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FOSSILS FROM THE LOWER CAMBRIAN OF BORNHOLM

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Synopsis

A Lower Cambrian fauna from Bornholm consisting of 34 species is described. The oldest of the Lower Cambrian rocks, the *Balka quartzite*, contains trace fossils referable to *Diplocraterion*, *Tigillites*, and *Skolithos*, and in addition to these some worm remains comparable to *Byronia* MATTHEW. After a hiatus follows *siltstone* („Green shales" of several authors) and *Rispebjerg sandstone* which represent one single cycle of sedimentation. The siltstone contains a rich fauna which is essentially endemic. Two new genera and seventeen new species are established. The Lower Cambrian age of the siltstone appears clearly from the occurrence of *Fordilla troyensis* WALCOTT and *Hyolithellus micans* BILLINGS. The Rispebjerg sandstone has only yielded a fragment of *Hyolithellus micans* and a single specimen of the trace fossil *Cruziana dispar* LINNARSSON. The conditions of sedimentation and the stratigraphical position of the Bornholm Lower Cambrian are disscussed.

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PREFACE

The Lower Cambrian palaeontological material described and discussed in the present paper is a result of the efforts of several collectors during a century. The greater part was collected by F. JOHNSTRUP, K. A. GRÖNWALL, and, particularly, by the present writer. The described and figured specimens are preserved in the Mineralogical and Geological Museum of the University of Copenhagen.

The writer is very grateful to the former Director of the Geological Survey of Denmark, Dr. H. ØDUM, for placing GRÖNWALL's collections at his disposal for study.

By the courtesy of the Director of the Geological Survey of Denmark, Dr. O. BERTHELSEN, the writer obtained permission to republish several figures from Danmarks Geologiske Undersøgelse, Ser. 2, No. 62 (K. HANSEN 1936: "Die Gesteine des Unterkambriums von Bornholm").

The writer is much indebted to Dr. H. WIENBERG RASMUSSEN of the Mineralogical and Geological Museum of the University of Copenhagen for permission to use the geological map of Bornholm in the present paper.

Special thanks are due to Dr. A. W. A. RUSHTON, who kindly sent specimens of *Coleoloides multistriatus* from the type locality, Woodlands Quarry, Hartshill, Warwickshire, and placed important information at the writer's disposal.

Last but not least, the writer is most indebted to Mr. C. HALKIER, who undertook the very difficult task of making good photographic prints of the fossils.

INTRODUCTION

The knowledge of the fossil faunas of the Lower Cambrian of Bornholm has hitherto been very incomplete.

From the lower part of the sequence of strata, the Balka quartzite, K. HANSEN (1936) mentions worm burrows. Some of these have proved to be referable to *Skolithos*, *Diplocraterion*, and *Tigillites*.[1]

In addition to these trace fossils some carbonized worm tubes, comparable with *Byronia*, have been found. The "genera" mentioned are the only fossils known from the Balka quartzite.

From the overlying siltstone sequence GRÖNWALL (1916) mentions the occurrence of *Hyolithes* (*Orthotheca*) *johnstrupi* HOLM, *Hyolithes* (*sensu stricto*) *nathorsti* HOLM, *Hyolithes* (*sensu stricto*) *lenticularis* HOLM, and *Torellella laevigata* LINNARSSON.[2]

In 1935 the present writer visited the siltstone outcrops in order to collect fossiliferous phosphorite nodules. The nodules were broken down to small pieces and studied by means of a binocular microscope. Several new fossils were discovered in this way, and the total number of species from the siltstone now amounts to thirty.

The location of Lower Cambrian sediments appears from the geological map (p. 8). The locality numbers used in the present paper are those introduced by HANSEN (1936).

The trace fossils of the Balka quartzite are easily accessible for study in the localities 229 and 230 on the eastern coast of the island, north and south of Snogebæk harbour, respectively.

The greater number of the fossils from the siltstone originate from outcrops along the streamlets Lilleaa, Læsaa, Grødbyaa, and Øleaa (see figs. 7–9, p. 44–46, and the list of fossils and localities p. 42–43).

[1] STEHMANN (1934) mentions the occurrence of *Monocraterion* (= *Tigillites*) and *Lepocraterion* (= *Tigillites*).

[2] The specimens of "*Torellella laevigata*" have turned out to be partly indeterminable, partly referable to *Hyolithellus micans* BILLINGS.

THE SEDIMENTS

Marine Lower Cambrian sediments, containing the fossils described in the present paper, cover considerable areas in the southern part of the island (see geological map p. 8). The Lower Cambrian series of strata are usually divided into the following units, mentioned in ascending order: Balka quartzite, Siltstone ("Green shales" of several authors), and Rispebjerg sandstone.

These sedimentary rocks have been described and discussed at some length by KAJ HANSEN (1936), and, as far as the petrography of the Bornholm Lower Cambrian is concerned, the reader is referred to HANSEN's paper. A brief account of the general character of the above-mentioned stratigraphic units is considered sufficient here.

The *Balka quartzite* is about 60 m. thick and developed as a fine-grained, more or less thin-bedded, quartzitic sandstone. Coarser beds occur in places, but they are rare. The colour of the quartzite is most frequently white, but the lowermost strata, which were deposited in shallow basins on the surface of the Eocambrian Neksø sandstone, have a greenish tint owing to the presence of a considerable amount of glauconite. In the upper part of the quartzite the rock may here and there be very dark, almost black, owing to the presence of pigment of organic origin. Thin beds of shale, very rich in mica, alternate with quartzite beds in the upper part. The bedding planes of the quartzite show ripple marks and poorly preserved trace fossils. At Snogebæk (Localities Nos. 228, 229, and 230) the quartzite is extremely rich in trace fossils referable to *Diplocraterion*, *Tigillites*, and *Skolithos*.

The Balka quartzite is overlain by about 100 m. of greyish-green *siltstone* known as the "green shales". The basal stratum is a quartz conglomerate of a thickness of about 20 cm. with much glauconite and pebbles of black shale, which may eventually originate from the shale beds of the Balka quartzite. The quartz grains of this basal conglomerate have been pressed into the shale pebbles which apparently must have had the character of

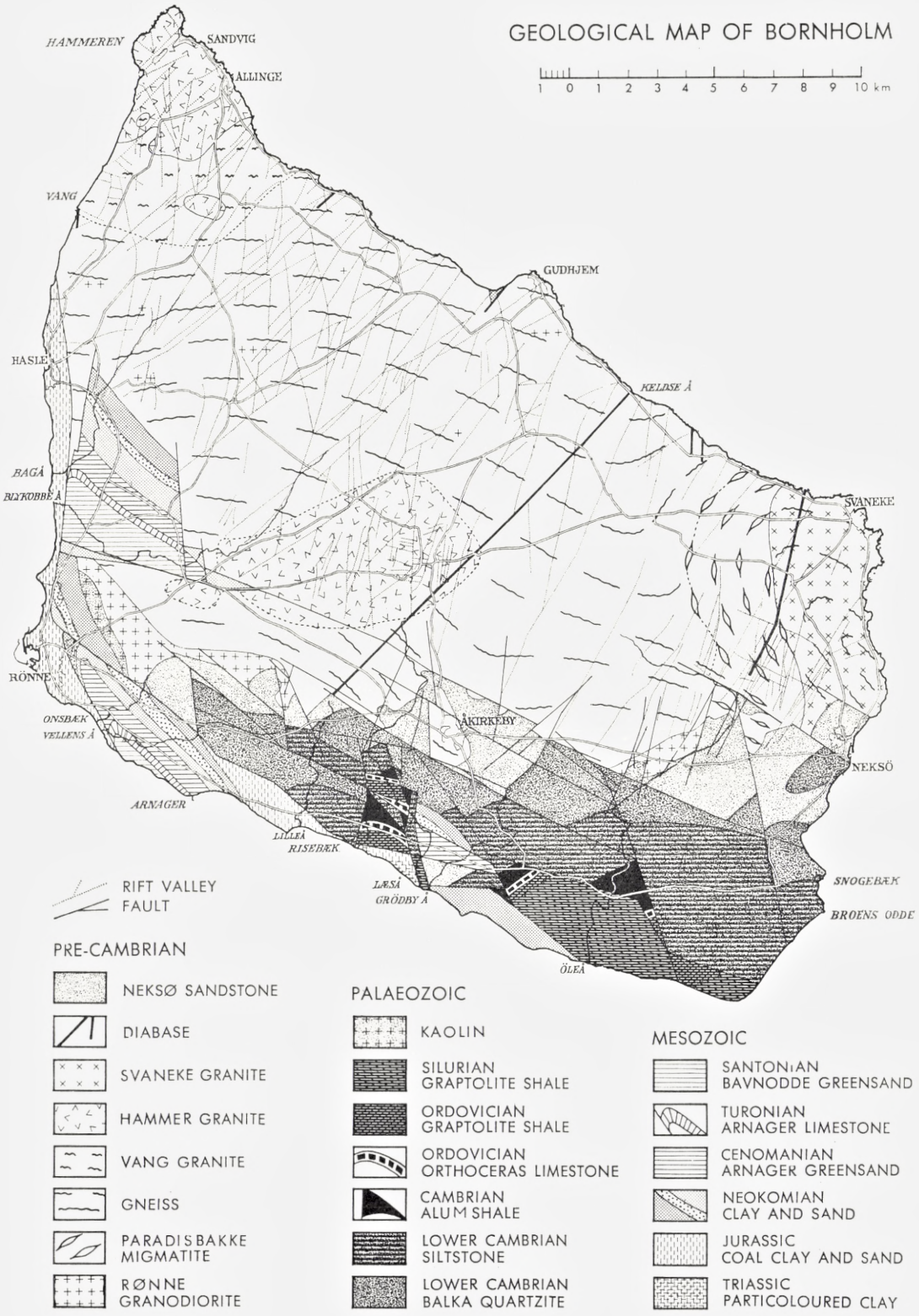

GEOLOGICAL MAP OF BORNHOLM
1 0 1 2 3 4 5 6 7 8 9 10 km
HAMMEREN
SANDVIG
ALLINGE
VANG
GUDHJEM
HASLE
KELDSE Å
BAGÅ
RØNNE
SVANEKE
ÅKIRKEBY
NEKSÖ
ONSBÆK
VELLENS Å
ARNAGER
LILLEÅ
RISEBÆK
LÆSÅ
GRØDBY Å
SNOGEBÆK
BROENS ODDE
ÖLEÅ
RIFT VALLEY
FAULT
PRE-CAMBRIAN
NEKSØ SANDSTONE
DIABASE
SVANEKE GRANITE
HAMMER GRANITE
VANG GRANITE
GNEISS
PARADISBAKKE MIGMATITE
RØNNE GRANODIORITE
PALAEOZOIC
KAOLIN
SILURIAN GRAPTOLITE SHALE
ORDOVICIAN GRAPTOLITE SHALE
ORDOVICIAN ORTHOCERAS LIMESTONE
CAMBRIAN ALUM SHALE
LOWER CAMBRIAN SILTSTONE
LOWER CAMBRIAN BALKA QUARTZITE
MESOZOIC
SANTONIAN BAVNODDE GREENSAND
TURONIAN ARNAGER LIMESTONE
CENOMANIAN ARNAGER GREENSAND
NEOKOMIAN CLAY AND SAND
JURASSIC COAL CLAY AND SAND
TRIASSIC PARTICOLOURED CLAY

Fig. 1. Quarry 1 km southwest of Aakirkeby. Balka quartzite alternating wiih thin shale beds. (Phot. C. POULSEN).

soft clay. The following series of strata shows some lithological variation, but the greater part of it has the character of siltstone. The bedding is, as a rule, indistinct, and the bedding planes irregular. Ripple marks have never been observed. Tracks and trails are very common, especially in the middle part of the sequence, where the rock is completely infiltrated by burrows and shows the characters of a typical bioturbidite. This part of the siltstone also contains numerous small, black phosphorite nodules measuring up to five cm. in diameter (text-fig. 3). The fauna of the siltstone is found at this

