An Early Ordovician Trilobite Fauna from Bornholm

by

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Contents

Abstract

This paper deals with an early Ordovician (Early Ontikan) trilobite fauna from the basal part of the "Orthoceras limestone" on Bornholm. The Skelbro Limestone Formation is a new name for the basal part, previously known as the Umbonata limestone (C. POULSEN, 1936). A new genus, *Hallanta* (family Styginidae) and 11 new species are erected. The environment is discussed, and it is concluded that the limestone was deposited in shallow water. The assemblage, which contains a total of 25 species, is transitional between the faunas of the *Megistaspis estonica* Zone and the *Megistaspis lata* Zone (sensu JAANUSSON, 1960). It represents a new zone, the *Cyclopyge stigmata* Zone, which is regarded as the oldest zone within the Volkhov Stage (= "Limbata" + Lepidurus limestone). At present no stratigraphical equivalents are known from the Scando-Baltic region.

Acknowledgements

The fossil material from the Skelbro Limestone, which forms the basal part of the "Orthoceras limestone" on Bornholm, consists of trilobites collected by various persons throughout the years 1880–1958. The trilobites described and figured are in the collections of the Mineralogical and Geological Museum of the University of Copenhagen.

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Introduction

The "Orthoceras limestone" was briefly described and discussed by JOHNSTRUP (1891). NØRREGAARD (1907) studied the lithology and mineral content of Ordovician limestones from Bornholm and Sweden. GRÖNWALL (1916)

stated that the limestone on Bornholm was in complete agreement with the "Orthoceras limestone" in Southeast Scania, but then differed somewhat from the almost black limestone at Fågelsång. GRÖNWALL's statements were confirmed by FUNKQUIST (1919).

C. POULSEN (1936) revised the species from the "Orthoceras limestone" after having made additional collections. He divided the limestone into two units, of which the upper one comprised the "Limbata" limestone and lower part of the Asaphus series. The lower unit was named after the abundantly occurring *Cyclopyge umbonata* (= *C. stigmata* n. sp.).

The "Umbonata" limestone supposedly contained a faunal assemblage with relationships to species in older as well as younger beds in Scandinavia and the Baltic region. C. POULSEN concluded that the transitional assemblage indicated that the "Umbonata" limestone represented a specific stratigraphical unit. It was stated that a possible equivalent was to be found at Fågelsång in Scania, where *Cyclopyge umbonata* occurs in the lower part of the "Orthoceras limestone" sequence.

HADDING (1958) described the texture in hand specimens and thin-sections of the Swedish and Danish "Orthoceras limestone". He stated that the pits in the upper discontinuity surface of the "Umbonata" limestone on Bornholm were filled with glauconite grains, phosphorite fragments, and a dense, dark, bituminous and phosphatic substance.

The present writer's own study has shown that *Cyclopyge umbonata* does not occur on Bornholm, and the specimens of *C. "umbonata"* have been assigned to *C. stigmata* n. sp. The basal part of the sequence at Fågelsång, Scania, cannot represent a stratigraphical equivalent.

The Skelbro Limestone Formation is suggested as the formal name for the basal part of the "Orthoceras limestone" on Bornholm. It represents a separate biostratigraphical unit, for which the *Cyclopyge stigmata* Zone would be the appropriate name.

Localities

As part of the Fenno-Scandian border zone Bornholm is intersected by faults. Lower Palaeozoic sediments are preserved in relatively small down-faulted areas in the southern part of the island.

The Skelbro Limestone trilobites described in the present paper originate from two localities: Skelbro at Risebæk, and 400 metres east of Skelbro. The localities represent now abandoned limestone quarries. They are shown on the map, text-fig. 1. The Skelbro Limestone is presently accessible only with difficulty at Skelbro and at Limensgade (not shown on the map), but only few indeterminable fossil fragments have been found at the latter locality.

The limestone is easily recognized in hand specimens on account of the angular, up to three cm long fragments or pebbles of black phosphorite.

Stratigraphy

Introduction

C. POULSEN (1936) established the lower part of the "Orthoceras limestone" on Bornholm as a separate unit which was named the Umbonata limestone after the commonly occurring *Cyclopyge* which was supposed to be identical with *C. umbonata*. This species is common in the lower part of the "Orthoceras

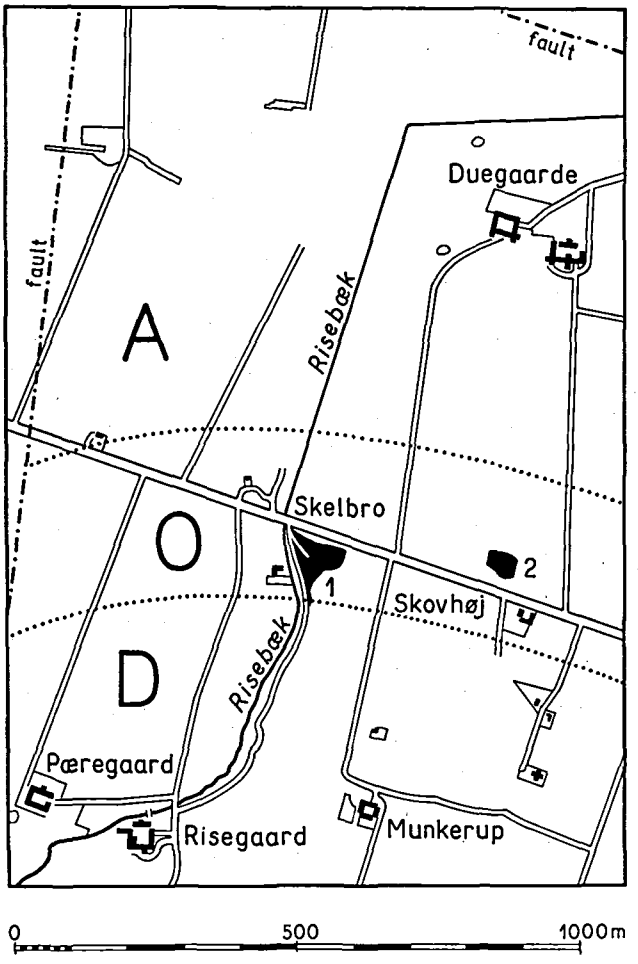

Fig. 1. Location of the two quarries from which the trilobites of the Skelbro Limestone originate.
The map shows part of a fault block. O = "Orthoceras limestone". D = Dicellograptus shales. A = Middle and Upper Cambrian alum shales. 1 = Skelbro. 2 = 400 metres east of Skelbro.

