is evident that the involute and rather inflated Macrocephalitid stage persists to a size at which the slender *K. (S.) tychonis* has already acquired its uncoiling body-chamber. The ribbing is also slightly coarser in the present species, and the primary costae are more conspicuous, as in *K. (S.) antiquus*. Both these species are somewhat transitional, in this respect, to *K. (S.) rosenkrantzi* and *K. (S.) nobilis* in which there is more definite tuberculation of the lateral end of the primary ribs, at least at one stage.

The half of the outer whorl preserved belonged to the body-chamber. It is characterised by the closely set primaries, as in *K. (S.) tychonis*, but the secondaries, not visible in the photograph on account of the defective preservation (and the angle of illumination), are retained to the end. They are about two and a half times the number of the primary costae. Compared with the more trigonal whorl-shape of the Macrocephalitic stage, with a high and perpendicular umbilical wall, the section of the body-chamber (fig. 1b) is more evenly rounded, with a gentle inner slope. The suture-line is complex but similar to that of *K. (S.) tychonis*, so far as it can be traced. There is a septal surface at the end of the earlier whorls, but not at the beginning of the body-chamber portion.

The fragmentary second specimen included by Sokolov and Bodylevsky in their *K. svalbardensis* is indistinguishable from the inner whorls of the present species at the same diameter. *K. (S.) plenus*, McLearn has not only different ribs on the body-chamber, but is tuberculate in the macrocephalic stage, at which there is considerable likeness to the present species.

The septate macrocephalic inner whorls of an example (no. 335) comparable to the young *K. (S.)* aff. *tychonis* figured in Plate XXVI, fig. 4, but with slightly more distant and stronger ribbing, may be doubtfully attached to the present species.

Horizon and Locality:— Horizon with calcareous concretions, Vardekløft, loc. A and B (2 fragments) and South of *Goniomya* Kløft, loc. D (holotype).

#### 4. *Kepplerites (Seymourites) rosenkrantzi*, sp. nov.

(Plate XIX, fig. 3; Pl. XXVI, fig. 1).

The example on which this species is based varies considerably in proportions at successive stages, as shown in the following table:—

Diameter in mm.....	52	77	105	145
Whorl-height (% of diameter).....	50	50	47	31
Whorl-thickness (% of diameter) ...	59	58	50	34
Umbilicus (% of diameter).....	23	23	26	39

The earlier whorls, on account of their having a distinct spine at the lateral termination of the primary ribs, resemble the true *Gowericerias* more than do the three species previously described. *G. ventrale*, Buckman<sup>1)</sup>, especially, is very similar although less globose and less

<sup>1)</sup> Type Ammonites, vol. IV, 1922, pl. CCLXXXVIII.



involute, but as in *G. gowerianum*, J. de C. Sowerby sp.<sup>1)</sup> (and its varieties *metorchum* and *childanum*, Buckman<sup>2)</sup>) the primary ribs are much longer and sharper than in the Greenland species, so that occasionally there is a suggestion of bituberculation. The inner whorls of these *Gowericeras*, however, figured by Buckman<sup>3)</sup> as '*Torricellites*', differ considerably. For they are loosely coiled and not macrocephalitoid, and not only is the primary ribbing different, but there are only two or three secondaries to each primary. The secondaries, moreover, are short and rigid, and they form a distinct tubercle at the sharply marked ventro-lateral angles.

In the present species the runcinate stage is only very slightly developed, at a very small diameter, and there is only a faint notch in the peripheral ribs. This produces merely a siphonal band such as foreshadows the groove in the later Berriasellidae on the inner whorls of Upper Jurassic Perisphinctids, and one of Zittel's<sup>4)</sup> figures of *Virgatosphinctes transitorius* (Oppel) well illustrates this type of periphery. The ventro-lateral rows of tubercles are scarcely visible and the evenly rounded venter is perfectly uninterrupted already after 25 mm diameter. The aspect of these inner whorls is somewhat between that of a young *Emileia* and an immature *Stephanoceras*<sup>5)</sup>. At 35 mm diameter, there are 18 primaries, strongly tuberculate at the point of greatest whorl-thickness, and 56 secondaries. The whorl-section is that of another young *Stephanoceras* figured by Quenstedt<sup>6)</sup>.

The number of secondary ribs to each primary subsequently increases to four (and occasionally five), but on the body-chamber the ribbing tends to become more irregular and much finer, so that the primaries also are elongated and closely-spaced. A small portion of the outer whorl of the holotype is missing, but another piece was left out in the photograph to expose the inner whorls. The body-chamber is complete from the last septal edge to the mouth-border, and the peristome with its ventral lappet is almost intact. The whorl-section from being macrocephalic or subreniform, is changed to more nearly circular at the end, and the umbilical wall which is first coronate then perpendicular and high, once more becomes rounded and low near the end. The suture-

<sup>1)</sup> Mineral Conchology, vol. VI, p. 94, 1827, pl. D XLX, fig. 2 (B. M. no. 43917). It is interesting to note that at Brora in Sutherland, this species reaches much larger dimensions (140 mm diameter) than in England.

<sup>2)</sup> Type Ammonites, vol. III, 1921, pl. CCLIV, and vol. IV, 1923, pl. CDIV.

<sup>3)</sup> Type Ammonites, vol. IV, 1922, pl. CCCXXXVI.

<sup>4)</sup> "Die Cephalopoden der Stramberger Schichten". Pal. Mitteil., vol. II, Abt. 1, 1868, pl. XXII, fig. 1c (middle portion of ventral band only).

<sup>5)</sup> See Quenstedt: "Ammoniten des Schwäbischen Jura", II, 1887, pl. LXIV, fig. 7, and pl. LXVII, fig. 8.

<sup>6)</sup> *Ibid.*, pl. LXVI, fig. 7.

line is highly complex and resembles that of *K. (S.) tychonis* or of *K. (S.) plenus*, McLearn sp.<sup>1</sup>) but the external saddle has a much slenderer base. The suture-line, at 30 mm diameter, shows the deep lateral lobe of the adult, and the same general plan, but the inner part of the first lateral saddle touches the lateral tubercle whereas, later, even the second lateral saddle is outside this point. In the more globose young *Gowericeras* of similar aspect (but less coronate and more runcinate), the first lateral saddle encloses the tubercle and the principal lateral lobe is short and greatly reduced, while the external saddle is very plump. In the typical *Gowericeras* of the Kellaways Clay and their descendants in the Kellaways Rock ('*Galilæiceras galilæi*', Buckman non Oppel) the second lateral saddle of the adult suture-line is always well inside the lateral tubercle.

The details of the inner whorls, given above are partly based on a paratype of the following dimensions:—

Diameter in mm.....	70	130
Whorl-height (in % of diameter).....	42	41
Whorl-thickness (in % of diameter)...	60	43
Umbilicus (in % of diameter).....	27	31

It differs from the holotype merely in having a more open umbilicus in the earlier stages. As it is still septate at the end, it must have been of considerably larger size than the holotype, but umbilical enlargement had already begun.

'*Yakounoceras ingrahami*, McLearn<sup>2</sup>) seems to be close to the present species, but its preservation is rather poor. It differs in proportions and perhaps in its comparatively short first lateral lobe. *K. (S.) gitinsi* (McLearn<sup>3</sup>) differs chiefly in its more coarsely-ribbed earlier stages with long primaries and *K. (S.) nobilis* has a more flattened whorl-section, a smaller umbilicus, and different inner whorls.

There is a very poorly preserved example of perhaps yet another Greenland species of *Seymourites* which is somewhat transitional to *K. (S.) gitinsi* and has coarser ribbing. In this respect it resembles what has been referred to on p. 80 as the true *kepleri*-group, and it is more coarsely ribbed than any of the doubtful examples that have been included in *K. (S.) svalbardensis*, Sokolov and Bodylevsky.

Horizon and Locality:— Horizon with calcareous concretions, South of *Goniomya*-Kløft, loc. D, 540 m (2 specimens); also Vardekløft, loc. C, 540—550 m (one doubtful example).

<sup>1</sup>) *Loc. cit.* (Nat. Mus. Canada, Bull. 54), 1929, p. 5, pl. i, fig. 1, pl. ii, figs. 1, 2.

<sup>2</sup>) *Ibid.*, p. 9, pl. vii, figs. 1—2.

<sup>3</sup>) *Ibid.*, p. 8, pl. iv.

5. *Keplerites* (*Seymourites*) *antiquus*, sp. nov.

(Plate XXII, fig. 1).

The holotype of this species is slightly deformed, as though crushed obliquely, and only one side is preserved, forming the surface of a rounded clay-ironstone nodule. But the form is so clearly different from the other species here described that it may safely be named, its resemblance to *K. (Seymourites) loganianus* (Whiteaves<sup>1</sup>)), also being only superficial.

The present diameter of the specimen is over 150 mm, but the fact that the umbilical wall is gently rounded on the left (of the picture) and overhanging on the right indicates that the flattening of the outer whorl is not original. If it is remembered that the holotype of *K. (S.) loganianus* is also imperfect and distorted<sup>2</sup>), it seems fair to assume that the whorl-shape of the two species was similar and only slightly less robust than that of *K. (S.) plenus* (McLearn<sup>3</sup>)). Even if the flattening of the outer whorl of the present form, however, be accidental and the diameter, therefore, originally smaller, the width of the umbilicus cannot have been more than about 20 % of the diameter; i.e. it was much less than in Whiteaves's species.

The ribbing of the form here described also differs in having the primary portion scarcely tuberculate and giving rise to five secondaries. The thickened lateral end of the primaries thus is fasciculate rather than tuberculate and on the inner whorl the primaries are more distantly spaced than in *K. (S.) loganianus*. The obvious difference in the comparative length of primaries and secondaries in the two species is of less import, for in *K. (S.) plenus*, on the earlier (more macrocephalitic) half of the outer whorl, the primaries are also rather short. Judging by the beginning excentrumbilication, the last half whorl of the example here described includes part of the body-chamber, but there are suture-like markings to quite near the end. Unfortunately the preservation is against the preparation of the suture-line even on the earlier part of the outer whorl where small portions can be seen.

The sharp and robust primary ribs visible in the umbilicus, prevent confusion of the present species with the smaller *K. (S.) svalbardensis*, but *K. (S.) peramplus* is closer, although it has fewer secondary ribs to each primary. In all of them the more macrocephalitic inner whorls, however, are similar.

Horizon and Locality:— Horizon with calcareous concretions, South of *Goniomya*-Kløft, loc. D, 540 m (holotype).

<sup>1</sup>) Mesozoic Fossils, I,1, *loc. cit.*, 1876, p. 27, pl. VIII, fig. 2 only.

<sup>2</sup>) See also McLearn, *loc. cit.* (Nat. Mus. Canada, Bull. no. 54), 1929, p. 6.

<sup>3</sup>) *Ibid.*, p. 5, pls. I and II.

6. *Keplerites (Seymourites) nobilis*, sp. nov.

(Plate XXIII, figs. 4a—f).

The fragmentary holotype of this form shows the following dimensions in the adult and at two previous stages:—

Diameter in mm. . . . .	28	72	105
Whorl-height (in % of diameter) . . . . .	47	48	49
Whorl-thickness (in % of diameter) . . . . .	43	44	42
Umbilicus. (in % of diameter) . . . . .	23	14	19

The inner whorls, in an excellent state of preservation (see Plate XXIII, figs. 4d—f) have the appearance of a typical *Sigaloceras*<sup>1</sup>), being compressed, with faintly tuberculate primaries and a definitely runcinate venter. The ends of the ribs at the two ventro-lateral edges are distinctly raised, although not thickened, and the venter itself is thus slightly sulcate, but the ribs are continuous across. A similar periphery is found in the young examples of *S. quinqueplicatum* (Buckman) above referred to (p. 85), but they are more evolute and like all other *Sigaloceras*, have a simpler suture-line.

The peripheral flattening is lost soon after the stage shown in the figure (d—f) and the whorl-section becomes more rounded, but the sides remain compressed and more nearly parallel than in any other species of *Seymourites*. The umbilicus narrows after the early runcinate stage, but widens out again towards the end which is still in the septate stage. It is probable that the body-chamber was as uncoiled as in *K. (S.) tychonis*. The umbilical border is rounded, but the high wall is vertical. The delicate primary costae of the inner whorls become more prominent with increase in size and the terminal tubercle is very conspicuous up to the earlier half of the outer whorl. There are first three and then four or five secondaries to each primary and these are inclined forward, whereas the primaries begin with a very decided backward bend on the umbilical border. The second half of the outer whorl is almost smooth; the primaries are more closely spaced and untuberculate, as in *K. (S.) tychonis*, and the secondaries are still visible on the periphery. In spite of the fact that the preservation of this portion is defective, there can be no doubt that the ribbing is disappearing before the body-chamber stage.

The suture-line is complex and similar to that of *K. (S.) tychonis*. The somewhat unusual appearance of the details in fig. 4b is due to the weathering out of portions of the lobes.

<sup>1</sup>) Compare e.g. Douvillé, *Cosmocerotidés*, *loc. cit.*, 1915, pl. VIII, fig. 5, (*Keplerites calloviensis*).

*K. (S.) rosenkrantzi* with similarly tuberculate inner whorls differs in whorl-section and especially in its *Gowericeras*-like coiling; so that the two forms might even be referred to different genera by followers of Buckman. But in the English Kellaways Rock there are various similar passage-forms between *Gowericeras* and *Sigaloceras* (such as '*Galilæiceras*', '*Galilæites*', and '*Galilæanus*') that may equally well be attributed to either, and generic separation of *K. (S.) nobilis* from *K. (S.) rosenkrantzi* or the untuberculate forms of the *tychonis* group is unnecessary. Among the Canadian species, there is none that can be compared to the present species any more than can the entirely different European forms.

Horizon and Locality:— Horizon with calcareous concretions, Upper Vardekløft Formation. Loc. A, 560 m (holotype).

Genus *KOSMOCERAS*, Waagen, 1869.

Sub-genus *Gulielmiceras*, Buckman, 1920.

Sub-genotype:— *Amm. gulielmii*, J. Sowerby, Miner. Conchol., vol. iv, p. 5, 1821, pl. CCCXI.

The Greenland example described below, by its long lateral apophyses, persistence of the costation, and suture-line, is close to undoubted specimens of this genus from the Kellaways Rock of South Cave, Yorkshire, but there is no tuberculation, at least on the outer whorl. There is thus a certain resemblance to young *Sigaloceras*, and it is advisable to review this genus. With regard to Buckman's<sup>1)</sup> interpretation of Hyatt's genus, established<sup>2)</sup> for *Amm. calloviensis*, Sowerby (in d'Orbigny) it is only necessary to point out that not only do d'Orbigny's<sup>3)</sup> original example, i.e. the type of *S. galilæii* (Oppel), and Buckman's *S. micans* represent merely the inner whorls of larger species of the *calloviense*-group, but that the supposed highly developed suture-line becomes greatly simplified near the body-chamber. There is, in fact, considerable variability in the degree of complexity of the saddles, but the general plan of the suture-line is the same in all these early Kosmoceratids. I am figuring (in Text-fig. 5), for comparison, two suture-lines taken from the holotype of *S. calloviense* (Sowerby's largest example<sup>4)</sup>), about half a whorl apart, showing the broadening of the saddles, decrease in depth of the

<sup>1)</sup> Type Ammonites, vol. III, 1921, p. 54.

<sup>2)</sup> In Zittel's Text-Book of Palæontology (first English ed. by Eastman), 1900, p. 587.

<sup>3)</sup> Pal. Française, Terr. Jurass., vol. I, 1847, p. 455, pl. CLXII, figs. 10—11.

<sup>4)</sup> Mineral Conchology, vol. II, pl. CIV, 1815; fig. 2 is a young *S. micans*, with much finer ribbing; fig. 3 is an immature example of a late *Gowericeras* ('*Galilæiceras galilæii*', Buckman).

external lobe, and other changes. To realise the negligible value of the differences in the frilling of the saddles, it is only necessary to compare the elements of the two sides of a given individual.

There are transitions in the external characters between *Sigaloceras* and the more inflated *Gowericeras* on the one hand and the compressed *Gulielmiceras* on the other. The Greenland species described below as *K. (G.) pauper* may be held to be such a passage-form, for it may also be compared to *S. quinqueplicatum* and *S. enodatum* (Nikitin), the former ('*Gulielmina*', Buckman) grouped by Brinkmann in *Keplerites*, the latter ('*Catasigaloceras*', Buckman) identified by Brinkmann with *Sigaloceras* of the *calloviense*-group, yet referred to the sub-genus *Zugokosmokeras*. Among the examples in the British Museum labelled by the same authority '*Cosmoceras (Keplerites) quinqueplicatum*', there are various



Text-fig. 5. *Sigaloceras calloviense* (J. Sowerby). External suture-lines at 52 mm diameter (a) and at 82 mm (b = last but one). Kellaways Rock, Wiltshire (B. M. no. 43924a).

species, including forms almost referable to *Gowericeras lahuseni* (Parona and Bonarelli)<sup>1)</sup> on the one hand and flattened varieties leading to *K. gulielmii* on the other. But since the rather coarsely ribbed type of *S. calloviense* itself has small tubercles in the umbilicus and, on the body-chamber, acquires coarse pleats, it is only slightly removed from '*Galilæiceras trichophorum*, Buckman<sup>2)</sup>, and connects up directly with '*Galilæites*' and '*Galilæanus*', which differ from *S. galilæii* merely in remaining rounded-whorled after a very short runcinate stage.

We may then consider *Sigaloceras* to represent a development of *Keplerites*, more or less parallel with *Gowericeras* and *Seymourites*, but typically untuberculate and with the *Kosmoceras* characters more conspicuous and sometimes persisting to the end (*S. franconicum* and *S. staffelbergense*, Greiff sp. = '*Catasigaloceras*', Buckman). *Gulielmiceras*, on the other hand (including the genotype of '*Anakosmokeras*', Buckman) does not develop an inflated or smooth body-chamber, but

<sup>1)</sup> See Lahusen, *loc. cit.* (1883), pl. vi, figs. 8a, b; and Brinkmann, *loc. cit.* (1929), pl. iv, fig. 2 = B. M. no. C. 25941.

<sup>2)</sup> Type Ammonites, vol. iv, 1922, pl. cxcxi.

coarsens its ornament, while lengthening the lateral lappet, so that it must be kept distinct from *Gulielmites* (*jason*-group), with smooth outer whorl and no lappets, as well as from the other groups of *Kosmoceras*. Buckman's '*Anakosmokeras*' *effulgens*, already included by Brinkmann in *K. jason*, is a *Gulielmites*; '*Anakosmokeras*' *trinodum*, referred by Brinkmann to *K. pollucinum* (Teisseyre) does not belong to either *Gulielmites* or *Gulielmiceras*.

Buckman considered *K. (G.) gulielmii* to be a form of the Kellaways Clay and thus started a remarkable series of assumptions involving a whole imaginary (Reineckeian) age. *Gulielmiceras*, in fact, first appears in the upper *calloviense* (*enodatus*) subzone and is commonest in the *anceps* zone (*jason* and *castor-and-pollux* subzones).

*Kosmoceras (Gulielmiceras) pauper*, sp. nov.

(Plate XXIV, figs. 3a, b; Pl. XXVI, fig. 5).

The unique example on which this species is based has the following dimensions:—

Diameter in mm.....	34
Whorl-height (in % of diameter).....	43
Whorl-thickness (in % of diameter).....	31
Umbilicus (in % of diameter).....	28

The inner whorls are crushed up to the last septum, but the section then (at 20 mm diameter) is compressed, with flattened, gently convex sides and a concave, smooth, and faintly channeled periphery, bordered by two rows of tubercles which are not exactly opposite one another. The tubercles mark the peripheral terminations of the projected secondaries, but the irregular union of 2 or 3 of these into bundled primary ribs is indistinct, since the middle of the side tends to smoothness, at least on the cast. On the remainder of the body-chamber, where the test is preserved, the fine ribbing becomes increasingly more biconcave forward and the median bulge forward is finally produced into the long lateral 'ear'. At the same time the angularity of the venter has disappeared and the secondary ribs continue across it with a forward sinus, almost as in *Sigaloceras enodatum* (Nikitin)<sup>1</sup>) or in *S. quinqueplicatum* (Buckman)<sup>2</sup>). On account of the general compression of the shell, the umbilical wall, though perpendicular, is low and the edge is rounded as in other discoidal *Gulielmiceras*.

The last few suture-lines are visible (Plate XXVI, fig. 5) and they are characterised by extreme simplicity. The low saddles and the second

<sup>1</sup>) *Loc. cit.* (Elatma I), 1881, p. 112, pl. x (III), figs. 12—13.

<sup>2</sup>) *Type Ammonites*, vol. VI, 1925, pl. DLXXXVI, (sub "*Gulielmina*").

lateral lobe are bifid; the first lateral lobe is irregularly trifid. A very similar suture-line is found in *Sigaloceras franconicum* and *S. staffelbergense* (Greiff), and allies from the *jason*-zone of Wurtemberg and Franconia in the British Museum, and in the varieties *planicerclus*, *curvicerclus*, and *crispatus*, Buckman<sup>1)</sup>, from the Kellaways Rock of South Cave in Yorkshire. But *K. (G.) gulielmi* itself has the same type of simple suture-line and among a number of South Cave forms of feebly tuberculate *Gulielmiceras*, associated with the forms of *Sigaloceras* above mentioned, there are some that are almost indistinguishable from the Greenland example (L.F.S. 343). The somewhat similar young *K. (Gulielmites) jason* (Reinecke) has a more distinct umbilical tubercle, and a less simplified suture-line.

Horizon and Locality:— *Tychonis* horizon, near Point Constable (1 specimen).

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## 2. Order Belemnnoidea.

### Family Belemnitidae.

Sub-family *Cylindroteuthinae*, Stolley emend. Naef, 1922<sup>2)</sup>.

Genus *CYLINDROTEUTHIS*, Bayle, 1878.

All the East Greenland belemnites in the collections before me belong to this one sub-family, and apparently to the genus *Cylindroteuthis*, Bayle, 1878, itself; but at least one form might seem referable to the genus *Pachyteuthis*, Bayle, 1878. The former comprises species with slender, elongated, and usually cylindrical guards and only slight excentricity of the apical line; the latter genus includes the short and thick forms, with pronounced excentricity. Both have a slender embryonal stage and a weak or short ventral groove, confined to the posterior part of the rostrum. Of course, the reference of a given form to *Pachyteuthis* rather than *Cylindroteuthis*, merely because the alveolus is one half the length of the guard, seems rather artificial, and the excentricity of the apical line is also difficult to appraise. Thus Lissajous<sup>3)</sup> thought that *Belemnites subredivivus*, Lemoine<sup>4)</sup> (= *Bel. redivivus*, Blake<sup>5)</sup> non Mayer), by its proportions and the depth of the alveolus, was closer to *Pachyteuthis* than to the *puzosianus*-group (*Cylindroteuthis*) to which

<sup>1)</sup> Type Ammonites, 1923, vol. iv, pl. CDXVII, vol. v, pls. CDXXXIV—V (sub "*Catasigaloceras*").

<sup>2)</sup> "Die Fossilen Tintenfische", Jena, 1922, pp. 242 etc.

<sup>3)</sup> In Roman: "Repertoire Alphabétique des Belemnites Jurassiques". Trav. Lab. Géol. Lyon, fasc. VIII, mém. no. 7, 1925, pp. 128, 142.

<sup>4)</sup> Revue Critique de Paléozoologie (XIX) no. 4, oct. 1915, p. 157.

<sup>5)</sup> "Fauna of the Cornbrash". Mon. Pal. Soc., 1905, p. 59, pl. VII, figs. I—II.



conical *C. subrediviva*. Thus the worn example represented in Plate XVI, fig. 2, belongs to a more elongated species than the associated *C. subrediviva*, for in a longer but less well-preserved example in a similar sandstone slab (No. 4926) the alveolus is more clearly shown to be less than half of the total length.<sup>4</sup> The flattening of the sides, especially of the earlier portions, is distinct, in the Vardekløft fragments, as in the large specimen from Mt. Hjørnefjæld, or in the slender young, figured in Plate II, fig. 2, which, however, is more difficult to separate from *C. subrediviva*, described below.

Lissajous considered this species, despite its long alveolus, to be probably only a medium-sized *C. magnifica* (d'Orbigny) but as he also described the latter as very close to *C. puzosiana* (d'Orbigny) the species can be well kept distinct.

Horizon and Localities:— *Pecten* Beds, Mt. Hjørnefjæld, at 700 m (many examples), at locality 2, 760 m (1 doubtful example). Vardekløft Formation, *tychonis*-bed 560 m, locality B (1 example), locality C, 440—445 m (many specimens). *Arcticoceras* beds, Mt. Mikael, 545—570 m (12 examples), and at 600 m (1 example).

## 2. *Cylindroteuthis subrediviva* (Lemoine).

(Plate XII, fig. 3; Pl. XXI, figs. 2, 3).

1897. *Belemnites panderi*, Newton, in Newton and Teall: *loc. cit.* (Quart. Journ. Geol. Soc., vol. LIII), p. 498, pl. xxxix, figs. 11—14.
1899. *Belemnites* m. f. *subextensus*, Nikitin — *panderi*, d'Orbigny; Pompeckj: *loc. cit.* (Cape Flora), p. 100, pl. 1, figs. 18—21.
- 1899 — — — — — — *panderi*, d'Orbigny; Pompeckj: "Marines Mesozoicum von König-Karls-Land." Öfv. Kon. Vetensk.-Akad. Förh., No. 5, p. 454.
1905. *Belemnites redivivus*, Blake (non Mayer): Fauna of the Cornbrash, *loc. cit.*, p. 59, pl. vii, figs. 1—2.
1915. *Cylindroteuthis redivivus* (Blake); Lissajous: "Quelques remarques sur les *Belemnites* jurassiques". Bull. Soc. Hist. nat. Mâcon, p. 13.
1915. *Belemnites subredivivus*, Lemoine; Revue Critique de Paléozoologie, xix, No. 4, Oct., p. 157.
1920. *Pachyteuthis* m. f. *subextensa-panderi*, Pompeckj sp.; Bülow-Trummer, in Diener, *loc. cit.*, Fossilium Catalogus, p. 206.

1920. *Cuspiteuthis rediviva* (Blake) Bülow-Trummer, in Diener; *ibid.*, p. 106.
1925. *Belemnites subextensus-panderi*, Pompeckj; Lissajous, in Roman; *loc. cit.* (Repertoire alphabétique), p. 141.
1925. *Cylindroteuthis rediviva* (Blake) Lissajous; in Roman; *loc. cit.*, pp. 128, 142.

There is abundant material of this species, yet most of it is so fragmentary that it is not easy to select examples for illustration. One of the most favourably preserved is the specimen figured in Plate XXI, fig. 2, yet even this is corroded and includes only a small portion of the alveolar cavity. Most of the other fragments are like that figured in Plate XXI, fig. 3 and the restoration in Plate XII, fig. 3, is based on such fragments. Since, however, the more compressed and more elongated *C. subextensus* is also represented among the numerous belemnite remains from Vardekløft, the identification of most of them must be provisional.