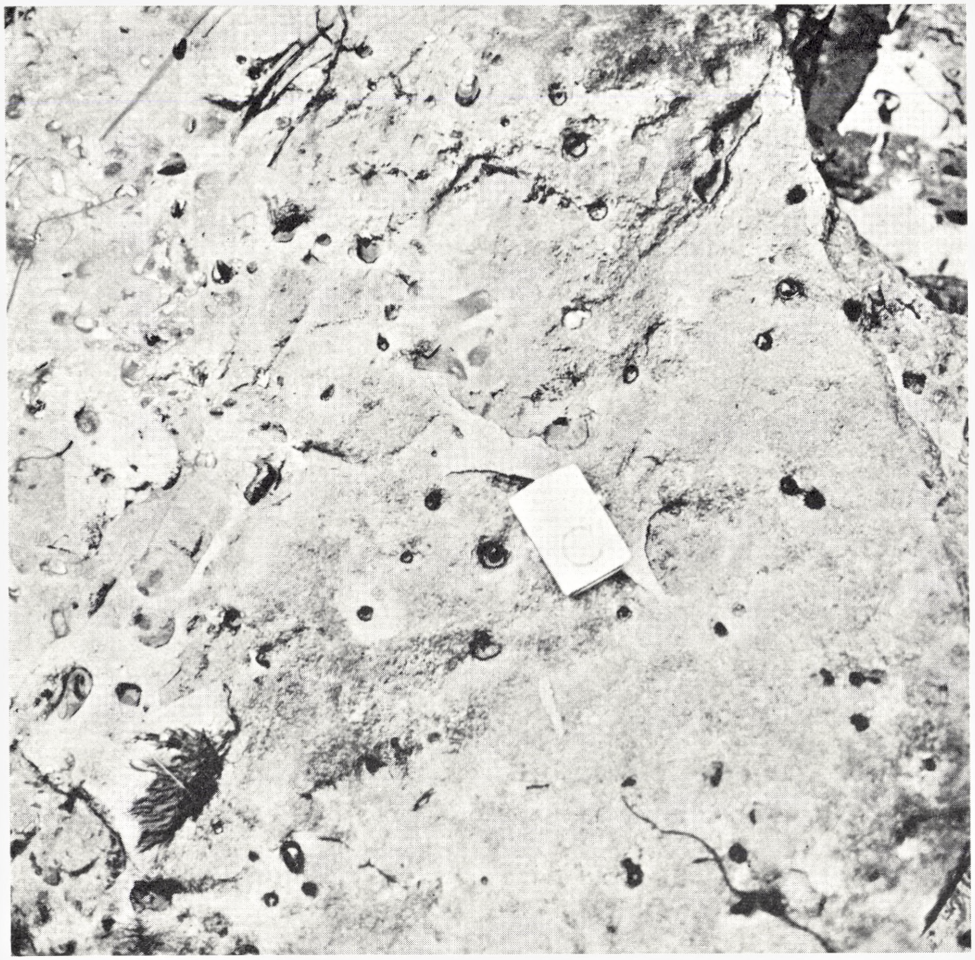


Fig. 2. Exposed bedding plane in Balka quartzite just south of Snogebæk harbour (locality 230), showing trace fossils (*Diplocraterion* and *Tigillites*). (Phot. V. Poulsen).

level and almost exclusively in the phosphorite nodules. Thirty species are now known, the commonest being *Orthotheca johnstrupi* Holm and *Coleoloides multistriatus* Cobbold. In the uppermost part of the siltstone sequence a gradually increasing size of the quartz grains has been observed, and the rock grades into the overlying Rispebjerg sandstone.

The *Rispebjerg sandstone* is about 3 m. thick. It is coarse-grained. The lower part (about 2.60 m.) is developed as quartzite, which is, in places, somewhat porous; the upper part has a matrix consisting of black phospho-

Fig. 3. Siltstone with black phosphorite nodules at Broens Odde (locality 232). (Phot. V. Poulsen).

rite. The only fossils known from the Rispebjerg sandstone are a specimen of *Cruziana dispar* Linnarsson and a specimen of *Hyolithellus micans* Billings, the latter possibly reworked.

In his paper of 1936 (p. 136, fig. 30) Hansen illustrated his opinion concerning the Lower Cambrian sedimentation by means of his "Epirogenetische Kurve des Unterkambriums von Bornholm". According to Hansen the Balka quartzite, the siltstone ("Green shales"), and the Rispebjerg sandstone represent one single cycle of sedimentation, the three units

indicating shallow, deeper, and shallow-water conditions, respectively. The present writer, however, is of opinion that the basal conglomerate of the "Green shales" indicates a sedimentary break, and, consequently, the whole Lower Cambrian sequence should represent two cycles of sedimentation. On the other hand, the fossiliferous zone of the "Green shales", containing phosphorite nodules and showing a slight increase in the size of the quartz grains, may indicate a regressive tendency in the environment of the Bornholm region, as shown in HANSEN's diagram.

The phosphorite nodules in the siltstone have been formed *in situ* as phosphatic impregnations of the sediment around organic remains. The greater part of these organic remains are shells of calyptoptomatids which fail to show any special orientation. Accordingly, currents do not appear to have had any essential influence. In his discussion of the occurrence and formation of phosphatic nodules KUENEN (1950) says: "It appears that they are generated under the same conditions as glauconite, that is, mainly in depths less than 1000 m. and where sedimentation is slow or absent". The generally fine-grained nature of the Bornholm Lower Cambrian siltstone may very well indicate slow sedimentation, and the absence of ripple marks on the bedding planes points to a sea bottom beyond the reach of wave action. The Balka quartzite and the Rispebjerg sandstone, however, are shallow-water deposits. The trace fossils *Diplocraterion*, *Skolithos*, and *Tigillites*, which occur in abundance at certain levels in the Balka quartzite, are generally believed to be worm burrows, and, provided that this biotope indicates conditions similar to the recent biotope dominated by *Sabellaria*, it is an obvious conclusion that the quartzite was deposited so close to the coast that the sea bottom was laid bare during low tide.

The above-mentioned sediments constitute the only existing Lower Cambrian on the island of Bornholm, but, as shown by C. POULSEN (1942) and V. POULSEN (1963 and 1965), the occurrence of a considerable amount of Lower Cambrian fossils, i. a. eocystid plates, *Stenothecopsis* spp., and fragments of *Holmia* sp. in the Middle Cambrian *Exsulans* limestone and Kalby clay indicates the former presence of thin, unconsolidated, late Lower Cambrian sediments, which were removed by erosion during a period of emergence.

FOSSILS FROM THE BALKA QUARTZITE

Phylum *ANNELIDA*

Class Polychaetia GRUBE, 1850

Order Sedentaria LAMARCK, 1818

Family uncertain

Genus et sp. ind. (cf. *Byronia* MATTHEW, 1899)

Pl. 3, fig. 5.

Material: Several tubes preserved as black, glistening, transversely wrinkled films in sandy, micaceous shale from the upper part of the Balka quartzite.

Locality: Graanakkestuen, north of Store Kannikegaard in Bodilsker parish.

Remarks: The genus *Byronia* has been characterized as follows: "Tube curved, horny, wall thin, outer surface bearing concentric annulations" (HOWELL 1962, p. 163, fig. 104 (1)). This description is also adequate with regard to the Bornholm specimens, when the different state of preservation is taken into consideration. The Bornholm species differs from the type species of *Byronia* (*B. annulata* MATTHEW, 1899) in having slender tubes; the apertural width of the Bornholm species is about 2.0 mm. and the corresponding length of the tubes is about 20 mm., whereas the apertural width of *Byronia annulata* is 2.5 mm. corresponding to a tube length of about 17.5 mm. The Bornholm specimens were originally labelled by the writer as *Ottoia* WALCOTT, but they appear to be more in conformity to *Byronia*.

TRACE FOSSILS

In a few localities, 228 (quarry at Hunsemyre), 229 (low coast cliffs at Snogebæk harbour (northern side)), and 230 (low coast cliffs just south of Snogebæk harbour) trace fossils comparable to *Diplocraterion* TORELL and *Tigillites* ROUAULT (text-fig. 2) occur in abundance. In locality 229 some of the strata have the character of "pipe rock" due to the occurrence of a coarse type of *Skolithos* HALDEMAN. All these trace fossils are poorly preserved, and the material does not contribute to the understanding of their origin.

FOSSILS FROM THE SILTSTONE ("GREEN SHALES")

The fossils occur almost exclusively in black phosphorite nodules; the very few fossils found outside the nodules have practically always an internal mould consisting of black phosphorite.

It admits of no doubt whatever that the fauna of the siltstone was benthonic. The writer is of opinion that the horizontal distribution of the fossils may be approximately that of the living individuals on the Lower Cambrian sea bottom.

It is a very remarkable fact that brachiopods and trilobites are entirely lacking. Nevertheless thin-shelled inarticulate brachiopods may have been members of the fauna, and their phosphatic shells may eventually have been engaged in the concentration of phosphate in the sediment resulting in the formation of the black phosphorite nodules.

The fossils are, as a rule, preserved as external and internal moulds, but in one single small, slightly phosphatic limestone lens collected by Johnstrup at "Grødbyaa between Grødby and Grammegaarde", that is between localities 134 and 143, several of the fossils are found with their mineralized exoskeleton preserved; unfortunately, it has been impossible to find more concretions of this type.

Phylum *PORIFERA*
Class Hyalospongea Vosmaer, 1886
Order Lyssakida Zittel, 1877
Family uncertain
Genus et species ind. I (cf. *Pyritonema* M'Coy, 1850)

Pl. 1, figs. 1–2.

Material: Numerous scattered hexacts in phosphorite nodules.

Localities: 58 (coast cliff west of Julegaard), 139 (Grødbyaa), 178 and 194 (Øleaa).

Remarks: Only hexacts are known; they are fairly similar to those described and figured by Rauff (1893–1894, p. 264, Pl. 6, figs. 7–15) as *Pyritonema gracile* (Hinde), from which they differ mainly by having less expanded ray bases. *Pyritonema*, however, is only known from extremely fragmentary specimens, and it can hardly be regarded as a valid genus. Accordingly, a safe determination of the fragmentary Bornholm material must be left out of consideration.

Class uncertain
Order uncertain
Family uncertain
Genus et species ind. II

Pl. 1, fig. 3.

Material: *Hyolithellus* tube in siltstone with megascleres of undeterminable types in the interior.

Locality: 194 (Øleaa).

Genus et species ind. III

Pl. 1, fig. 4.

Material: A specimen of *Hyolithes* in siltstone, with burrows containing a few spicule-like bodies which are much obscured by subsequent silicification.

Locality: 194 (Øleaa).

Remarks: In the writer's opinion these burrows may be a result of the activity of some excavating sponge.

Phylum *MOLLUSCA*
Class Pelecypoda Goldfuss, 1820
Order uncertain
Family uncertain
Genus *Fordilla* Barrande, 1881
Fordilla troyensis Walcott, 1886

Pl. 2, fig. 1.

1873. Bivalve of uncertain class; gen. nov., Ford, Am. Jour. Sci., 3rd ser., vol. 6, p. 139.
1881. *Fordilla*, Barrande, Acéphales. Etudes Loc. et Comp., 8°, p. 391–393, Pl. 361.
1886. *Fordilla troyensis* Walcott, U. S. Geol. Surv., Bull. 30, p. 123–125, Pl. 11, figs. 3, 3a–c.
1890. *Fordilla troyensis* Walcott, U. S. Geol. Surv., 10th Ann. Rep., p. 615, Pl. 73, figs. 2, 2a–c.
? 1919. *Fordilla troyensis* (?) Cobbold, Geol. Mag., dec. 6, vol. 5, p. 156, Pl. 4, fig. 33.
1931. *Fordilla troyensis*, Ulrich & Bassler, Proc. U. S. Nat. Mus., vol. 78, Art. 4, p. 97, Pl. 4, figs. 14–15.

1932. *Fordilla troyensis* POULSEN, Meddelelser om Grønland, vol. 87, no. 6, p. 16–17, Pl. 2, figs. 3–5.
1956. *Fordilla troyensis* LOCHMAN, Bull. Geol. Soc., America, vol. 67, p. 1372–1373, Pl. 1, figs. 5–10.

Material: Five specimens in black phosphorite nodules, represented by more or less fragmentary moulds of the interior and exterior of the shell.

Localities: 46 (Lilleaa), 139 (Grødbyaa), and 173 (Øleaa).

Remarks: ULRICH & BASSLER (1931) regarded *Fordilla* as a phyllopod because this genus "has the calcareo-phosphatic structure of the genera here referred to the Limnadiidae", but WALCOTT's reasons (WALCOTT 1886) for referring *Fordilla troyensis* to the Pelecypoda rather than to the Crustacea —not least the thickness of the shell, which exceeds that of Cambrian Crustacea except that of the trilobites—cannot be rejected without further ceremony; it should be noticed in this connection that specimens from the Lower Cambrian of East Greenland consist of irregularly grained calcite of the type found in shells where aragonite has been replaced by calcite; phosphate is not met with in the Greenland specimens. LOCHMAN (1956) is of opinion that "the calcareo-phosphatic appearance of the shell may be caused by an outer chitinous layer. Such a layer could be the source of the carbonaceous film retained on many specimens," and the author mentioned adds that "considering the nature of this material it would seem unwise to arbitrarily reject *Fordilla* as a member of the Pelecypoda"; it should be noticed in this connection that muscle scars comparable to those of pelecypods have not yet been observed. The Bornholm specimens agree fairly well with LOCHMAN's photographic figures, but the fragmentary state of preservation prevents additions to previous descriptions.