limestone" at Fågelsång in Scania, and it was suggested that the beds at Skelbro and Fågelsång might be stratigraphical equivalents.

The reason for separating the basal part of the limestone as a unit apart from the rest of the sequence was the mixed assemblage of trilobites. The fauna included species known from the Planilimbata limestone and species known from the "Limbata" limestone and lower part of the Asaphus series.

The present writer demonstrates (pp. 81–82) that *Cyclopyge umbonata* does not occur in the sequence on Bornholm. The specimens represent a new species,

Cyclopyge stigmata. All the specimens from Fågelsång belong to *C. umbonata*, and the associated trilobite species from that locality suggest a level considerably younger than early Volkhovian. Thus the basal part of the limestone at Skelbro and Fågelsång cannot be contemporaneous.

The stratigraphical divisions of the Scandinavian and Baltic Lower Ordovician have been revised and changed considerably within the last few years. Especially JAANUSSON (1960a, b) has advocated the necessity of distinguishing between chrono-stratigraphical, litho-stratigraphical, and bio-stratigraphical units.

The classification used in the present paper is in accordance with JAANUSSON (1960a, b) with the exception that an additional zone, the *Cyclopyge stigmata* Zone, has been added to the Volkhov Stage as the oldest unit (see text-fig. 2).

Previously the entire Ontikan sequence of limestones on Bornholm was known as the "Orthoceras limestone". However, this term has been applied to Swedish limestones ranging from Ontikan to Viruan, and new, objective stratigraphical units must be established.

JAANUSSON (1960a, p. 300) introduced the Komstad Formation to comprise the Scanian limestones between the Lower and Upper Didymograptus Shale. The faunal content of the Komstad Formation has not yet been studied in detail, but it is very likely that the upper part of the "Orthoceras limestone" on Bornholm faunistically and lithologically falls within the limits of this formation. The Komstad Formation on Bornholm probably comprises the zones of *Asaphus lepidurus* and *A. expansus* (Langevoj and Hunderum Substages).

The basal part of the "Orthoceras limestone" on Bornholm is without any lithological Baltoscandian equivalents, and the Skelbro Limestone Formation is here introduced as the formal name for this unit.

The Skelbro Limestone Formation

Type locality. – Old limestone quarry at Skelbro, Risebæk (loc. 1 on the map, text-fig. 1). At present the formation is not exposed. It is delimited vertically by the underlying Dictyonema Shale and the overlying Komstad Limestone. The locality is part of a fault block, the strata of which dip about 5° ssw.

Stratigraphical position. – The main part of the Skelbro Limestone belongs to the *Cyclopyge stigmata* Zone (new name) which is the lowermost zone of the Volkhov Stage. The conglomerate forming the basal part of the limestone and delimited by a discontinuity surface has not yielded any fossils and is arbitrarily placed in the same zone.

Lithology. – The lithology of the Skelbro Limestone has not yet been studied in detail due to the lack of suitable exposures with complete sections.

The Skelbro Limestone consists of 12 cm of conglomeratic limestone with pebbles of phosphorite overlain by about 30 cm of limestone in layers of calcilutite, calcarenite, and "calcisiltite" which is rather homogeneous and with a grain size belonging to the silt fraction.

The upper part of the Dictyonema Shale is impregnated with phoshporite and fragments of this form the pebbles which entirely outweigh the light-grey limestone matrix in the basal part of the overlying conglomerate. Upwards the

SERIES	SUBSERIES	CHRONO-STRATIGRAPHY OF BALTOSCANDIAN LIMESTONES		PREVIOUS DIVISIONS ("STAGES")	TRILOBITE ZONES
		STAGE	SUBSTAGE		
OELANDIAN	ONTIKAN	KUNDAN	ALUOJAN	VAGINATUM LIMESTONE	Megistaspis gigas
					Megistaspis obtusicauda
			VALASTEAN		Asaphus raniceps
			HUNDERUMIAN		Asaphus expansus
		VOLKHOVIAN	LANGEVOJAN	LEPIDURUS LIMESTONE	Asaphus lepidurus
				"LIMBATA" LIMESTONE	?
					Megistaspis lata
					Cyclopyge stigmata
		LATORPIAN	BILLINGENIAN	PLANILIMBATA LIMESTONE	Megistaspis estonica
					Megalaspides dalecarlicus
			HUNNE-BERGIAN		Megistaspis planilimbata
					Megistaspis armata
	TREMA-DOCIAN			CERATOPYGE LIMESTONE	Apatokephalus serratus

Fig. 2. Divisions of the Baltoscandian early Ordovician limestones. Mainly after JAANUSSON 1960.

conglomerate gradually passes into grey limestone with scattered phosphorite pebbles and a notable content of glauconite and mostly epigenetic pyrite. Thus there is no lithological difference between the matrix of the conglomerate and the Skelbro Limestone. Fossils have not been found in the groundmass of the conglomerate.

The Skelbro Limestone also contains scattered pebbles of phosphorite which in a few instances tend to be concentrated at distinct horizons.