I can see no difference either between Blake's Cornbrash form and the figured example, or between the Greenland forms and the Franz Josef Land belemnites described by Newton and Pompeckj. The numerous Cape Flora fragments in the British Museum of Natural History, unfortunately, are all too small to help in the comparison, but the figures of both these authors seem to me sufficiently clear to allow of identification. The proportions of all are pretty much the same, but it could be claimed that in its slightly deeper alveolus the Cornbrash type differs from the Arctic forms. In Pompeckj's and Newton's figures, however, the alveolar ratio is  $2\frac{1}{4}$  against  $2\frac{1}{6}$  in Blake's type and the axial proportion of a paratype was given by Blake as 4 which agrees with that of Newton's figure or the original of Plate XXI, fig. 2. The differences therefore seem very slight and negligible.

Horizon and Localities:— *Arcticoceras* beds, Mt. Mikael, 545—570 m (1 example); Vardekløft Formation, below *tychonis* bed, 440—445 m (many fragments).

### 3. *Cylindroteuthis?* sp. ind.

(Plate XIII, fig. 2; Pl. XVI, fig. 7, Text-fig. 6).

Associated with numerous *Arctocephalites* at Mt. Hjørnefjæld there were found numbers of phragmocones and portions thereof, some of gigantic size (see Text-fig. 6). From the size alone one might be inclined to refer these to forms of *Megateuthis*, e.g. *M. gigantia* (auct.) which, however, does not occur above the *parkinsoni* beds of the Upper Bajocian. Newton<sup>1)</sup> recorded phragmocones of large species from Windy

<sup>1)</sup> *Loc. cit.* (in Newton and Teall), 1897, p. 501.

Gully, Franz Josef Land, and one of his specimens is before me (B.M. no. C. 7256). It is so crushed that the diameter cannot be measured, but apparently the phragmocone was not larger than that figured in Plate XIII, fig. 2. On the other hand, the septal surface shown in Text-fig. 6 has diameters of 92 and 81 mm and there are other casts of chambers of similar size and various smaller ones down to phragmocones



Text-fig. 6. *Cylindroteuthis?* sp. ind. Septal surface of a portion of a gigantic phragmocone. *Arctocephalites* Beds of Mt. Hjørnefjæld, locality 2 (760 m).

much smaller than that figured in Plate XVI, fig. 7. Unfortunately, the only fragment of a guard associated with these gigantic phragmocones is small and might well belong to *C. subrediviva*, above discussed.

Horizon and Locality:— *Arctocephalites* Beds, Mt. Hjørnefjæld, locality 2, 760 m (20 specimens).

### b. Class *Gastropoda*.

#### Family *Trochonematidae*.

Genus *AMBERLEYA*, Morris and Lycett, 1850.

*Amberleya* sp. ind.

A fragmentary and crushed example, on account of the presence of three obtuse spiral edges may be compared to the *Amberleya* sp.

figured and described by Pompeckj<sup>1)</sup> who pointed out that the presence of the group of *Amberleya capitanea* (Münster) in the boreal Jurassic had already been recorded by Tullberg<sup>2)</sup>. Both the Cape Flora example, however, and the presumed Oxfordian Novaya Zemlya form are of later age than the Greenland species here discussed and it is not suggested that the occurrence of the latter has any significance from a stratigraphical or biological point of view. Two still less complete and very doubtful examples of perhaps yet another species of *Amberleya* from another locality and a still earlier horizon differ in having the spiral ridges scarcely perceptible and yet two other small fragments from a third locality retain traces of the fine and oblique, reticulate ornamentation found in well preserved Liassic forms of *Amberleya*. In these the test is fairly thin and the cast shows the spiral ridges (though not the finer ornamentation) almost as well as the test. On the other hand, a comparison of d'Orbigny's '*Turbo puschianus* and *T. jasicofianus*<sup>3)</sup>' shows that the correct identification of a crushed sandstone cast showing spiral ridges is impossible.

The cast of another turbinid shell differs from those described above as *Amberleya* in being almost perfectly smooth and rounded, and in having remains of a very thick test at the base, not only near the umbilicus as in other *Amberleya*, but apparently passing between the whorls. This may be yet a third species but it cannot be placed even generically with any accuracy.

Horizon and Localities:— *Arctocephalites* Beds, Mt. Hjørnefjæld, locality 1, 700 m (2 examples); locality 2, 760 m (2 examples); lowest *Arcticoceras* beds, Mt. Mikael, 500 m (2 examples).

### Family *Naticidae*.

Genus *NATICA*, Scopoli, 1777.

1. *Natica* sp. nov.? aff. *chauviniana*, d'Orbigny.

(Plate IV, figs. 11a, b).

[Cf. 1852. *Natica chauviniana*, d'Orbigny; Pal. Française, Terr. Jurass. vol. II, p. 198, pl. CCXCI, figs. 12—13].

This is the commonest gastropod in the Greenland deposits here dealt with, but the two figured examples and the numerous other sandstone casts available show slight differences. Thus some are entirely

<sup>1)</sup> *Loc. cit.* (Cape Flora), 1899, p. 68, text-figs. 12a, b.

<sup>2)</sup> "Über Versteinerungen aus den Aucellen-Schichten Novaya Semlyas. Vet.-Akad. Bih. Stockholm, vol. VI, No. 3, 1881, p. 9, pl. II, figs. 1—3.

<sup>3)</sup> *Loc. cit.* (in Murchison, Verneuil and Keyserling), 1845, pp. 450—451, pl. XXXVII, figs. 15—16 and 19—20.

smooth while others have the oblique striae of growth more or less distinctly marked on the last whorl. In a few there is even a suggestion of linear striation or a slight deviation from the normal spiral angle (just under  $90^\circ$ ) and, of course, there is some variation in proportions. Remains of test show this to have been fairly thin and the casts have a deep umbilicus with rounded border. They may all be taken to belong to one species, and the general shape suggests comparison to d'Orbigny's species which, however, differs in its spiral angle ( $104^\circ$ ) and in having the last whorl perhaps slightly wider. In the Greenland form the proportion is not dissimilar, but the base is more flatly rounded.

Since all the specimens are defective and the aperture especially is not shown completely in any one, it is impossible further to discuss this probably new species. But I may mention that Blake<sup>1)</sup> had identified with d'Orbigny's form a Cornbrash example that differed in the great width of the last whorl as well as in the spiral angle, the latter being only  $84^\circ$ . There is little resemblance between Blake's drawing and the Greenland form; in fact, the Scarborough *Natica* figured by Blake<sup>2)</sup> as *N. montreuilensis*, Hébert and Deslongchamps, is almost more like the species here described, than his *N. chauviniana*, although not the French original<sup>3)</sup>. D'Orbigny's species, then, if perhaps too widely interpreted by Blake and the writer, seems still the species most closely comparable to the Greenland form.

*Neritina adducta*, Keyserling<sup>4)</sup>, and especially the form figured by Lahusen<sup>5)</sup> seem to resemble the species here described, but the spiral angle of the original was given as  $120^\circ$ , with the last whorl comprising 85 % of the total height.

Horizon and Locality:— *Arctocephalites* beds, Mt. Hjørnefjæld, locality 1, 700 m (40 examples).

## 2. *Natica* (*Ampullina*?) sp. ind.

(Plate XIV, fig. 5).

A single small cast in the rock full of *N.* sp. nov. aff. *chauviniana*, above described, by its shape seems to be referable to a species like *N.* (*A.*) *amata*, d'Orbigny<sup>6)</sup>, but the aperture is unknown. Since the unique cast, however, is only 8.5 mm in height and imperfect at the base, the identification must remain uncertain, even generically. The

<sup>1)</sup> *Loc. cit.* (Fauna of the Cornbrash), 1905, p. 81, pl. VIII, fig. 6.

<sup>2)</sup> *Ibid.*, fig. 4.

<sup>3)</sup> Mémoire sur les fossiles de Montreuil-Bellay (Maine et Loire). Bull. Soc. Linn. Normandie, vol. V, 1860, p. 31, pl. II, fig. 2.

<sup>4)</sup> *Loc. cit.* (in Middendorf's Reise), 1848, p. 254, pl. IV, fig. 12.

<sup>5)</sup> *Loc. cit.* (Inoceramen-Schichten), 1886, p. 8, pl. II, fig. 11.

<sup>6)</sup> Pal. Française, Terr. Jurass. vol. II, 1851, p. 205, pl. CCXCVI, figs. 3—4.

restored and enlarged outline given in Plate XIV, fig. 5, shows that the flattening of the whorls is rather against comparison of this small form with the common *N. punctura*, Bean<sup>1</sup>), which at first, seemed the most appropriate form for comparison. On the other hand, whereas this is a Cornbrash species, d'Orbigny's form comes from much higher beds (Rauracian-Sequanian)<sup>2</sup>), and the resemblance in whorl-shape is probably accidental.

Horizon and Locality:— *Arctocephalites* beds, Mt. Hjørnefjæld, locality 1, 700 m (1 example).

### Family Pyramidellidae.

Genus *CHEMNITZIA*, d'Orbigny, 1839.

'*Chemnitzia*' sp. nov.?

(Plate III, figs. 8a, b).

In addition to the two figured examples there are several more that show merely the transverse pleats, but in the well-preserved specimens the fine longitudinal striation can be seen as well, while still others, only doubtfully included here, seem to be almost smooth, perhaps merely on account of the poor preservation (as casts in sandstone). It is those that show only the ribs, especially a weathered example on a slab of rock from Mt. Mikael, that most resemble the *vetusta*-group of *Cerithium* (in Hudleston<sup>3</sup>) but this, in Europe, is restricted to beds not higher than the Great Oolite. The spiral angle of about 20°, the presence of about 12 to 14 crescentic costae per whorl, and the fine spiral lineation, suggest comparison especially to *Ch. vetusta major*, Hudleston<sup>4</sup>), but this does not show the distinct thickening of the costae towards the lower half that is observed in the more favourably preserved examples under review. These are all Bajocian or even earlier forms, but Hudleston already mentioned that forms of the *vetusta* group had been found in beds of presumed Lower Oxfordian age. It seems probable that the Greenland form is an undescribed member of this *vetusta* group.

Horizon and Locality:— *Arctocephalites* beds, Mt. Hjørnefjæld, locality 1, 700 m (17 examples).

<sup>1</sup>) See Blake, *loc. cit.* (Fauna of the Cornbrash), 1905, p. 79.

<sup>2</sup>) See Maire: "Les Gastropodes du Jurassique supérieur graylois, III", in *Études géologiques et paléontologiques sur l'arrondissement de Gray*. Bull. Soc. Grayloise d'Emulation, 1927, p. 86.

<sup>3</sup>) Contributions to the Palaeontology of the Yorkshire Oolites. No. 2: Gastropoda of the Oxfordian and Lower Oolites, pt. 3, Geol. Mag. 1882, p. 27 (of reprint).

<sup>4</sup>) *Ibid.*, p. 29, pl. vi, fig. 12.

Family *Cerithiidae*.Genus *PROCERITHIUM*, Cossmann, 1913.*Procerithium* spp. ind.

(Plate X, figs. 2a—f).

There seem to be slight differences among the impressions, in a coarse sandstone, of these delicately ornamented shells, so that they probably belong to various species, but as most of the molds are too fragmentary for identification and since none shows the base, they can only be provisionally recorded as *Procerithium* spp. ind. It is probable that they have their closest relations among those forms from the Yorkshire Cornbrash that Blake<sup>1</sup>) recorded as *Bittium pingue*, *B. lorieri* (Hébert and Deslongchamps) and *Cerithinella biserialis*, &c., but at least one (Plate X, fig. 2e, f) might also be compared to *Cerithium renardi* (Rouiller)<sup>2</sup>). It should be added that the examples here figured represent plasticine squeezes from the natural molds. Thus the details of ornamentation have lost considerably in sharpness, especially in the three enlarged views.

Horizon and Locality:— *Arctocephalites* beds, Mt. Hjørnefjæld, locality 1, 700 m (14 examples).

c. Class *Pelecypoda*.1. Order *Anisomyaria*.Family *Aviculidae*.Genus *PSEUDOMONOTIS*, Beyrich, 1862.1. *Pseudomonotis* aff. *doneziana*, Borissjak.

(Plate IV, fig. 5).

1909. *Pseudomonotis echinata* (Sowerby) var. *doneziana*, Borissjak: "Die Pelecypoden der Jura-Ablagerungen im Europäischen Russland — IV, Aviculidae". Mém. Com. géol. N. S. livr. 44, pp. 9 and 22, pl. II, figs. 3—6.

This may turn out to be a new species, differing from the form of the Donez Basin in its smaller size and less convexity, but while a distinct specific name would seem desirable for the form here figured

<sup>1</sup>) *Loc. cit.* (Fauna of the Cornbrash), 1905, pp. 67—70, pl. VII, figs. 10—11, 14a, b.

<sup>2</sup>) See Lahusen, *loc. cit.* (1883), p. 37, pl. III, fig. 7.

since it is so common in the Greenland deposits, the preservation of the shells (in a sandstone) unfortunately is not very favourable. They generally form clusters like that represented in Plate IV, fig. 5. But whereas this consists of the remains of only a few shells, some of the blocks are made up of hundreds of small casts of presumably this one form, to the exclusion of other fossils. These casts show, at a length and breadth of about 10 mm, a thickness of only 3.75 mm, the convexity being about the same in the two valves which then, are approximately equal, externally, except for the lower umbo of the right valve. It should be added that in many examples the right valve is imbedded in the concavity of the large left valve, as in Quenstedt's<sup>1)</sup> figure of '*Monotis echinata*' from the Brown Jura Gamma. As this author stated, on breaking up the clusters the internal casts often fall out which caused Münster to consider the shell to be equivalve. The lower part of the figure (Plate IV, fig. 5) shows the position whence came one of those nuclei that yielded the above measurements. At a length of 15 and a height of 14 mm, which is about the maximum of the more complete shells, the convexity of the left valve, however, is still slight, its thickness being just under 4 mm.

The radial ornamentation in these forms consists of fairly irregular primary ribs with generally one finer secondary rib in between, whereas in *P. echinata* (Smith)<sup>2)</sup>, this intercalation of a fine rib is rather the exception. The ribs also do not generally extend to the umbonal region but this is partly due to the preservation, like the absence of the finer details of the ribbing, for in one example there can be seen the ornamentation of Borissjak's fig. 5, with the concentric striae distinctly curved backward on the posterior ear, also what appear to be bases of spines in concentric rows. But these spines are elongated in the direction of the ribs, and far apart.

There is a comparatively large posterior ear, as in the very similar young examples of *P. doneziana* figured by Borissjak, but the anterior end is damaged in all the examples.

The right valve is more strongly and distantly ribbed than the left; and the ribs, though not regular, are mostly primaries. The straight hinge of the posterior wing can be seen, but the anterior end again is not preserved.

While Quenstedt's form above cited, although perhaps more convex, resembles the Greenland form in the different ornamentation of the two valves, the true *P. echinata* is quite distinct in the great con-

1) Der Jura, 1858, Atlas, pl. LI, fig. 5, p. 382.

2) "Stratigraphical System of Organized Fossils". London, 1816—19, p. 67; "Strata identified by Organised Fossils", 1817, Cornbrash, plate, fig. 8.



vexity of its left valve, with total absence of an anterior ear, also in its spiny ribbing, but the flattened, comparatively smooth right valve is similar. While *P. sp. cf. ornati* (Quenstedt) recorded by Pompeckj<sup>1)</sup> from Franz Josef Land differs in shape, *Eumicrotis curta*, Meek and Hayden<sup>2)</sup> is closer, but both have concentric striae on the right valve. *P. ferniensis*, McLearn<sup>3)</sup>, being much more inequivalve, is correspondingly less closely related to the Greenland form.

Horizon and Localities:— *Arctocephalites* Beds, Mt. Hjørnefjæld, locality 1, 700 m (many examples); locality 2, 760 m (2 examples); *Arcticoceras* Beds, Mt. Mikael, 500 m (5 examples); 570 m (2 examples); Cathedral Mtn., *Cranocephalites* Beds, 370 m (3 doubtful examples).

## 2. *Pseudomonotis* sp. ind.

(Plate IV, figs. 4a, b; Pl. XXVI, fig. 7).

A number of more or less doubtful examples differ from the *Pseudomonotis* described above chiefly in the convexity of the left valve and the larger size of the posterior wing. There is no right valve and the larger examples figured are rather imperfect; and though included here they are perhaps not representative. The first (4a) shows a somewhat elongated shape (length = 16 mm, height = 14 mm, thickness = 5 mm) with the lower margin subparallel to the long and straight hinge. The larger specimen (4b), also an internal cast, is almost smooth, and shows the large and projecting umbo. On external molds of presumably the same species, the fine radial costation is visible, in addition to concentric striation, but there is as little resemblance to the strong ornamentation of *Oxytoma inaequalvis*, var. *borealis*, Borissjak, as to the spiny ribs of *Pseudomonotis echinata* (Smith), which also has a much wider and more rounded umbo, as has also the var. *subechinata*, Lahunen<sup>4)</sup>. The finely ornamented *Oxytoma* sp., figured by Borissjak<sup>5)</sup> from the Lower Callovian of Elatma, on the other hand shows some resemblance to the group of forms here discussed although it was described as only slightly convex.

*Avicula cf. münsteri*, Bronn, as figured by Hovaïsky<sup>6)</sup> also resembles

<sup>1)</sup> *Loc. cit.* (Cape Flora), 1899, p. 62, text-fig. 10.

<sup>2)</sup> "Palæontology of the Upper Missouri". *Smithson. Contrib. Knowl.* no. 172, 1864, pt. 1, p. 81, pl. III, figs. 10a—e.

<sup>3)</sup> *Loc. cit.* (*Trans. Roy. Soc. Canada*), 1924, p. 42, pl. III, figs. 1—4.

<sup>4)</sup> See especially Borissjak, *loc. cit.* (1909), pl. II, figs. 14—18.

<sup>5)</sup> *Loc. cit.* (1909), p. 18, pl. I, fig. 1.

<sup>6)</sup> "L'Oxfordien et le Sequanien des gouvernements de Moscou et de Riasan". *Bull. Soc. Imp. Nat. Hist., Moscou, N. S.*, vol. XVII, (1903) 1904, p. 252, pl. VIII, figs. 18—19.

the Greenland forms but not de Loriol's<sup>1)</sup> species, quoted by this author, since it has entirely different ornamentation. The resemblance to certain *Oxytoma* is probably due only to the poor preservation of the Greenland material, for in *P. elegans* (Münster)<sup>2)</sup> there is an elongated variety and the form figured by Schmidtil<sup>3)</sup> as *P. aff. echinatae* (Sowerby) is a very close ally of the present form in spite of its greater height.

Horizon and Localities:— *Arctocephalites* Beds, Mt. Hjørnefjæld, locality 1, 700 mm (many examples); *Arcticoceras* Beds, Mt. Mikael, 500 m (4 examples).

### Family *Pinnidae*.

Genus *PINNA*, Linnaeus, 1758.

*Pinna sublanceolata*, Eichwald.

(Plate XVII, fig. 4).

1865. *Pinna sublanceolata*, Eichwald: *Lethaea Rossica* etc., p. 546, pl. xxiii, fig. 5.

The specimen here figured shows much better agreement with an example of a *Pinna* which I collected in the Corallian rocks of Weymouth than with similar lanceolate forms from earlier formations, e.g. the English Cornbrash. It is possible that the Corallian species is referable to *P. ledonica*, *P. de Loriol*<sup>4)</sup> which is said to differ from the true *P. lanceolata*, *J. Sowerby*<sup>5)</sup> in small details; and in the Greenland form, with a curvature as slight as in the Corallian species, differences might be found in the number of longitudinal striae or their distances apart, but these are not considered to be of specific value, with the data available at present. I am thus including the Greenland forms in *P. sublanceolata*, Eichwald, not only because this is the older name, but because they seem to differ from the true *P. lanceolata* in exactly those points that caused Eichwald to separate his species. The horizon of this, however, is probably also Upper Jurassic.

Horizon and Locality:— *Arcticoceras* beds, Mt. Mikael, 545—570 m (the figured example and an impression of a second individual, in the matrix of a specimen of *Arcticoceras kochi*).

<sup>1)</sup> "Étude sur les Mollusques et Brachiopodes de l'Oxfordien supérieur et moyen du Jura bernois". *Mém. Soc. Pal. Suisse*, vol. xxviii, 1901 (Suppl.), p. 93, pl. vi, fig. 2.

<sup>2)</sup> See Schmidtil: "Zur Stratigraphie und Faunenkunde des Doggersandsteins im nördlichen Frankenjura". *Palæontogr.* vol. lxxviii, 1926, p. 3, pl. i, figs. 9—10.

<sup>3)</sup> *Ibid.*, p. 4, pl. i, fig. 11.

<sup>4)</sup> "Étude sur les Mollusques et Brachiopodes de l'Oxfordien supérieur et moyen du Jura lédonien". *Mém. Soc. Pal. Suisse*, vol. xxxi, 1904, p. 212, pl. xxiii, fig. 3.

<sup>5)</sup> *Mineral Conchology*, vol. iii, 1819, p. 145, pl. 281.

Family *Pernidae*.Genus *INOCERAMUS* (J. Sowerby), Parkinson, 1819.1. *Inoceramus* aff. *ambiguus*, Eichwald.

(Text-fig. 7).

1871. *Inoceramus ambiguus*, Eichwald: "Geognostisch-Paläontologische Bemerkungen über die Halbinsel Mangyschlak &c.", p. 189, pl. xx, figs. 1—3.

The identification of this form is based on the resemblance in general shape and the strong concentric ribbing, but as the unique



Text-fig. 7. *Inoceramus* aff. *ambiguus*, Eichwald. Right valve of worn and incomplete example from the *Arctocephalites* Beds of Mt. Hjørnefjæld, locality 1 (700 m).

specimen is a sandstone cast (of the right valve), there is no trace of the fibrous texture or any internal detail. Umbo and hinge area are broken off and the median, convex, and the posterior parts of the valve are worn. The length of the shell was much greater than the width. The identification is questioned only because Eichwald's Alaskan *I. ambiguus* may not be the same species as his original Volgian type<sup>1)</sup>, although Martin<sup>2)</sup> recorded this species together with '*Macrocephalites*'.

*I. obliquiformis*, McLearn<sup>3)</sup>, from the Fernie Shales of Blairmore,

<sup>1)</sup> "Lethæa Rossica ou Paléontologie de la Russie", vol. II, sect. 1, 1865, p. 493, pl. XXI, figs. 8a, b.

<sup>2)</sup> The Mesozoic Stratigraphy of Alaska. U. S. Geol. Bull. 776, 1926, table on pp. 150—53.

<sup>3)</sup> "New Pelecypods from the Fernie Formation of the Alberta Jurassic". Trans. Roy. Soc. Canada (IV), 1924, p. 41, pl. III, fig. 9.

Alberta, has closer concentric lamellae, like *I. obliquus*, Morris and Lycett<sup>1</sup>), the difference in shape of both these species being perhaps of less import in view of the fragmentary condition of the present example. *I. ferniensis*, Warren<sup>2</sup>), especially the strongly ornamented specimen figured by this author in fig. 1, seems still closer, but it remains to be seen whether the Bajocian-Bathonian forms can be kept distinct from *I. ambiguus* which also varies considerably in the strength of the corrugations. In the form described below as *I. retrorsus*, Keyserling, the intervals between the ribs are still much wider. Certain specimens included in *I. galoi*, Boehm<sup>3</sup>), however, and the Andine and New Zealand examples of this species figured by Stehn<sup>4</sup>) and Trechmann<sup>5</sup>) are again very similar. This form seems to range at least from the Callovian to the Kimmeridgian and the occurrence of similar forms of *Inoceramus* together with *Belemnites gerardi* in the basal Spiti Shales has been discussed by various authors. It may therefore be assumed that the boreal species like *I. ambiguus*, if really distinct from the southern forms, also have a wide range.

Horizon and Locality:— *Arctocephalites* beds, Mt. Hjørnefjæld, locality 1, 700 m (1 example).

## 2. *Inoceramus retrorsus*, Keyserling.

(Text-fig. 8).

1848. *Inoceramus retrorsus*, Keyserling; Fossile Mollusken, in Middendorff: Reise in den äussersten Norden und Osten Sibiriens, vol. 1, pt. 1, p. 250, pl. iv, figs. 4—5.

The two Greenland examples here figured are merely casts in a very coarse, micaceous sandstone (with the two valves in each case) and there is nothing visible either of hinge or test, but the general aspect is so similar to that of Eichwald's *I. porrectus*<sup>6</sup>) that the identi-

✓ <sup>1</sup>) "Monograph of the Mollusca from the Great Oolite". Pt. II, Bivalves, Pal. Soc., 1853, p. 24, pl. vi, fig. 12.

<sup>2</sup>) "A New Pelecypod Fauna from the Fernie Formation, Alberta". Trans. Roy. Soc. Canada, (3) vol. XXVI, sect. iv, 1932, p. 15, pl. ii, figs. 1—3.

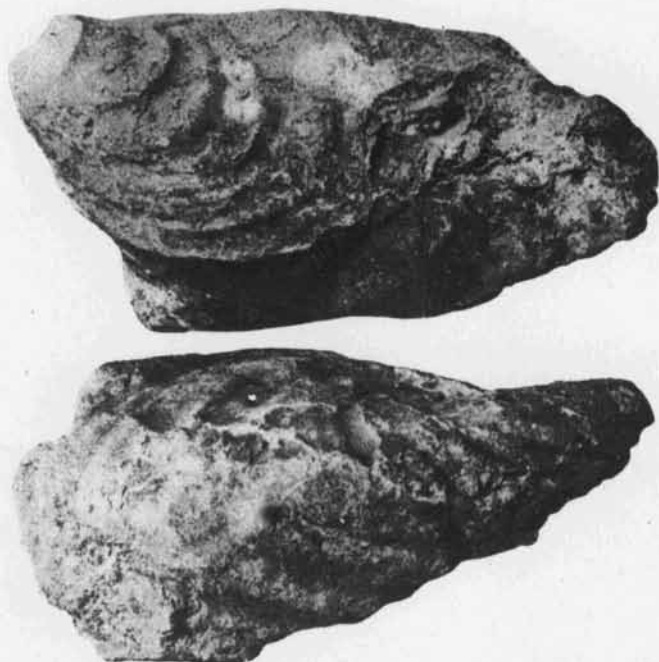
<sup>3</sup>) "Die Südküsten der Sula-Inseln Taliabu und Mangoli. 2. Der Fundpunkt am oberen Lagoi auf Taliabu". In Beitr. z. Geol. v. Niederländ. Ind. I, Paläontographica, Suppl. IV, Lief. 2, 1907, p. 68, pl. ix, figs. 10—14, pl. x, figs. 1—2.

<sup>4</sup>) *Loc. cit.* (in Steinmann), 1924, p. 139, pl. v, fig. 5 only.

<sup>5</sup>) "Jurassic Rocks of New Zealand", Quart. Journ. Geol. Soc., vol. LXXIX, 1923, p. 274, pl. xv, figs. 1—2.

<sup>6</sup>) *Loc. cit.* (Geogn. Pal. Bemerk. &c.) 1871, p. 191, pl. xix, figs. 1—2.

fication is qualified only because the horizon of the type is doubtful. Lahusen<sup>1)</sup>, who showed that of all Eichwald's Alaskan species, *I. porrectus* was the only one definitely identifiable with Keyserling's earlier form, figured an example that shows perhaps less resemblance to the Greenland specimens than does Eichwald's original, but Keyserling's type itself might be considered to be somewhat intermediate between *I. porrectus* and the species described above as *I. ambiguus*.