Genus et species ind.

Pl. 2, fig. 2.

Material: A couple of almost complete internal moulds of right and left valve in black phosphorite nodule.

Locality: 46 (Lilleaa).

Description: Shells transversely elongate, subelliptical in outline, somewhat convex, 1.25 times as long as high. Umbones moderately prominent, situated almost in the middle of the dorsal margin. Cardinal margin not visible throughout, but apparently bluntly angular; a row of six poorly developed teeth in front (?) of the umbo of the right (?) valve suggests the

presence of a taxodont hinge. Adductor muscular impressions not preserved. Surface of the interior of the right (?) valve marked with a few broad folds parallelling the ventral margin, whereas such folds are hardly discernible in the left (?) valve; a faintly marked keel extends from the posterior (?) part of the umbonal region to the posterior end of the ventral margin.

Dimensions: Height 1.7 mm., length 2.2 mm.

Remarks: The material is considered too imperfect to permit of any determination. Judging from the nature of the cardinal region, the specimens may be referred to the taxodont group of pelecypods.

Class Monoplacophora Wenz in Knight, 1952
Order Tryblidioidea Lemche, 1957
Superfamily Tryblidiacea Pilsbry in Zittel-Eastman, 1899
Family Tryblidiidae Pilsbry in Zittel-Eastman, 1899
Subfamily Proplininae Knight & Yochelson, 1958
Genus *Proplina* Kobayashi, 1933

Proplina? *prisca* n. sp.

Pl. 3, fig. 1.

Material: External mould of right side of a shell in black phosphorite nodule.

Locality: 77 (Læsaa).

Description: Shell small, very high, bilaterally symmetrical, with incurved, somewhat depressed apex overhanging anterior end. The most elevated point is about 1/6 the distance from the apex to the posterior end; from this point the outline curves regularly to the posterior end and anteriorly to the apex; outline from the apex to the anterior margin concave. Aperture circular. External surface marked by numerous, closely set lines of growth.

Dimensions:

Apertural diameters	2.00 mm.
Distance of apex from anterior margin	1.25 –
– – – – posterior –	2.85 –

Remarks: As mentioned above, the material consists of a single external mould; accordingly, muscle scars have not been observed, and the reference of the species to the genus *Proplina* and the Monoplacophora is questionable; otherwise the agreement with *Proplina* is fairly satisfactory. *Proplina*? *prisca*

differs from the type species (*Metoptoma cornutaformis* WALCOTT, 1879) in having a much higher shell, a less overhanging apex, and an external surface with finer concentric markings; it shows greater resemblance to *Proplina ampla* KOBAYASHI, 1933, but it is readily distinguished from that species by its higher shell and its less overhanging apex.

Order Archinacelloidea KNIGHT & YOCHELSON, 1958
Superfamily Archinacellacea KNIGHT, 1956
Family Hypseloconidae KNIGHT, 1956
Genus *Pollicina* HOLZAPFEL, 1895
Pollicina? *cambrica* (MOBERG, 1892)

Pl. 3, fig. 2.

1892. *Dentalium? cambricum* MOBERG, Geologiska Föreningens i Stockholm Förhandlingar, vol. 14, part 5, p. 117, Pl., figs 16–17.

Material: Three specimens in greyish brown phosphatic nodule, preserved as internal and external moulds.

Locality: 137 (Grødbyaa).

Description: Shell bilaterally symmetrical, regularly curved, rapidly tapering, with circular cross-section. The apertural plane appears to be perpendicular to the longitudinal shell axis. The rate of taper is about 1 in 3. Internal and external surfaces smooth.

Dimensions:

Height of shell	about 3 mm.
Apertural diameters	– 1 –

Remarks: The Bornholm material agrees perfectly with MOBERG's description and figures of *Dentalium*? *cambricum*. The shells of Scaphopoda, however, are open at both ends, and, accordingly, MOBERG's species should be excluded from this class. The species shows considerable resemblance to the genus *Pollicina* HOLZAPFEL. It is distinguished from the type species of that genus (*Cyrtolithes corniculum* EICHWALD, 1860) by its smaller size, less curved shell, and smooth external surface.

Muscle scars have not yet been observed in the shell of *Pollicina*, and the reference of this genus to a family of the Monoplacophora is therefore questionable.

Class Gastropoda Cuvier, 1797
Subclass Prosobranchia Milne Edwards, 1848
Order Archaeogastropoda Thiele, 1925
Suborder Bellerophontina Ulrich & Scofield, 1897
Superfamily Bellerophontacea M'Coy, 1851
Family Sinuitidae Dall in Zittel-Eastman, 1913
Subfamily Sinuitinae Dall in Zittel-Eastman, 1913
Genus *Prosinuites* n. g. (type species: *Prosinuites bornholmensis* n. sp.)

Diagnosis: Shell bilaterally symmetrical, cap-shaped, with blunt apex overhanging the posterior margin. Anterior and posterior margin with broad shallow sinuses, that of the anterior margin having a tendency to generate a more or less obscure selenizone (pl. 3, figs. 4, 5, and 8).

Remarks: In the writer's opinion the bilateral symmetry and the tendency to develop a selenizone are characters which may indicate that *Prosinuites* should be regarded as a primitive member of the Bellerophontacea, in which development of coils had not yet taken place. The shape of the anterior emargination is fairly similar to that of the genus *Sinuites* Koken.

Prosinuites bornholmensis n. sp.

Pl. 3, figs. 3–9.

Material: Four internal moulds from grey limestone lens.

Locality: Grødbyaa between Grødby and Grammegaarde (exact locality unknown).

Description: Shell bilaterally symmetrical, with blunt, somewhat depressed apex overhanging the posterior margin; length (distance from the apex to the anterior margin) about twice the height; the most elevated point is about 1/4 the distance from the apex to the posterior end. Aperture approximately circular, with broad, shallow anterior and posterior emarginations, the posterior one terminating an obscure selenizone.

Dimensions:	I	II (holotype)	III
Length	5.8 mm.	6.6 mm.	6.6 mm.
Height	3.3 –	3.7 –	? –
Diameter of aperture	4.3 –	4.7 –	5.6 –

Remarks: Helcionella? emarginata Cobbold, 1919 from the Lower Cambrian red, sandy limestone of Woodlands Quarry, Hartshill, may belong to the new genus *Prosinuites*; it differs, however, from the Bornholm species in having a lower shell with more strongly overhanging apex.

Class Calyptoptomatida Fisher, 1962
Order Hyolithida Matthew, 1899
Suborder Hyolithina Matthew, 1899
Family Orthothecidae Syssoiev, 1958
Genus *Circotheca* Syssoiev, 1958
Circotheca sp.

Pl. 5, figs. 8–9.

Material: One fragmentary external mould and one fragmentary internal mould in black phosphorite nodules.

Locality: 46 (Lilleaa).

Description: Shell slender, slightly curved, tapering at a rate corresponding to an apical angle of about 13°. Transverse section circular. Judging from the lines of growth, the plane of the apertural margin has a slight ventro-dorsal declination. External surface marked by numerous, crowded, extremely delicate growth lines of equal strength, and spaced about 12–14 to the millimetre; coarser lines of growth occur at irregular intervals.

Dimensions: The fragmentary state of preservation prevents exact information with regard to the size of the shell; in the writer's opinion a shell length of about 25–30 mm. is fairly probable.

Remarks: It is probable that the material represents a new species, but the fragments at hand do not allow of any adequate specific description or use as a holotype. The species appears to be closely related to *Circotheca stylus* (Holm, 1893), which is the type species of the genus *Circotheca* Syssoiev, but it differs clearly from that species in the lack of longitudinal surface markings.

Genus *Orthotheca* Novak, 1886
Orthotheca groedbyensis n. sp.

Pl. 6, figs. 7–8.

Material: One fragmentary internal mould of the shell (holotype) and one fragmentary external mould in black phosphorite nodules.

Locality: 137 (Grødbyaa).

Description: Shell apparently straight, tapering at a rate corresponding to an apical angle of about 5°, with semielliptic transverse section. Ventral side slightly concave, with rounded lateral margins. Judging from the external mould, the shell surface is probably smooth.

Dimensions:

Estimated length	25 mm.
Lateral width near aperture	1.8 –
Dorso-ventral diameter near aperture	1.4 –

Affinities: Orthotheca groedbyensis is probably closely related to *Orthotheca holmi* Cobbold[1] from the Lower Cambrian *Protolenus* limestone at Comley in Shropshire; the shell of both species have almost exactly the same semielliptic transverse section; the essential distinguishing character is the apical angle which is 8° in *Orthotheca holmi* and about 5° in *Orthotheca groedbyensis.*

Orthotheca johnstrupi Holm, 1893

1893. *Hyolithus (Orthotheca) johnstrupi* Holm, Sveriges geologiska Undersökning, Ser. C, No. 112, p. 56, Pl. 1, figs. 28–33, 71.

Material: A very large number of fragmentary specimens preserved as internal and external moulds in siltstone and black phosphorite nodules.

Localities: 75, 77, 82[2], and immediately north of the bridge at Limensgade (Læsaa); 134 (Grødbyaa); 177 (Øleaa).

Remarks: This species is one of the dominant macro-fossils in the siltstone and the black phosphorite nodules, but the new material is not better preserved than that described by Holm, and, accordingly, it does not allow of any additions to Holm's description.

Orthotheca pervilis n. sp.

Pl. 6, figs. 1–2.

? 1893. *Hyolithus (Orthotheca)* sp. No. 1, Holm, Sveriges geologiska Undersökning, Ser. C, No. 112, p. 108, Pl. 1, figs 51–52.

Material: One single fragmentary internal mould of the shell with adjoining fragmentary external mould (holotype) in black phosphorite nodule.

Locality: 77 (Læsaa).

Description: Shell apparently straight, tapering at a rate corresponding to an apical angle of about 8°, with almost evenly rounded dorsal side,

[1] In Cobbold's paper of 1931 (*Quart. Journ. Geol. Soc.* London, vol. 87, pt. 3) *Orthotheca holmi* is regarded as identical with "*Hyolithus* (*Orthotheca*) sp. no. 1" figured by Holm 1893 (Sveriges Geologiska Undersökning, Ser. C, No. 112, Pl. 1, figs. 51–52), but Cobbold's species from Comley shows a striking difference from the Swedish species with regard to the shape of the transverse section of the shell, that of the former having a much longer dorso-ventral diameter.

[2] Reworked specimens?

rounded lateral margins, and concave ventral side. Outline of transverse section reniform. External shell surface smooth.

Dimensions:

Estimated length of the shell	33 mm.
Lateral diameter of figured transverse section	6.0 –
Dorso-ventral – – – – –	2.8 –

Remarks: Holm (1893, p. 108) was of opinion that his "*Hyolithus* (*Orthotheca*) sp. no. 1" differs from other species of his group "Plicati" in having a larger, straight shell with a smaller apical angle, so that it should probably be regarded as an independent species, but, considering the rather poor state of preservation, he did not introduce a specific name. The Bornholm specimen agrees perfectly with Holm's description and figures, and the present writer is almost sure that it should be referred to the same species. The fact that Holm's specimen and the Bornholm specimen are of Lower Cambrian age, whereas the closely related species of the group "Plicati" are Middle Cambrian, confirms the view that the Lower Cambrian specimens represent an independent species, for which the present writer proposes the name *Orthotheca pervilis*. The Bornholm specimen is designated as holotype.

Genus *Trapezotheca* Syssoiev, 1958

Trapezotheca? *pistrinensis* n. sp.

Pl. 6, figs. 3–6.

Material: One single fragmentary internal mould of the shell in black phosphorite nodule.

Locality: 77 (Læsaa).

Description: Shell apparently straight, tapering at a rate corresponding to an apical angle of about 9°, with a slight constriction just behind the aperture, strongly arched dorsal side, slightly concave ventral side, and rather narrowly rounded lateral margins. Dorso-lateral part of transverse section approximately parabolic. Aperture almost at right angles to the shell axis. Part of the dorsal crest shows a system of delicate, closely set transversal ridges, which may have a relation to external surface markings.