Several discontinuity surfaces are present, and thus the basal conglomerate is terminated by a surface with small and shallow, irregular pits outlined by a thin brown mineralized crust presumably pyritiferous. A second discontinuity surface just below the upper one shows equally spaced tubules extending one to two cm down into the conglomerate. The straight tubules are about five mm in diameter and have a rounded bottom. This surface seems to be accompanied by a phosphatic impregnation or stain.

At least one discontinuity surface with tubules, but without a mineralized crust is to be found within a calcilutite layer in the Skelbro Limestone, and the upper boundary of the limestone is a pitted surface much like the upper surface of the subjacent conglomerate. The pits in the discontinuity surface at the top of the Skelbro Limestone have a black crust which, according to HADDING (1958, p. 182), consists of a bituminous and phosphatic substance with glauconite grains and phosphorite fragments.

Judging from the hand specimens the Skelbro Limestone contains horizons of dense calcilutite with few trilobite fragments, calcarenite which is rich in trilobites, and "calcisiltite" which has not previously been recorded from the "Orthoceras limestone" in the Scando-Baltic region.

Discussion. – The Skelbro Limestone Formation appears as a distinctive unit even if the lithology has not been studied in detail. Thus the phosphorite pebbles and the "calcilutite" component indicate specific conditions of sedimentation.

The faunal evidence indicates that the hiatus between the *Megistaspis estonica* Zone and the *M. lata* Zone is considerable. The hiatus has been interrupted by a small transgression which only left deposits on Bornholm. The lithology of the Skelbro Limestone suggests that the deposition took place in shallow water possibly not far from the coast.

Fine-grained allochthonous elements may have been transported out to the sea from nearby land areas by the wind.

The age of the trilobite fauna

The twenty-five trilobite species from the Skelbro Limestone may be placed in four groups. One group comprises the species which for different reasons cannot contribute to solve the question of the age of the fauna. The second group includes species with affinities to the fauna of the Latorp Stage. The third group is composed of species with affinities to the fauna of the Volkhov Stage. The fourth group comprises species which in other regions range across the boundary between the two stages.

At present the following species are without stratigraphical significance:

Celmus? *longifrons* n. sp.
Cyclopyge stigmata n. sp.
Genus et species indet. no. 1
– – – – no. 2
Hallanta modesta n. gen. et n. sp.

Metaptychopyge? sp. indet.
Metopolichas? sp. indet.
Symphysurina? sp.
Trinucleoides praecursor n. sp.

Celmus? *longifrons* n. sp. and *Trinucleoides praecursor* n. sp. are both believed to be representatives of considerably younger genera. The new species of *Trinucleoides* is the first to be recorded apart from the Bohemian type species which is of Llanvirnian age. The Celmidae only contains *Celmus*, and the variations at the generic level are unknown. *Celmus*? *longifrons* n. sp. is only hesitantly included in the Celmidae, and it probably represents a new genus. *Cyclopyge stigmata* n. sp. is probably more closely related to the Scanian *C. umbonata umbonata* from the *Asaphus expansus* Zone than to any other species of *Cyclopyge*, but at the same time shows occipital structures which are unique within the Cyclopygidae. *Cyclopyge stigmata* n. sp. is the predominant member of the assemblage and has been chosen to designate the new zone. *Hallanta* n. gen. is only known from the Skelbro Limestone, although it seems to be related to a Scanian species from the Komstad Limestone (see discussion p. 83). The pygidial fragment of *Metaptychopyge*? sp. indet. cannot provide any reliable information. The fragment is possibly identical with the species from the Lower *Didymograptus* Zone ($3b_{\gamma-\delta}$) described by SKJESETH (1952, pp. 166–167, pl. 3, fig. 1–8) as *Ptychopyge herambensis*. *Metopolichas*? sp. indet. may or may not be related to *Metopolichas*? sp. from the Planilimbata or "Limbata" level on Öland. *Symphysurina*? sp. belongs to an unsatisfactorily defined genus which evidently ranges from the *Apatokephalus serratus* Zone into the *Megistaspis lata* Zone. The genus apparently is absent in Sweden in the Billingen Substage, but returns in the Volkhov Stage in Närke, where it is represented by a very small species. The specimen of *Symphysurina*? from Skelbro is somewhat larger and strongly resembles *Symphysurina*? *oriens* (MOBERG & SEGERBERG, 1906) from the Ceratopyge limestone. Thus it is not known, whether the Skelbro specimen represents an old or a young type.

The following species are known from the Latorp Stage or are closely related to species from this stage:

Ampyx glaber n. sp.
Geragnostus danicus n. sp.
Harpides nodorugosus n. sp.
Pseudosphaerexochus (*Pateraspis*) *inflatus* n. sp.
Remopleuridiella groenwalli n. sp.
Selenoharpes excavatus (LINNARSSON, 1875).

Species of *Ampyx* have not been thoroughly analysed, and nothing is known of the relationships of *Ampyx glaber* n. sp. The new species may be related to *A. volborthi* SCHMIDT, 1894. *Ampyx glaber* n. sp. is also occurring in the upper part of the Lower *Didymograptus* Zone in Norway. *Geragnostus danicus* n. sp. in some respects resembles *G. wimani* TJERNVIK, 1956 from the *Megistaspis planilimbata* Zone, but differs slightly in pygidial morphology. The pygidium of *Trinodus* aff. *glabratus* from the upper part of the Lower *Didymograptus* Zone figured by SKJESETH (1952, pl. 4, fig. 18) may be conspecific with the