Text-fig. 8. *Inoceramus retrorsus*, Keyserling. Left and Right valves of two double-valved but crushed specimens from Cathedral Mtn. (*Cranocephalites* beds, 370 m).

There is also great resemblance between the Greenland forms and *I. haasti*, Höchstetter<sup>2)</sup>, which has more recently been discussed by Trechmann<sup>3)</sup>. This author considered it of 'Oxfordian or rather later' age, but it appears probable that in the Southern as well as in the boreal Jurassic the coarsely-ribbed individuals existed side by side with the more closely-costate forms through a large part of the Upper Jurassic.

A large *Inoceramus* somewhat comparable to the species here described (or the last one) was figured by Newton<sup>4)</sup> from Windy Gully

<sup>1)</sup> "Die Inoceramen-Schichten an dem Olenek und der Lena". Mém. Acad. Imp. Sci. St. Pétersb., (7) vol. xxxiii, No. 7, 1886, p. 3, pl. 1, fig. 1.

<sup>2)</sup> In Zittel: Palaeontologie von Neu-Seeland", 1864, p. 33, pl. viii, figs. 5a, c.

<sup>3)</sup> *Loc. cit.* (Jurassic Rocks of New Zealand), 1923, p. 275, pl. xv, fig. 3.

<sup>4)</sup> In Newton and Teall: "Rocks and Fossils from Franz Josef Land". Quart. Journ. Geol. Soc. vol. lrv, 1898, p. 650, pl. xxix, fig. 4.

on Franz Josef Land, but it is too imperfect for detailed comparison.

Horizon and Locality:— Ammonite-horizon, 370 m, Cathedral Mountain (2 examples).

3. *Inoceramus* sp. juv. ind.

(Plate IV, fig. 12).

The small cast of a right valve here figured is almost smooth but shows concentric lines which are close and rather regular for an *Inoceramus*. Thus *I. ferniensis*, Warren, above referred to, or at least the example with smooth umbones, figured by this author in his fig. 3 (pl. II) soon acquires comparatively coarse pleats, while the finely-ribbed *I. lucifer*, Eichwald<sup>1)</sup>, differs in shape. *I. fittoni*, Morris and Lycett<sup>2)</sup>, is perhaps closer but seems less elongated and less oblique, while *I. fuscus*, Quenstedt<sup>3)</sup> differs merely in its more curved anterior border. The umbo and anterior margin of the figured specimen, unfortunately, are damaged, and two small specimens are still more doubtful, so that the identification must remain uncertain.

Horizon and Locality:— *Arctocephalites* beds, Mt. Hjørnefjæld, locality 1, 700 m (3 examples).

Family *Pectinidae*.

Genus *PECTEN*, Osbeck, 1765

Sub-genus *Entolium*, Meek, 1864.

*Entolium demissum* (Phillips).

(Plate XXVI, fig. 2).

1829. *Pecten demissus*, Phillips, Geology of Yorkshire, pl. vi, fig. 5.

1930. *Entolium demissum* (Phillips) Arkell: "Monograph of British Corallian Lamellibranchia," II, Pal. Soc., p. 91, pl. VII, fig. 4 (pl. IX, fig. 8, 1931).

The smaller examples from the *Pecten*-Bed of Mt. Hjørnefjæld are elongated (Height = 20 mm, Length = 16 mm) but in larger specimens the proportions are 41.5 : 37; 33 : 30; or 31 : 28, i.e. about 90 %. This is the reverse of what is observed in *E. disciforme* (Schübler) which was united by Schmidtil<sup>4)</sup> with Phillips's species. In this Bajocian form

<sup>1)</sup> *Loc. cit.* (Geogn.-Pal. Bemerk.) 1871, p. 194, pl. XVIII, figs. 5—6.

<sup>2)</sup> *Loc. cit.* (Monogr. Mollusca Great Oolite, II) 1853, p. 24, pl. III, fig. 14.

<sup>3)</sup> Der Jura, 1858, p. 355, pl. XLVIII, fig. 18.

<sup>4)</sup> Zur Stratigraphie und Faunenkunde des Dogger-Sandsteins im Nördlichen Frankenjura, II. Paläontogr. vol. LXVIII, 1926, p. 22.

the dimensions of the young have been given as 16:17 or 106%, but much narrower individuals also occur. The internal casts from a higher horizon (yielding that figured in Plate V, fig. 4), are poorly preserved, but in the larger specimens from the *Pecten* Bed also (e.g. Plate XXVI, fig. 2) the auricles are generally damaged. The apical angle is about 110° as in the example figured by Morris and Lycett<sup>1)</sup> which has been separated from *E. demissum*, but is apparently only an early mutation<sup>2)</sup>.

Horizon and Localities:— *Pecten* Bed, Mt. Hjørnefjæld, locality 6, 700 m (many examples), locality 1, 700 m (18 examples), locality 2, 760 m (8 examples); Mt. Mikael, lowest *Arcticoceras* Beds, 500 m (1 example); Cathedral Mountain, *Cranocephalites* Beds, 340 m (1 example).

Sub-genus *Camptonectes*, Meek, 1864.

*Camptonectes rigidus* (J. Sowerby).

(Pl. V, fig. 4; Pl. X, fig. 5).

1918. *Pecten rigidus*, J. Sowerby; Mineral Conchology, vol. III, p. 5, pl. ccv, fig. 8.

1930. *Camptonectes rigidus* (J. Sowerby) Arkell: Monograph of British Corallian Lamellibranchia. (Pal. Soc.), pt. II, p. 97.

1931. — — — — — Arkell: 'Upper Great Oolite, Bradford Beds and Forest Marble of South Oxfordshire &c.' Quart. Journ. Geol. Soc., vol. LXXXVII, p. 596.

The larger right valve here figured, unfortunately, has lost its posterior auricle, and there are only a few more impressions, even less complete. I am including the Greenland form in Sowerby's species because it shows apparent agreement with typical examples of this species and because the proportion of length to height is 92%, not 85% as in *C. laminatus* (J. Sowerby), or 98% as in the typical *C. lens* (J. Sowerby). As shown by Arkell, however, the definite identification of examples without the auricles intact is often impossible.

Horizon and Localities: — *Pecten* Bed, Mt. Hjørnefjæld, locality 6, 700 m (3 examples); loc. 1, 700 m (2 examples).

<sup>1)</sup> *Loc. cit.* (Mollusca Great Oolite, III), 1854, p. 127, pl. XIV, fig. 7.

<sup>2)</sup> See Douglas and Arkell: "Stratigraphical Distribution of the Cornbrash, II. The North-Eastern Area". Quart. Journ. Geol. Soc. vol. LXXXVIII, 1932, p. 157.

Genus *VELATA*, Quenstedt, 1856.*Velata* sp. ind.

Only the impression of a fragment is preserved but by its size and characteristic ornamentation it may be referred to this genus. The ribbing is finer and more wavy than that of *Hinnites velatus* (Goldfuss) as figured by Morris and Lycett<sup>1</sup>), a form which is now referred by Arkell<sup>2</sup>) to *V. jason* (d'Orbigny). In the enlarged figure of the ornamentation of *V. grada* (Bean) given by Lycett<sup>3</sup>), the transverse striae are closer in proportion to the radial costae than they are in the Greenland fragment.

Horizon and Locality:— *Arctocephalites* beds, Mt. Hjørnefjæld, locality 1, 700 m (1 example).

Family *Ostreidae*.Genus *OSTREA*, Linnaeus, 1758.*Ostrea* sp. ind.

The poorly-preserved cast of part of the interior of a valve of an *Ostrea* (or *Exogyra*?) without ligament pit may be recorded separately because it is evidently a much larger form than that referred below to *Exogyra* cf. *reniformis*, and because it is from a lower bed. There is some resemblance to the *O. eduliformis*, Schlotheim, figured by Schmidtil<sup>4</sup>) but not to the examples from the Liassic 'Oyster Bed' on Mt. Nathorst, figured by Madsen<sup>5</sup>).

Horizon and Locality:— *Pecten* Beds, Mt. Hjørnefjæld, locality 6, 700 m (one example).

Genus *LIOSTREA*, H. Douvillé, 1904.*Liostrea*? sp. ind.

There is only a single left valve without recognisable surface of attachment, rather convex and with growth-lamellae irregular but the shell nearly all broken off, so that the internal cast is almost smooth. The example may be compared to *Ostrea* cf. *duriuscula*, Phillips, figured by Lahusen<sup>6</sup>), but the preservation is such that external shape alone has to be relied on. Lahusen's form came from the *lamberti* zone, Phillips's type<sup>7</sup>) from the Coralline Oolite, but the latter is larger than and less

<sup>1</sup>) *Loc. cit.* (Mollusca Great Oolite, II), 1853, pl. II, fig. 2a.

<sup>2</sup>) *Loc. cit.* (Monograph Corallian Lamellibranchia), III, 1931, p. 121.

<sup>3</sup>) *Loc. cit.* (Mollusca Great Oolite Suppl.), 1863, pl. XXXIII, fig. 10a.

<sup>4</sup>) *Loc. cit.* (Palæontographica, vol. LXVII), 1925, pl. III, fig. 14.

<sup>5</sup>) *Loc. cit.* (Jurassic Fossils from East Greenland), 1904, p. 177, pl. VII.

<sup>6</sup>) *Loc. cit.* (Mém. Com. géol. I, 1), 1883, p. 20, pl. I, fig. 10.

<sup>7</sup>) *Loc. cit.* (Geology of Yorkshire), 1829, pl. IV, fig. 1.



like the Greenland example, and probably not a *Liostrea*. The comparison to Lahusen's figure thus is merely meant to indicate a similarity of general appearance.

Horizon and Locality:— *Tychonis* Bed, Vardekløft Formation, South of *Goniomya* Kløft, locality D, 540 m (1 example).

Genus *EXOgyRA*, Say, 1819.

*Exogyra* cf. *reniformis* (Goldfuss) Krenkel.

1915. *Exogyra reniformis*, Goldfuss; Krenkel: 'Monographie der Kello-way Fauna von Popilani', *loc. cit.*, p. 302, pl. xxv, figs. 34—35.

The irregular, internal casts of portions of two valves of a small *Exogyra*, with remains of the very thick test, may be compared to Krenkel's Popilany form, but perhaps more because they are of similar size than because of agreement in the features described by Krenkel. The specimen is also worn and encloses the cast of a gastropod.

Horizon and Locality:— Lowest *Arcticoceras* beds, Mt. Mikael, 500 m (1 example).

### Family *Mytilidae*.

Genus *MODIOLUS*, Lamarck, 1799.

*Modiolus* sp. ind.

Some small internal casts in sandstone may be the young of the common *Modiolus bipartitus* (J. Sowerby)<sup>1</sup>), although they could perhaps belong to a more elongated form like *M. plicatus* (Sowerby)<sup>2</sup>) since they might be compared especially to such a comparatively smooth individual as that figured by Benecke<sup>3</sup>). The dimensions of the best of the Greenland examples, however, are only as follows:— 16.5 mm length, 6 mm height, at posterior end, 5 mm at anterior end, and 5 mm thickness (of both valves). *Modiolus frankensis*, McLearn<sup>4</sup>) seems to be a comparable small form, but differs in its very low anterior end.

Some larger fragments, doubtfully included here, may even have belonged to forms of *Myoconcha*, like those figured by Morris and Lycett<sup>5</sup>)

Horizon and Locality:— *Arctocephalites* Beds, Mt. Hjørne-fjæld, locality 1, 700 m (4 specimens and 7 doubtful fragments).

<sup>1</sup>) Mineral Conchology, vol. III, 1818, p. 17, pl. ccc, fig. 4.

<sup>2</sup>) *Ibid.*, 1819, p. 87, pl. ccxlviii, fig. 1.

<sup>3</sup>) "Versteinerungen der Eisenerz-Formation von Deutsch-Lothringen und Luxemburg". Abh. Geol. Spez. K. v. Els.-Lothr. N. F. Heft VI, 1905, p. 168, pl. ix, fig. 6.

<sup>4</sup>) *Loc. cit.* (Trans. Roy. Soc. Canada), 1924, p. 53, pl. vii, figs. 1—2.

<sup>5</sup>) *Loc. cit.* (Monogr. Mollusca Great Oolite, II), 1853, p. 77, pl. III, figs. 17—18.

## 2. Order *Homomyaria*.

### Family *Trigoniidae*.

Genus *TRIGONIA*, Bruguière, 1789.

*Trigonia* sp. ind.

A small example of apparently a finely-ribbed *Trigonia* has the surface of the left valve almost entirely worn away, but it shows what looks like fine, concentric striation, much like *T. lingonensis* Dumortier, as represented by Lycett<sup>1</sup>). The right valve shows an area, with fine longitudinal striae, divided into two portions, as in the form just mentioned, but separated from the costate side by a strong, though worn, keel. The fine costation, however, closer even than that of *T. hemisphaerica*, Lycett<sup>2</sup>), is visible only near the anterior border, and there, instead of being curved upward, it is straight or even turned down at the margin. I do not know of any *Trigonia* with similar straight ribbing across the valve, except, perhaps (the rather different) *T. stelzneri*, Gottsche<sup>3</sup>), but as a far larger part of the surface is corroded, it is difficult to say how much of the peculiar aspect of the costation is due to the weathering.

Horizon and Locality:— *Arctocephalites* Beds, Mt. Hjørnefjæld, locality 2, 760 m (1 example).

### Family *Astartidae*.

Genus *ASTARTE*, Sowerby, 1816.

*Astarte* sp. ind.

A fragment of a thick-shelled form with strong concentric ribs probably belonged to a species like *A. elegans* (Sowerby)<sup>4</sup>) which has been recorded from the Yorkshire Cornbrash<sup>5</sup>).

Horizon and Locality:— *Arcticoceras* beds, Mt. Mikael, 600 m (1 example).

### Family *Cardiidae*.

Genus *PROTOCARDIA*, Beyrich, 1845.

*Protocardia* aff. *subtrigona* (Morris and Lycett).

(Plate II, fig. 5).

1853. *Cardium subtrigonum*, Morris and Lycett, Monograph of the Great Oolite Mollusca pt. II, p. 64, pl. VII, fig. 3.

<sup>1</sup>) Monograph of the British Fossil Trigoniae. Pal. Soc. III, 1875, p. 98, pl. XXII, figs. 1—2.

<sup>2</sup>) *Ibid.*, IV, 1877, p. 174, pl. XXXI, fig. 5.

<sup>3</sup>) *Loc. cit.* (Palæontographica, Suppl. III, 2), 1878, p. 24, pl. VI, fig. 1a.

<sup>4</sup>) See especially in Phillips, *loc. cit.* (Geology of Yorkshire), 1829, pl. XI, fig. 41.

<sup>5</sup>) In Fox-Strangways: Jurassic Rocks of Britain, vol. I, Yorkshire. Mem. Geol. Survey, 1892, p. 265.

1863. *Cardium subtrigonum*, Morris and Lycett; Lycett: Supplement to Monograph, pl. xxxv, figs. 2, 2 a.

Numerous internal casts resemble this species in general aspect and proportions but are generally small, the figured example being one of the largest, although a few less complete casts exceed it in size. The left valve is larger than the right and the striated posterior area may be slightly more excavated than in Morris and Lycett's type, but otherwise there is good agreement. *P. concinna* (v. Buch) and *P. cognata* (Phillips) recorded by Krenkel<sup>1)</sup> from the "Kellaway Beds" of Popilany, have much more pointed umbones, and *P. schucherti*, McLearn<sup>2)</sup>, very similar at first sight, differs in proportions, which in the present form are the following:— Length = 18 mm, Height of left valve = 17 mm, right valve = 16 mm, Thickness (of both valves) = 12 mm. The two forms recently figured by Schmidtil<sup>3)</sup> and doubtfully attached to *P. subtrigona* are less closely comparable to the Greenland examples than Lycett's larger Great Oolite specimen.

Horizon and Locality:— *Arctocephalites* Beds, Mt. Hjørnefjæld, locality 1, 700 m (40 examples and fragments.)

### Family *Pleuromyidae*.

Genus *PLEUROMYA*, Agassiz, 1842.

#### 1. *Pleuromya decurtata* (Phillips).

(Plate VI, fig. 5; Pl. VII, fig. 6).

1829. *Amphidesma decurtatum*, Phillips, Geology of Yorkshire, I, pl. vii, fig. 11.

1843. *Pleuromya decurtata* (Phillips) Agassiz, Les Myes, p. 232.

1923. — — — Lamplugh, Kitchin and Pringle: 'The Concealed Mesozoic Rocks in Kent'. Mem. Geol. Survey, pp. 68, 69.

There appears to be no difference between the Greenland examples now before me and the common individuals in the Lower Calcareous Grit (Nothe Grit) of Dorset; and although Phillips's type came from the Cornbrash, this species ranges up into much higher beds. The example figured by Morris and Lycett<sup>4)</sup> seems less closely comparable to the

<sup>1)</sup> *Loc. cit.* (Palæontographica, vol. LXI), 1915, p. 324.

<sup>2)</sup> *Loc. cit.* (Trans. Roy. Soc. Canada), 1924, p. 57, pl. ix, figs. 4 and 10.

<sup>3)</sup> *Loc. cit.* (Palæontographica, vol. LXVIII), 1926, p. 63, pl. viii, fig. 5.

<sup>4)</sup> *Loc. cit.* (Monograph Great Oolite Mollusca), pt. III, 1854, p. 137, pl. xv, figs. 10a, b.

Greenland examples than the Corallian specimens. It is possible, however, that some of the doubtful examples belong to related species and not to *P. decurtata* itself, the crushing producing a resemblance to *P. recurva* (Phillips)<sup>1</sup>). The posterior end of the smaller example (Plate VI, fig. 5) is somewhat worn and perhaps was originally crushed, but the valves could not have gaped considerably; on the other hand, the anterior end seems to show agreement with Schmidtil's<sup>2</sup>) figure of *Homomya* aff. *obtusa*, Agassiz. The example is, however, included here because it is apparently closer to the other less poorly preserved individuals of the present species than to Agassiz's<sup>3</sup>) original *Homomya obtusa*.

Some of the crushed examples might also be compared to *Gresslya peregrina*, Phillips<sup>4</sup>), especially as figured by Krenkel<sup>5</sup>) under the name of *G. abducta* (Phillips). Both these species had been recorded already by Madsen<sup>6</sup>) from a bed on Mt. Nathorst which included Toarcian fossils, but his forms are different from the examples here discussed.

Horizon and Localities:— *Arcticoceras* Beds, Mt. Mikael, 545—570 m (4 examples); *Arctocephalites* Beds, Mt. Hjørnefjæld, locality 2, 760 m (10 examples); *Cranocephalites* Beds, Cathedral Mtn. 370 m (1 example).

## 2. *Pleuromya securiformis* (Phillips).

(Plate V, fig. 5; Pl. XVII, fig. 3).

1829. *Amphidesma securiformis*, Phillips, Geology of Yorkshire I, p. 144, pl. VII, fig. 10.

The example figured in Plate V, fig. 5 is worn at the two ends and thus seems too short but it agrees with typical examples of this species, although it could equally well be attached to *P. elongata* (Münster)<sup>7</sup>) which precedes Phillips's species in the Lower Oolites. *P. polonica* (Laube), recently described by Krenkel<sup>8</sup>) from the 'Kellaway' Beds of Popilany is slightly more elongated.

In another specimen, represented in Plate XVII, fig. 3, the two valves are slightly crushed one upon the other and the trigonal outline

<sup>1</sup>) *Loc. cit.* (Geology of Yorkshire, I), 1829, pl. v, fig. 25.

<sup>2</sup>) *Loc. cit.*, Palæontographica, vol. LXVIII, 1926, p. 77, pl. x, figs. 9a—c.

<sup>3</sup>) *Loc. cit.* (Les Myes), 1843, p. 161, pl. XVI, figs. 1—3.

<sup>4</sup>) *Loc. cit.* (Geology of Yorkshire, I), 1829, p. 144, pl. VII, fig. 12.

<sup>5</sup>) *Loc. cit.* (Palæontographica, vol. LXI), 1915, p. 332, pl. XXVII, figs. 38—39.

<sup>6</sup>) *Loc. cit.* (Jurassic Fossils from East Greenland), 1909, p. 186, pl. VIII, figs. 3—4.

<sup>7</sup>) See Schmidtil, *loc. cit.* (II, 1926), p. 70, pl. VIII, fig. 19, pl. IX, figs. 8—10, pl. x, fig. 8.

<sup>8</sup>) *Loc. cit.* (Palæontographica, vol. LXI), 1915, p. 330, pl. XXVII, fig. 5.

is suggestive of *Tancredia* or some *Thracia*, like *T. canadensis*, McLearn<sup>1</sup>). Still another example has an indistinct transverse ridge, much like the Yorkshire specimen figured by Morris and Lycett<sup>2</sup>).

Horizon and Locality:— *Arctcephalites* Beds, Mt. Hjørnefjæld, locality 1, 700 m (2 examples); *Arcticoceras* beds, Mt. Mikael, 500 m (3 examples).

3. *Pleuromya* aff. *burnsi*, Warren.

(Plate XVI, fig. 4).

1932. *Pleuromya burnsi*, Warren: "A New Pelecypod Fauna from the Fernie Formation, Alberta". Trans. Roy. Soc. Canada (3) vol. XXVI, sect. IV, p. 23, pl. II, figs. 6—7.

Since the example here figured (and enlarged  $\times 2$ ) is too small to be definitely identified, the comparison to Warren's species (from a lower horizon) is not meant to imply more than general affinity. Similar forms of *Pleuromya* from the Yorkshire and Brora Callovian, like *P. recurva*, Phillips are less strongly and concentrically ribbed, but various other comparable species have been figured by Agassiz and later authors from the Lower Oolites and *P. burnsi* may well be a synonym of one of them.

Horizon and Locality:— Horizon with calcareous concretions, Upper Vardekløft Formation, locality A, 560 m (1 example, in the matrix of *Kepplerites* (*Seymourites*) *nobilis*, nov.).

Family *Panopæidae*.

Genus *HOMOMYA*, Agassiz, 1842.

*Homomya* sp. ind.

(Plate XX, fig. 3).

The figured example is believed to be merely a gibbose individual of a form of *Homomya*, slightly deformed by pressure, but the posterior margin is worn and the gaping of the valves is merely suggested by the curvature of one of the broken sides.

Another form of probably the same genus is more distinctly ribbed, like the Kimmeridgian genotype, *H. hortulana*, Agassiz<sup>3</sup>), but it is so badly crushed that no identification is possible.

Six still more doubtful specimens may belong to a still shorter form, but could also be *Pleuromya* of the *decurtata* group, or even the short variety of *Gresslya peregrina*, figured by Lycett<sup>4</sup>).

<sup>1</sup>) New Pelecypods from the Fernie Formation of the Alberta Jurassic. Trans. Roy. Soc. Canada (3) vol. XVIII, sect. IV, (1924) p. 56, pl. IX, figs. 8—9.

<sup>2</sup>) *Loc. cit.* (Mollusca of the Great Oolite), 1854, pt. II, p. 136, pl. XIII, fig. 15.

<sup>3</sup>) *Loc. cit.* (Les Myes), 1842, p. 155, pl. XV, figs. 1—15.

<sup>4</sup>) *Loc. cit.* (Suppl. Monog. Mollusca etc.), 1863, pl. XXXVI, fig. 2b.

Horizon and Localities:— *Arcticoceras* Beds, Mt. Mikael, 545—570 m (1 example); 600 m (1 example); Cathedral Mtn., *Cranoccephalites* Beds, 370 m (1 example); *Arctocephalites* Beds, Mt. Hjørne-fjæld, locality 2, 760 m (6 examples).

Genus *GONIOMYA*, Agassiz, 1838.

*Goniomya v-scripta* (J. Sowerby).

(Plate VII, figs. 4a—c).

1854. *Goniomya v-scripta* (Sowerby) Morris and Lycett: "Monograph of the Mollusca from the Great Oolite &c." (Pal. Soc.), p. 140, pl. XIII, fig. 16.

The three fragments figured show little more than the umbonal portions of single valves, at which stage the v-shaped markings are truncated by cross-bars. There is, however, a larger and double-valved example that, although also fragmentary, shows very good agreement with a Yorkshire specimen before me, indistinguishable from Morris and Lycett's original. In *G. elegantula*, Tullberg<sup>1)</sup>, the Vs are truncated to a much later stage.

Horizon and Localities:— *Arctocephalites* beds, Mt. Hjørne-fjæld, locality 1, 700 m (5 examples), locality 2, 760 m (2 examples); *Arcticoceras* Beds, Mt. Mikael, 500 m (1 example).

### Family *Pholadomyidae*.

Genus *PHOLADOMYA*, J. Sowerby, 1823.

*Pholadomya* cf. *angustata* (J. Sowerby).

1823. *Lutraria angustata*, J. Sowerby: Mineral Conchology of Gt. Britain, vol. IV, p. 29, pl. CCCXXVII.

1874. *Pholadomya angustata*, (J. Sowerby) Moesch: "Monographie der Pholadomyen". Abh. Schweiz. Pal. Ges. vol. I, p. 33, pl. x, figs. 2—4.

Non 1904. — — — Madsen: "Jurassic Fossils from East Greenland", *loc. cit.*, p. 187, pl. VI, figs. 20 a, b.

A badly worn individual seems to show much better agreement with Sowerby's equal-sized original than does Madsen's Mount Nathorst

<sup>1)</sup> "Über Versteinerungen aus den Aucellen-Schichten Novaja-Semljas". Bihang K. Svenska Vet. Akad. Hand. vol. VI, no. 3, 1881, p. 12, pl. I, figs. 6—8.

example; but as it is poorly preserved and the umbonal portion is worn away, the identification can be only approximate. Moesch's form also is less closely comparable, and among Agassiz's many species, inflated forms like *P. flabellata*<sup>1)</sup> seem to me more like the Greenland example than the same author's compressed *P. angustata*<sup>2)</sup>. A smaller example in a better state of preservation might well be compared to *P. ovulum*, Agassiz, especially as figured by Moesch<sup>3)</sup>.

Horizon and Locality:— *Arctocephalites* Beds, Mt. Hjørnefjæld, locality 1, 700 m (1 example); locality 2, 760 m (1 fragment).

### Family *Anatinidae*.

Genus *ANATINA*, Lamarck, 1809.

*Anatina* sp. juv.

The cast of a small left valve of a form of the group of *A. undulata*, Sowerby<sup>4)</sup>, was found in the matrix of the *Arctocephalites* figured in Plate VI, fig. 3. It is too immature and imperfect for definite identification but may have been less elongated or sharpened posteriorly than the type (from the Brora 'Roof-Bed' = *koenigi* zone) or Phillips's<sup>5)</sup> Oxford Clay example (*renggeri* zone).

Horizon and Locality:— *Arctocephalites* Beds, Mt. Hjørnefjæld, locality 2, 700 m (1 example).

### *Incertae Sedis*.

Genus *ROSENBUSCHIA*, Roeder, 1882.

*Rosenbuschia*? sp. nov. ind.

There is a large number of mostly minute shells, generally merely sandstone casts or impressions, but occasionally showing an extremely thin, translucent, almost horny test. They are transversely elongated, greatly compressed and flattened, inequilateral, and have a subcentral umbo which scarcely projects. There are merely faint concentric striae of growth and a general resemblance in the other characters that can be observed to *R. typica*, Roeder<sup>6)</sup>, especially as figured by P. de Loriol<sup>7)</sup>.