Dimensions:

Estimated length of the shell	42 mm.
Dorso-ventral width at aperture	4 –
Lateral – – –	6 –

Remarks: In the *Treatise on Invertebrate Paleontology*, vol. W, p. 127 FISHER gives the following generic diagnosis of *Trapezotheca*: "Cross section trapezoidal with flat or slightly concave venter. Aperture almost at right angles to shell axis." The type species of *Trapezotheca* (*Hyolithus* (*Orthotheca*) *aemulus* HOLM, 1893) has a subtrapezoidal cross section, although the dorsal angularities have a somewhat rounded appearance. The cross section of *Trapezotheca*? *pistrinensis* differs from that of the type species by having an evenly rounded dorsal crest, and, accordingly, it is not subtrapezoidal, but even a very slight depression of the dorsal crest would immediately result in a cross section similar to that of the typical *Trapezotheca*. The cross section of the Bornholm species appears to be intermediate between that of a specific group of *Orthotheca* (the "Plicati" of HOLM) and that of the type species of *Trapezotheca*, and, accordingly, the present writer is of opinion that maintainance of SYSSOIEV's genus *Trapezotheca* may be questionable.

The apical angle and the cross section serve to distinguish the Bornholm species from similar species of *Trapezotheca* and *Orthotheca*.

Family Hyolithidae NICHOLSON, 1872
Genus *Hyolithes* EICHWALD, 1840
Hyolithes balticus n. sp.

Pl. 3, fig. 10; Pl. 4, fig. 1.

Material: One single fragmentary specimen from black phosphorite nodule, showing the internal mould of the shell and small parts of the external mould.

Locality: 46 (Lilleaa).

Description: Shell straight, tapering almost uniformly at a rate corresponding to an apical angle of about 22°. Dorsal side slightly convex; ventral side slightly concave; lateral margins rounded. Ratio of diameters 1 to 3. Aperture not preserved, but surface markings indicate that it has an evenly rounded, moderately projecting ventral lip and a rectilinear dorso-lateral margin. Surface of internal mould marked by faintly indicated, broadly rounded ridges paralleling the apertural margin and spaced about 6–7 to the millimetre; in the external mould these ridges are very strong and clearly marked.

Dimensions: Neither aperture nor apex is preserved, and, accordingly, it is impossible to estimate the size of the shell. The fragment at hand is about 5.5 mm. long.

Remarks: The apical angle combined with the surface markings and the extremely short dorso-ventral diameter should characterize the species. *Hyolithes balticus* appears to hold a very isolated position; at any rate, the writer has not succeeded in finding any closely related species.

Hyolithes groenwalli n. sp.

Pl. 4, figs. 2–8; Pl. 5, figs. 1–6; text-fig. 4.

Material: Five fragmentary specimens with preserved shell in grey limestone lens and eight associated appendages of the type frequently referred to as *Helenia* by several authors.

Locality: According to the original labels the material was collected by F. Johnstrup in 1869 at the Øleaa between Grødby and Grammegaarde. The exact location is unknown. One appendage has been collected by the present writer from black phosphorite nodule in locality 46 (Lilleaa).

Description: Shell slightly curved towards the dorsal side, tapering at a rate corresponding to an apical angle of about 10°. Aperture with evenly rounded, moderately projecting ventral lip and a slightly concave dorso-lateral margin. Transverse section almost semicircular; ratio of diameters 1 to 2. Ventral side slightly convex, with faintly marked, narrow, concave zone along lateral margins; dorsal side strongly and evenly convex. External surface marked by irregularly spaced longitudinal ridges of unequal strength spaced about 2–3 to the millimetre, and irregularly spaced lines of growth of unequal strength spaced about 7–9 to the millimetre; these surface markings have a tendency to form a reticulate pattern on the dorsal face.

Dimensions: Apertural width of the holotype is 6 mm.; estimated total length about 40 mm.

Affinities: Hyolithes groenwalli, which is especially characterized by its small apical angle, semicircular transverse section, and irregularly spaced longittudinal ridges, shows some resemblance to *Hyolithes princeps* Billings from the Lower Cambrian of Newfoundland and Massachusetts with regard to the curvature of the shell and the reticulate pattern of the dorsal side, but it differs clearly from the American species in having a much smaller apical angle, semicircular transverse section, and longitudinal ridges on the ventral face.

The associated appendages (the *Helenia* of some authors) are, as mentioned above, represented by eight specimens. Walcott (1889) described the "type species", *Helenia bella* Walcott, as follows: "Shell an elongate, narrow, flattened, curved tube. The plane of the flattened surfaces is slightly twisted, so as to throw lateral margins about one quarter of a turn around

and to incline the upper and lower faces nearly 45° at one extremity as compared with the other. The curvature is nearly semicircular. The cross section is an elongated ellipse. The form of the aperture of the larger extremity, as indicated by the striae of growth, has the peristome arching forward on one of the flattened sides and curving slightly backwards on the opposite side. As far I am able to determine, the shell was open at the smaller end, as in *Dentalium*, or the extremity was decollated in all the specimens collected." . . . "Surface marked by irregular, transverse or concentric, imbricating lines of growth that vary in number and size on the same specimen and in different specimens."

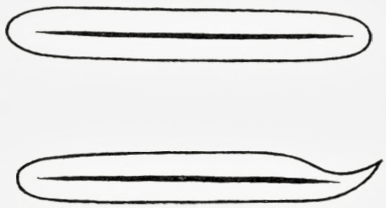


Fig. 4. Appendages of *Hyolithes groenwalli*, n. sp., cross section of a specimen with dorsal furrow (below) and another specimen without furrow (× 30).

Fisher (1962) published the following generic diagnosis: "Elongate, narrow, flattened, curved tube, degree of curvature increasing toward closed end; cross section elongate-elliptical. Surface marked by irregular, transverse or concentric imbricating lines that vary in number and size."

Marek's (1961) description of material from Bohemia has contributed essentially to the knowledge of appendages; his description runs as follows: "E. L. Yochelson describes the shape of the appendages which suggests a curve of logarithmic nature. In the material from Bohemia this shape is also clearly visible. The curvature of the appendages increases towards their narrower distal end, while the part closer to the hyolithid shell is less curved. As established in well-preserved, non-compressed material, the shape of the appendages in cross-section was that of a flattened ellipse. So far it has not been found whether they were compact or hollow, the latter possibility being more probable. In wellpreserved specimens the fine transverse growth lines may be seen on the surface of the appendages; the lines are sometimes curved towards the distal end of the appendage, which is rounded. In addition to it, sculpture formed by very fine transverse furrows has also been established. The coarse longitudinal lines visible in some appendages only, which have also been mentioned by E. L. Yochelson,

seem to be due to pressure. The appendages were composed, no doubt, of the same mass as the shells and opercula of *Hyolithes*. Contrary to V. A. Sysoiev's (1959) assumption, they were firm structures incapable of coiling and withdrawing into the shell. This means that the appendages projected out of the shell during the animal's life, which was possible due to small openings originating at the contact of the operculum with the shell between the so-called lateral sinuses on the operculum and the insignificant indentation on the sides of the aperture."

The Bornholm material agrees in all essentials with Marek's description, but it is now possible to add a few facts. According to Bøggild (1930), the shell of *Hyolithes* consists of irregularly grained calcite of the type found in shells of molluscs in which primary aragonite has been replaced by calcite; *Hyolithes groenwalli* as well as the associated appendages have the structure mentioned, and it can hardly be doubted that the hyolithid shells and their appendages consisted of aragonite. Transverse sections show that the appendages are hollow, but the walls are thick so that the cavity is very inconsiderable (fig. 4). The appendages here referred to *Hyolithes groenwalli* very clearly show the transverse, imbricating lines of growth, and these lines are spaced about 5–9 to the millimetre. The coarse longitudinal line, regarded by Marek as a result of pressure, is well-developed in some of the Bornholm specimens which have certainly not been deformed. The longitudinal line has the shape of a broad furrow; it is situated on the dorsal side and extends along the rounded antero-lateral margin apparently to the distal end (Pl. 5, fig. 1); the longitudinal furrow is better developed in some specimens than in others and is sometimes entirely lacking. A few specimens show three indistinctly marked longitudinal furrows on the ventral surface (Pl. 5, fig. 3).

As compared with the appendages of other species, those of *Hyolithes groenwalli* are easily distinguished by their wider, more rapidly tapering body and the location of the dorsal longitudinal furrow close to the antero-lateral margin.

Hyolithes lenticularis Holm, 1893

1893. *Hyolithus lenticularis* Holm, Sveriges Geologiska Undersökning, Ser. C, No. 112, p. 79, Pl. 5, figs. 23–28.

Material: Four fragmentary internal moulds of the shell, three specimens in siltstone and one in black phosphorite nodule.

Locality: 77 (Læsaa).

The specimens are poorly preserved, and accordingly nothing can be added to Holm's description.

Hyolithes nathorsti Holm, 1893

Pl. 6, fig. 9.

1893. *Hyolithus nathorsti* Holm, Sveriges Geologiska Undersökning, Ser. C, No. 112, p. 87, Pl. 1, figs. 65–70.

Material: To the few specimens described and figured by Holm have been added a few fragmentary internal and external moulds of the shell, partly from black phosphorite nodules, partly from coarse sandstone just below the Rispebjerg sandstone,[2] and two external moulds of an operculum in black phosphorite nodules possibly belonging to this species.

Localities: 77, 84 (Læsaa), 232 (Broens Odde), 173 (Øleaa (operculum)), 46 (Lilleaa (operculum)).

Description: The poorly preserved fragments of the shell do not allow of any addition to Holm's description. The opercula, however, are well-preserved; they are tentatively referred to *Hyolithes nathorsti* and may be described as follows:[1] Outline subcircular, with a very broadly rounded triangular tendency. The furrow separating the cardinal shield from the conical shield is shallow. Rooflets indistinctly defined, without any indication of lateral sinuses. Conical shield moderately convex, with an apical angle of about 135°. External surface marked by numerous fine lines of growth paralleling the margin of the operculum and by extremely delicate, faintly marked, rounded riblets radiating from the apex and only visible in the middle portion of the conical shield.

Dimensions:

Length of operculum	3.8 mm.
Width – –	4.6 –
Length – conical shield	3.3 –

Affinities: The operculum here referred to *Hyolithes nathorsti* and that of *Hyolithes tenuistriatus* Linnarsson as figured by Holm (1893, pl. 1, fig. 88) have several characters in common, but the former clearly differs from the latter by having a rounded triangular outline, a smaller apical angle of the conical shield, and better developed radiating surface markings on the conical shield.

[1] The morphological terms applied to the operculum are those proposed by Marek (1963).
[2] Reworked specimens?

Hyolithes sp. I.

Pl. 6, figs. 10–11.

Material: Three internal moulds of the operculum in black phosphorite nodules.

Locality: 46 (Lilleaa).

Description: Outline subcircular with slightly triangular tendency. Convex main portion entirely surrounded by a very wide, almost flat border delimited by a strong groove; the groove becomes wide in front of the rooflets, where it sinks to deep, triangular pits (natural casts of a bipartite cardinal process) separated from each other by a bridge (natural cast of the central pit). The furrow separating the cardinal shield from the conical shield is shallow. Rooflets fairly well defined, rapidly expanding from the apex of the conical shield to the lateral margin, and without any indication of lateral sinuses. Conical shield moderately convex, with an apical angle of about 100°. Surface of the internal mould marked by relatively coarse, closely set, radiating ridges of varying strength on the conical shield, the rooflets, and the cardinal process, each of the ridges carrying a single row of closely set granules; border smooth.

Dimensions:

Length of operculum	4.7 mm.
Width – –	4.7 –
Length – conical shield	3.8 –

Affinities: The writer is of opinion that the above-described operculum may represent a new species, but it has not been possible to combine it with any of the *Hyolithes* shells at hand, and, accordingly, a specific name for this fossil has been left out of consideration. It shows some resemblance to to the operculum of *Hyolithes strettonensis* Cobbold, 1921, from which it differs by having a much wider border, a smaller cardinal process, and the internal surface marked by radiating ridges.

Hyolithes sp. II.

Pl. 5, fig. 7.

Material: One specimen represented by the external mould of the ventral surface of the shell in black phosphorite nodule.

Locality: 46 (Lilleaa).

Description: Shell straight with exception of the apical end, which is slightly curved towards the dorsal side, rapidly tapering at a rate corresponding to an apical angle of about 20°. Aperture with evenly rounded, moderately projecting ventral lip. Ventral side slightly convex, merging into rounded lateral margins. External surface of ventral side marked by lines of growth of subequal strength, spaced about 14 to the millimetre.