species from Skelbro and is at least closely related. *Harpides nodorugosus* n. sp. is fairly closely related to the Tremadocian *Harpides rugosus* (SARS & BOECK, 1838), but shows important differences in the occipital region. The Skelbro species is found in Sweden in the upper part of the *Megistaspis estonica* Zone. On the other hand no Swedish species of *Harpides* are known to range onto the *Megistaspis lata* Zone. The subgenus *Pateraspis* has hitherto only been recorded from Bohemia, but *Pseudosphaerexochus praecursor* described from the Planilimbata limestone on Öland by REGNÉLL (1940, p. 5, p. 1, figs. 6a–c) undoubtedly belongs to subgenus *Pateraspis* and is probably closely related to *Pseudosphaerexochus* (*Pateraspis*) *inflatus* n. sp. from Skelbro. *Remopleuridiella groenwalli* n. sp. seems to occur in the upper part of the Lower *Didymograptus* Zone at Ringsaker in Norway. The holotype of *Selenoharpes excavatus* (LINNARSSON, 1875) originated from the *Megalaspides dalecarlicus* Zone in Närke, and this species evidently is an old element in the Skelbro Limestone assemblage.

Thr following species are known from the Volkhov Stage or are closely related to species from this stage:

Megistaspis (*Megistaspis*) cf. *lata* (TÖRNQUIST, 1884)
– – sp. no. 1
– – sp. no. 2
Paraptychopyge sp.
Raymondaspis imparilis n. sp.
Symphysurus (*Symphysurus*) *dorsatus* n. sp.

Species of *Paraptychopyge* make their first appearance in early Volkhovian, and species of *Megistaspis* (*Megistaspis*) have not previously been recorded from levels below the *Megistaspis lata* Zone. The *Megistaspis* pygidia from the Skelbro Limestone all show the characteristic triangular or parabolic outline, well-defined distinctly furrowed pleural ribs, and the two anterior axial rings are accentuated by deeply impressed ring furrows. *Raymondaspis* has a long vertical range, but after having seen the material collected in Närke by TJERNVIK the present writer is convinced that the pygidium of *Raymondaspis imparilis* n. sp. with regard to convexity, outline, and especially the morphology of the axis seems to be most closely related to Swedish species from the *Megistaspis lata* Zone. *Symphysurus* (*Symphysurus*) *dorsatus* n. sp. approaches *S.* (*S.*) *palpebrosus* with regard to the cephalic terrace lines and the cephalic and glabellar length/width ratio. In these respects the new species can be said to represent a young element in the assemblage.

The last group of trilobite species, which are known from the Latorp Stage as well as from the Volkhov Stage, comprises:

Cyrtometopus sp.
Nileus exarmatus TJERNVIK, 1956
Niobella imparilimbata (BOHLIN, 1955)
Raymondaspis limbata (ANGELIN, 1854).

Cranidia of *Cyrtometopus* are difficult to assign to species. The cranidium from Skelbro apparently is identical to that of *Cyrtometopus priscus* TJERNVIK, 1956 from the *Megistaspis estonica* Zone, but TJERNVIK has found exactly the

same type of cranidia in the *Megistaspis lata* Zone in Närke, and a specific assignment is not yet possible. *Nileus exarmatus* TJERNVIK, 1956 is a very important species in the assemblage. TJERNVIK's investigations seem to show that the evolution of the different *Nileus* species follows characteristic trends which may be extremely important for the stratigraphical divisions of the Volkhov Stage. *Nileus exarmatus* makes its first appearance in the upper part of the *Megistaspis planilimbata* Zone, becomes very common in the succeeding zones of *Megalaspides dalecarlicus* and *Megistaspis estonica*, and is still found in the *Megistaspis lata* Zone. All the specimens of this species from the Latorp Stage are characterized by the presence of a few scattered terrace lines which are developed in the lateral portions of the cephalon and pygidium. Specimens of *Nileus exarmatus* from the *Megistaspis lata* Zone are distinguished by the extremely fine and very closely situated terrace lines which cover the cephala and pygidia. The test is preserved in one of the nileid pygidia from Skelbro, and this specimen shows the fine striation characteristic of the Volkhovian material. The holotype of *Niobella imparilimbata* (BOHLIN, 1955) is a pygidium from the lower part of the "Limbata" limestone on Öland. The present writer believes that the holotype represents the extreme transverse end of the range of variation. Some of the pygidia from the Skelbro Limestone approach the length/width ratio of the holotype, while the remaining ones are identical with the species described by TJERNVIK as *Niobella* sp. aff. *imparilimbata* which here is included in *N. imparilimbata*. The species *imparilimbata* thus ranges from the *Megalaspides dalecarlicus* Zone into the *Megistaspis lata* Zone. *Raymondaspis limbata* (ANGELIN, 1854) is undoubtedly most frequently occurring in the Billingen Substage, but has been reported from the "Limbata" limestone in Sweden by various authors.

It is interesting that early representatives of *Trinucleoides* and *Pateraspis*, which were previously believed to be exclusively Bohemian forms, occur in southern Scandinavia. Referring to similarities between *Pliomerops actinura* (DALMAN) and the Bohemian *Pliomerops senilis* (BARRANDE) REGNÉLL (1940, p. 11) suggested that a communication must have existed between the Baltic and Bohemian seas in the early Ordovician. The occurrence of *Trinucleoides* and *Pateraspis* seems to support that suggestion.

It will appear from the discussion above that the Skelbro Limestone contains an assemblage of trilobite species indicating a position somewhere between the zones of *Megistaspis estonica* and *M. lata*, but an assignment to one of these two zones is not possible. The present writer is of the opinion that the occurrence of *Paraptychopyge*, *Megistaspis* (*Megistaspis*), and the densely striated *Nileus exarmatus* deserves special attention. It is concluded that the Skelbro Limestone should be placed as the oldest unit within the Volkhov Stage (no name available for lower substage) rather than as the youngest unit within the Billingen Substage. The new unit would most conveniently rank as a zone, for which the *Cyclopyge stigmata* Zone would be the appropriate name.