<sup>1)</sup> *Études Critiques sur les Mollusques fossiles*. II. Les Myes. Neuchâtel, 1842, p. 109, pl. II<sup>c</sup>, figs. 10—12.

<sup>2)</sup> *Ibid.*, p. 117, pl. III<sup>1</sup>, fig. 4—6.

<sup>3)</sup> *Loc. cit.* (1874), p. 48, pl. xx, figs. 1—11.

<sup>4)</sup> *Mineral Conchology*, vol. v, 182, pl. D XLVIII, figs. 1—2 (*Sanguinolaria*).

<sup>5)</sup> *Geology of Yorkshire*, 1829, pl. v, fig. 1.

<sup>6)</sup> *Beitrag zur Kenntnis des Terrain à chailles und seiner Zweischaler in der Umgegend von Pfirt im Oberelsass*. 1882, p. 97, pl. II, fig. 7.

<sup>7)</sup> "Étude sur les mollusques et brachiopodes de l'Oxfordien supérieur et moyen du Jura bernois". *Mém. Soc. Pal. Suisse*, suppl. 1, vol. xxviii, 1901, p. 56, pl. IV, figs. 3—5.

Not having been able to find any other comparable form, I submitted these examples to Mr. L. R. Cox and I was glad to find that he independently came to the conclusion that there was no other genus for them than *Rosenbuschia*. It is, of course, possible that some of the associated small shells belong to other groups, including perhaps the equally flattened and elongated genus *Solenotellina*, Roeder<sup>1</sup>).

Horizon and Localities:— *Arctocephalites* Beds; Mt. Hjørnefjæld, locality 1, 700 m (many examples), locality 2, 760 m (6 examples).

## II. Phylum Arthropoda.

### Class Cirripedia.

Genus *EOLEPAS*, Withers, 1928.

*Eolepas* sp. nov. aff. *bathonica*, Withers.

(Plate XXI, figs. 4a—c).

Cf. 1928. *Eolepas bathonica*, Withers: Catalogue of Fossil Cirripedia. I. Triassic and Jurassic. (British Museum), p. 74, pl. II, figs. 7—9.

There is the impression of a tergum of which a plasticine-squeeze is figured in Plate XXI, fig. 4 a, in natural size, also an enlarged view ( $\times 2$  and reversed) to show the characteristic ornamentation. The two carinae represented in fig. 4 c are fragmentary, but Mr. Withers kindly informed me that this is probably a new species of *Eolepas*, allied to the Bathonian species described by him.

Horizon and Locality:— *Arctocephalites* Beds, Mt. Hjørnefjæld, locality 1, 700 m (3 plates).

## III. Phylum Molluscoidea.

### Class Brachiopoda.

#### Order Inarticulata.

Genus *LINGULA*, Bruguière, 1789.

*Lingula beani*, Phillips.

1899. *Lingula beani*, Phillips; Pompeckj: Jurassic Fauna of Cape Flora, *loc. cit.*, p. 54, pl. I, figs. 2—5.

This species has been so exhaustively described by Pompeckj that I can add nothing to his remarks. The Greenland forms, found in a

<sup>1</sup>) See P. de Loriol, *ibid.*, p. 57, pl. IV, fig. 6.



single nest, do not seem to differ from the Franz Josef Land examples. The largest, however, is only 10 mm long.

Horizon and Locality:— *Arcticoceras* Beds, Mt. Mikael, 500 m (20 specimens).

Genus *ORBICULOIDEA*, d'Orbigny, 1847.

*Orbiculoidea reflexa* (J. de C. Sowerby).

(Plate XX, fig. 4).

1899. *Discina reflexa* (J. de C. Sowerby) Pompeckj: "Jurassic Fauna of Cape Flora", *loc. cit.*, p. 58, pl. I, figs. 6—9 (10?).

This species also has been discussed in great detail by Pompeckj. The numerous convex valves in the Greenland collections, preserved in sandstone, are often crushed and therefore very variable, but occasionally they show the finer details, e. g. the two reniform muscle-impressions and the pedicle-slit below the apex. The largest examples are about 11 mm long and 5 mm high; smaller ones (as in Plate III, fig. 2) occur in the matrix of many of the other fossils here described from the same beds.

Horizon and Localities:— *Arctocephalites* Beds, Mt. Hjørnefjæld, locality 1, 700 m (many examples); locality 2, 760 m (2 examples), *Arcticoceras* Beds, Mt. Mikael, 500 m (15 examples); 545—570 m (1 example).

#### IV. Phylum Echinodermata.

Class *Crinoidea*.

Order *Articulata*.

Genus *PENTACRINITES*, Blumenbach, 1804.

*Pentacrinites* sp. ind.

Cf. 1899. *Pentacrinus* sp. ex aff. *bajociensis* (d'Orbigny) P. de Loriol; Pompeckj: "Jurassic Fauna of Cape Flora", *loc. cit.*, p. 51, pl. I, fig. 1.

Cf. 1904. — sp. cf. *andreae*, P. de Loriol; Madsen: Jurassic Fossils from East Greenland, *loc. cit.*, p. 172, pl. VI, figs. 1—6. \*

The two fragments found in the *Arctocephalites* Beds of Mt. Hjørnefjæld are not sufficiently well preserved to be compared in detail either with the Toarcian form recorded by Madsen from the Oyster-Bed or with the later Franz Josef Land example described by Pompeckj. It

must suffice to record the persistence of the genus in the East Greenland deposits.

Horizon and Locality:— *Arctocephalites* Beds, Mt. Hjørnefjæld, locality 1, 700 m (2 fragments).

✓  
r.p.

## C. THE LOCALITIES AND THEIR FOSSIL ASSEMBLAGES.

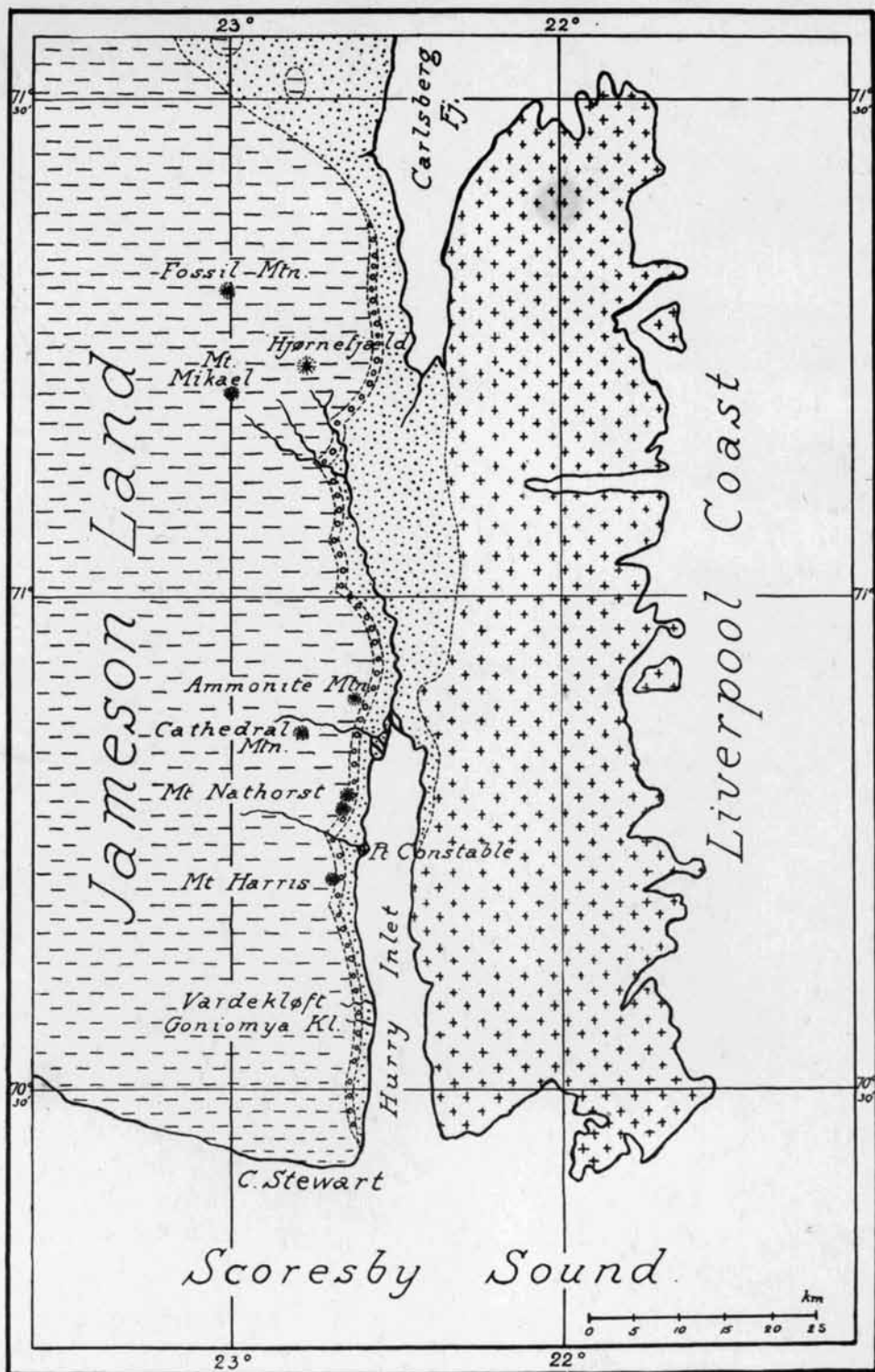
It is advisable to list the assemblages from the different localities separately, before discussing their stratigraphical significance; for not only are the extremes (Goniomykløft and Antarctic Harbour) nearly 100 miles apart, but there are differences in facies, and it has to be seen whether dissimilarity of faunas indicates differences in age of the deposits. The localities are indicated on the sketch-map (Text-fig. 9), the geological boundaries on which have been inserted from Mr. Rosenkrantz's map of 1929 (in Lauge Koch's *Geology of East Greenland*). The position of Antarctic Harbour, farther north ( $72^{\circ}$  N.) is indicated in the sketch-map of Jameson Land appended to Madsen's account (1904). The most southerly of the localities is:—

1) **Goniomykløft**, which is a ravine immediately to the south of Vardekløft<sup>1</sup>). The succession at this locality (D) is the same as that at localities A, B, and C of

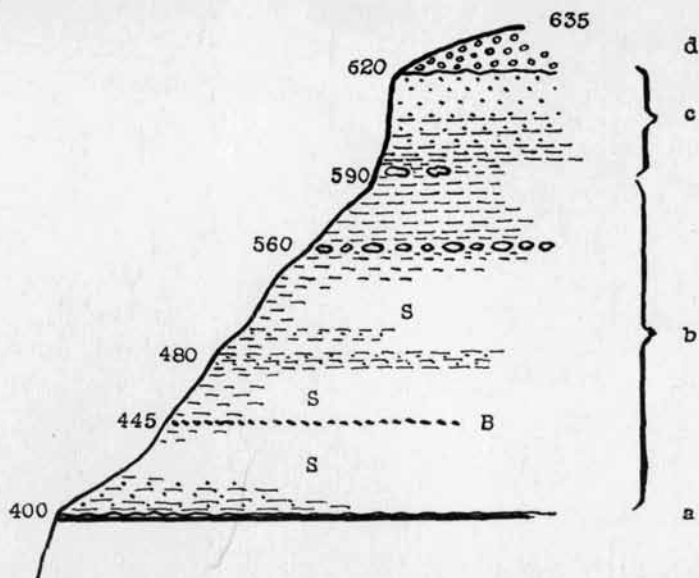
2) **Vardekløft**, which is given in text-fig. 10. The sequence in fact, was drawn up by Mr. Rosenkrantz from the evidence of these four localities and the fauna from the Ammonite Bed, or "Horizon with calcareous concretions", is said to be the same at each locality. The concretions occur in horizontal beds of micaceous shales, but often weather out and lie about loose on the surface. At locality B, however, some ammonites were found in a different matrix, e. g. a red ironstone, or rather clay-ironstone weathering to red; and Mr. Rosenkrantz who considered the ammonites to belong to the genus *Quenstedioceras*, thought that these red concretions possibly came from a higher horizon. From the succession on Mt. Mikael (Text-fig. 13) it is, however, clear that there are beds with *Arcticoceras* below the *tychonis* horizon (or the "horizon with calcareous concretions"). These forms having also been mistaken for *Quenstedioceras* by Rosenkrantz<sup>2</sup>), he suggested the name Fossil Mountain Formation for beds in the north that I take to be merely a repetition of the Vardekløft Formation (in a different facies) of the south of Jameson Land.

<sup>1</sup>) See Text-fig. 44, p. 146 in Rosenkrantz (in Lauge Koch's *Geology of East Greenland*, 1929).

<sup>2</sup>) *Ibid.* (1929), pp. 146—47.



Text-fig. 9. Sketch-map of fossil localities in the eastern part of Jameson Land, showing outcrop of Jurassic (shaded) with a band of Rhaetic (circles) at the base and separated by Permian-Triassic (dotted) from Metamorphic Series (crosses) of Liverpool Land. (After Rosenkrantz, 1929).



Text-fig. 10. Diagrammatic Section at Vardekloft (combining details from localities A, B and C and Goniomyakloft D). After A. Rosenkrantz.

a = "Oyster Bed" at 400 m with crinoid sandstone below; top of Liassic succession.  
 b = micaceous shales, with belemnite layer B at 445 m (locality C), sandstone at 480 m (locality A, with a single belemnite, not brought back), and ammonite horizon with fossil wood at 560 m.  
 c = sandstone, coarse above, and interbedded with shale below; fossil wood at 590 m.  
 d = Pleistocene gravel. S = screes.

The fauna of the horizon with calcareous concretions then consists of the following species:—

*Cadoceras crassum*, Madsen.

— *freboldi* sp. nov.

— *victor* sp. nov.

— sp. nov. aff. *victor* sp. nov.

— (?) sp. ind.

— *dubium* sp. nov.

— *franciscus* sp. nov.

— *variabile* sp. nov.

*Paracadoceras ammon* sp. nov.

*Kepplerites* (*Seymourites*) *tychonis*, Ravn.

— — *peramplus* sp. nov.

— — *rosenkrantzi* sp. nov.

— — *antiquus* sp. nov.

— — *nobilis* sp. nov.

*Cylindroteuthis subextensa* (Nikitin).

*Liostrea* ? sp. ind.

*Pleuromya* aff. *burnsi*, Warren.

[Fossil Wood].

The numerous belemnite fragments from the 445 m level are referable to:—

*Cylindroteuthis subextensa* (Nikitin).  
— *subrediviva* (Lemoine).

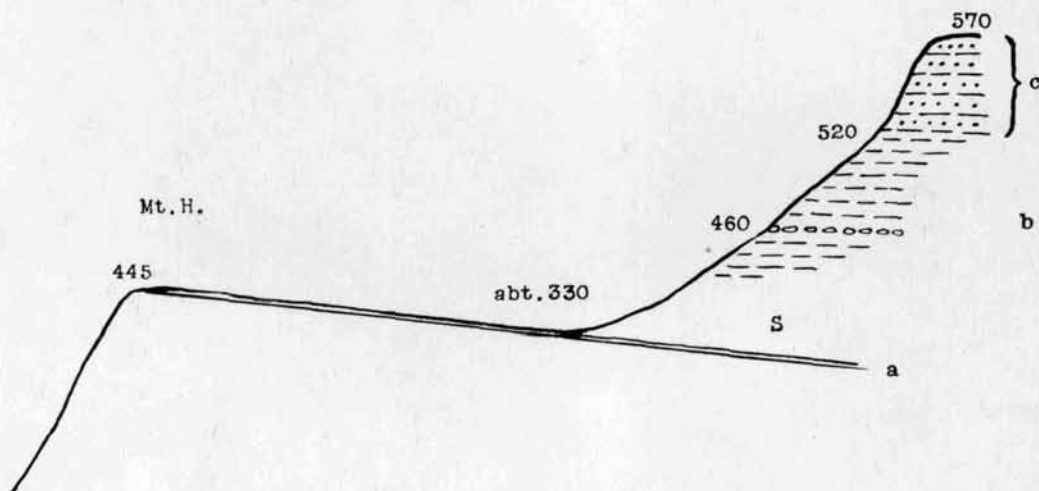
They are black, with white, crystalline calcite in the alveolus, and apparently came out of shales. The former species has been found also in the higher ammonite beds and both occur in the *Arcticoceras* beds of Mt. Mikael. The forms that have been referred to as being possibly from a different horizon are:—

*Arcticoceras* cf. *kochi* sp. nov.  
— sp. nov.? aff. *kochi* nov.

It should be added, however, that many of the *Cadoceras* and *Keplerites* are also preserved in clay-ironstone and that typical *Arcticoceras* on Mt. Mikael, occur immediately below the *tychonis* level.

The age of these faunas will be discussed in the next chapter. Here it need only be pointed out that the same ammonite horizon has been found at only one other locality (no. 3 below) but that a few corresponding forms (in quite a different matrix) are listed below from locality no. 5 (e) on Mt. Mikael.

3) **Near Point Constable** (locality west of Mt. Harris). There are only three ammonites, found loose at an altitude of about 460 m on the scree-covered slopes; they are identical in mode of preservation with



Text-fig. 11. Diagrammatic Section across Mt. Harris and cliff west of it. (After A. Rosenkrantz).

a = "Oyster Bed". b = ammonite horizon, with fossil wood, in shales at 460 m.  
c = coarse sandstone without fossils (520—570 m). S = scree.

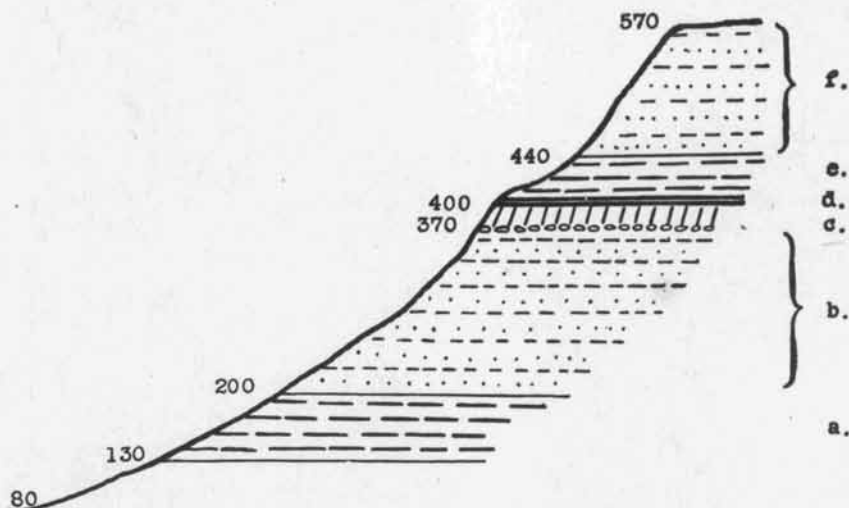
those from the horizon of calcareous [or clay-ironstone] concretions in the micaceous shales at Vardekløft. The three forms are:—

*Cadoceras calyx* sp. nov.

— *variabile* sp. nov.

*Kosmoceras* (*Gulielmiceras*) *pauper* sp. nov.

The special significance of the last species is referred to in the next chapter. It will be seen from Mr. Rosenkrantz's section that the shaly beds continue upward, so that the *Kosmoceras* might have come from a



Text-fig. 12. Diagrammatic Section on Cathedral Mountain. (After T.M.Harris).  
 a = blue clay. b = sandstone with a few belemnites (not brought back) and perhaps partly-hidden blue clay. c = *Cranocephalites* horizon at 370 m. d = Basalt at 400 m, with basalt scree below, also a few belemnites in sandstone (not brought back). e = black shales with fossil wood. f = yellow sandstone with fossil wood and thin bands of shale.

little higher. Otherwise there seems to have been little change in the beds, more or less horizontal in the cliff-section, as shown in the photographs, between Vardekløft and this locality.

There is, unfortunately, little information available with regard to the succession on Mt. Nathorst to the south and Ammonite Mtn. to the north of the next locality:—

4) **Cathedral Mountain**, on Owl River, where a section has been measured by Dr. T. M. Harris and kindly communicated to me by Mr. Rosenkrantz (Text-fig. 12).

The ammonite horizon, characterised by numerous species of *Cranocephalites*, is here at 370 m, as against 500 m on Ammonite Mtn.,

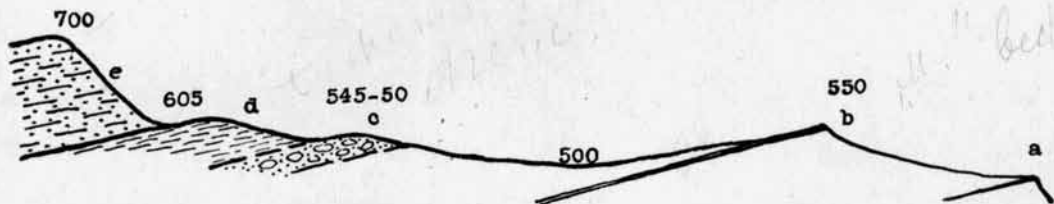
but as Cathedral Mtn. lies some distance to the west and since the slight dip is inland, this difference of level may not mean anything. On the other hand the Liassic Oyster Bed below, found to be at about 510—525 m on Mt. Nathorst, has not been seen on Cathedral Mountain. The Shale Formation in between the two sandstones is apparently greatly reduced. Some belemnites found in the lower sandstones were not brought back, but the fossils from the top show rather a variety of sandstone-matrices.

The assemblage from the ammonite horizon is as follows:—

- Cranocephalites vulgaris* sp. nov.  
 — *gracilis* sp. nov.  
 — *maculatus* sp. nov.  
 — *subextremus* sp. nov.  
*Inoceramus retrorsus*, Keyserling.  
*Pecten (Entolium) cf. demissus* Phillips.  
*Pseudomonotis* sp. ind.  
*Pleuromya decurtata* (Phillips).  
*Homomya* sp. ind.

One other ammonite, *Arctocephalites greenlandicus* sp. nov., is in a slightly different preservation from the rest of the ammonites and may have come from beds above. But it also has a sandy matrix and since some belemnites in a sandstone were observed among the basalt scree immediately above the *Cranocephalites* horizon, this ammonite may be from only a slightly higher horizon if not actually occurring together with *Cranocephalites*. In the case of the *Inoceramus* and one or two more fossils, the rock also is a very coarse sandstone with large flakes of white mica.

5) **Mt. Mikael** (also called Mt. Nordenskjöld on the labels). Mr. Rosenkrantz to whom I owe the section here reproduced (Text-fig. 13) informs me that most of the country was covered with snow



Text-fig. 13. Diagrammatic Section on Mt. Mikael. (Adapted from A. Rosenkrantz). a = Oyster Bed. b = position of "*Macrocephalites*" beds = top of Mt. Hjørnefjæld at about 550 m. c = sandstone with concretions and *Arcticoceras kochi*, 545—550 m. d = shales and sandstones with top at 605 m marking position of *tychonis*-horizon. e = unfossiliferous upper sandstone.

and that with the exception of the *Arcticoceras* horizon (545—50 m) the fossils were not *in situ* but lying loose at the surface. I believe that Rosenkrantz is right in correlating the *Macrocephalites* horizon (abt. 550 m) with the top beds of Mt. Hjørnefjæld, as the position above the Oyster Bed alone suggests. No fossils, however, were collected there on account of the snow cover. The lowest horizon of the succeeding *Arcticoceras* beds has yielded the following fauna, preserved in more or less phosphatized nodules in a micaceous sandstone:—

- (a) *Arcticoceras* sp. juv. ind.  
 — sp (Plate XI, fig. 3).  
*Cylindroteuthis* ? sp. (indeterminable fragments).  
*Amberleya* sp. ind.  
*Pseudomonotis* aff. *doneziana*, Borissjak.  
 — spp. ind.  
*Exogyra* cf. *reniformis* (Goldfuss) Krenkel.  
*Pleuromya* cf. *securiformis* (Phillips).  
 — ? sp. ind.  
*Goniomya v-scripta* (J. Sowerby).  
*Lingula beani*, Phillips.  
*Orbiculoidea reflexa* (J. de C. Sowerby).  
 [Fossil Wood].

The outcrop of the next higher beds (with *Arcticoceras kochi*), found to be *in situ* between 545 and 550 m (545—570 m on the labels), yielded the following assemblage:—

- (b) *Pleurocephalites* ? sp. ind.  
*Arcticoceras kochi* sp. nov.  
 — spp. juv.  
*Cylindroteuthis subextensa* (Nikitin).  
 — *subrediviva* (Lemoine).  
*Pinna sublanceolata*, Eichwald.  
*Pleuromya decurtata* (Phillips).  
*Homomya* sp. ind.  
*Orbiculoidea reflexa* (J. de C. Sowerby).  
 [Fossil Wood].

The matrix is a coarse, micaceous, sandstone, indistinctly flaggy, like the matrix of *Cylindroteuthis* figured in Plate XVI, fig. 2, from the Belemnite Bed at Vardekløft (445 m). It seems to me probable that Madsen's *Macrocephalites ishmae* came from beds below the *tychonis* horizon at Vardekløft and that the similarity in the belemnites from



the 445 m level at Vardekløft and the 545 m horizon on Mt. Mikael is not accidental. In other words, the *Arcticoceras* Beds at Vardekløft follow on the Upper Lias without the intervention of the lower beds found farther north.

From 570 m on Mt. Mikael there are only:—

- (c) *Arcticoceras* sp. juv. ind.  
*Pseudomonotis* sp. ind.  
*Protocardia* sp. ind.

and from 600 m, in a similar micaceous sandstone matrix but also picked up loose, a few more forms, still with *Arcticoceras*:—

- (d) *Arcticoceras kochi* sp. nov.  
— *michaelis* sp. nov.  
— sp. juv. ind.  
*Cadoceras pseudishmae* sp. nov.  
*Cylindroteuthis subextensa* (Nikitin).  
*Astarte* sp. ind.

A slab with remains of a *Chemnitzia* and other mollusca, including a belemnite and perhaps part of *Arcticoceras*, is labelled 610 m but also was not found *in situ*.

The highest assemblage from Mt. Mikael, labelled 605 and 620 m, includes:—

- (e) *Kepplerites* (*Seymourites*) *tychonis*, Ravn.  
— — *svalbardensis*, Sokolov and Bodylevsky.  
*Cadoceras* ? spp. ind.

and deserves special consideration. For while I have no doubt about the identification of the examples of *Kepplerites*, the three specimens doubtfully listed as *Cadoceras* ? before me are crushed and look different from either the usual European species of this genus or the Vardekløft examples. But among the specimens collected by O. Nordenskjöld at his locality 2 on Fossil Mountain there is a somewhat similar, crushed ammonite (one of the *Olcostephanus* ? or *Simbirskites* ? identified by Pompeckj and quoted by Madsen)<sup>1)</sup> and associated not only with *Kepplerites* but with forms like Madsen's figured example.<sup>2)</sup> Rosenkrantz in 1929<sup>3)</sup> expressed his opinion that the *Simbirskites* ? mentioned by Madsen

<sup>1)</sup> *Loc. cit.* (Jurassic Fossils from East Greenland), 1904, p. 198.