Dimensions: Apertural width about 2 mm.; estimated length of the shell about 6 mm.

Remarks: The specimen described above may represent a new species, the apical angle surpassing that of most Lower Cambrian species, but the fragmentary state of preservation does not allow of any safe identification or use as a type.

Hyolithes sp. ind.

Material: A fragment of the ventral side of the shell in black phosphorite nodule.

Locality: 58 (coast cliff at Julegaard).

Remarks: Judging from the fragment at hand, the shell must have been much larger than those of all the species described above; it is possible that it represents a distinct species, but the material does not allow of any use of it as a basis for description and comparison.

Family Halkieriidae n. fam.
Diagnosis the same as that of the genus *Halkieria*
Genus *Halkieria* n. g.
(Type species *Halkieria obliqua* n. sp.)

Diagnosis: Shell elongate, with slightly convex, almost flat ventral side and moderately convex dorsal side, curved towards the ventral side, tapering towards the apex at an increasing rate, bilaterally symmetrical or slightly twisted so as to show a tendency to form an ascending spiral. External surface markings of the ventral side consisting of delicate, transverse lines of growth and a distinctly marked, median longitudinal groove; external dorsal markings consisting of fairly coarse, transverse lines of growth crossed by strongly marked longitudinal ridges.

Remarks: The affinites of this new genus are uncertain. The general habit of the shell, however, is not very far from that of the *Hyolithina* Matthew, 1899, and, accordingly, *Halkieria* and the family Halkieriidae are provisionally placed in that suborder.

Halkieria obliqua n. sp.

Pl. 2, figs. 3–4.

Material: Four external moulds of the dorsal side and two external moulds of the ventral side in black phosphorite nodules.

Localities: 46 (Lilleaa) and 126 (Grødbyaa).

Description: Shell about three times as long as wide, with slightly convex, almost flat ventral side and moderately convex dorsal side, tapering towards the apex at an increasing rate, curved towards the ventral side, slightly twisted so as to form an ascending spiral. External surface markings of the ventral side consisting of delicate, transverse lines of growth and a strongly marked, median, longitudinal groove; those of the dorsal side consisting of rather coarse, transverse lines of growth crossed by strongly marked longitudinal ridges, which are spaced about 10 to the millimetre and provided with minute granules where they cut across the lines of growth.

Dimensions:	I (holotype)	II
Length	about 3.3 mm.	about 4.0 mm.
Maximum width	– 1.15 –	– 1.36 –

Remarks: Halkieria obliqua is easily distinguished from the only other known species (*Halkieria symmetrica* n. sp.) by its twisted shell and the larger number of dorsal, longitudinal ridges.

Halkieria symmetrica n. sp.

Pl. 2, fig. 5.

Material: One external mould of the dorsal side and part of the ventral interior in black phosphorite nodule.

Locality: 126 (Grødbyaa).

Description: Shell about 3.6 times as long as wide, bilaterally symmetrical, with slightly convex, almost flat ventral side and strongly convex dorsal side. Dorsal surface markings consisting of indistinctly marked, transverse lines of growth crossed by strongly marked, prominent longitudinal ridges which are spaced about 6 to the millimetre and furnished with minute, closely set granules on their crests.

Dimensions:

Length	about 4.5 mm.
Maximum width	– 1.1 –

Remarks: Halkieria symmetrica is readily distinguished from the type species (*Halkieria obliqua* n. sp.) by its bilaterally symmetrical shape and by the smaller number of longitudinal ridges.

Phylum *POGONOPHORA JOHANSSON*, 1937 (as class Pogonophora)

The position of the Pogonophora in the animal kingdom has been much discussed and is still a problem. The present writer is not ready to discuss this question here, the more so because the genus *Hyolithellus* BILLINGS mentioned below, which was referred to the Pogonophora by V. POULSEN in 1963, fails to throw light on the problem. The group is here tentatively regarded as a phylum.

Class Hyolithelloida nov.
(Class proposed to include the order Hyolithellida SYSSOIEV, 1957).
Order Hyolithellida SYSSOIEV, 1957 (emend. V. POULSEN, 1963)
Family Hyolithellidae WALCOTT, 1886
Genus *Hyolithellus* BILLINGS, 1871

As mentioned above, V. POULSEN (1963) referred the genus *Hyolithellus* to the Pogonophora. This opinion was supported by several points of resemblance emphasized by that author, e. g. the relatively high content of calcium, nickel, and zinc in the tubes. Furthermore, X-ray fluorescence analysis of extraordinarily well-preserved tubes of *Hyolithellus* shows that no phosphorus is present. The same well-preserved material also shows that the tubes of *Hyolithellus* and those of the recent Pogonophora have several amino acids in common, i. a. Alanin.[1] Finally the length of the tube, as shown by the below-mentioned specimen of *Hyolithellus micans* BILLINGS from northern Sweden, is another point of resemblance. It appears from the above-mentioned paper by V. POULSEN (1963) that *Discinella* HALL and *Mobergella* HEDSTRÖM should not be regarded as opercula of *Hyolithellus*.

Hyolithellus micans BILLINGS, 1871

Pl. 7, figs. 1–2.

1871. *Hyolithellus micans* BILLINGS, Canadian Naturalist, 2nd ser., vol. 6, p. 215, fig. 3a on p. 213.
1886. *Hyolithellus micans* WALCOTT (pars), Bull. U. S. Geol. Surv., No. 30, p. 142, Pl. 14, figs. 2, 2a–b.

[1] Written communication from Dr. DAVID B. CARLISLE of the Anti-Locust Centre, London.

1888. *Hyolithellus micans* Shaler & Foerste, Bull. Mus. Comp. Zool. Harvard, vol. 16, p. 34, Pl. 2, fig. 23.
1890. *Hyolithellus micans* Walcott (pars), U. S. Geol. Surv., 10th Annual Report, p. 624, Pl. 79, figs. 1, 1a–b.
1891. *Hyolithellus micans* Lapworth, Geol. Mag., p. 522.
1893. *Hyolithellus micans* Holm, Sveriges Geologiska Undersökning, Ser. C, No. 112, p. 108, Pl. 1, figs. 14–15.
1899. *Hyolithellus micans* Matthew, Bull. Nat.-Hist. Soc. New Brunswick, No. 18, p. 192, Pl. 2, figs. 1a–d.
1899. *Hyolithellus micans* Matthew, Trans. Roy. Soc. Canada, vol. 5, Sect. 4, p. 109, Pl. 6, figs. 1a–d.
1920. *Hyolithellus micans* Cobbold, Quart. Journ. Geol. Soc. London, vol. 76, Pl. 24, figs. 19–21.
1925. *Hyolithellus micans* Störmer, Fennia, vol. 45, No. 1, p. 16, Pl. 1, fig. 5; Pl. 2, fig. 2 (?).
1932. *Hyolithellus micans* C. Poulsen, Meddelelser om Grønland, vol. 87, No. 6, p. 19; p. 30, Pl. 7, fig. 10.
1945. *Hyolithellus micans* Kautsky, Geologiska Föreningens i Stockholm Förhandlingar, p. 138, Pl. 14, figs. 1–5.
1956. *Hyolithellus micans* Lochman (pars), Bull. Geol. Soc. America, p. 1369, Pl. 2, figs. 11–21.
1963. *Hyolithellus micans* V. Poulsen, Biologiske Meddelelser, Kongelige Danske Videnskabernes Selskab, vol. 23, No. 12, p. 1–14, figs. 1b–c.

Material: Two tube fragments with preserved shell in grey limestone lens and 10 external moulds in black phosphorite nodules and siltstone.

Localities: 46 (Lilleaa), 77 (Læsaa), an unnumbered locality between Grødby and Grammegaarde (Grødbyaa), 178 (Øleaa), and 232 (Broens Odde).

Description: Tubular shell curved and irregular near the apical end, but straightening towards the aperture. Growth angle of mature specimens varying from 1°–4°. Cross section circular, up to about 3 mm. in diameter. Wall thin at the apical end, increasing gradually in thickness towards the aperture by addition of laminae. Surface markings consisting of a faint irregular annulation and transverse striation. Internal surface of tube smooth. As far as known, complete specimens have never been found. Fragments are usually 5–10 mm. in length; the longest specimen known, a tube fragment from the Lower Cambrian of Aistjakk in northern Sweden, is about 171 mm. long, and its maximum diameter is about 2 mm.

Genera and species of uncertain systematic position.

Family Coleolidae Fisher, 1962

Fisher's description of the family reads as follows: "Tubuliform calcium-carbonate shells, extremely elongate-conical, almost cylindrical and com-

monly slightly curved towards the apex; cross section circular to elliptical; comparatively thick-walled; laminated, interior surface smooth. Exterior surface smooth or with oblique or longitudinal ornamentation. Opercula and septa unknown. Length 0.5–75 mm., diameter 0.5–2.5 mm. at aperture."

Remarks: The position of the Coleolidae in the zoological system has been discussed by SANDBERGER (1852), ROEMER (1853), HALL (1879 and 1888), SYSSOIEV (1958), and FISHER (1962). According to the last-mentioned author "much may be said for retaining the coleolids in the Mollusca. Coleolids are possibly ancestral scaphopods but if so, they reveal no evidence of the burrowing habits of living scaphopods. On the other hand, early scaphopods may have been pelagic." The present writer has had an opportunity of studying fairly well-preserved specimens of *Coleoloides multistriatus* COBBOLD from the Lower Cambrian of Woodlands Quarry at Hartshill in the Nuneaton district, Warwickshire. Two of these are preserved so as to show the laminated nature of the shell, which appears to consist of three distinct layers. This character is in favour of a scaphopod assignment. It deserves notice in this connection that the chemical properties of the shell of *Coleoloides multistriatus* are practically identical with those of the shell of *Dentalium* (*Antalis*) *entalis* L. On the other hand, the shells of scaphopods differ from those of the coleolids by having an aperture at each end, and, accordingly, the position of the Coleolidae is still uncertain.

Genus *Coleoloides* WALCOTT, 1889

Coleoloides bornholmensis n. sp.

Pl. 8, figs. 3–4.

Material: Seven external moulds of fragmentary shells in black phosporite nodules.

Localities: 46 (Lilleaa) and 132 (Grødbyaa).

Diagnosis: A *Coleoloides* with extremely coarse surface markings consisting of longitudinal ridges defined by deep longitudinal grooves.

Description: Shell extremely elongate-conical. Cross sections circular. Surface markings extremely coarse, consisting of about 12–14 deep longitudinal grooves defining prominent longitudinal ridges, which communicate by anastomosis in a few places and are provided with a faintly marked longitudinal furrow on their crest. The initial portion of the shell smooth up to an estimated distance from the apex of about 3 mm., where faint surface markings appear increasing gradually in strength so as to be fully developed at an estimated distance from the apex of about 5 mm.

Dimensions:

Length of figured fragment	7.4 mm.
Anterior diameter of the same	0.25 –

Remarks: Coleoloides bornholmensis differs from all species hitherto known, except *Coleoloides rugosus* (p. 35), by having extremely coarse surface markings, and it differ sfrom the last mentioned species by having a more acute apical angle and more regular surface markings.

Coleoloides multistriatus Cobbold, 1919

Pl. 8, fig. 2; Pl. 9, figs. 1–4.

1919. *Coleoloides typicalis* Walcott var. *multistriatus* Cobbold, Geol. Mag., N. Ser., Decade 6, Vol. 6, p. 154, Pl. 4, figs. 30–32.

Material: Six external moulds in black phosphorite nodules and eight fragmentary shells in grey limestone lens.

Localities: 139 (Grødbyaa) and an unnumbered locality between Grødby and Grammegaarde (Grødbyaa).

Cobbold's description reads as follows: "Straight tubes of circular section with very slight taper are plentiful in the rock specimens to hand, but very rarely preserve the original surface. In two instances (15 and 38), however, the external surface marks are perceptible; they are very closely set spiral lines, numbering about seventy in the whole circumference of the tube, which is one millimetre in diameter; they are inclined at such an angle as to make one complete circuit of the tube in an length equal to about 10 diameters. . . . The tubes vary in diameter from 1 to 1.3 millimetres."