In Sweden the faunal change from the *Megistaspis estonica* Zone to the *M. lata* Zone is very abrupt, and the hiatus between these two zones represents a considerable time interval. The *Cyclopyge stigmata* Zone probably corresponds to only a part of the hiatus. The transgression, which reached Bornholm, was of short duration, and the sea was then inhabited by a "mixed" assemblage

composed of the remaining of the old elements and the first of the young elements which were to dominate in the Volkhov Stage. Then the sea withdrew completely, and when it returned to Baltoscandia to deposit the "Limbata" limestone the majority of the old fauna elements had disappeared.

The uppermost part of the Lower *Didymograptus* Zone (= upper part of 3bC; ERDTMANN – in press) at Heramb in Norway shows some relationship to the *Cyclopyge stigmata* Zone. This conclusion is based on the Norwegian specimens of *Geragnostus danicus* n. sp.?, *Nileus exarmatus*, *Ampyx glaber* n. sp., *Remopleuridiella groenwalli* n. sp., and *Megistaspis* (*Megistaspis*) *polyphemus*.

The Environment

The trilobites in the Skelbro Limestone are almost exclusively represented by exuviae or fragments. Complete exoskeletons include two enrolled specimens of *Symphysurus* (*Symphysurus*) *dorsatus* n. sp. and one outstretched specimen of *Nileus exarmatus* TJERNVIK. Additional enrolled specimens of these two species from the Skelbro Limestone are in the collections of the Palaeontological Institution of Uppsala. The outstretched specimen indicates orientation of life rather than of death, and quick burial rather than extreme tranquility of the water.

Two species, *Cyclopyge stigmata* n. sp. and *Ampyx glaber* n. sp., occur abundantly and are to be found in practically all the hand specimens. The two species are represented by up to ten times the number of specimens of any of the other species. The larger forms like *Megistaspis*, *Metopolichas*?, and *Paraptychopyge* are represented only by their pygidia, and these may possibly have been transported to the place of deposition floating at the surface of the sea. A few imperfectly preserved brachiopods are seen in the Skelbro Limestone, and certain layers contain a fair amount of ostracodes (*Rigidella*, *Tallinellina*, *Aulacopsis* and others which are to be described in a future paper).

BOHLIN (1949, p. 560, and 1955, p. 118) discussed the significance of the random orientation of the fossils in Ordovician limestones. He concluded that limestones with this type of fossil orientation were laid down within a very short time, "probably within a few hours". It was assumed that such a limestone bed was composed of material which was carried away by the water during a violent storm or some other natural catastrophe and then rapidly settled on the bottom. Trilobites and other fossils were swept away at the same time; they sank to the bottom and were locked between the comparatively large sediment particles forming the matrix, and fixed in the position in which they happened to have been swept down to the bottom.

The writer believes that the random orientation of the fossils in the Skelbro Limestone may have been initiated by organic agencies, as scavengers and other animals tilted the fragments and pushed them down into the still soft bottom. It is characteristic that the Skelbro Limestone show no or practically no sorting of the components. The limestone is build up by a mixture of large fossil fragments, small fragments, material of the lutite fraction, phosphorite pebbles, and glauconite. The sediment is to a large extent allochthonous, but

the material most likely originated from the vicinity of the place of final deposition, as the sand fraction mainly is constituted by shell debris from the disintegration of the fossils by other animals. The undistorted fossils indicate that the limestone has not been seriously compacted.

The structure of the discontinuity surfaces in the Ordovician limestones indicates that the sea bottom in many instances must have been lithified before deposition of the next bed took place. Upon the hard and smooth limestone floor the subsequently deposited loose carbonate sediment could easily be moved back and forth by currents and storms and be in part transported into deeper parts of the basin or to places with tranquil water (JAANUSSON 1961, p. 233). There is reason to believe that fossils and sediment particles in this manner could be shifted back and forth occasionally without being notably abraded; the fossils would be well protected by the surrounding calcareous mud. Finally, lithification stopped the migration of the sediment.

The conditions discussed above seem to be applicable to the formation of the Skelbro Limestone. It seems likely that the sea bottom was tilted a few degrees at the initiation of an emergence, and the loose material would be set into movement as a gentle mud flow which also picked up the phosphorite pebbles and glauconite from the underlying beds. The material was not subject to a long transportation and the fossils were protected against abrasion by the viscous mud. The fairly large number of trilobites species indicates a mixture of originally stratigraphically separate faunules.

The coast may not have been far away, and allochthonous elements like fine sand and clay may have been brought to the sea by the wind.

The upper discontinuity surface in the Skelbro Limestone was briefly described by NØRREGAARD (1907) and HADDING (1958). The lack of suitable exposures prevents a detailed discussion on the origin of discontinuity surfaces. The problems related to their formation have been summarized by JAANUSSON (1961). It is generally assumed that the discontinuity surfaces were lithified prior to the deposition of the overlying bed. JAANUSSON concluded that the lithification most likely took place during periods of emergence and it was followed by solution of calciumcarbonate and formation of a thin residual soil. During subsequent submergence the residual soil was removed, slight abrasion affected the drowned surface, and boring organisms might attack the limestone.

LINDSTRÖM (1963) described discontinuity surfaces and their relation to supposed sedimentary folds from the early Ordovician sections in Västergötland and on Öland. Different structures caused LINDSTRÖM to conclude that the discontinuity surfaces were formed when the limestone was submerged, and in view of the estimated slow rate of sedimentation he suggested that deposition took place at a depth of one to a few hundred metres. LINDSTRÖM further stated that whatever fluctuations did occur, the very fact that the "folds" were preserved indicated that the sea bottom was not laid bare.

The present writer's material does not throw any light on the probability of submarine lithification and solution. However, it is believed that the lithology and the fauna of the Skelbro Limestone indicate deposition in shallow water, and the limestone was deposited within a very short time as a mud flow which was lithified during the rapidly following emergence.