<sup>2)</sup> *Ibid.*, p. 195, pl. x, fig. 2.

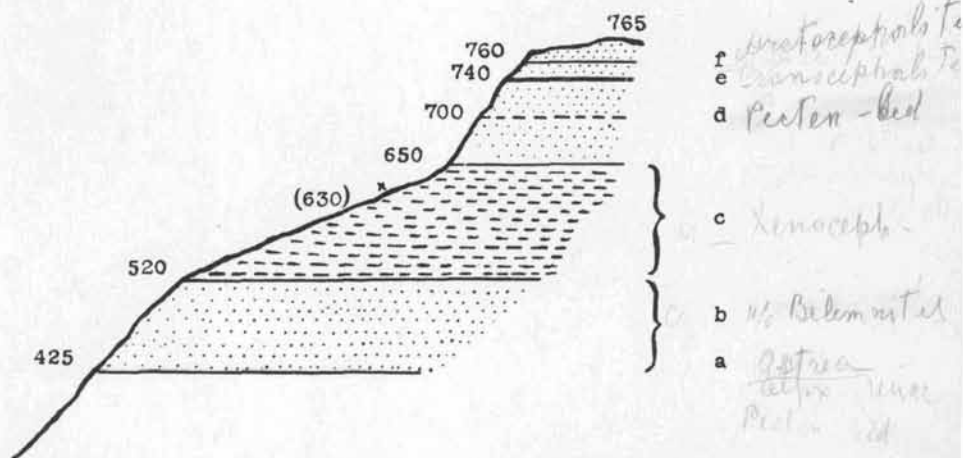
<sup>3)</sup> In Lauge Koch, Geology of East Greenland, *loc. cit.* p. 147.

<sup>in this</sup> This horizon (on the neighbouring Fossil Mountain) should probably more correctly be referred to the Cardioceratids and he therefore assumed them to be of 'Oxfordian' age. Undoubtedly these 'Olcostephanids' are undescribed species, and the preservation of all is such that I can offer no identifications and no opinion whether Pompeckj was right in considering them to be elements of a much later age. They seem to me to have their nearest relations perhaps among the Polyptychitids and *Subcraspedites* of the Aquilonian and Infra-Valanginian, but I cannot explain their admixture with *Kepplerites*. Yet it is possible that on Mt. Mikael, as on Fossil Mountain, the *tychonis* bed is overlain unconformably by similar sandstones with an entirely different fauna. But what the relation of this latter fauna is to that Portlandian-Bononian assemblage recorded by Rosenkrantz from the Cape Leslie Formation, I am unable to say in the absence of recognizable ammonites. No doubt future collections of material in a better state of preservation will enable us to express a more emphatic opinion on the age of these doubtful forms, mixed up with the Callovian *tychonis* fauna. For the present, it must suffice to point out that the Corallian-Kimmeridgian *Amoeboceras* fauna also, known from farther north (Wollaston Foreland, Kuhn Island), seems to be absent in Jameson Land. As the beds are mostly coarse sandstones and admittedly littoral deposits, the thickness alone may prove a very deceptive factor in correlation.

6) **Mt. Hjørnefjæld.** At this locality, situated to the east of Mt. Mikael and Fossil Mountain, only the lower beds crop out. Mr. Rosenkrantz, who kindly sent the appended section (fig. 14) correlated the lowest *Pecten*-Belemnite bed (or *Demissus*-Grit, 700 m) with the *Arctocephalites* layer at the top of a plateau (locality 1, also at 700 m) north-east of the summit of Mt. Hjørnefjæld (765 m), but I would place the latter still higher than the top horizons, at 740 m and 760 m in the section, on the evidence of the fauna listed below. For this includes, in addition to three body-chambers of *Arctocephalites nudus*, a large number of small ammonites, some of which are the first *Arcticoceras*; and they connect directly with the lowest fauna collected on Mt. Mikael (at 500 m). The matrix of the phosphatised, concretionary, specimens from the two is also identical, and the abundance of *Orbiculoidea* and other peculiarities are equally striking. On the other hand, while the collection from this locality 1 includes many examples of a rock full of *Pseudomonotis*, the *Arctocephalites* Beds of locality 2 (760 m) are characterised by an abundance of gigantic phragmocones of belemnites, unknown from 1.

According to Mr. Rosenkrantz's information, the layer of concretions, spread over the ground in great quantities at locality 1, is succeeded below by a yellow sandstone full of belemnites, i. e. a veritable

"belemnite-battlefield". Unfortunately, the belemnites were decomposed and there are no examples in the collections before me, but Rosenkrantz considers this to be possibly identical with the similar belemnite bed on Fossil Mountain, i. e. Nordenskjöld's locality 1 at 450 m. As I have been able, by the kindness of Prof. Ravn, to examine the few fossils recorded by Madsen (p. 198) from this locality, I may say that this assemblage seems to me to be more like that from the *Pecten* Bed on Mt. Hjørnefjæld, although the quartz-grit there is not quite so coarse. In any case, since belemnites of the same type occur in most of the beds, they are not very helpful and since the assemblage from locality 2 is



Text-fig. 14. Diagrammatic Section on Mt. Hjørnefjæld. (After A. Rosenkrantz). a = Oyster Bed at 425 m. b = coarse yellow sandstone (with one undetermined belemnite). c = unfossiliferous, micaceous shales (the x at 630 m marks the spot where *Xenocephalites borealis* was picked up loose). d = *Pecten*-belemnite horizon ("*Demissus* Grit") in sandstone. e = *Cranocephalites* Bed. f = *Arctocephalites* Beds.

intimately related to that from locality 6 (and 2 b) at 740 m, it seems probable that there is an unknown thickness of belemnite beds in between the two *Arctocephalites* horizons, mentioned below (d and e).

Two ammonites were found loose on the slope at 630 m, namely:—

*Cranocephalites pompeckji* (Madsen) var. *intermedia*, nov.

*Xenocephalites borealis* sp. nov.

The former, by its matrix, undoubtedly came down from the *pompeckji* beds at locality 6 (740 m on labels, 760 m in section, according to Rosenkrantz); the second does not show much matrix but what there is is a very coarse grit and identical with the matrix of that other *Xenocephalites* ('*Ammonites* sp. ind.' of Madsen) from Nordenskjöld's locality 1 on Fossil Mountain. The fauna from there, as I have already

stated, seems to me comparable to that of the *Pecten* Bed, i. e. the lowest fauna before me from Mt. Hjørnefjæld, and it seems possible that *Xenocephalites* may yet be found to mark a distinct ammonite horizon, perhaps lower than the first *Cranocephalites* bed.

The assemblage from the 700 m *Pecten*-Belemnite Bed (or *Demissus* Grit, without ammonites) is as follows:—

- (a) *Cylindroteuthis subextensa* (Nikitin).  
*Pecten* (*Entolium*) *demissus*, Phillips.  
 — (*Camptonectes*) *rigidus*, Sowerby.  
*Ostrea* sp. ind.  
*Liostrea* ? sp. ind.  
*Eryma* ? sp.  
 Fossil Wood.

At the next higher horizon (740 m) ammonites only were found (at locality 2 b, southwest of the summit) all stained red or pink but still in a sandstone with occasional large quartz-grains. The forms are:—

- (b) *Cranocephalites* cf. *pompeckji* (Madsen).  
 — cf. *vulgaris* sp. nov.  
 — *subbullatus* sp. nov.  
 — *furcatus* sp. nov.

A very similar but perhaps not perfectly identical fauna was collected in a micaceous sandstone at locality 6 (east of the summit), also at 740 m, but Rosenkrantz, in his section, puts this at 760 m, i. e. definitely higher than the last assemblage. This second *Cranocephalites* fauna includes:—

- (c) *Cranocephalites pompeckji* (Madsen).  
 — *vulgaris* sp. nov.  
 — *maculatus* sp. nov.  
 — cf. *furcatus* sp. nov.

The difference is greater than appears from the lists, partly perhaps on account of difference in preservation; yet the first assemblage is definitely closer to the *Cranocephalites* fauna from Cathedral Mountain, far to the south, while the second assemblage resembles the fauna from Antarctic Harbour, over 50 miles to the north. Even if these two assemblages from Mt. Hjørnefjæld, thus, cannot be clearly separated, there seems to be reason for assuming that the *pompeckji-vulgaris* fauna is later than that characterised by the inflated forms (*subbullatus*).

The large fauna collected at locality 2 (2 a) near the summit of Mt. Hjørnefjæld (760 m), although correlated by Rosenkrantz with the higher *Cranocephalites* fauna 6, does not include a single example of this genus, but a host of entirely different forms, namely:—

- (d) *Arctocephalites nudus* sp. nov.  
 — *elegans* sp. nov.  
 — sp. ind.  
 — *ornatus* sp. nov.  
 — *sphaericus* sp. nov.  
 — sp. nov.  
 — (?) *platynotus* sp. nov.  
*Cylindroteuthis subextensa* (Nikitin).  
 — (?) sp. ind.  
*Amberleya* sp. ind.  
*Pseudomonotis* aff. *doneziana* (Borissjak).  
*Trigonia* sp. ind.  
*Protocardia* sp. ind.  
*Pleuromya decurtata* (Phillips).  
*Homomya* sp. ind.  
*Goniomya v-scripta* (Sowerby).  
*Pholadomya* cf. *angustata* (Sowerby).  
*Anatina* sp. ind.  
*Rosenbuschia* ? sp. nov.  
*Orbiculoidea reflexa* (Sowerby).  
*Serpula* ?

It has already been mentioned that a number of these forms occur in the assemblage listed below from locality 1, and as 2 a is directly above (and north-east of) locality 2 b the complete change in the fauna is very striking. It is, perhaps, improbable that there is a break, for the young *Cranocephalites* are much like *Arctocephalites* and only the adult of both genera differ sufficiently for generic separation. But whereas the *Cranocephalites* horizons appear to be merely seams of ammonite remains, in a sandstone series, the phosphatised concretions with an abundance of fossils in the *Arctocephalites* Beds indicate slower deposition or even condensation of an already existing deposit, after the manner of nodule beds or phosphate horizons in other successions.

I have already mentioned that I believe the fauna from locality 1, at only 700 m but away to the north-east, to belong to a still higher horizon. It includes:—

- (e) *Arctocephalites nudus* sp. nov.  
*Arcticoceras* sp. juv. ind.

- Cylindroteuthis* sp. ind.  
*Amberleya* sp. ind.  
*Natica* sp. nov.? aff. *chauwiniana*, d'Orbigny.  
 — (*Ampullina* ?) sp. ind.  
*Chemnitzia* sp. nov.  
*Procerithium* spp. ind.  
*Pseudomonotis* aff. *doneziana*, Borissjak.  
 — sp. ind.  
*Inoceramus* aff. *ambiguus*, Eichwald.  
 — sp. juv. ind.  
*Pecten* (*Entolium*) *demissus*, Phillips.  
*Velata* sp. ind.  
*Modiolus* sp. ind.  
*Protocardia* aff. *subtrigona* (Morris and Lycett).  
*Pleuromya* aff. *securiformis* (Phillips).  
*Goniomya v-scripta* (J. Sowerby).  
*Pholadomya* cf. *angustata* (J. Sowerby).  
*Rosenbuschia* ? sp. ind. nov.  
*Eolepas* sp. nov. aff. *bathonica*, Withers.  
*Orbiculoidea reflexa* (J. de C. Sowerby).  
*Pentacrinus* sp. ind.  
 Worm Tracks.  
 [Fossil Wood].

It is matter for regret that on account of the snow no collecting was possible in the lower beds on Mt. Mikael, for an inspection of text-fig. 13 (p. 129) will show that there the complete succession down to the Upper Liassic Oyster Bed could have been obtained.

7) **Antarctic Harbour.** The fossils from the hills east of this harbour (in King Oscar Fjord, 72° N.) are the following:—

- Cranocephalites* cf. *pompeckji* (Madsen).  
 — *inversus* sp. nov.  
 — *inconstans* sp. nov.  
 — sp. ind.  
 — *subbullatus* sp. nov.  
 — sp. nov.  
*Cylindroteuthis* ? sp. ind.

They are from the ironstone bands (vi) in the succession already published by Parkinson and Whittard<sup>1)</sup>, and were collected on two ridges, namely specimens No. 36—40 on ridge A, at 1400 feet, and

<sup>1)</sup> *Loc. cit.* Quart. Journ. Geol. Soc., vol. LXXXVII, 1931, p. 653.

41—47 on ridge B at 1500 ft. O. D., but obviously from the same horizon. It is unfortunate that the fossils are in so poor a state of preservation, but as already mentioned, they may be of slightly earlier date than the *pompeckji* fauna of Cathedral and Ammonite Mountains, for of the one species common to both there is only a single fragment in the present assemblage. It will be noticed that only a few fossiliferous horizons have been found in an enormous thickness of beds, attributed to the Jurassic and the belemnites from bed III were not brought back.

## D. STRATIGRAPHICAL AND PALAEOONTOLOGICAL CONCLUSIONS

### I. The Limits of the Vardekløft Formation.

I have attempted to show in the last chapter that the fossils here described come from a formation which terminates above with sandstones that in at least one locality may turn out to belong to a high Jurassic horizon. Below, another thickness of sandstones, with only indeterminate belemnites, separates the lowest fossiliferous bed from the underlying Toarcian "Oyster Bank". There must be a great stratigraphical break at the top of this Oyster Bed which is conspicuous in all the sections here given except on Cathedral Mountain where it must have been overlooked. Considering that the belemnites from the lowest beds at Vardekløft and from the *Pecten-Belemnite* Sandstone ('*Demissus* Grit') of Mt. Hjørnefjæld are the same forms that occur higher, with the ammonites, it may be held that the fresh cycle of sedimentation began with the beds immediately above the 'Oyster Bank' and that after the deposition of the Upper Liassic strata there was a period of emergence. Frebold has already shown how the East Greenland area, in this respect, differed from the region of the Barents Sea, where there was, if not a continual submergence, at least a succession of smaller transgressions in Lower Oolite times. I may say at once that I entirely agree with Frebold in assuming the existence of a continuous Jurassic sea corresponding to the present-day North Atlantic and North Sea and allowing of free communication between the boreal and north-west European provinces. As this author has shown, this Jurassic sea was always just on or just off the coast of East Greenland, and even if the presumed absence of e. g. Bajocian deposits on the latter should yet prove to be erroneous, it affects neither the palaeogeography nor the present discussion. The 400 ft. of micaceous shales which on Mt.

<sup>1</sup>) *Loc. cit.* (Verbreitung und Ausbildung des Mesozoikums in Spitzbergen), 1930, p. 110.

Hjørnefjæld are intercalated between the lowest sandstones and the higher arenaceous beds with the 'Demissus Grit', have so far proved entirely unfossiliferous. That is to say that while at Vardekloft the micaceous shales of the upper half of the succession now to be discussed, rest directly on the Upper Lias, in the north of Jameson Land, even the lower half of our sequence is separated from the Oyster Bed by over 900 ft. of unfossiliferous deposits. While, thus, for the purposes of our present review, the gap between the Lias and the 'Macrocephalites Beds' is not less conspicuous, it would be unsafe to rule out the future discovery of intermediate faunas.

With the sequence also terminating abruptly above, with the *Keplerites-Cadoceras* beds, it is now possible to summarise it as follows, the smaller divisions for the present being more or less provisional. Including the unfossiliferous beds below, just discussed, down to the "Oyster Bank", this sequence represents the emended 'Vardekloft Formation'.

<i>Keplerites-Cadoceras</i> Beds	{	<i>pauper</i> horizon	
	{	<i>tychonis</i> ( <i>victor</i> ) horizon	
<i>Arcticoceras</i> Beds	{	<i>pseudishmae</i> horizon	
	{	<i>kochi</i>	—
	{	[ <i>Lingula</i>	— ]
<i>Arctocephalites</i> Beds	{	[ <i>Natica</i>	— ]
	{	<i>ornatus</i>	—
<i>Cranocephalites</i> Beds	{	<i>pompeckji</i>	—
	{	<i>subbullatus</i>	—

It will be attempted in the next chapter to find the correct place for this sequence in the geological time-scale.

## II. The Age of the Faunas.

It may be pointed out that even the position of the highest (*Keplerites*) beds in the above table is not so obvious as it might seem to the casual observer. On the one hand, *Keplerites*, in Europe, occurs below the beds with *Gowericeras* which are the equivalents of the Kellaways Clay and therefore the real Lower Callovian. On the other hand, an auriculate form from the Vardekloft Formation has been figured as *Kosmoceras* (*Gulielmiceras*) *pauper* sp. nov., and it is so close to the inner whorls of some *Keplerites* (e. g. Plate XXIV, fig. 2) that there is no doubt about its being also from the shales with the *tychonis* horizon, though perhaps from a higher level. Such a *Gulielmiceras*, in Europe, would be taken to denote a horizon not lower than the true Kellaways



Rock, for *Gulielmiceras* did not really become dominant until Lower Oxford Clay times, e. g. what I consider to be the upper *anceps* zone. *Gulielmiceras* is thus an undoubted Middle and Upper Callovian element, while *Kepplerites* is pre-Callovian, i. e. Upper Bathonian in my interpretation in Europe.

Before discussing the significance of this apparent anomaly it may be advisable to consider the associated species of *Cadoceras*. Not a single one is known from Europe except perhaps *C. victor* which could be compared to the group of forms centring in *C. elatmae* (Nikitin). These are Lower Callovian forms and the Cornbrash *C. breve*, Blake, although so far known in only a single, imperfect example, is probably still closer. The unique *Paracadoceras* has some resemblance to a species recorded from British Columbia, but the succession there, as in Alaska, is not sufficiently well-known for detailed comparison. The Macrocephalitids that occur above the *Cadoceras* beds in Canada are doubtful, and those from below have not been figured<sup>1)</sup>; but the Alaskan species of *Pseudocadoceras* that are associated with *Paracadoceras* and *Cadoceras* in British Columbia, would indicate a Middle or Upper Callovian age if correctly identified and if the European sequence holds in the boreal province. Unfortunately, again, no *Cadoceras* of the more typical *doroschinnosnessenskii* group has been found in the beds with *Cadoceras brooksi* of British Columbia. No forms of *Cadoceras* have also so far been found in Spitsbergen, and in Petchora Land and Siberia, where the Upper Jurassic transgression similarly brought the first ammonites in Lower Callovian times, the succession can only be traced upward, not downward.

There remains Franz Josef Land whence both *Arctocephalites* and *Cadoceras* have been recorded. Pompeckj put the clays with *Arctocephalites koettlitzii* and *A. pilaeformis* ('*Macrocephalites pila*', Pompeckj non Nikitin) in the Lower Callovian, but recorded from there *Cadoceras frearsi* (d'Orbigny) and *C. nanseni*, although the latter species was probably derived from higher beds in the Middle Callovian. With regard to the former species it is only necessary to point out that the small fragment figured by Pompeckj is not definitely identifiable and may even be a young *Arcticoceras*. I have specially figured young examples of both genera so that their similarity can be appreciated (see p. 57). Even admitting, however, that the upper beds with *Cadoceras tchefkini* and *Pseudocadoceras nanseni* are distinct from the lower beds with *Arctocephalites* (and doubtful young) there is still a thickness of 50 ft. of unfossiliferous beds in between and no sign of the *Kepplerites* (and early *Cadoceras*) fauna which in Spitsbergen seems developed to the exclusion of the higher *Cadoceras* beds above and the *Arctocephalites*

<sup>1)</sup> Crickmay, *loc. cit.* (Jurassic History of North America), 1931, p. 41.

<sup>2)</sup> *Loc. cit.* (Jurassic Fauna of Cape Flora), 1899, p. 131.

beds below. Even the succession at Cape Flora, thus, is as yet too incompletely known to be of help for our present purpose, but it again illustrates the incompleteness of the Boreal Jurassic. There is even some uncertainty about the presence of the Divesian (*lamberti* zone), as determined by Pompeckj<sup>1</sup>) on the strength of a very doubtful "*Quenstedioceras verutumnum*, Sintzow (non Leckenby)". The less uncertain *Q. lamberti* (Sowerby), from the base of the basalt, figured by Newton<sup>2</sup>), which does not look like a *Pseudocadoceras*, seems to indicate higher beds, but even so the succession must be incomplete.

As regards *Cadoceras* then, it can only be stated that the East Greenland species do not include a single form that points to the Middle rather than to the Lower Callovian or to a still earlier horizon. Even in the Roof Bed at Brora, the lowest marine bed in the transgressive Upper Jurassic of Scotland, the *Cadoceras* associated with *Gowericeras* (larger than any found in England) are more advanced than those of Greenland and the same holds for the *Cadoceras* of the Kellaways Clay of Wiltshire.

*Kepplerites*, however, similar to those here described have long been known from British Columbia, and Crickmay<sup>3</sup>) has recently recorded similar Kosmoceratids from California as well as Alaska. Unfortunately, there is again lack of detailed information. McLearn<sup>4</sup>) simply records his *Seymourites* (and '*Jakounoceras*') from the upper part of the Yakoun Formation (apparently widely separated from the *Defonticeras* fauna in the Lower Yakoun) and the associated immature forms recorded as '*Torricelliceras*' and '*Galilæites*?' are useless since they are merely immature *Kepplerites* similar to some young examples here figured. Crickmay records only pelecypods with his '*Gowericerates*', mostly undescribed, and both authors have obviously been influenced by Buckman's spurious 'chronology'.

It can, of course, still be held that the *Kepplerites* here described in reality represent a mixture of forms of different horizons. '*Yakounites*' and '*Jakounoceras*', McLearn, were created on small differences, and the Greenland forms now figured show features more diverse than those differentiating 'genera' like '*Galilæanus*' and '*Galilæites*' and the other so-called *Gowericerates*, mentioned on p. 81. But it is just by assuming, first that because individuals differed slightly, they might indicate different horizons, and then, that because they could be heterochronous, they should be put into separate genera, that Buckman

<sup>1</sup>) *Loc. cit.* (Jurassic Fauna of Cape Flora), 1899, p. 120.

<sup>2</sup>) In Newton and Teall: "Additional Notes on Rocks and Fossils from Franz Josef Land". *Quart. Journ. Geol. Soc.*, vol. LIV, 1898, p. 649, pl. XXIX, fig. 2.

<sup>3</sup>) *Loc. cit.* (Jurassic History of North America), 1931, pp. 40—43.

<sup>4</sup>) *Loc. cit.* (Nat. Mus. Canada, Bull. 54), 1929, p. 2.

succeeded in obscuring Jurassic chronology in his incredibly tangled table of hemerae<sup>1</sup>). Common-sense suggested to Quenstedt many years ago that what we now call *Kepplerites* was merely a Macrocephalid group, with a runcinate periphery on the inner whorls. In England, this group together with the first *Cadoceras* appears in Upper Cornbrash times. In Mediterranean countries and even in Poland Macrocephalitids existed much earlier in the Bathonian, and in the upper part of this formation became extremely abundant and world-wide, but there is not anywhere in the Boreal Province a fauna that includes a possible ancestral stock of *Kepplerites*. I do not thus agree with Crickmay<sup>2</sup>) that the "Gowericeratines" and *Cadoceras*, not to mention any Macrocephalitids, had arisen in the Arctic. This author himself has pointed out that these three stocks have rarely been found together or even in the same stratal section, in North America; and the isolated records from other circumboreal areas tell the same tale of impoverished faunas and cryptogenous elements at often widely separate levels.

Whether *Seymourites* is considered to be an immigrant from the European-Caucasian area or whether it is believed to be an independent development of the same Macrocephalid stock that produced *Kepplerites* in Europe, it is not likely to have existed before Upper Cornbrash or latest Bathonian times. The presence of a *Kosmoceras* (*Gulielmiceras*), if proved to be from the *Kepplerites* (*Seymourites*) beds, might show them to be as late as the *Sigaloceras* beds of Europe (*anceps* zone) or the lowest Oxford Clay (with *Gulielmiceras*). If it is necessary to date this presumed single line of nodules by its latest fossil, then the age cannot be earlier than Middle Callovian. If, on the other hand, this thin ammonite bed be taken to include forms derived from earlier horizons, then there is no limit to speculation except consideration of the faunas found in the subjacent strata.

It has been shown that in the upper *Arcticoceras* beds of Mt. Mikael there occur forms like *Cadoceras pseudishmae* and *Arcticoceras michaelis* which are somewhat transitional between the two genera. Phylogenetically, of course, the presence of such passage-forms is unimportant. The contemporary seas in more southern latitudes were teeming with forms of the parent-stock and only very few managed to secure a temporary foothold in the Arctic areas, even in localities like East Greenland which must have been in open communication with the north-west-European Province throughout the Jurassic. But the typical *Arcticoceras* of the *ishmae*-type have their maximum development still lower (*kochi* horizon) and one of the associated Macrocephalitids, though only a fragment, has been described as *Pleurocephalites?* sp. ind., a

<sup>1</sup>) Type Ammonites, vol. VII, pts. 71—72, 1930 (ed. A. M. Davies).

<sup>2</sup>) *Loc. cit.* (Jurassic History of North America), 1931, p. 44.

genus that also occurs in the Kellaways Clay of Wiltshire and as late as the *jason* zone in Franconia, i.e. in the Middle Callovian. In the Petchora Basin, *Arcticoceras ishmae* is the common index-fossil of the lower Callovian and Sokolov<sup>1)</sup> records only *Macrocephalites krylowi* (Milachewitch) from the same beds, but no *Cadoceras*. Again, almost a single species and many individuals, but no local ancestry. Yet *M. krylowi* is a useful companion-species, if rare; for near Sergatch (Nijni Novgorod), in beds resting directly on Trias, Milachewitch<sup>2)</sup> found it associated with *Cadoceras elatmae* as well as with certain forms (*Perisphinctes undulato-costatus*) which recall Indian types<sup>3)</sup>. It is certainly not an early Macrocephalitid; and its close ally *M. pila*, Nikitin, also occurs associated with *Cadoceras elatmae* in the lowest clays exposed on the River Oka<sup>4)</sup>. As it is impossible for the Petchora form to be earlier than the more southern Russian Macrocephalitids, not to mention their prolific Polish and Caucasian (though not, perhaps, Indian) allies, it follows that *Arcticoceras* cannot be earlier than Lower Callovian.

At the base of the *Arcticoceras* beds I have put a *Lingula* horizon, named after its only distinctive fossil, and because the ammonites from these beds are too fragmentary to be definitely identified. One fragment is figured in Plate XI, fig. 3, as *Arcticoceras* sp. ind., and I have pointed out in the descriptive portion (p. 58) that this form again suggests a transition between *Arctocephalites* and *Arcticoceras*. Previous authors have always included the Franz Josef Land species of *Arctocephalites* in Keyserling's *Amm. ishmae*, as mere varieties, which shows that they are not strikingly different. But until now the two genera had not been found in the same section in their natural sequence; and since *Arcticoceras* is known only from East Greenland and the Petchora Basin, whereas *Arctocephalites* has a far wider range (from British Columbia to Franz Josef Land), it might be suggested that the former is indeed merely a local offshoot of the earlier *Arctocephalites*. I myself, however, prefer to look to the ubiquitous Macrocephalitids in the wider sense for the ancestry of *Arcticoceras*; for what has been said above (p. 51) with regard to the genera *Chamoussetia* and *Longaeviceras* should be a warning to those too ready to build up 'lineages'.