Remarks: The Bornholm specimens agree very well with the British material. The type locality is Woodlands Quarry, Hartshill, in the Nuneaton district, Warwickshire, where Cobbold's specimens were collected from a red sandy limestone. Dr. A. W. A. Rushton has kindly placed such material from this locality at the writer's disposal and even furnished important supplementary information. It appears from Dr. Rushton's studies that some specimens of *Coleoloides multistriatus* show striae at differing slopes at differing points or, in other words, the obliquity of the striae may vary considerably in one and the same specimen. In some specimens the striation is parallel to the longitudinal axis of the shell. It also appears from Dr. Rushton's material that the initial portion of the shell, up to a point where the diameter amounts to about 0.25 mm., has a smooth external surface. It

may be added that the striation appears to be sharply marked in some specimens and less so in others, varying from strongly marked striation to practically or absolutely smooth external surfaces.

Pl. 8, figs. 2, shows a normal specimen with preserved shell, collected from a grey limestone lens between Grødby and Grammegaarde (Grødbyaa); Pl. 9, figs. 1–4, shows irregular growth of three specimens in one and the same black phosphorite nodule from locality 139 (Grødbyaa).

Coleoloides paucistriatus n. sp.

Pl. 8, fig. 1.

Material: One single external mould of a shell in black phosphorite nodule.

Locality: 46 (Lilleaa).

Diagnosis: A *Coleoloides* with surface markings consisting of a small number of narrow longitudinal ridges and intervening, wide flat spaces.

Description: Shell extremely elongate-conical. Cross section circular. Surface markings consisting of about 10–12 narrow, slightly oblique longitudinal ridges and intervening spaces twice to three times as wide as the ridges; the ridges communicate by anastomosis in a few places.

Dimensions:

Length of the figured fragment	4.0 mm.
Anterior diameter of the same	0.2 –

Remarks: Coleoloides paucistriatus differs from all species of *Coleoloides* hitherto known by having very wide, flat spaces between the longitudinal ridges.

Coleoloides rugosus n. sp.

Pl. 8, fig. 5.

Material: One single external mould of shell fragment in black phosphorite nodule.

Locality: 46 (Lilleaa).

Diagnosis: A *Coleoloides* with rather rapidly tapering shell and extremely coarse surface markings consisting of irregularly undulating longitudinal ridges and intervening grooves of varying width in one and the same specimen.

Description: Shell elongate-conical. Cross section circular. Surface markings extremely coarse, consisting of about 14–16 irregularly undulating ridges, which communicate by anastomosis in a few places, and intervening grooves of varying width. Initial portion of the shell not preserved.

Dimensions:

Length of the figured fragment	1.7 mm.
Anterior diameter of the same	0.3 –

Remarks: *Coleoloides rugosus* appears to be closely related to *Coleoloides bornholmensis*, from which it differs by having a less acute apical angle and less regular surface markings.

Genus *Pseudorthotheca* Cobbold, 1935
Pseudorthotheca danica n. sp.

Pl. 7, figs. 3–4.

Material: Five external moulds in black phosphorite nodule.

Localities: 46 (Lilleaa), 142 (Grødbyaa), and 173 (Øleaa).

Diagnosis: A *Pseudorthotheca* with numerous annulations marked by irregular, engirdling ribs which communicate in places by anastomosis.

Description: Shell tapering at a rate corresponding to an apical angle of about 7°. Cross section circular. Surface markings consisting of sharply defined, closely set, rounded, somewhat irregular, transverse, thread-like ribs, which communicate in places by anastomosis, and are spaced rather regularly 12–13 in a length equal to the diameter of the shell.

Dimensions:

Length of holotype (Pl. 7, fig. 3)	about 3 mm.
Estimated total length of the same	– 7 –
Anterior diameter – – –	– 0.7 –

Remarks: The material at hand does not contribute to our knowledge with regard to the systematic position of *Pseudorthotheca*. The Bornholm species described above differs from the species hitherto described by having more irregular, partly inosculating ribs.

Genus *Glauderia* n. g.[1]
(Type species: *Glauderia mirabilis* n. sp.)

Diagnosis: Body slender, subcylindrical (or fusiform?), with subcircular cross section and two deeply impressed longitudinal grooves, which are diametrically opposed to each other and apparently extending along the

[1] Generic name derived from Julegaard, the name of the finding-place, by changing the order of succession of the relevant letters.

greater part (or total length?) of the shell. Shell phosphatic, apparently consisting of one single layer. External surface smooth. Interior of the shell densely granulated and showing two longitudinal ridges corresponding to the external longitudinal grooves.

Glauderia mirabilis n. sp.

Pl. 7, fig. 5.

Material: One single fragmentary specimen in black phosphorite nodule.
Locality: 58 (Coast cliffs at Julegaard, south coast of Bornholm).
Description: Same as that of the genus.
Dimensions:

Length of the figured fragment	6.25 mm.
Maximum diameter of the same	0.55 –

Remarks: Unfortunately the new genus *Glauderia* is only known from a single fragmentary specimen. Both ends of the body are lacking, and accordingly our knowledge of this strange fossil is very incomplete. The specimen, however, is so highly different from other fossils known to the writer that he does not hesitate to use it as the type of a new genus. It deserves notice, as a very rare exception, that the shell is preserved.

Genus *Halopoa* Torell, 1870

Halopoa cf. *imbricata* Torell, 1870

Text-fig. 5.

1965. *Halopoa imbricata* Martinsson, Geologiska Föreningens i Stockholm Förhandlingar, vol. 87, p. 219–221, text-fig. 29.

Material: Several specimens in fifteen samples of siltstone.
Locality: 232 (Broens Odde).
Remarks: The epichnial trace fossil *Halopoa* is probably present in most of the siltstone beds of the "Green shales".

The Bornholm specimens agree fairly well with the lectotype of *Halopoa imbricata* chosen by Martinsson (*op. cit.*, text-fig. 29), but their size is slightly smaller than that of the figured type specimen from the Lower Cambrian of Lugnås in Västergötland. The "imbricated" nature of the Bornholm specimens is only preserved in a few cases.

Fig. 5. *Halopoa* cf. *imbricata* TORELL (natural size) in siltstone from Broens Odde (locality 232).

It deserves notice that *Halopoa* shows great resemblance to *Gyrochorte* HEER, 1865 (Cambrian-? Tertiary) and to the Permian *Scoyenia* WHITE, 1929, which may belong to one and the same group of trace fossils, and, as mentioned by MARTINSSON (*op. cit.*, p. 219), "the differences may possibly turn out to be due to differences in lithology and preservation."

Fig. 6. *Cruziana dispar* LINNARSSON (natural size) in Rispebjerg sandstone from Borregaard on Øleaa.

FOSSILS FROM THE RISPEBJERG SANDSTONE

Phylum *ARTHROPODA*

Class Trilobita WALCH, 1771

Order Reedlichiida RICHTER, 1933?

Suborder Olenellina RESSER, 1938?

Genus et species ind.

Text-fig. 6.

Material: A trace fossil in Rispebjerg Sandstone.

Locality: Borregaard, Øleaa.

Remarks: The trace fossil agrees very well with that from the Lower Cambrian Sandstone at Lugnås, Sweden, described and figured by LINNARSSON (1871, p. 14–16, Pl. 3, fig. 12) as *Cruziana dispar*. The size of the trace indicates that it was probably made by an olenellid trilobite.

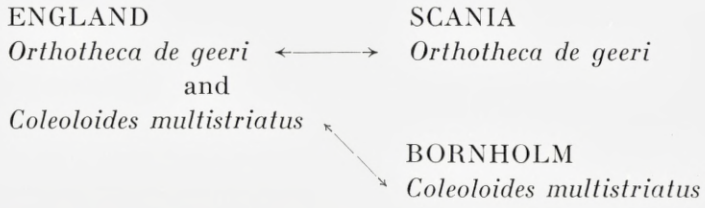
THE STRATIGRAPHIC SIGNIFICANCE OF THE FOSSILS

The occurrence of *Diplocraterion, Tigillites,* and *Skolithos* in the Balka quartzite is in favour of a correlation with the Scanian sandstone, which contains the same trace fossils and which has been referred to the *Mobergella holsti* zone (REGNÉLL 1960), although this guide fossil has never been found in Scanian strata. The Balka quartzite has likewise been referred to the *Mobergella holsti* zone (V. POULSEN 1966), but also here the guide fossil is lacking. It seems probable, as already mentioned, that the Balka quartzite is the stratigraphic equivalent of the Scanian sandstone with *Diplocraterion,* etc., but in the writer's opinion the reference of these rocks to the *Mobergella holsti* zone must be regarded as uncertain on account of the lack of palaeontological evidence.

It has been the practice to correlate the Lower Cambrian siltstone and Rispebjerg sandstone of Bornholm with the *Holmia torelli* zone of Scania (GRÖNWALL 1916; C. POULSEN 1935; HANSEN 1937; C. POULSEN 1942; V. POULSEN 1966). This correlation, however, is based on very unsatisfactory material, the fauna of the siltstone being essentially endemic. Only three species are known from other regions, viz. *Fordilla troyensis* WALCOTT, *Coleoloides multistriatus* COBBOLD, and *Hyolithellus micans* BILLINGS.[1]

[1] GRÖNWALL (1916) mentions the occurrence of *Torellella laevigata* LINNARSSON. The present writer, however, has examined the specimens in question, some of which must be regarded as undeterminable, whereas others proved to be fragments of *Hyolithellus micans* BILLINGS.

Hyolithellus micans appears to have a considerable vertical distribution within the Lower Cambrian, and the stratigraphic range of *Fordilla troyensis* is not yet sufficiently known; accordingly, these widely distributed species are left out of consideration here. *Coleoloides multistriatus* is only known from the Lower Cambrian siltstone of Bornholm and from Lower Cambrian sandy limestone at Hartshill, Warwickshire, England. In the last mentioned locality it is associated with *Orthotheca de geeri* Holm, which is one of the characteristic species of the Scanian *Holmia torelli* zone. *Orthotheca de geeri*, however, has never been found in the Lower Cambrian siltstone of Bornholm, and accordingly the correlation of the siltstone with the *Holmia torelli* zone of Scania is based on very meagre evidence, as shown in the following scheme:



List of Fossils and Localities	Lilleaa 46	Julegaard 58	Læsaa 75	77	82	84
Genus et sp. ind. (cf. *Byronia* Matthew)						
Diplocraterion sp.						
Tigillites sp.						
Skolithos sp.						
Genus et sp. ind. I (cf. *Pyritonema* M'Coy)		+				
– – – – II						
– – – – III						
Fordilla troyensis Walcott	+					
Genus et sp. ind. (pelecypod)	+					
Proplina? *prisca* n. sp.				+		
Pollicina? *cambrica* (Moberg)						
Prosinuites bornholmensis n. g. et n. sp.						
Circotheca sp.	+					
Orthotheca groedbyensis n. sp.						
– *johnstrupi* Holm			+	+	+	
– *pervilis* n. sp.				+		
Trapezotheca? *pistrinensis* n. sp.				+		
Hyolithes balticus n. sp.	+					
– *groenwalli* n. sp.	+					
– *lenticularis* Holm				+		
– *nathorsti* Holm	+			+		+
– sp. I	+					
– – II	+					
– – ind.		+				
Halkieria obliqua n. g. et n. sp.	+					
– *symmetrica* n. sp.						
Hyolithellus micans Billings	+			+		
Coleoloides bornholmensis n. sp.	+					
– *multistriatus* Cobbold						
– *paucistriatus* n. sp.	+					
– *rugosus* n. sp.	+					
Pseudorthotheca danica n. sp.	+					
Glauderia mirabilis n. g. et n. sp.		+				
Halopoa sp.						
Cruziana dispar Linnarsson						

132 —	134 —	137 —	139 —	142 —	Grødbyaa between Grødby and Grammegd.	173 Øleaa	177 —	178 —	191 —	194 —	232 Broens Odde	228 Hundsemyre	229 North of Snogebæk Harbour	230 South of Snogebæk Harbour	Graanakkestuen
															+
												+	+	+	
												+	+	+	
													+		
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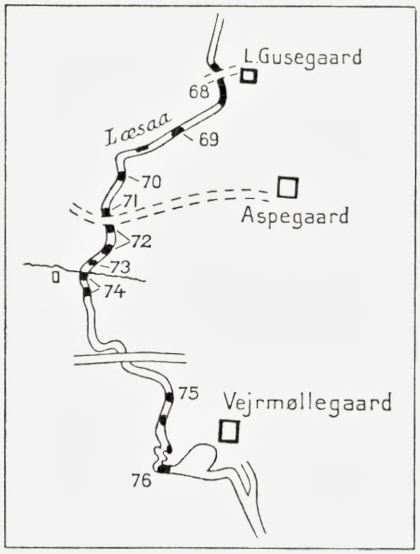