The Ordovician sequence on Bornholm is rather incomplete, and the developed parts are usually thinner than in neighbouring regions. Probably as a consequence of activity along the faults in the border zone Bornholm was emerged for considerable lengths of time. These conditions seem to be more consistent with the concept of a shallow water environment, and the discontinuity surfaces in the Skelbro Limestone may thus well have been formed during periods of emergence.

Descriptions of Genera and Species

Class **Trilobita** WALCH, 1771

Order Agnostida KOBAYASHI, 1935

Suborder Agnostina SALTER, 1864

Family **Geragnostidae** HOWELL, 1935

Genus *Geragnostus* HOWELL, 1935

Type species: *Agnostus sidenbladhi* LINNARSSON, 1869.

Geragnostus danicus n. sp.
Pl. 1, figs. 1–3.

1936 *Trinodus lentiformis* (ANG.). – C. POULSEN: Ordovizium von Bornholm, p. 49. (Listed).
1936 — n. sp. aff. *tardus* (BARR.). – C. POULSEN: Ordovizium von Bornholm, p. 49. (Listed).
?1952 — aff. *glabratus* (ANGELIN). – SKJESETH: Lower Didymograptus Zone, p. 157, pl. 4, fig. 18. (Description and fig. of pygidium).

Derivation of name. – Latin *danicus* = Danish.

Holotype (here selected). – Internal mould of pygidium (MMH no. 9417), pl. 1, fig. 1.

Other material. – One cephalon, one pygidium, and six internal moulds of pygidia.

Horizon and locality. – *Cyclopyge stigmata* Zone; quarry at Skelbro, Risebæk.

Diagnosis. – Shields highly convex. Faint transverse glabellar furrow in front of elongate median tubercle. Glabella slightly constricted opposite midpoint. Cephalic border strongly down-sloping postero-laterally. Pygidial axis consisting of two rings and terminal piece, half the length of pygidium, with median keel partly outlined by disconnected anterior ring furrow, second ring furrow transaxial; short terminal axial piece with flat diamond-shaped tubercle which posteriorly protudes into axial furrow. Marginal spines poorly developed.

Description. – The shields are rather highly convex. Cephalon is about as wide as long, sub-quadrate in outline. Glabella is about two-thirds the length of cephalon and about half the width at base, with a slight and narrow constriction opposite midpoint, tapering forwards, gently rounded anteriorly. The low frontal lobe of glabella is delimited by an indistinct transverse furrow which is situated somewhat in front of the constriction, curving backwards

mesially; the main lobe is more convex, with an elongate median tubercle reaching transverse furrow; the basal lobes are broadly triangular, meeting behind glabella. Axial furrows and preglabellar furrow are moderately wide, well-impressed. The genae are steeply down-sloping laterally, almost overhanging cephalic border postero-laterally, anteriorly moderately down-sloping. Border furrow is shallow throughout, almost effaced in front of glabella; the essentially flat cephalic border is of uniform width, strongly down-sloping postero-laterally, anteriorly less so. Postero-lateral corners of cephalon are softly rounded; anterior margin of cephalon is evenly curved.

The pygidium is highly convex, sub-semicircular in outline. Extremely small marginal spines are displayed by a single specimen, whereas the others (internal moulds) do not show any trace of spines. The axis is about half the length of the pygidium. The two anterior axial rings are tapering backwards; the short terminal axial piece is almost parallel-sided, gently rounded posteriorly. The ring furrows are shallow, but distinct. A median keel, which is low on first ring and rising into an elongate tubercle on second ring, disconnects anterior ring furrow, the two sections of which turn in forward direction mesially, outlining the keel, joining the wide articulating furrow. The forward-curving posterior ring furrow touches posterior end of the median keel, and it delimits a second axial ring which is somewhat longer than anterior ring. The terminal axial piece is low, at its rear extremity provided with a low and rather indistinct diamond-shaped tubercle, the posterior end of which protudes into the shallow postaxial part of the otherwise well-impressed axial furrows. The confluent pleural fields are sub-equal in width throughout, strongly down-sloping antero-laterally, moderately so posteriorly. Pygidial border is essentially flat; marginal spines (when present) are diminutive; border furrow is wide and shallow, better impressed behind the articulating facets.

Thoracic segments are unknown.

The surface of both shields is apparently smooth.

Dimensions. – Length of cephalon (MMH no. 9419, pl. 1, fig. 3) 2.7 mm, width at base about 2.4 mm; length of holotype pygidium (pl. 1, fig. 1) including articulating half ring 4.0 mm, width about 3.7 mm.

Affinities. – The most conspicuous feature in *Geragnostus danicus* n. sp. is the very short pygidial axis which is only half the length of the pygidium. In this respect the pygidium resembles that of *Trinodus* M'COY, 1846. Species of *Geragnostus* are characterized by possessing a pygidial axis, the first two rings of which are tapering backwards, whereas the terminal piece is often parallel-sided, thus making the whole axis appear concave-sided. In *Trinodus* the terminal axial piece is rather strongly tapering, and the axis appears as being convex-sided. Despite the short terminal axial piece the new species clearly shows a concave-sided pygidial axis, and the specimens, which C. POULSEN referred to *Trinodus*, are transferred to *Geragnostus*. All the specimens seem to belong to the same species.

The associated cephalon is apparently without well-defined specific diagnostic features. It strongly resembles that of *Geragnostus wimani* TJERNVIK, but the genae of the Danish species are steeper posteriorly. The transverse glabellar furrow is very faint in *G. danicus* n. sp. This may be related to the state of preservation. The cephalon differs from that of the type species, *G. sidenbladhi*

(LINNARSSON), in the more posterior position of the median tubercle, and in the transverse furrow being shallower. It differs from that of *G. crassus* TJERNVIK in possessing a narrower cephalic border, and from that of *G. lepidus* TJERNVIK in having a more pronounced median tubercle.