It has been shown in the last chapter that there are two *Arctocephalites* assemblages which may even be separated by an unknown thickness of belemnite beds. The lower, which I am naming after one of the most distinctive species (*A. ornatus*) is known to occur about 20 m above the *Cranocephalites* beds. The less prolific upper horizon,

1) *Loc. cit.* (Ammoniten-Fauna des Petschoraschen Jura), 1912, p. 49.

2) *Loc. cit.* (Études paléontologiques, II), 1879, p. 8.

3) See Spath, *loc. cit.* (Pal. Indica, pt. IV), 1931, pp. 312, 317.

4) *Loc. cit.* (Elatma, II), 1885, p. 50, pl. VIII(x), figs. 45—46.

with only three examples of *A. nudus* (a species that also occurs in the lower beds) but in addition some young *Arcticoceras*, is inserted in the table as a 'Natica horizon', but like the succeeding *Lingula* horizon this is intended merely to denote the existence of intermediate beds. When a designation is available for the unnamed *Arcticoceras* figured in Plate XI, fig. 3, it will probably cover both these provisional horizons.

*Arctocephalites* also has been considered to be Callovian in Franz Josef Land, partly because of the associated 'Cadoceras', already mentioned (p. 139), partly because *A. pilaeformis*, nov., was mistaken for the later *Pleurocephalites pila* (Nikitin). Now one of the most characteristic features of *Arctocephalites* is the smooth body-chamber, a supposed catagenetic feature of late Macrocephalitids. Buckman compared to *A. arcticus* a form from the Middle Callovian (*calloviense* or *anceps* zone) of Yorkshire ('*Catacephalites*' *durus*) that has now turned out to be merely a poorly-preserved *Cadoceras*. Crickmay recorded Macrocephalitids "of *Catacephalites* aspect" from below his *Cadoceras brooksi* fauna on Harrison Lake (British Columbia) and degenerate Macrocephalitids from above, said to "correspond in age" again to this '*Catacephalites*'. A smooth body-chamber, of course, may be developed in any stock; such an *Arctocephalites nudus*-like form as that figured by Stehn from the Andes was associated with probably early species although many of them were misidentified, but *Nothocephalites* and the large *Pleurocephalites* of the *polyptychus*-group have smooth body-chambers, and are of late age. The true *Macrocephalites* never lost its costation entirely; *Kamptocephalites* and *Indocephalites* are always ribbed to the end. On the other hand, the Mexican *M. cadoceroides*, Burckhardt, referred to above (p. 33) and compared to *Arctocephalites*; although from an unknown bed, is apparently again a late species.

It is necessary to discuss the probable affinities of *Arctocephalites* because the stratigraphical evidence has been interpreted differently by Rosenkrantz who even put the beds with *Cranocephalites* above the top of the succession given on p. 126. Frebold's acquiescence in this high and "possibly already Middle Callovian" age of what is here described as the earliest of all the boreal Macrocephalitids, i.e. the genus *Cranocephalites*, may be taken as another indication that the assumed biological status of a group is no criterion of its geological date of existence. *Cranocephalites* is no more a "biologically early" form than is *Arctocephalites*, yet it is the first to appear; and I can suggest only that both are specialised offshoots of the Macrocephalid root-stock, dominant in the larger open seas of the time. In the descriptions I have repeatedly referred to the resemblance between *Cranocephalites* on the one hand, and *Bullatimorphites* and *Morrisiceras* on the other, the last of which may also have an uncoiling body-chamber (*Morrisiceras*

*comma*, Buckman). These are of Lower Bathonian age (Fuller's Earth Rock of England) while *Defonticeras*, a comparable Stephanoceratid in the deposits preceding the strata with Macrocephalitids in North America, is said to be Bajocian. Since no ammoniferous formations of either Bajocian or Bathonian age have so far been found in non-American boreal areas, there is clearly scope for speculation in regard to the position of *Cranocephalites*. Personally I would consider the evident affinity of *Cranocephalites* with *Arctocephalites* and of the latter with *Arcticoceras* as indicating that the three faunas are at least not widely separated. Since in Europe, the first true *Macrocephalites*, with *Epistrenoceras contrarium* (d'Orbigny) and *Paroecotraustes serrigerus* (Waagen), also appear only later in the Bathonian, it seems reasonable to suggest that both the Greenland Arctocephalitid beds are of about Cornbrash age, i.e. near the top of the Bathonian.

I cannot add anything to what Frebold<sup>1)</sup> has said concerning the temporary transgressions during the Bajocian and Bathonian in the area of the boreal sea. Scotland, which as is well shown in Frebold's<sup>2)</sup> map, forms an important intermediate station between the Greenland and European Jurassics, after at partial emergence in earlier Bathonian times, did not experience a renewed subsidence until the close of this formation. The incoming of a fauna characteristic of the Cornbrash (but without ammonites) has been recorded<sup>3)</sup> from Raasay in the west; and in Yorkshire a marine fauna with many Macrocephalitids appears at the same time, but on the East Coast of Scotland, at Brora, the first marine beds following the Great Estuarine Series below, belong to the Lower Callovian. This seems to me evidence in favour of the East Greenland transgression having occurred about the same time, towards the close of the Bathonian period and the first ammonites to be found in abundance in the newly flooded areas were local modifications of those stocks that swarmed in the more southern seas of the period, i.e. the Macrocephalitids. I have stated in my revision of the Jurassic Cephalopod Fauna of Kachh that I imagine the dispersal of the ammonites to have occurred in the free-swimming, larval stage and I take this to explain, in part, the peculiarities of the impoverished boreal assemblages, often showing only one or two genera and few species but enormous numbers of individuals.

With the position of the *Cranocephalites* and *Arctocephalites* assem-

<sup>1)</sup> *Loc. cit.* (Verbreitung und Ausbildung des Mesozoikums in Spitzbergen), 1930, pp. 109—110.

<sup>2)</sup> *Loc. cit.* (Oberer Lias und Unteres Callovien in Spitzbergen), 1929, p. 19, text-fig. 5.

<sup>3)</sup> Lee and Pringle: "A Synopsis of the Mesozoic Rocks of Scotland". Trans. Geol. Soc. Glasgow, vol. XIX, pt. 1, 1932, p. 199.

Correlation Table.

		Zones	East Greenland	Britain	Barents Sea	North America	Poland and Russia
CALLOVIAN	middle	calloviense	Seymourites { pauper victor	South Cave Kellaways Rock (with <i>Sigaloceras</i> ) Irony Sandstone, Yorkshire	Cape Flora ( <i>tchefkini</i> ) K. Charles Is. <i>K. svalbardensis</i> Spitsbergen	Higher <i>Cadoceras</i> beds (Alaska)  Chinitna Shale (Alaska)	<i>Cadoceras tchefkini</i>  <i>Cadoceras elatmae</i>
		lower					
	upper	macrocephalus { upper } koenigi lower } herveyi	Arcto-cephalites { [Natica] ornatus	Yorkshire Cornbrash [w. <i>Kamptokephalites</i> & <i>Dolikephalites</i> ].	<i>Arctocephalites</i> K. Charles Is. & Cape Flora	<i>Arctocephalites</i> (Fernie Formation) Blairmore.	<i>D. typicus</i> (Iron - Oolite)
BATHONIAN	upper	discus	Crano-cephalites { pompeckji subbullatus	—	Novaya Zemlya ( <i>C. pompeckji</i> ).	—	<i>M. cannizzaroi</i> (w. <i>Epistrenoce- ras contrarium</i> in upper <i>serrigerus</i> zone).
		wagneri	—	Estuarine Series in Scot- land and Yorkshire	Doubtful deposits in King Charles Islands	unknown	First <i>Macroce- phalites</i> (Lower <i>serrigerus</i> zone).
	lower	morrisi aurigerus	unknown	—	—	—	<i>morrisi</i> <i>aurigerus</i>

blages thus assumed to be probably uppermost Bathonian, the *Arcticoceras* fauna would automatically be placed in the lowest Callovian and it only remains to decide whether the succeeding *Seymourites-Cadoceras* Beds should be considered to be both Lower and Middle Callovian. I am in favour of adopting this view not only on account of the presence of a species of *Kosmoceras*, at a locality where there are higher beds, but also because there is a possibility of the ammonite horizon at Vardekloft itself representing a condensed deposit. Although the ammonites are fairly well preserved, the formation of the clay-ironstone nodules in which they are found indicates a pause in sedimentation, however, slight. Moreover, it has already been mentioned that those concretions, even at Vardekloft, come from four different spots, and that while some were partly embedded in the micaceous shales, others were found loose at the surface. The separation of a lower *victor* from an upper *pauper* horizon in the preceding correlation table (p. 145) is based on the assumption that the ammonites in these nodules are not of the same age. Future work may show that *Kepplerites* (*Seymourites*) *rosenkrantzi*, with *Gowericeras* inner whorls, belongs to the earlier assemblage and *K. (S.) nobilis*, with its *Sigaloceras* beginning, to the later; as they both develop the *Seymourites* body-chamber, like the rest of the *Kepplerites* here discussed, it would be rash to assume that their relative position could not be the reverse. I offer no apology for rejecting, in the above table, Buckman's extreme interpolation method in favour of an approximate, homotaxial, correlation in Pia's<sup>1</sup>) sense. An exact comparison of the nine local but interconnected horizons here listed with a corresponding sequence elsewhere is obviously impossible, even if the base were more definitely fixed.

### III. Correlation of the Boreal Jurassic.

In the correlation table (p. 145) the non-ammonitiferous deposits of the King Charles Islands have been inserted because the position of the marine Bathonian there seems to be indicated by the abundance of *Ps. echinata*. Apart from the difficulty, however, of accurately dating other, more doubtful assemblages of indifferent pelecypods, their occurrence at a few localities does not alter the fact that during the Bajocian and Lower Bathonian, the seas off East Greenland and in the north-west of America, perhaps also in the vicinity of the Barents Sea, were receding and that the Great Upper Jurassic transgression which has universally been described as Callovian began already at different stages in the Upper Bathonian in many of the different localities affected.

<sup>1</sup>) Grundbegriffe der Stratigraphie &c., 1930, pp. 65 and 129.



In the summary of the results of my Revision of the Jurassic Cephalopod Fauna of Kachh, I have shown that the British Jurassic forms a particularly useful standard for universal correlation. This is not only because in the south there is sufficient evidence of Mediterranean influence to make it part of what has for some time been accepted to represent the neritic, marginal, central-European province (in Uhlig's<sup>1</sup>) sense), but because in the north, especially in Scotland, where there are no longer any corals, the boreal influence is becoming increasingly felt. By the kindness of Mr. Rosenkrantz I have been able to examine some Upper Liassic ammonites from Jameson Land and I was struck by the similarity of this fauna (however impoverished) to that of Yorkshire, while the black micaceous shales with *Amoeboceras nathorsti* of the East Coast of Scotland, in hand specimens, could not be distinguished from the similar shales of various localities in Spitsbergen that I described in 1921<sup>2</sup>).

I do not agree with those authors who deny the existence of marked differences in the boreal and West European ammonite faunas. Nikitin seemed surprised that *Cadoceras* and *Cardioceras* which, after Neumayr, had always been considered to be typical boreal elements, occurred in Western Europe with identical forms. Yet there is no doubt that *Cadoceras* did not migrate farther south; and while later authors like Pompeckj and R. Douvillé thought the Arctic Macrocephalitids of particular import as the parent stock of all the Cardioceratids in the widest sense, it has been shown in the present work that they are themselves probably only immigrants from the European and other Provinces. The difference is noticeable already in the Toarcian; in the north there are again only two genera (*Pseudolioceras* and *Dactylioceras*) but *Phylloceras* and *Lytoceras* which during this only period in the whole of the Jurassic had lived in numbers in the latitude of Yorkshire, are almost unknown from farther north<sup>3</sup>). Of course, Frebold already pointed out that the differences between the Callovian faunas of the boreal province and western Europe were not fundamental<sup>4</sup>), but he endorsed the opinions of Pompeckj and Salfeld, although he had his own view of the isolation that accounted for the faunal peculiarities of the boreal Jurassic (as opposed to climatic differences). Thus Frebold, perhaps influenced by Buckman, thought that the dissimilarity of the faunas might, at least in part, be due to comparison of heterochronous elements and that for

<sup>1</sup>) "Die Fauna der Spiti-Schiefer des Himalaya, ihr geologisches Alter und ihre Weltstellung". Denkschr. K. Akad. Wiss. Wien, Math. Nat. Kl. vol. LXXXV, 1910, p. 42.

<sup>2</sup>) Spath: Ammonites from Spitsbergen. Geol. Mag., 1921, p. 351.

<sup>3</sup>) See below, p. 151.

<sup>4</sup>) *Loc. cit.* (Oberer Lias und Unteres Callovien in Spitzbergen), 1929, p. 18.

example all the time during which *Arctocephalites* ('*Macrocephalites ishmæ* var. *arctica*') flourished in the boreal seas, there might have been a long-continued period of regression in western Europe. This is a view I should have favoured some years ago; but I do not think it is borne out by the correlation given in the table on p. 145. The Arctic Macrocephalitids are merely local races, just as the *Keplerites* and *Cadoceras*, or even the *Gulielmiceras*, here described, are special types not found elsewhere. In the Kimmeridge Clay of Dorset, which contrary to Salfeld<sup>1)</sup> I do not consider of boreal affinity, there are many *Subplanites*, some like species now recorded from Somaliland, but all the associated forms would not be expected in Africa. In the boreal province or even in Scotland and Yorkshire, *Cardioceras* and *Amoeboceras* are not accompanied by the forms that occur with them in the Central European Argovian and Kimmeridgian, yet the Cardioceratid succession in the one province is as unbroken as the Perisphinctid in the other. Isolation of the Boreal Sea may have been more complete than it is at the present day, especially if the connection with the Pacific was as temporary as Crickmay's maps show it to have been. But this does not explain why ammonites spread from south to north in Europe and from north to south in America and why always only a few found the conditions in the Arctic sea favourable enough to increase in numbers though not in diversity.

Cardioceratids themselves illustrate this and far from being genuine 'boreal' types they are far more diverse in England than anywhere farther north, while various important groups among them, such as *Chamoussetia* (the original of the genotype-species of which came from Savoy) have never been found at all in boreal areas. The Arctic Cardioceratids, in fact, are a comparatively poor selection of only a few types of *Quenstedioceras*, *Cardioceras* and *Amoeboceras* and the same may be said of the Virgatitids and Craspeditids.

Before discussing these two stocks I may also refer to the Reineckeids. These are a particularly characteristic element of Mediterranean faunas throughout the Lower, Middle and even Upper Callovian, and as Haug<sup>2)</sup> has already pointed out, are absent from Russia. The many forms of *Reineckeia* found in Kachh can be matched perfectly in Mexico where they are also associated with comparable early forms of *Peltoceras* (in the Upper Callovian). But *Reineckeia* has not been found north of Mexico. This is perhaps not surprising, considering the general lack of information concerning the Callovian, although Crickmay has now recorded Kepleritids from California. *Keplerites* and *Rei-*

<sup>1)</sup> "Zum Problem des Borealen Jura und der Borealen Unterkreide". Centralbl. f. Min. etc. 1921, p. 170.

<sup>2)</sup> *Loc. cit.* (Traité de Géologie, II, 2), 1907, p. 1117.

*neckeia*, however, occur together in Europe (Caspian to England) and it is interesting to notice how they gradually replace each other from South to North. Thus while there is a total absence of Kosmoceratids (as of Cardioceratids) from Kachh, *Reineckeia* becomes very scarce in England and is absent from Yorkshire, North Germany, and Lithuania. It seems surprising, therefore, that Buckman<sup>1)</sup> recorded a "good" *Reineckeia*-fauna from Mull in the Inner Hebrides. This might seem to support the contention that a Reineckeian age should be interpolated between his Kosmoceratan and Proplanulitan ages and that the local absence of *Reineckeia* was merely due to lack of deposits. Of course, I had already shown<sup>2)</sup> how Buckman misinterpreted this Reineckeian age and I noticed that the 'good' Reineckeian beds of Mull had become 'of doubtful age' in Lee<sup>3)</sup>, while Pringle<sup>4)</sup>, less cautious, thought the beds might be referred to "a low portion in the *ornatum* zone". I have now been able to examine the original material, by the kindness of Dr. J. Pringle, and my suspicion that the ammonites were not *Reineckeia* at all was confirmed. But I little thought that most of the specimens were clearly identifiable; and while there were many undoubted examples of *Rasenia* that might conceivably have been mistaken for *Reineckeia* by a beginner, the numerous associated *Amoeboceras kitchini* (Salfeld) should never have been identified as *Kosmoceras elizabethae*. Both *Rasenia* and *Amoeboceras*, it may be emphasised, are north-European elements. *Reineckeia* thus remains what such masters as Neumayr and Uhlig had always considered it to be, i.e. a typical southern element, and since it has a long range and occurs associated with Macrocephalitids in the south and with Kosmoceratids in Western Europe it is one of the most useful genera for correlation. A valuable companion is *Phlycticer* which also has never been found in Yorkshire, despite Buckman's assertions to the contrary.

The Virgatitids are not confined to Russia, but occur from Portland to Poland, and, associated with Mediterranean types, in the Tithonian of Moravia; and although there are fresh-water deposits in north-west Germany and no higher Jurassic beds than those with *Anavrigatites* on the Danube, the Central-European—Central-Russian area shows the greatest development of the Virgatitids of which only a few again migrated north. The Craspeditids are less conspicuous in England because of the termination of marine conditions in the south and a retreat of

1) "The 'Kelloway Rock' of Scarborough". Quart. Journ. Geol. Soc., vol. LXIX, 1913, p. 160.

2) Notes on Yorkshire Ammonites. The Naturalist, Nov. 1926, p. 325.

3) In Lee and Bailey: "Pre-Tertiary Geology of Mull, Loch Aline and Oban", Mem. Geol. Surv. Scotland, 1925, pp. 108—114.

4) In Lee and Pringle, *loc. cit.* (Mesozoic Rocks of Scotland), 1932, p. 207.

the sea in Yorkshire, but that this sea persisted only a short distance off to the east is proved by the *Subcraspedites* in the Spilsby Sandstone and the Polyptychitids of the Speeton Clay and the Drift along the east coast of Scotland, showing continuous communication with the Central Russian area across the regions of the North Sea and the Baltic. The Craspeditids are so closely linked with the Virgatitids of the Portlandian that they cannot be assumed to have developed quite independently of the ammonites in the Portlandian Sea, even if they are found in greater variety in Central Russia and the Volga Basin.

Sokolov and Bodylevsky<sup>1)</sup> have recently shown that most of the records of Craspeditids from outside this area were based on misidentifications of other ammonites or on the occurrence of forms of *Buchia* (*Aucella*). Since I myself recorded doubtful Craspeditids from Spitsbergen, I am glad to be able to confirm these authors' suspicion that the two examples are not identical with any described species of Craspeditids from the Upper Volgian of Russia. But they are undoubtedly *Craspedites* and if they are at least as close to forms like *C. subpressulus* or *C. bidevexus* from the Rjasan Horizon as to some of the many Upper Volgian examples before me, it makes little difference to the present argument. Sokolov and Bodylevsky themselves recorded a *Craspedites* cf. *subpressulus*, Bogoslawsky, from Spitsbergen, and whether they all come from the uppermost 'Aquilonian' or the *Subcraspedites* beds of the Infra-Valanginian, the period at which communication was opened again between the Volgian and the Boreal Seas would be only slightly different. What is more important is the fact that for these Craspeditids as for the Virgatitids, the centre of dispersal was not in the Polar Sea and that while the latter received a few stragglers, none migrated south. Sokolov and Bodylevsky assumed that there was no communication during Upper Volgian times with the Southern Seas, but it must not be forgotten that there were in existence, in the latter, numbers of prolific ammonite stocks. Among these, certain members of the Spiticeratinae, such as *Proniceras* and *Umiaites*, in Portlandian times, showed as much resemblance to the Craspeditids as the varied contemporary Perisphinctids did to their few representatives in the boreal sea. Yet it seems to me probable that while the ancestral stocks of the true Craspeditids in the Volgian Basin and of the gigantic Perisphinctids of the equally restricted Portland sea came from the neritic marginal region of the Mediterranean Province, the supposed Craspeditids found from Tanganyika to Mexico have little to do with the Russian forms, in spite of Burckhardt's<sup>2)</sup> statements to the contrary.

<sup>1)</sup> *Loc. cit.* (Jura- und Kreidfaunen von Spitzbergen), 1931, p. 141.

<sup>2)</sup> 'Bemerkungen über die russisch-borealen Typen im Ober-Jura Mexicos und Südamerikas'. Centralbl. f. Min. etc. 1911, p. 482.

I am fully in agreement with Frebold<sup>1)</sup> when he wrote that the region of the present day 'Norwegian Sea' may be assumed to have been covered throughout Mesozoic times by a sea; for the traces of its transgressions could be seen at the most diverse periods in the form of marine sediments, whether in East Greenland or in Andö (Lofoden Islands), in Spitsbergen or on Bear Island, &c., and the constancy of this Mesozoic Sea also made it probable that, as to-day, this was a fairly deep sea and not only a flooded continental area. It is along the western shores of this sea that we can trace the impoverishment of the ammonite fauna as between the south of England and Scotland, as I have shown elsewhere<sup>2)</sup>. A further reduction is noticeable in East Greenland on the one hand and in Spitsbergen on the other, in any case so far as the Cardioceratids are concerned, while the Polyptychitids are perhaps less definitely reduced compared with their allies in the Speeton and North German successions, although the abundance of these ammonites in e.g. the Petchora Basin makes it probable that there was again open communication with the Central Russian sea.

Prof. J. Perrin Smith<sup>3)</sup>, who also believed in the influence of ocean currents and climate on the formation of biological provinces, has shown how such a simple matter as the opening or closing of the Bering Strait would satisfactorily account for all the changes in character and distribution of the marine faunas.

The occurrence of an isolated Neocomian *Lytoceras* in North-East Greenland as of *Phylloceras* in the Middle Lias of Northern Siberia and in the Callovian of Alaska may be due to such temporarily increased facility for faunal interchange, but it cannot alter the fact that generally these two 'stenothermal' stocks did not frequent the more northern seas. Those who believe with Haug<sup>4)</sup> that these stocks lived in deep water may still maintain that only a few marginal and shallow-water deposits have so far been found in the area of the Arctic Sea. The absence of *Phylloceras* and *Lytoceras* thus might be merely apparent, but it seems to me that their gradual disappearance in the European countries, as one passes north from the Mediterranean province, is in favour of their never having penetrated the northern seas, except in isolated (and possibly drifted) individual shells. Moreover, to my mind, the limestones of Cape Vigilio were shallow-water deposits as clearly as their equivalents in the Inferior Oolite of Dorset (with only a few *Lytoceras*

<sup>1)</sup> *Loc. cit.* (Verbreitung und Ausbildung des Mesozoikums in Spitzbergen), 1930, p. 119.

<sup>2)</sup> Revision of the Jurassic Cephalopod Fauna of Kachh (Cutch), pt. vi, *loc. cit.*, 1932.

<sup>3)</sup> American Journal of Science (4), vol. xvii (1904), p. 233.

<sup>4)</sup> *Traité de Géologie*, vol. II, pt. 2, 1907, p. 1119.

remaining), and as I have pointed out on other occasions the thin, smooth, shells of *Phylloceras* and *Lytoceras* were adapted to a pelagic mode of life, unlike the majority of the trachyostracous, benthonic, ammonites of the neritic, marginal, areas.

To find a counterpart to the North Atlantic communication with the boreal sea, it is necessary to go to the west coast of North America. An interchange of southern and northern elements has been suggested in the case of the '*Aucellae*' although this is now discredited since they have been found to range also from New Zealand to the Andes. As regards the ammonites, the evidence is far less clear than it is in Europe. The Tuxedni sandstone of Cook Inlet, Alaska, has typical Bajocian (and perhaps Bathonian) Stephanoceratids, together with *Phylloceras* and *Lytoceras*, and comparable faunas have been found not only in the Queen Charlotte Islands but also in Mexico and as far south as Chile. The supposed Middle Jurassic faunas of California, unfortunately, are almost without definite ammonites, and I cannot agree with Goranson<sup>1)</sup> that they are important because they contain the last representatives of the Mediterranean fauna on the West Coast, before the Eocene invasion. In the absence of any reliable evidence it is even doubtful whether the presence of reef corals in the Hinchman Formation can be compared to the last appearance of corals in the latitude of Yorkshire in Europe.

In the succeeding Chinitna Shale of Alaska, the fauna still includes three species of *Phylloceras* and apparently three Ooppelids, in addition to Macrocephalitids, but these, like the forms from the Fernie Shale of British Columbia, are boreal types and they are associated with *Kepplerites* (*Seymourites*) and numerous forms of *Cadoceras* and *Pseudocadoceras*. But from the still higher Naknek Formation of Cook Inlet, Martin<sup>2)</sup> again lists four species of *Phylloceras* and two of *Lytoceras*, together with *Cardiocerates* such as were as common in the more isolated Sundance Sea as in northern Siberia. The admixture of the Mediterranean and Pacific elements clearly shows that the Arctic Ocean would have been open to immigrants from the south, such as *Xenocephalites*, at various stages during the Upper Jurassic, but the absence of information from the northern coast of Alaska or the Siberian side of the Bering Strait makes it difficult to appraise the difference in the fauna with increase of latitude. I have elsewhere<sup>3)</sup> suggested that the range

<sup>1)</sup> "A Correlation of the Mesozoic Formations of the Pacific Coast of North America". *Am. Journ. Sci.* (5), vol. VIII, 1924, p. 77.

<sup>2)</sup> "The Mesozoic Stratigraphy of Alaska". *U. S. Geol. Surv.-Bull.* 776, 1926, p. 178.

<sup>3)</sup> Revision of the Jurassic Cephalopod Fauna of Kachh (Cutch), *loc. cit.*, pt. VI, 1932.

of *Amoeboceras* down the Pacific Coast of North America to California but not to Mexico may be a counterpart to the gradual and lateral replacement of the southern Oppelids by the North European *Rasenia* and *Pictonia*. Crickmay<sup>1)</sup>, however, has rightly pointed out that the greatest caution is necessary when attempting a climatic correlation of the Upper Jurassic and for the present it is possible only to state that the existence of climatic zones was probable, even if they were less marked than at the present day. This has lately been suggested even by Burekhardt<sup>2)</sup> who previously rather opposed Neumayr and Uhlig's views, but the dependence of ammonite dispersal on the ocean currents of each period to which I have directed attention must also be taken into consideration. I may add that I do not visualise either the Shetland Straits of Neumayr or the Mackenzie Straits across the Yukon area as narrow channels and I would particularly object to the reconstruction of the Pacific Seas in the Jurassic Period, given by the late Prof. J. W. Gregory<sup>3)</sup> in his Presidential Address to the Geological Society of London in 1930. If caution is advised in correlating Jurassic faunas surely Prof. Gregory flung it to the winds in proposing his Spiti-Chile sea across the Pacific in Kimmeridgian-Portlandian times. Nothing results more definitely from the present inquiry than that Frebold's and Crickmay's maps of the Jurassic boreal sea are substantially correct. There will be minor adjustments with increase of knowledge, e.g. in the relative merits of the Bering or what I have called the Mackenzie Straits; and I believe that the Hebrides and the north-west of Scotland were already dissected and open to the North Atlantic in the west in spite of all Gregory's<sup>4)</sup> arguments to the contrary; but taken on the whole, the distribution of the continents and oceans seems to have been almost the same as at the present day.