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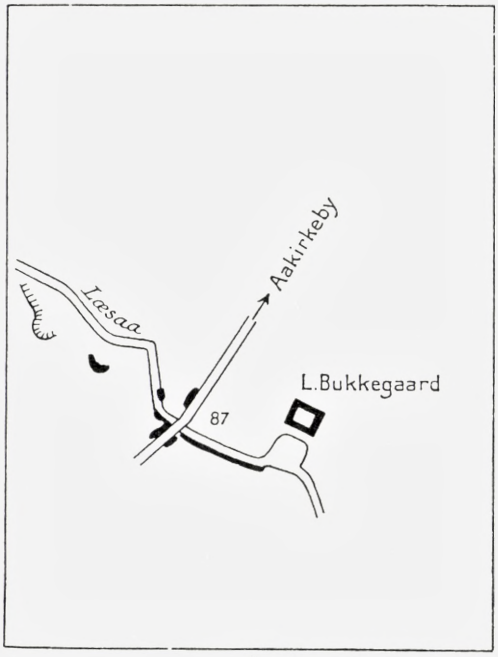

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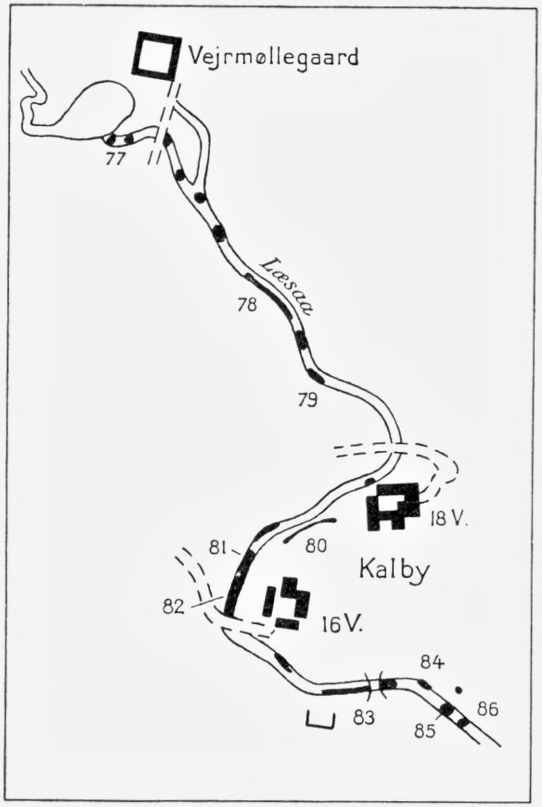

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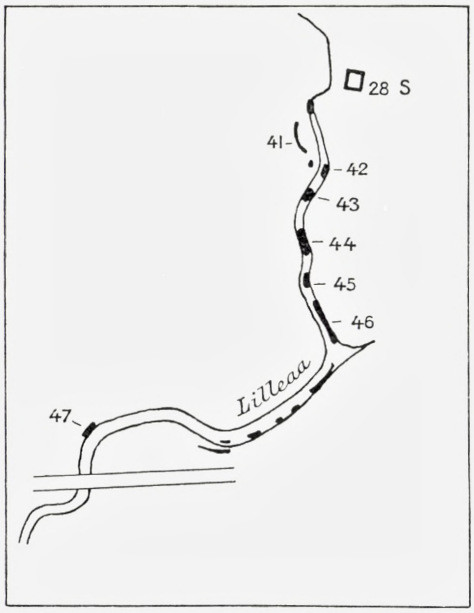

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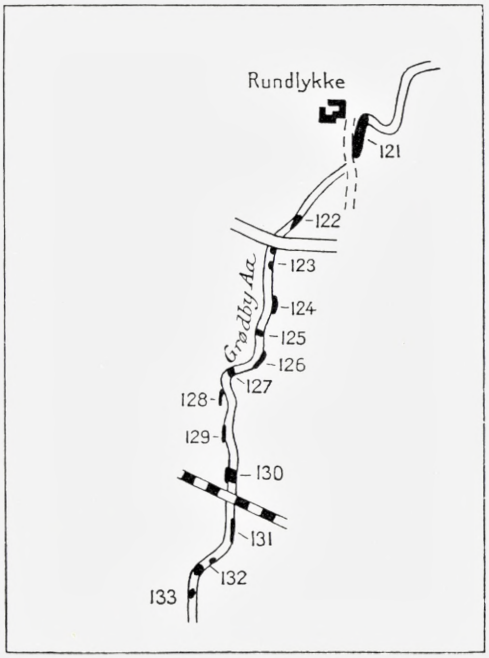
Fig. 7. Outcrops of siltstone along Lilleaa (a) and Læsaa (b–d) (from K. Hansen 1936).



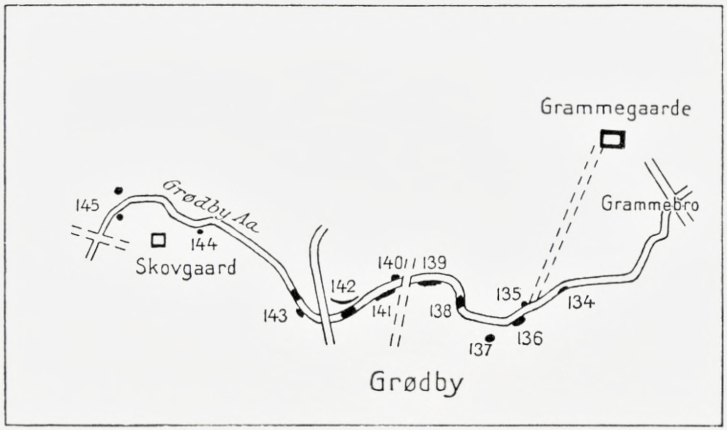


Fig. 8. Outcrops of siltstone along Grødbyaa (from K. HANSEN 1936).

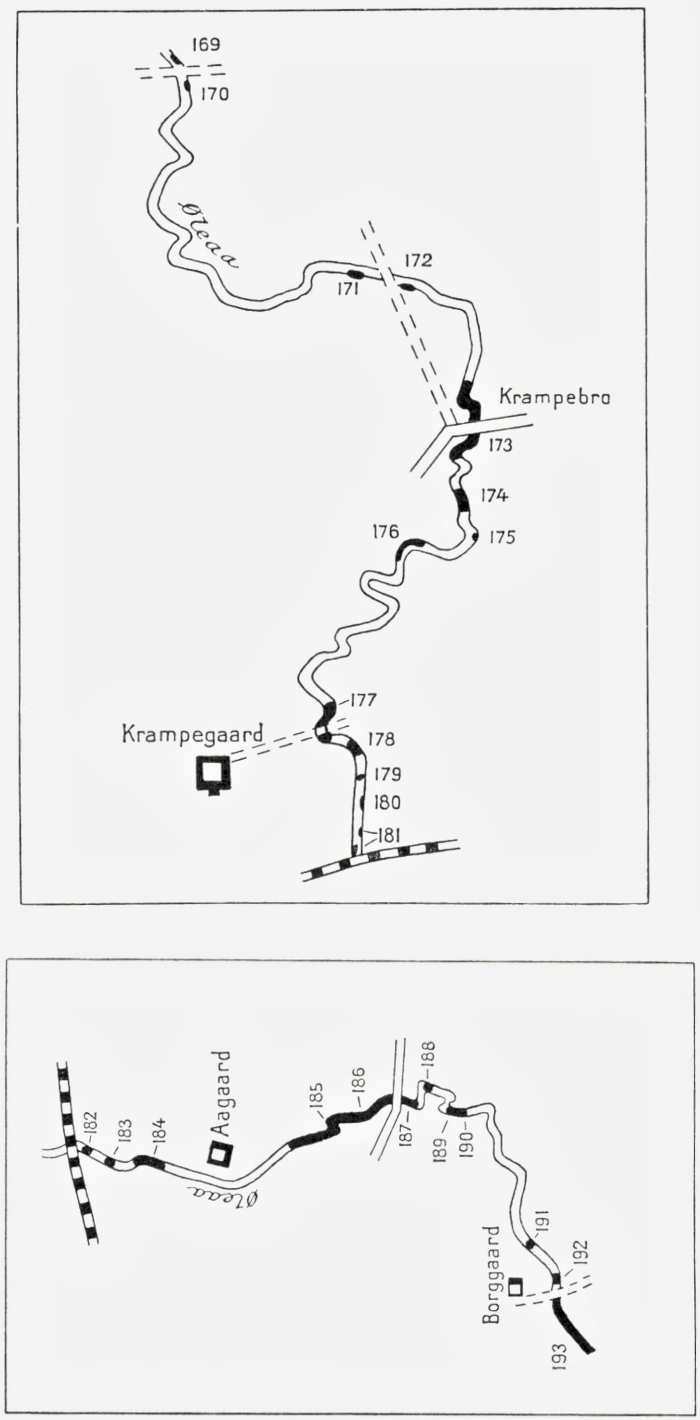


Fig. 9. Outcrops of siltstone along Øleaa (from K. Hansen 1936).

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Indleveret til Selskabet den 1. februar 1967.
Færdig fra trykkeriet den 14. september 1967.

PLATES

PLATE 1

Fig. 1. Genus et species ind. (cf. *Pyritonema*), external mould of hexacts (× 24), Locality 178 (Oleaa). (p. 14).

– 2. Genus et species ind. (cf. *Pyritonema*), hexact (× 24), Locality 139 (Grødbyaa).

– 3. Spicules of indeterminable poriferan genus in the interior of *Hyolithellus* sp. (× 15), Locality 194 (Oleaa). (p. 15).

– 4. Internal mould of indeterminable hyolithid marked by boring organism; cavities contain indeterminable spicules (× 15), Locality 194 (Oleaa). (p. 15).

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PLATE 2

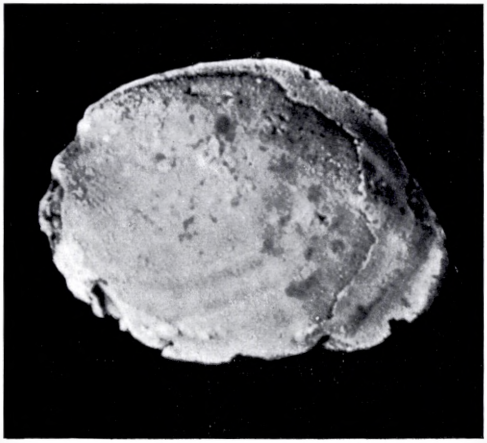
Fig. 1. *Fordilla troyensis* WALCOTT, internal mould (× 16), Locality 139 (Grødbyaa). (p. 15).

– 2. Genus et sp. ind. (pelecypod), internal mould of right valve (× 16), Locality 46 (Lilleaa). (p. 16).

– 3. *Halkieria obliqua* n. g. et n. sp., cast of dorsal side, *holotype*, (× 26), Locality 46 (Lilleaa). (p. 30).

– 4. *Halkieria obliqua*, n. g. et n. sp., cast of ventral side (× 22), Locality 126 (Grødbyaa).

– 5. *Halkieria symmetrica* n. sp., cast, showing part of dorsal exterior and part of ventral interior, *holotype*, (× 22), Locality 126 (Grødbyaa). (p. 30).



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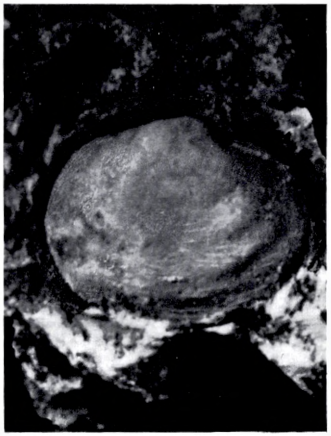

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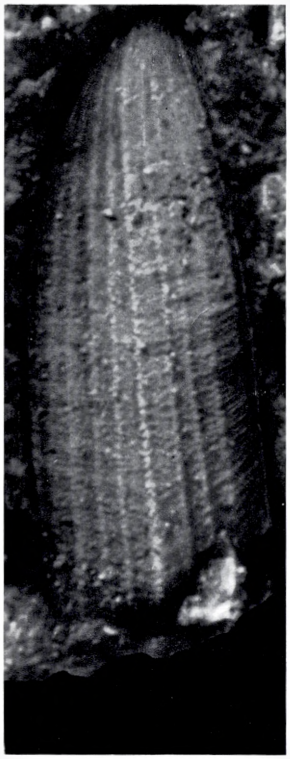

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PLATE 3

Fig. 1. *Proplina*? *prisca* n. sp., cast of external mould, *holotype*, (× 20), Locality 77 (Læsaa). (p, 17).