The pygidium of *Geragnostus danicus* n. sp. is readily distinguished from those of *G. sidenbladhi*, *G. crassus*, *G. lepidus*, and *G.? explanatus* TJERNVIK by the more strongly tapering axis. In this respect it strongly resembles *Geragnostus wimani*, but again differs in having an extremely short terminal axial piece.

The pygidium of *Trinodus* aff. *glabratus* (ANGELIN) figured by SKJESETH (1952, pl. 4, fig. 18) resembles that of *Geragnostus danicus* n. sp. and may be conspecific. A minor difference is to be found in the proportions of the terminal axial piece which in SKJESETH's specimen seems to be slightly smaller.

Order Ptychopariida SWINNERTON, 1915

Suborder Ptychopariina RICHTER, 1933

Family **Remopleurididae** HAWLE & CORDA, 1847

Genus *Remopleuridiella* ROSS, 1951

Type species: *Remopleuridiella caudalimbata* ROSS, 1951.

Remopleuridiella groenwalli n. sp.

Pl. 1, fig. 4.

1936 *Remopleurides* n. sp. – C. POULSEN: Ordovizium von Bornholm, p. 49. (Listed).

?1952 — aff. *nanus* V. LEUCHT. – SKJESETH: Lower Didymograptus Zone, p. 157, pl. 5, figs. 4a, 6, 10. (Description and figs. of cranidia).

?1956 *Remopleuridiella* sp. no. 2. – TJERNVIK: Early Ordovician of Sweden, p. 204. (Description of cephalon and pygidium).

Derivation of name. – The species is named in honour of the late Dr. K. A. GRÖNWALL of the University of Lund, Sweden.

Holotype (here selected). – Internal mould of cranidium (MMH no. 9420), p. 1, fig. 4. This is the only known specimen from Bornholm.

Horizon and locality. – *Cyclopyge stigmata* Zone; quarry at Skelbro, Risebæk.

Diagnosis. – Flat cranidium wider than long. Median glabellar area with three shallow pairs of lateral glabellar furrows; anterior tongue narrow; median glabellar keel with row of indistinct tubercles. Depressed occipital ring with median tubercle anteriorly. Palpebral lobes flat, widest posteriorly, upturned anteriorly and laterally.

Description. – Cranidium is of low convexity, somewhat wider than long, almost entirely dominated by the glabella, ornamented with closely situated, fine raised lines arranged in a Bertillon pattern. Glabella is divided into a median area and an anterior tongue (terminology according to WHITTINGTON 1959, p. 376), provided with a faint and narrow median keel which shows traces of a number of small, regularly spaced tubercles; there are three pairs of lateral glabellar furrows which are only defined by a local obliteration of the Bertillon pattern; all three pairs are short, curving inward-backwards, situated

midway between sagittal axis and palpebral furrows. The glabellar tongue is narrow, strongly down-sloping, probably of a length usual for the genus (broken off in the single specimen at hand). The occipital ring is depressed, moderately long and wide, with a small median tubercle near the narrow, but well-impressed occipital furrow. Axial furrows are deeply impressed opposite the occipital ring, anterior to the occipital region rising, confluent with the narrow, but distinct palpebral furrows. Palpebral lobes are flat, slightly upturned anteriorly and laterally, wider and horizontal posteriorly.

Posterior area of fixigenae is not preserved.

Other parts of the dorsal exoskeleton are unknown.

Dimensions. – Length (estimated) of holotype cranidium about 4.0 mm, maximum width 5.4 mm.

Affinities. – *Remopleuridiella* is closely related to *Remopleurides* as pointed out by Ross (1951). The latter genus is restricted to the Middle Ordovician, and *Remopleuridiella* is very likely restricted to the Lower Ordovician.

Unfortunately most of the glabellar tongue (including anterior border) and posterior area of fixigenae are missing in the Skelbro specimen, but in the present writer's opinion the narrowness of the anterior tongue is characteristic of *Remopleuridiella.*

Remopleurides includes many species, some with and some without lateral glabellar furrows. It has been pointed out that the furrows in many instances only show on the inside of the test, and as proper information as to the nature of the material is not always available in the literature, some confusion has arisen with regard to the glabellar furrows. Ross (1951, p. 86) stated that the glabellar furrows are absent on both the interior and exterior surface of the test of *Remopleuridiella.* The species figured by TJERNVIK (1956, pl. 2, fig. 5) and SKJESETH (1952, pl. 5, fig. 4a, 6, 10) possess three pairs of furrows, and that number is also found in the specimen from Skelbro. Pronounced variations in the glabellar furrows are most likely characteristic of the Remopleurididae, and, accordingly, differences in this feature alone can hardly justify a distinction above the specific level.

Remopleuridiella groenwalli n. sp. differs from the type species in possessing lateral glabellar furrows and in the palpebral lobes being widest posteriorly instead of at midline across glabella.

SKJESETH (1952) described *Remopleurides* aff. *nanus* v. LEUCHTENBERG from the Lower *Didymograptus* Zone (3b) at Ringsaker. TJERNVIK (1956) hesitantly included SKJESETH's specimens in his *Remopleuridiella* sp. no. 2 which was briefly described, but not figured. SKJESETH's figured cranidia in all preserved details strongly resemble the cranidium from Bornholm in the general outline, in the upturned palpebral lobes being widest posteriorly, and in the Bertillon pattern of the striation. The presence of a faint and narrow median keel with indistinct tubercles was not reported by SKJESETH, but the eventual absence of this ill-defined feature may be related to the state of preservation.