#### IV. Comparison with other Faunas.

It has already been shown that the great majority of the Greenland ammonites here described are special types, generically or at least specifically, but the belemnites are all northern types, although the material available is less satisfactorily preserved. The great dissimilarity

<sup>1)</sup> *Loc. cit.* (Jurassic History of North America), 1931, pp. 69—70.

<sup>2)</sup> "Étude synthétique sur le Mésozoïque mexicain". I. Mém. Soc. Pal. Suisse, vol. XLIX, 1930, p. 123.

<sup>3)</sup> "The Geological History of the Pacific Ocean". Quart. Journ. Geol. Soc., vol. LXXXVI, 1930, p. xci (Note also the confusion between the North Pacific coast and the Sundance sea to the east in the quotation from Goranson on p. xciii).

<sup>4)</sup> "The Geological History of the Atlantic Ocean". Quart. Journ. Geol. Soc., vol. LXXXV, 1929, p. cxx, etc.

in the belemnite faunas of the Arctic and north-European provinces on the one hand, and those of the Mediterranean province on the other has, of course, long been known, but there is some overlap, and while the southern *Belemnopsis* and *Hibolites*, sometimes with corals, may occur as far north as Yorkshire, *Cylindroteuthis* is quite common round the borders of the Paris Basin. Unfortunately, in the case of the belemnites again, there is scarcely any corroborative evidence from western North America. The boreal group of *Pachyteuthis densus* (Meek) was common enough in the Sundance Sea, but the absence of belemnites from Oaxaca in Mexico as from the Callovian coastal belt between California and Alaska makes it difficult to judge the position of a form like *Belemnites pistilliformis*, Eichwald (non Blainville). This occurred apparently together with Callovian ammonites and other belemnites of boreal affinity (*Cylindroteuthis*), but is probably a *Hibolites*. In view of the occurrence of *Phylloceras* and *Lytoceras*, however, associated with boreal types, as already discussed, the presence of even this *Hibolites* is not surprising.

The other invertebrates here recorded are of less interest because they only include few forms that are sufficiently well preserved for definite identification. The four species of Gastropods are types that might be expected to occur, judging by the forms already described from Koldeway Island, Spitsbergen, Franz Josef Land and Novaya Zemlya; and the resemblance with the fauna of Cape Flora is enhanced by the presence, in the *Arctocephalites* Beds or just above, of *Lingula beani*, *Orbiculoidea reflexa*, and *Pentacrinus*. The forms of *Pecten* and *Pseudomonotis*, here recorded, like the few oysters and especially the common *Pleuromya* and *Homomya*, belong to types of universal distribution and even the three species of *Inoceramus*, with a striking resemblance to Pacific types, can equally well be matched in northern Siberia. In the case of the single *Trigonia* which might be of greater interest, the poor state of preservation, unfortunately, prevents detailed discussion. Judging by Eichwald's mostly diagrammatic figures of his lamelli-branches, it is possible that most of the forms here described could have been attached to Alaskan species as much as to Yorkshire ones.

The presence of fossil wood in most of the beds and especially the coarseness of the micaceous sandstones indicate shallow-water conditions and proximity to a shore-line, while the comparative scarcity of fossils, at widely separated intervals, in a great thickness of sediments is well illustrated by the sequence given by Parkinson and Whittard at Antarctic Harbour (see p. 136). Such very incomplete Jurassic successions with always only littoral or shallow-water sediments, of course, are common enough in the Arctic, as has already been shown by Fre-



bold<sup>1</sup>). The same author's more recent observations<sup>2</sup>) in Wollaston Foreland are particularly instructive in this connection, for he records not only a great variability in the pelecypod fauna, dependent on a constant change in the conditions of existence, but conglomeratic deposits (in a presumed Callovian-Oxfordian sequence) that are undoubtedly river-gravels. But in such a facies it is perhaps all the more surprising to find a few ammonites that have been compared to South American species, coming out of a shaly series with '*Posidonomya*'.

In the case of two, *Cranocephalites subextremus* and *Arctocephalites* (?) *platynotus*, the generic reference alone indicates that the resemblance is superficial and that their similarity to a form like *Sphaeroceras extremum*, Tornquist, is due merely to common derivation from the same Macrocephalitid root-stock. There is nothing exactly like *Cranocephalites* known from anywhere else except Novaya Zemlya and perhaps Alaska, whence Eichwald<sup>3</sup>) already recorded an ammonite identified as *Amm. carteroni*, d'Orbigny, which was compared by Neumayr to the *bullati*. But these *bullati* are also found in the Dutch East Indies and in South America as well as in Europe, and as, moreover, their affinity with *Cranocephalites* is not established, nothing can be added to what has been said on p. 10. The discovery of *Macrocephalites* also, reported by Frebold in 1929 as an element strange to the Arctic, was later shown to apply to a *Kepplerites*; and in the case of the isolated *Pleurocephalites*, there is the presence of the intermediate *pila-krylowi* group in Russia. There remains one form, however, namely *Xenocephalites borealis*, nov., which was compared to the Andine *X. neuquensis*, Stehn, and which, with a less distinctive second species collected by O. Nordenskjöld, merits special discussion.

It may be mentioned that these forms have been considered to be probably the earliest Bathonian ammonites so far found in the Arctic. Their supposed allies are associated with *Reineckeia* in South America and Mexico, and might therefore be believed to belong to a much later date. But I have elsewhere shown that the earliest Reineckeids of the type of *R. antipodum* (Gottsche), unknown from elsewhere, may well be of the same age as the associated Macrocephalitids. In any case the Mexican *Reineckeia*, with many forms of *Phylloceras*, are accompanied by Macrocephalitids that show more resemblance to the Arctic types here described than to their Mediterranean equivalents. Thus while

<sup>1</sup>) *Loc. cit.* (Oberer Lias und Unteres Callovien in Spitzbergen), 1929, p. 23.

<sup>2</sup>) "Grundzüge der tektonischen Entwicklung Ostgrönlands in post-devonischer Zeit". Medd. om Grönland, vol. XCIV, no. 2, 1932, pp. 21—27.

<sup>3</sup>) *Loc. cit.* (Geognostisch-Palæontologische Bemerkungen etc.), 1871, p. 149, pl. x, figs. 1—2.

*Macrocephalites cadoceroides*, Burckhardt, is comparable to certain *Arctocephalites*, *M. nikitini*, Burckhardt, closely resembles *Xenocephalites borealis* here described. The genus *Xenocephalites* itself is a typical Andine element and it is accompanied in Mexico by another southern element, namely *Eurycephalites boesei* (Burckhardt). Now as *Phylloceras* and *Lytoceras* occur with Callovian boreal types in Alaska, and as the British Columbian '*Lilloettia*' and '*Buckmaniceras*' described by Crickmay could be *Arctocephalites*, I see no reason why the Pacific *Eurycephalites* should not have spread via Alaska into the Boreal Sea. This view is supported by the occurrence in the Argentine of a form that apparently cannot be distinguished from *Arctocephalites nudus*, although it may be a homoemorphous development of *Eurycephalites*.

But all this only shows that two of the four genera of Macrocephalitids are as closely allied to Pacific types as to Atlantic-European forms and that while *Xenocephalites* may be the only really Pacific element, *Pleurocephalites* is probably a European type. *Kosmoceras* must be of European origin, and *Keplerites* and *Cadoceras* also are probably immigrants from the same province. Of the only remaining ammonite genera *Paracadoceras* is apparently of boreal origin, and like the two last came into the North Pacific from the Arctic Ocean; *Arcticoceras* again is commonest in Russia. Out of nine ammonite genera, then, only one may actually represent a Pacific element, but even this is too incompletely known to rule out the possibility that it may be only a special local development, as is suggested by a second fragment. The belemnites again, are Arctic-North European types and not a single of the remaining invertebrates points definitely to a Pacific rather than an Atlantic-European origin. If it is further remembered that the Upper Lias ammonites have their nearest relations on the Yorkshire Coast, that the shales with *Amoeboceras nathorsti* are like those of the East Coast of Sutherland, and that the Portlandian ammonites so far recorded by Rosenkrantz are types known from Europe, it becomes clear that the European influence is dominant throughout the Jurassic.

Buckman<sup>1)</sup> stated in 1922 that there was little, if any, similarity between the ammonite faunas of Jureuropea and North America. What has been said above would suggest that just the reverse holds; for most of the North American Jurassic ammonites are European or boreal types although their identity is often hidden by a terminology inspired by Buckman. Thus the Bajocian Stephanoceratids have been recorded largely under unnecessary new names, while the validity of the 'genera' that have been proposed for Canadian Macrocephalitids is questioned in this paper. Ironically enough such European 'genera' as have been

<sup>1)</sup> Type Ammonites, vol. iv, 1922, p. 23.

used, e.g. '*Galilæites*' or '*Torricelliceras*' are based on misidentification of young *Keplerites*. The Pacific elements (*Phylloceras* and *Lytoceras*) are few and confined to the West Coast, but in the Cretaceous they become far more conspicuous.

Unfortunately, the Antarctic counterpart to the boreal province is as yet entirely unknown. It would be curious if *Seymourites* and *Grahamites*, first established for Antarctic forms (although the British Columbian genotypes happen to be Jurassic species) should, indeed, turn out to have been correctly identified, instead of being homoeomorphous Campanian *Kossmaticerates*; but otherwise the complete absence of Jurassic deposits (other than plant-bearing beds?) south of a latitude that might be expected to show climatic differentiation prevents discussion of this problem.

## E. SUMMARY OF RESULTS

- (1) The ammonites described include four genera of Macrocephalitids of which one (*Cranocephalites*) has been given a new name. With one curious exception, referred to a genus (*Xenocephalites*) known only from South America and Mexico, and apart from a doubtful fragment of a *Pleurocephalites*, these ammonites are Arctic types. The remaining ammonites belong to three Cadoceratid and two Kosmoceratid genera, again, all special, Arctic, forms.
- (2) The dispersal of ammonite-spawn being believed by the writer to have depended on ocean-currents, the migration of North European types into the Arctic Sea and of boreal types into the North Pacific and Sundance Seas is considered to be probable.
- (3) The first Bathonian ammonites recognised in the Arctic are not believed to be the ancestors of later so-called boreal stocks, like the Cardioceratidae; this family is also shown to afford a good illustration of the worthlessness of so-called recapitulational evidence.
- (4) The belemnites are all northern types but the other invertebrates, often mere sandstone casts, are not sufficiently distinctive for palæogeographical purposes.
- (5) The limits of the Vardekløft Formation of Rosenkrantz are redefined and its age is determined as Upper Bathonian and Lower Callovian. The presumed Oxfordian 'Fossil Mountain Formation' is shown to be largely a repetition of the Vardekløft Formation, succeeded by perhaps much later (post-Volgian?) beds.
- (6) The exact dating of the deposits by a refined European scale is shown to be impossible, but an approximate, homotaxial correlation is attempted and considered to be equally satisfactory. While the

incompleteness of the Arctic successions (always shallow water or littoral deposits) does not permit of an absolute refutation of Buckman's views, more evidence is adduced to show their essential unsoundness, biologically and geologically.

- (7) The distinctiveness of the Arctic province is upheld and the gradual change in the ammonite fauna, even in passing north from England to Scotland, is cited in favour of the existence of climatic zones, if perhaps in a less pronounced degree than at the present day. There is no evidence of even temporary isolation of the Arctic Sea.
  - (8) The palæogeographic reconstructions of the Arctic Sea given by Frebold and Crickmay are shown to be substantially correct and the relative permanence of continents and oceans, as previously accepted by the writer and as recently restated by Crickmay, is taken to be confirmed.
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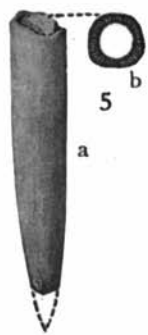
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*sculpted*



*G. vulgaris*



*G. vulgaris*  
 MUSEUM OF THE UNIVERSITY OF GÖTTINGEN



1a



2a

x

x



1b



2b

*C. vulgaris* v. *robusta*



3



b



4

*C. aff. vulgaris*



6a



b



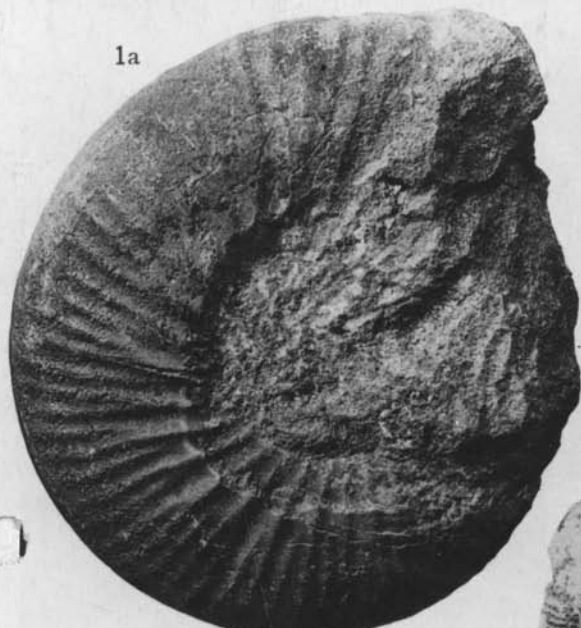
6b

*C. gracilis* v. *ornata*



5





1a

*P. gracilis*



2



1b



3

*C. cf. pompanoni*



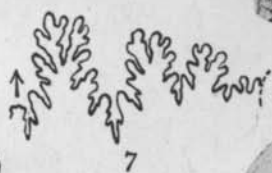
4

*C. cf. gracilis*



5

(x3)



7



6a

*maculatus*



a

8



b



6b



(x2)



7b

2



7a



*C. vulgaris* sp. *densicostata* (x2)



4a



5



a

3



b

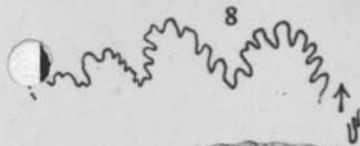
*C. vulgaris*



12



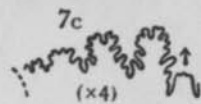
4b



8



6



(x4)



9a



a

11



b



10



9b

*C. pompilius*



1a

1b

2a

*Cef. inversus*

3

*C. vulgaris*  
*v. compressa*



6a

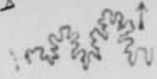
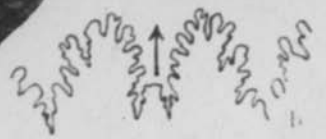


4



5

*v. laevis*



8

7 *v. intermedia*

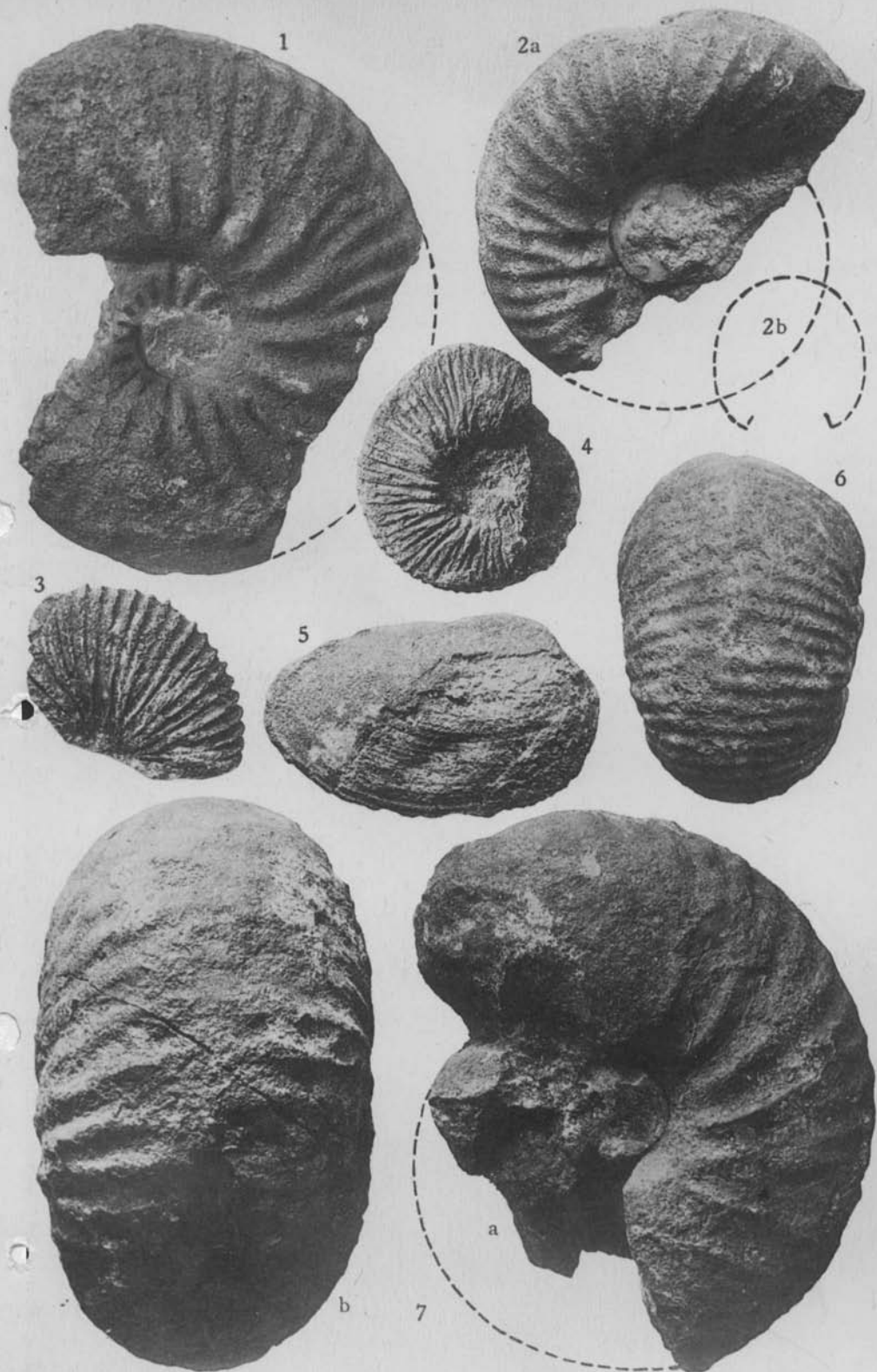


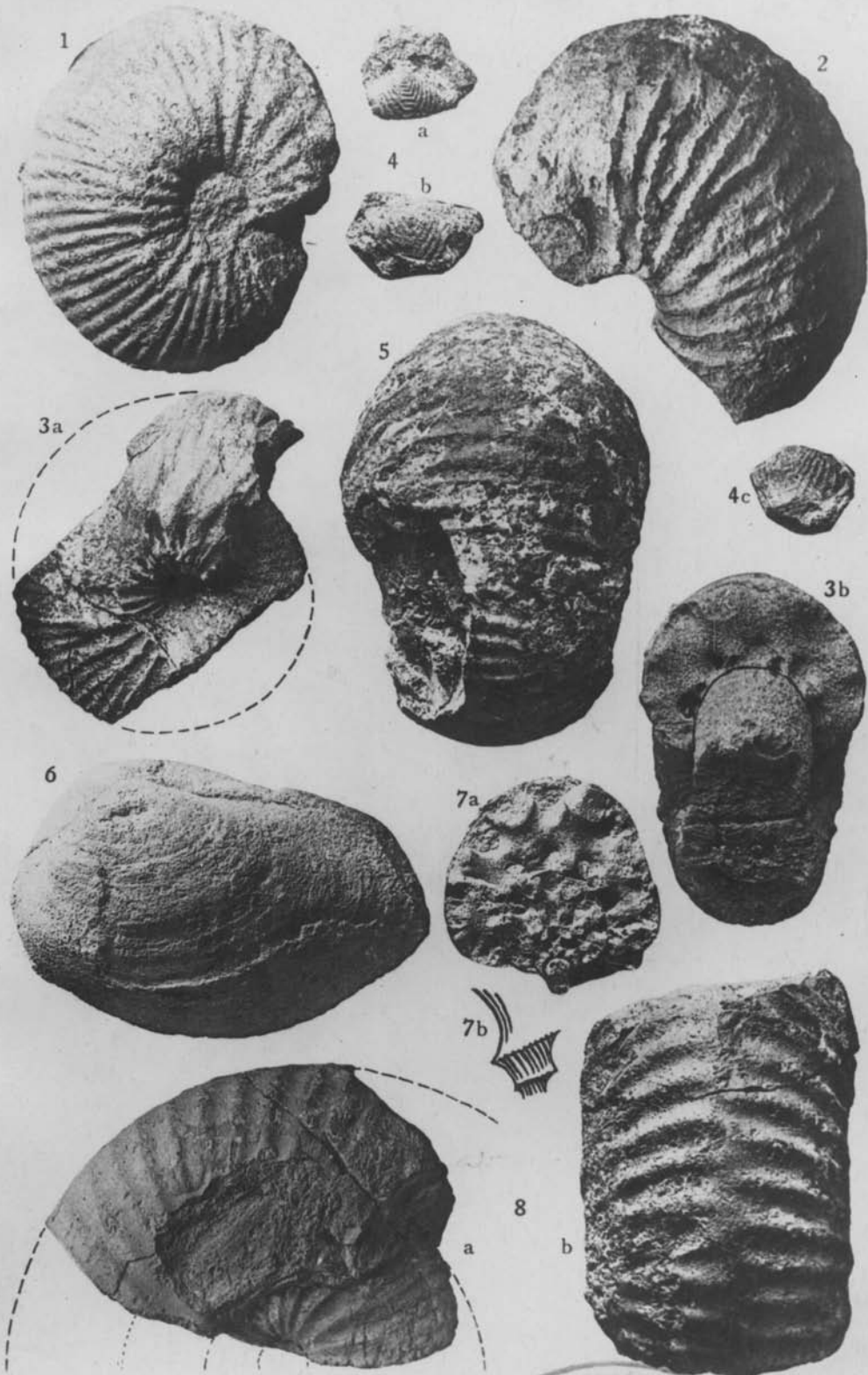
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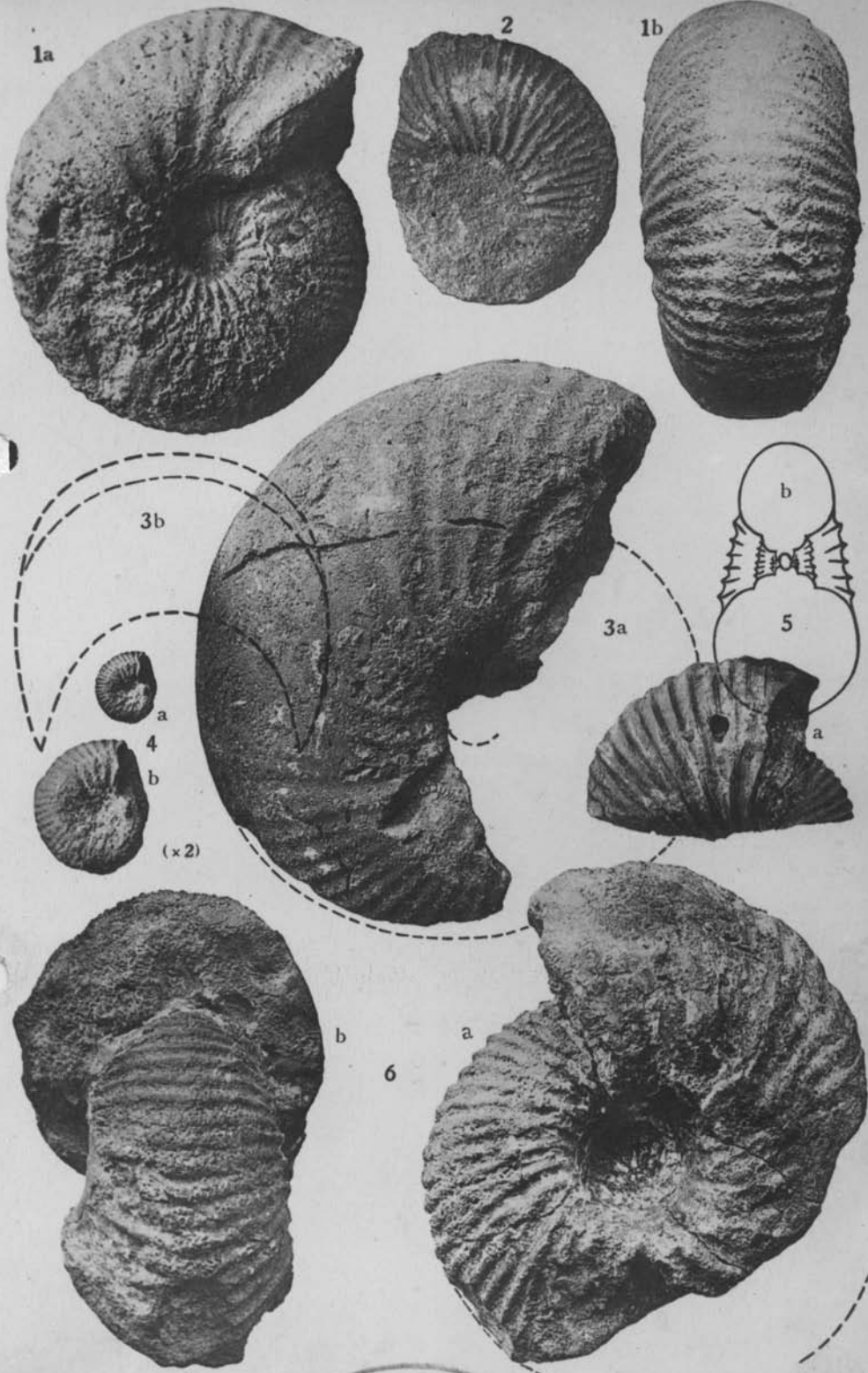
*v. costata*