– 2. *Pollicina*? *cambrica* (MOBERG), specimen figured upside down in order to facilitate comparison with MOBERG's "*Dentalium*? *cambricum*", (× 10), Locality 137 (Grødbyaa). (p. 18).

– 3–9. *Prosinuites bornholmensis* n. g. et n. sp. (p. 19).

– 3–4. Posterior and lateral views of internal mould, (× 6), Locality: the Grødbyaa between Grødby and Grammegaarde.

– 5–7. Lateral, posterior, and anterior views of internal mould, *holotype*, (× 6), Locality: the Grødbyaa between Grødby and Grammegaarde.

– 8. Anterior view of internal mould of specimen with clearly indicated selenizone (× 6), Locality: the Grødbyaa between Grødby and Grammegaarde.

– 9. Half anterior and half top-view of the specimen represented by figs. 3–4, (× 6).

– 10. *Hyolithes balticus* n. sp., ventral view of internal mould, *holotype*, (× 10), Locality 46 (Lilleaa). (p. 23).

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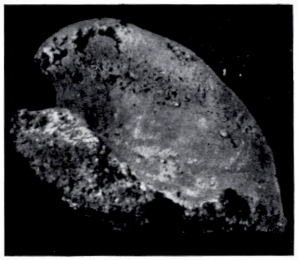

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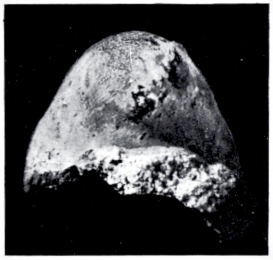

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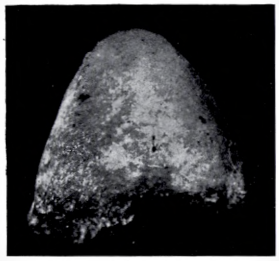

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PLATE 4

Fig. 1. *Hyolithes balticus* n. sp., dorsal view of internal mould, *holotype*, (× 10), Locality 46 (Lilleaa). (p. 23).

– 2–8. *Hyolithes groenwalli* n. sp., fragmentary specimens with partly preserved shell. (p. 24).

– 2–4. *Holotype*, dorsal, ventral, and lateral views, (× 3), Locality: the Grødbyaa between Grødby and Grammegaarde.

– 5–8. Another specimen; 5–6, ventral and dorsal views, (× 3); 7–8, external shell surface of ventral side, (× 24), and dorsal side (× 16); Locality: the Grødbyaa between Grødby and Grammegaarde.

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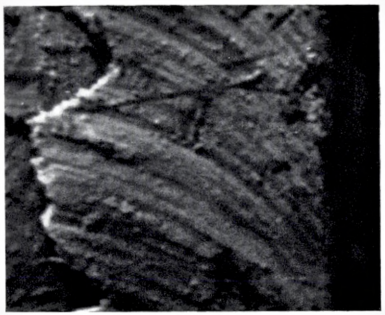

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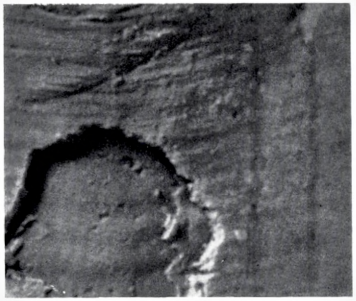

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PLATE 5

Fig. 1–4. Appendages ("supports" and "*Helenia*" of some authors) referred to the associated *Hyolithes groenwalli* n. sp.; Locality: the Grødbyaa between Grødby and Grammegaarde. (p. 24).

– 1. Left Appendage with well developed longitudinal furrow, dorsal view, (× 3).

– 2. Proximal part of the same turned 180° to show transversal lines on external mould of ventral side, (× 18).

– 3. Ventral side of left appendage, showing longitudinal furrows, (× 3).

– 4. Proximal part of the same turned 180° to show transversal lines, (× 18).

– 5–6. Cross sections of *Hyolithes groenwalli* n. sp., (× 3), same specimens as those represented by Pl. 4, figs. 6 and 5, respectively. (p. 24).

– 7. *Hyolithes* sp. II, cast of external mould of the ventral side, (× 12), Locality 46 (Lilleaa). (p. 28).

– 8–9. *Circotheca* sp., Locality 46 (Lilleaa). (p. 20).

– 8. Cast, showing external characters of the shell, (× 7).

– 9. Part of the same (× 18).

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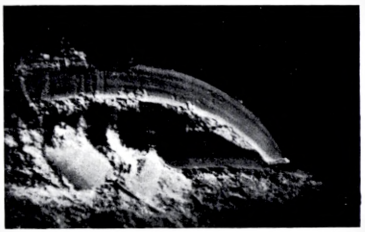

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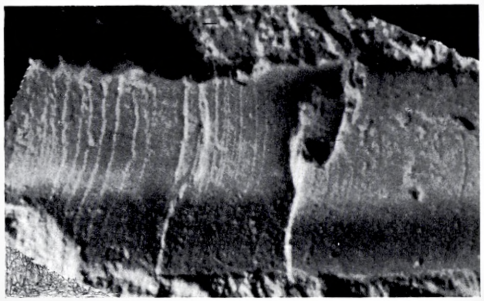

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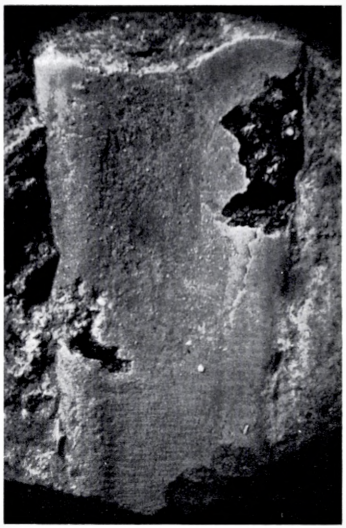
PLATE 6

Fig. 1–2. *Orthotheca pervilis* n. sp., Locality 77 (Læsaa). (p. 21).
– 1. Internal mould, ventral side, *holotype*, (× 6).
– 2. Cross section of the same, (× 6).
– 3–6. *Trapezotheca*? *pistrinensis* n. sp., Locality 77 (Læsaa). (p. 22).
– 3–5. Ventral, dorsal, and lateral views of internal mould, *holotype*, (× 3).
– 6. Cross section of the same, (× 3).
– 7–8. *Orthotheca groedbyensis* n. sp., Locality 137 (Grodbyaa). (p. 20).
– 7. Internal mould, dorsal side, *holotype*, (× 6.5).
– 8. Cross section of the same, (× 6.5).
– 9. Operculum (possibly belonging to *Hyolithes nathorsti* Holm), cast of external mould, (× 7), Locality 46 (Lilleaa). (p. 27).
– 10–11. *Hyolithes* sp. I, internal mould of operculum, topview and lateral view, (× 7), Locality 46 (Lilleaa). (p. 28).



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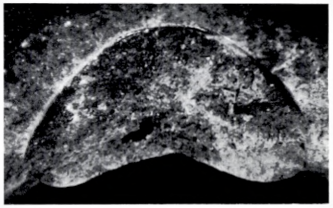

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PLATE 7

Fig. 1–2. *Hyolithellus micans* Billings. (p. 31).

– 1. Cast of external mould, (× 10), Locality 178 (Oleaa).

– 2. Specimen with preserved external surface, (× 10), Locality: the Grødbyaa between Grødby and Grammegaarde.

– 3–4. *Pseudorthotheca danica* n. sp., casts of external moulds, (× 18), Locality 142 (Grødbyaa). (p. 36).
(The specimen represented by fig. 3 is the *holotype*).

– 5. *Glauderia mirabilis* n. g. et n. sp., *holotype*, (× 20), Locality 58 (coast cliff at Julegaard). (p. 37).

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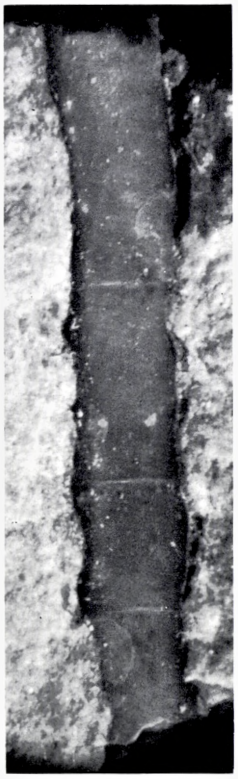

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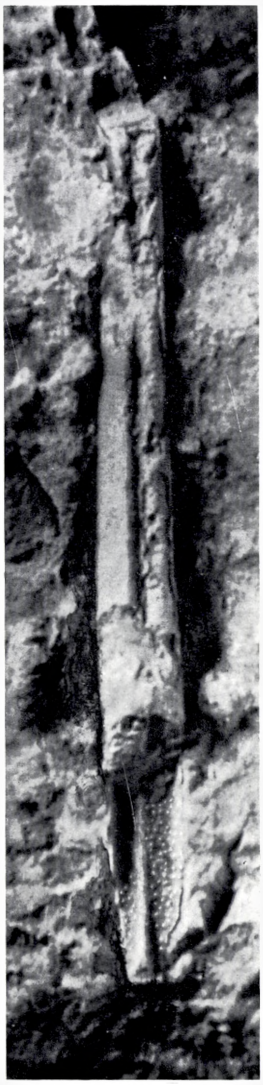

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PLATE 8

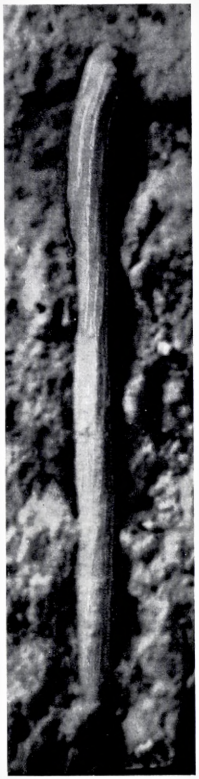
Fig. 1. *Coleoloides paucistriatus* n. sp., cast of external mould, *holotype*, (× 22), Locality 46 (Lilleaa). (p. 35).

– 2. *Coleoloides multistriatus* Cobbold, (× 16), Locality: the Grødbyaa between Grødby and Grammegaarde. (p. 34).

– 3. *Coleoloides bornholmensis* n. sp., cast of external mould, *holotype*, (× 10), Locality 132 (Grødbyaa). (p. 33).

– 4. The same enlarged to × 25 in order to show details of the external surface.

– 5. *Coleoloides rugosus* n. sp., cast of external mould, *holotype*, (× 27), Locality 46 (Lilleaa). (p. 35).



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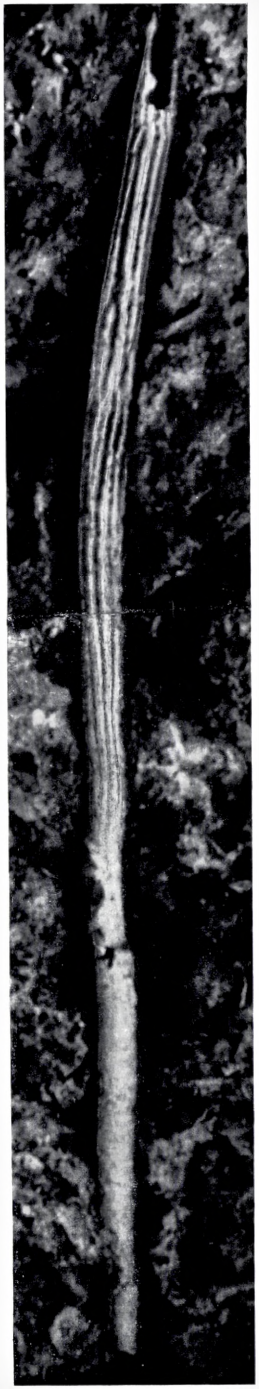

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PLATE 9.

Fig. 1–4. *Coleoloides multistriatus* Cobbold, casts of external moulds of more or less deformed specimens (p. 34).

– 1. Moderately deformed specimen, (× 6), Locality 139 (Grødbyaa).

– 2. The same enlarged × 24 to show the striae.

– 3. Much deformed specimen, (× 25), Locality 139 (Grødbyaa).

– 4. Another much deformed specimen (× 11), Locality 139 (Grødbyaa).

– 5. Genus et sp. ind. (cf. *Byronia* Matthew), (× 2), Locality: Graanakkestuen (p. 13).

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