*v. intermedia*



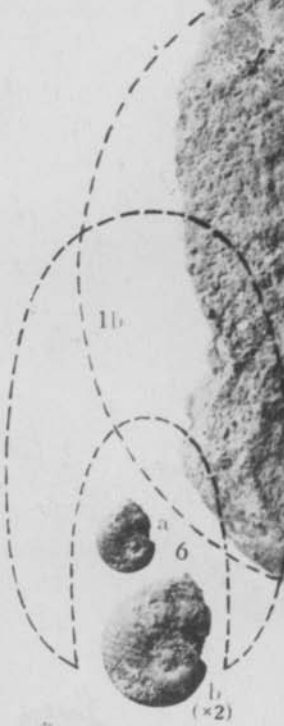






*Ps.-cad. nardis*

*D. greenlandicus*

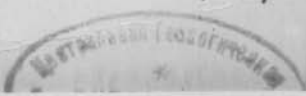


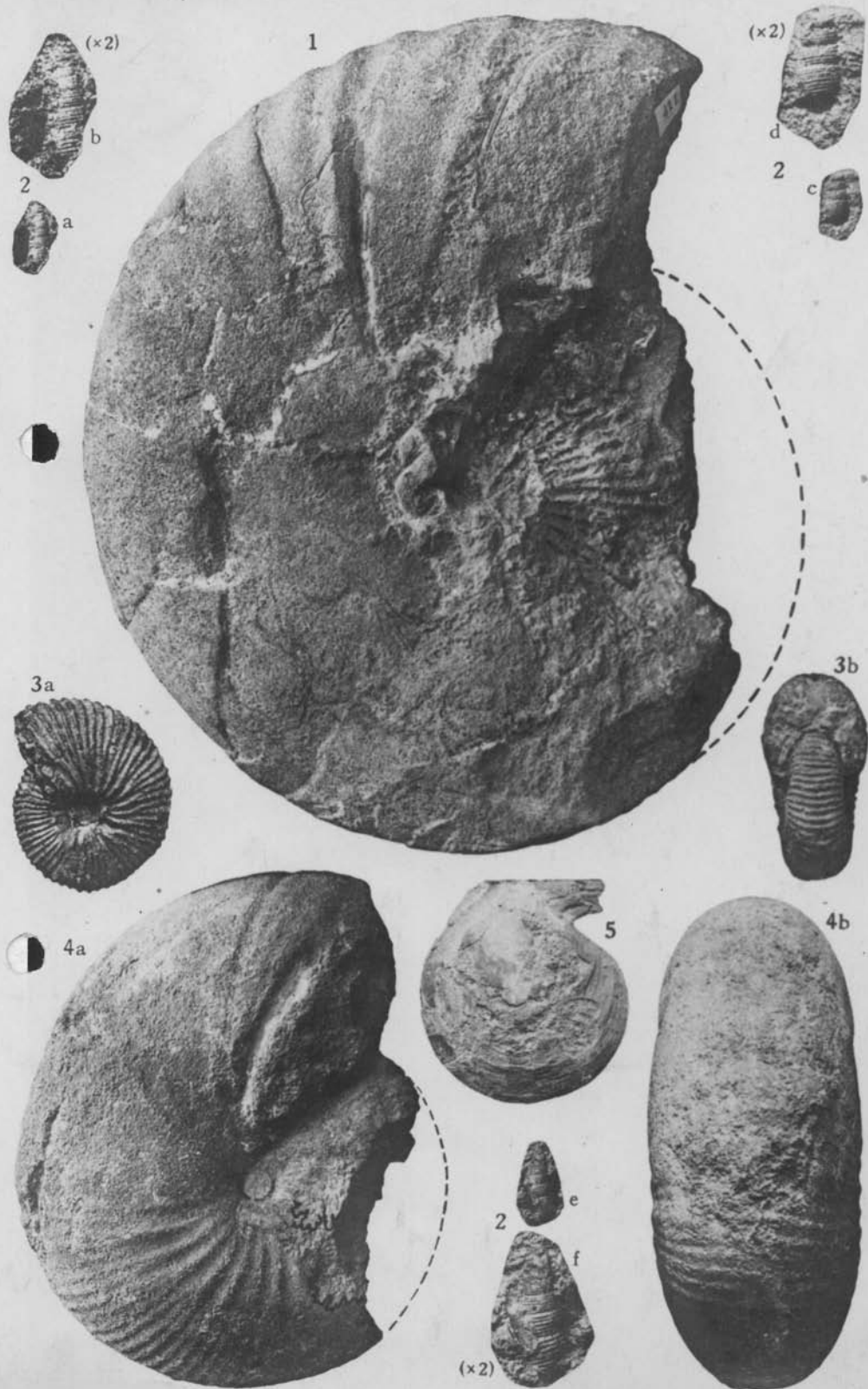
*D. aff. nudus*

*D. aff. nampick v. laevis*

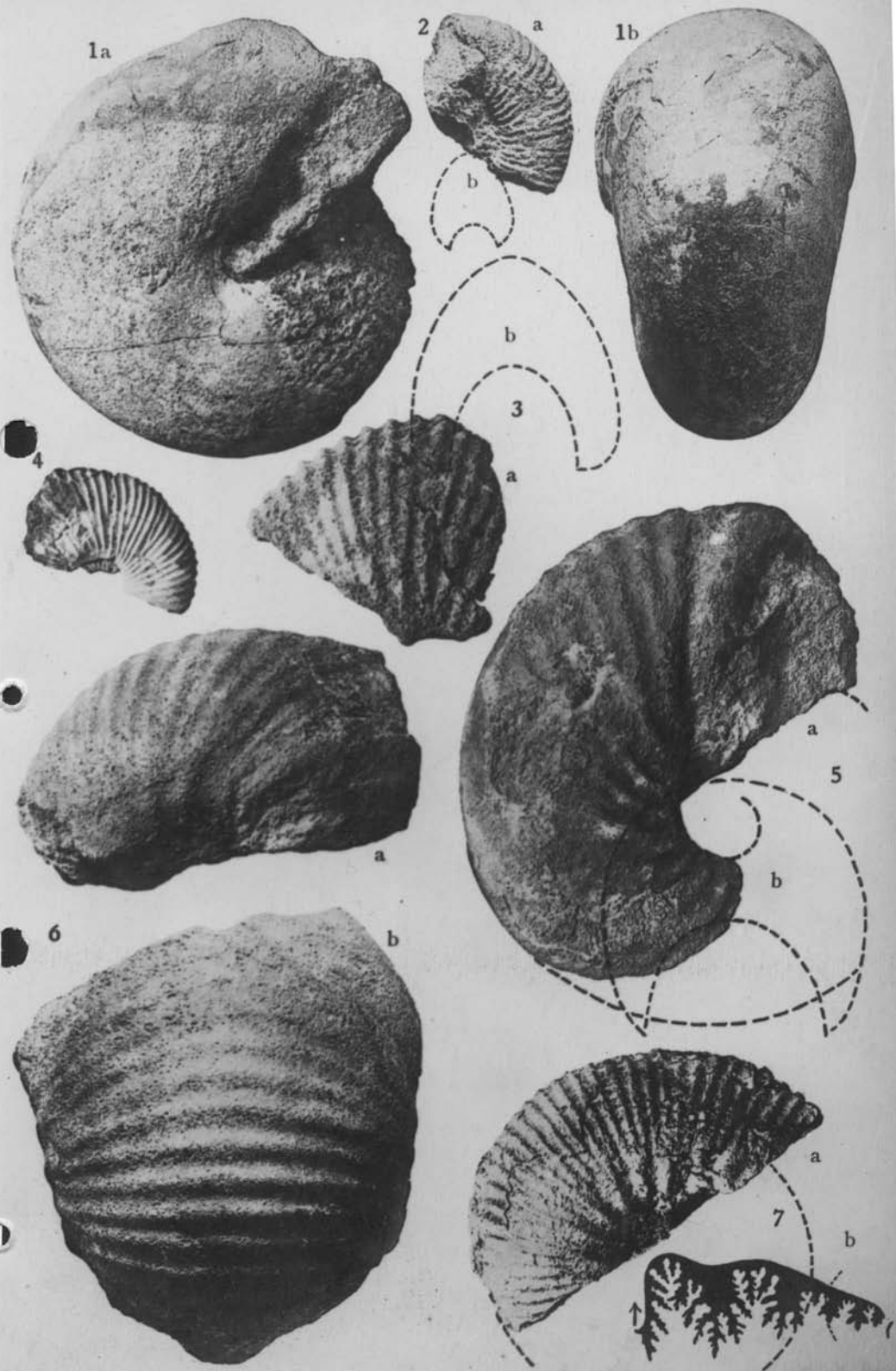


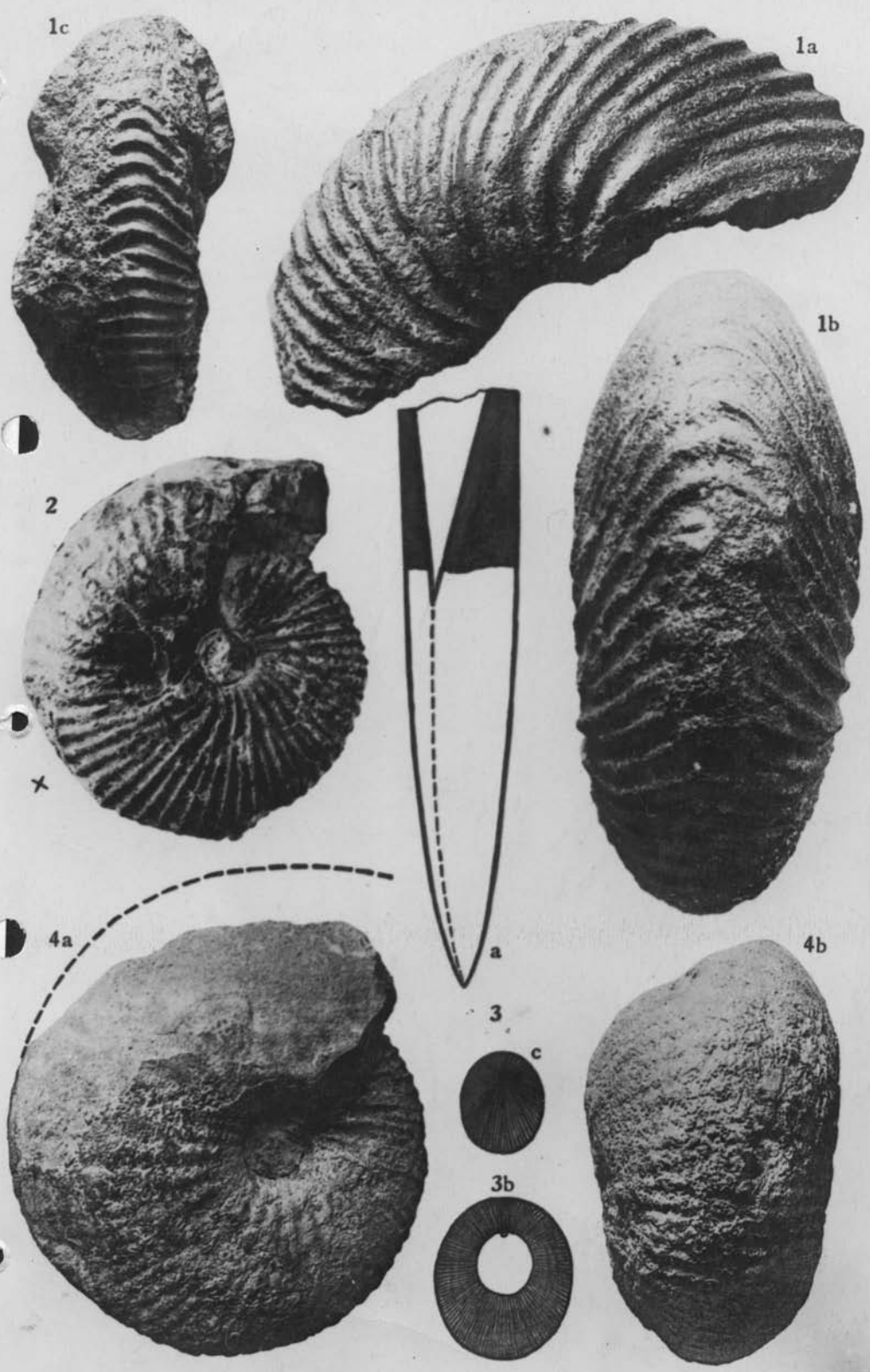
*C. subextremus*













1b



2



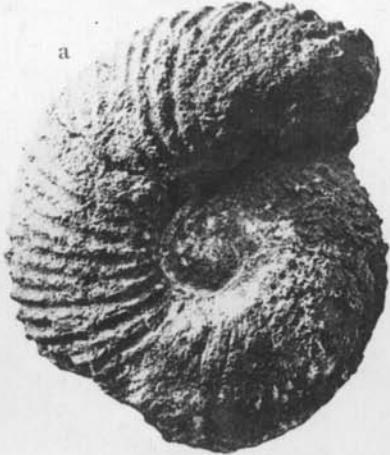
1a

*Cyprina*



b

3



a



4



5



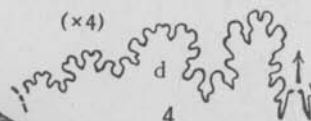
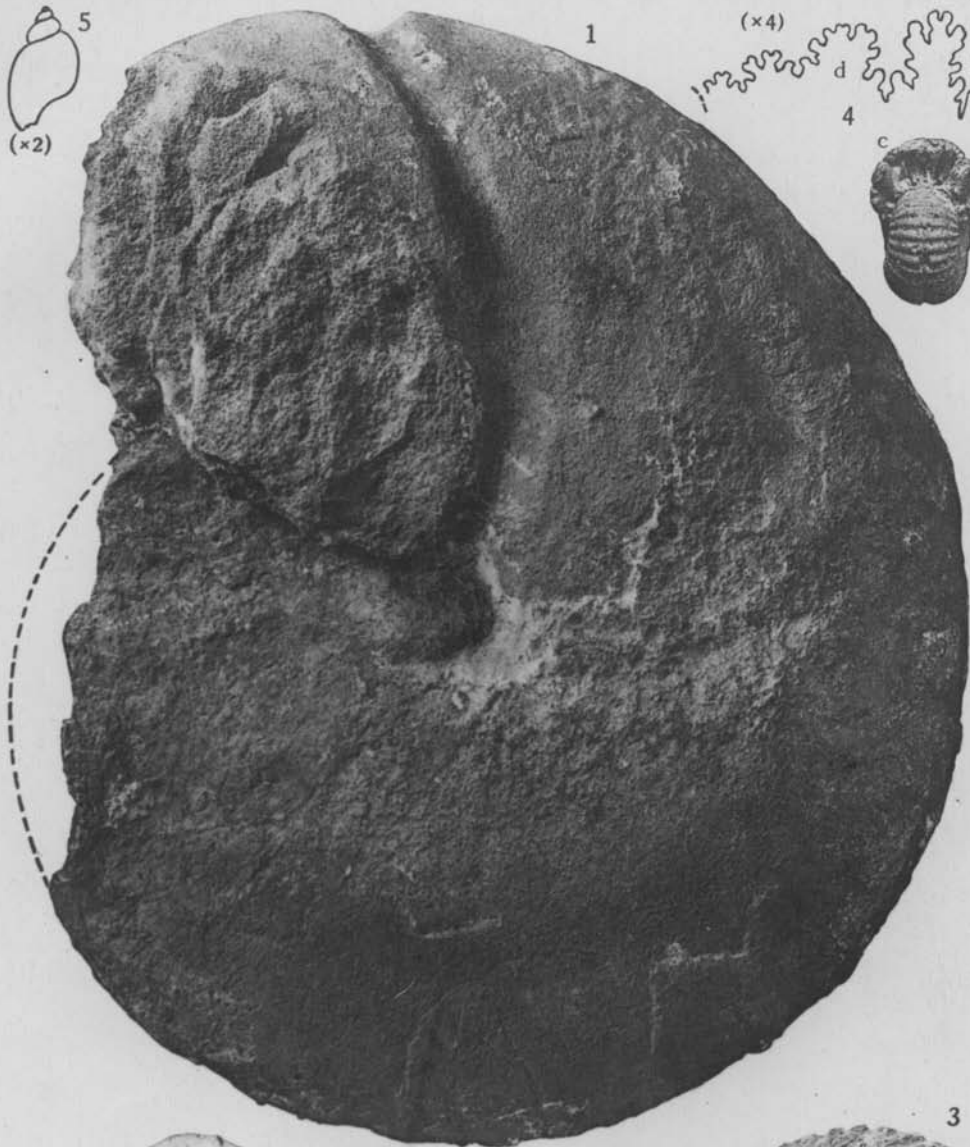
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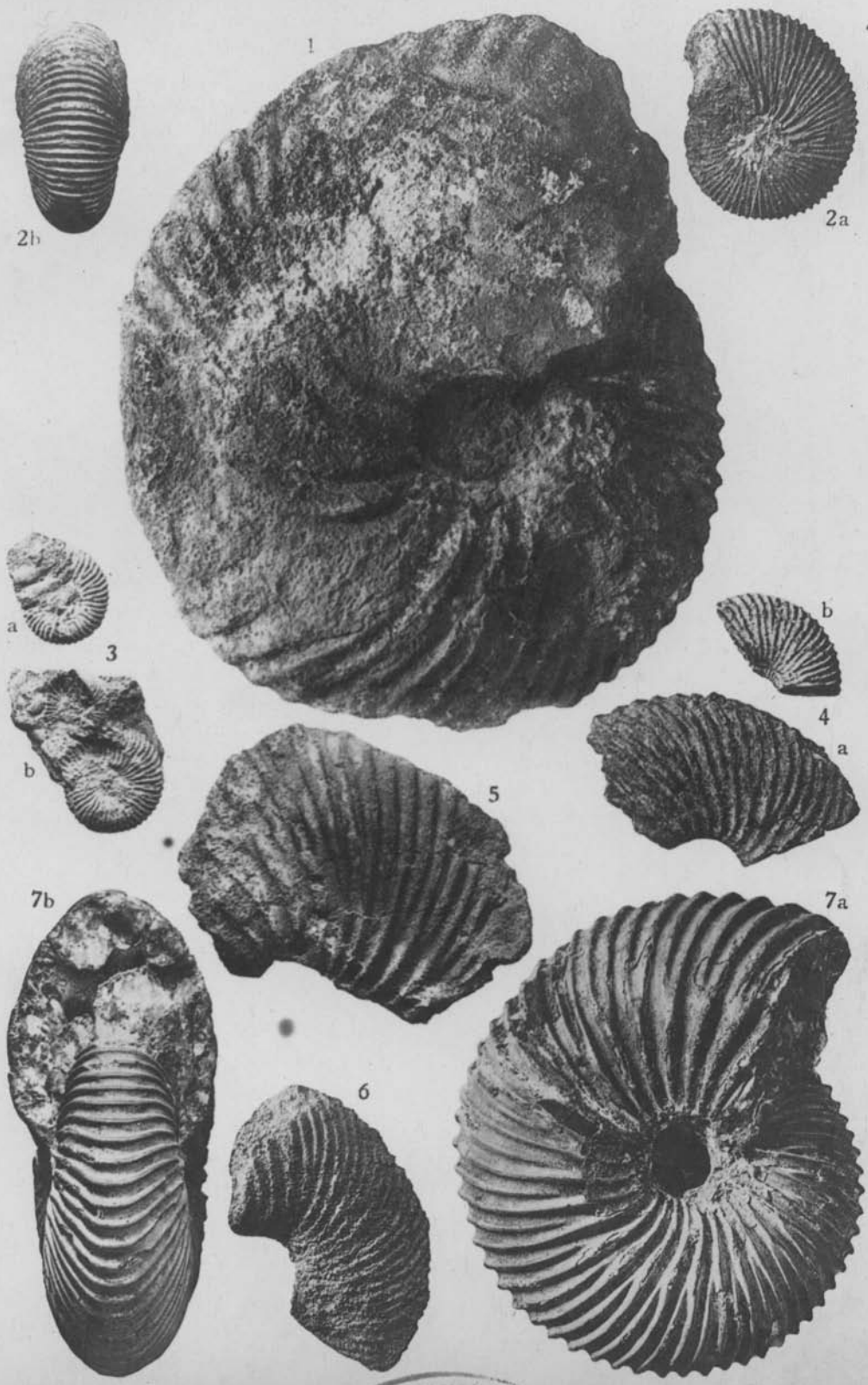
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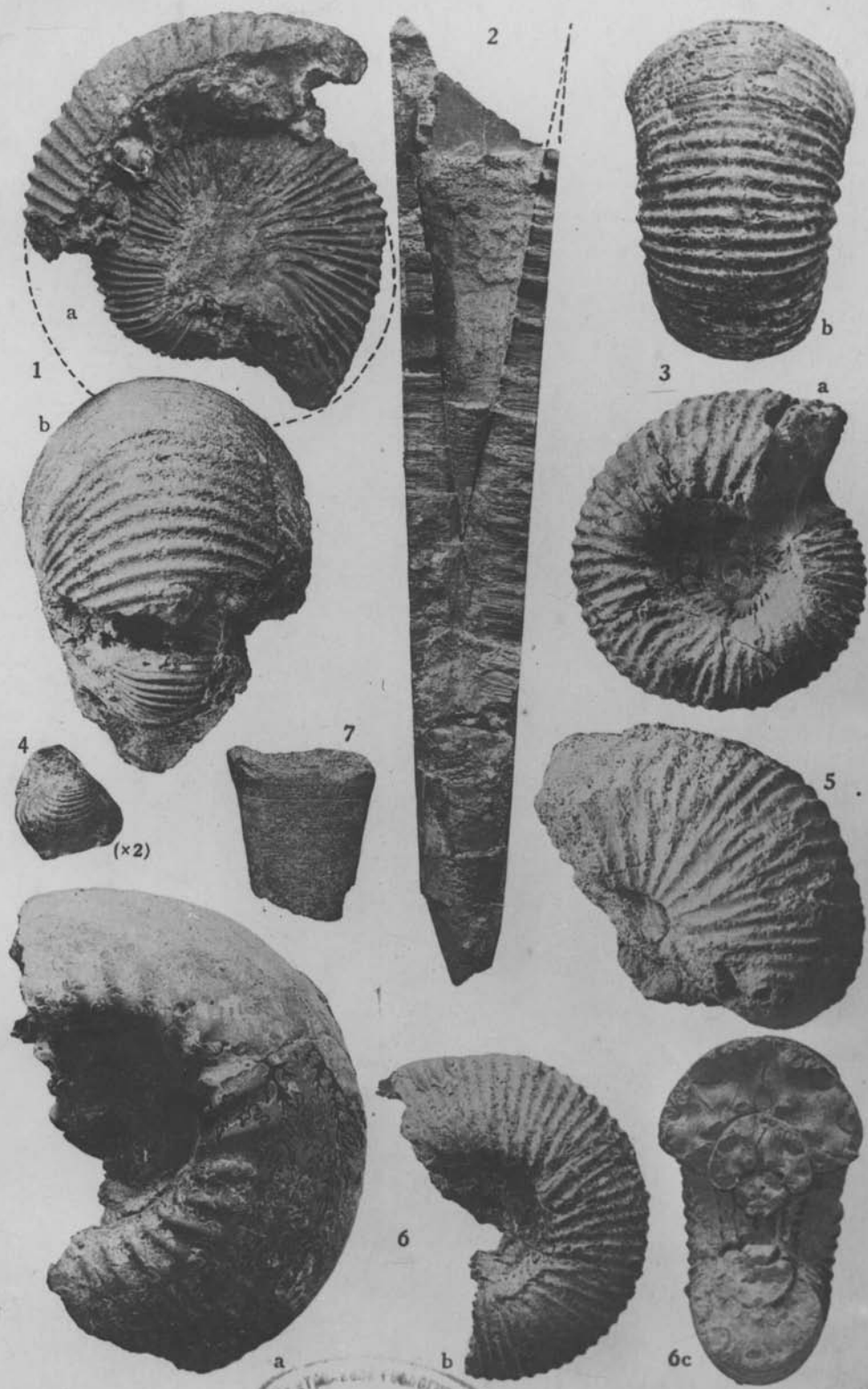
a



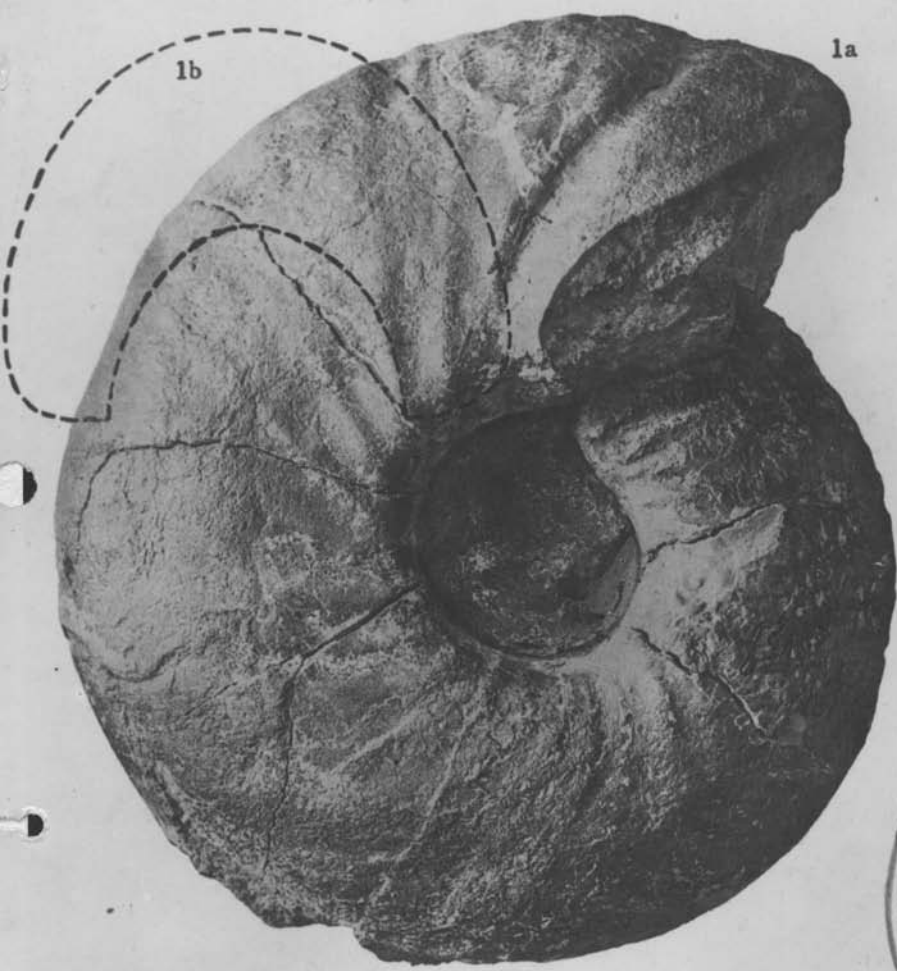




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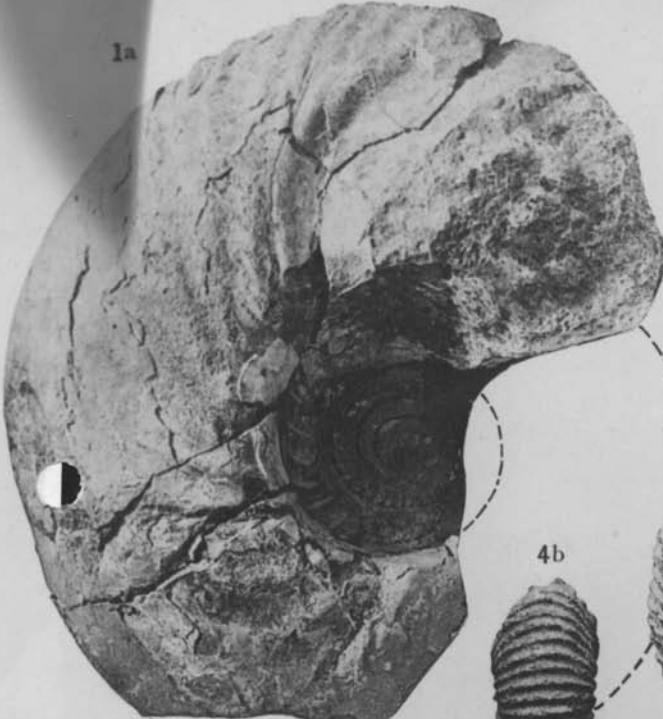
a

b

2



1a



3



2a



4b



5



1d



1c



4a



2b



1b