The new species also bears much resemblance to TJERNVIK's *Remopleuridiella* sp. no. 1, but has a different ornamentation consisting of raised lines, whereas a finely granulated test is seen in the Swedish species. The latter species is slightly older, belonging to the *Megistaspis planilimbata* Zone (upper part of the Hunneberg Substage).

Suborder Asaphina SALTER, 1864
Superfamily **Asaphacea** BURMEISTER, 1843
Family **Asaphidae** BURMEISTER, 1843
Subfamily Ptychopyginae BALASHOVA, 1964
Genus ***Metaptychopyge*** BALASHOVA, 1964
Type species: *Asaphus truncatus* NIESZKOWSKI, 1859.

Metaptychopyge? sp. indet.
Pl. 1, fig. 5.

Material. – Internal mould of fragment of pygidium (MMH no. 9422).

Horizon and locality. – *Cyclopyge stigmata* Zone; quarry at Skelbro, Risebæk.

Description. – The flat pygidium is probably sub-semicircular in outline, with softly rounded antero-lateral corners. Axial region is not preserved. Pleural field is of low convexity with about seven? faint, rounded, slightly sigmoidal ribs which terminate at shallow and ill-defined border furrow. Border is slightly convex. Doublure is broad, probably underlying most of the pygidium except for the axial region. The test of the pygidium is ornamented with scattered, transverse, undulating terrace lines (about 5 per 5 mm) which are partly disconnected and furcated. The coarse terrace lines on the doublure are of uniform size and rather far apart (about 6–7 per 5 mm; in a zone inside border furrow 4 per 5 mm), parallel to margin of pygidium.

Dimensions. – Length of the entire pygidium probably about 50 mm, width about 80 mm.

Remarks. – The terrace lines on the doublure show resemblance to those seen in *Pseudoasaphus*. In other respects the fragment exhibits ptychopygid characteristics.

It is possible that the specimen belongs to *Metaptychopyge herambensis* (SKJESETH, 1952), but too little is preserved for a safe identification. The species *herambensis* was described by SKJESETH as *Ptychopyge herambensis*, but the morphology of the pygidial doublure indicates that the species probably should be transferred to *Metaptychopyge*.

Genus ***Paraptychopyge*** BALASHOVA, 1964
Type species: *Ptychopyge plautini* SCHMIDT, 1904.

Paraptychopyge sp.
Pl. 1, fig. 6.

Material. – Internal mould of a pygidium (MMH no. 9421).

Horizon and locality. – *Cyclopyge stigmata* Zone; quarry at Skelbro, Risebæk.

Description. – The almost flat pygidium is sub-semicircular in outline, length about two-thirds the width, with softly rounded antero-lateral corners.

The axis is about four-fifths the length of the pygidium and about one-fourth the width at anterior margin, moderately tapering and descending to axial ring no. 7, posterior to this almost parallel-sided and ascending, the terminal piece being level with anterior ring; there are eleven or twelve axial rings, separated by wide and shallow ring furrows which become progressively fainter in posterior direction. Axial furrows are shallow and ill-defined.

Pleural fields are of low convexity, showing six to seven faint, rounded, sinuous ribs which terminate at wide and ill-defined border furrow; the adaxial portion of the two anterior ribs is faintly furrowed. Pygidial border is slightly convex, of almost uniform width throughout. Articulating facets are moderately inclined. Doublure is broad, underlying the entire pygidium except for the axis and a small triangular field on each side of the anterior part of the axis; the doublure has a shallow notch in the inner edge anteriorly, joins the axis just behind axial ring no. 8. Terrace lines on the doublure are fine, closely situated (about 25 per 5 mm), parallel to the margin of the pygidium; they are of practically uniform dimensions, partly disconnected and furcated.

The mould shows that the test of the pygidium is ornamented with more scattered, transverse, undulating terrace lines (about 10 per 5 mm) which are partly disconnected and furcated.

Dimensions. – Length of pygidium 25 mm, maximum width (at antero-lateral cornes) 36 mm; length of axis 20 mm, width of axis at anterior margin 9 mm; average width of border 5 mm.

Remarks. – Early Arenigian (Ontikan) Ptychopyginae are still imperfectly known, and the Scandinavian genera and species need to be revised. Accordingly, isolated pygidia are difficult to assign to species.

The pygidium of *Metaptychopyge herambensis* (SKJESETH, 1952) resembles that of *Paraptychopyge* sp. in some respects, but the doublural structure and terrace lines are quite different.

Subfamily Isotelinae ANGELIN, 1854

Genus *Megistaspis* JAANUSSON, 1956

Type species: *Trilobites limbatus* BOECK, 1838.

Megistaspis (*Megistaspis*) cf. *lata* (TÖRNQUIST, 1884).
Pl. 1, fig. 7.

1936 *Megalaspis limbata* SARS & BOECK [partim]. – C. POULSEN: Ordovizium von Bornholm, pp. 48 and 50. (Listed).

Material. – Internal mould of pygidium (MMH no. 9424).

Horizon and locality. – *Cyclopyge stigmata* Zone; quarry at Skelbro, Risebæk.

Description. – Pygidium is parabolic, gently convex, length three-fourths the width, with acutely rounded antero-lateral corners. Axis is about five-sixths the length of the pygidium and about one-fifth the width at anterior

margin, being almost level with inner portion of pleural fields, moderately tapering to axial ring no. 8, then slightly expanding, terminal piece swelling to a low knob which is softly rounded; about fifteen axial rings (including terminal piece) may be distinguished, separated by wide ring furrows which are very shallow mesially, moderately impressed laterally, becoming progressively fainter in posterior direction; the two anterior ring furrows are more deeply impressed than the others. Axial furrows are wide and well-impressed.

Pleural fields are gently convex, showing half rib and eight pleural ribs with narrow and shallow interpleural furrows; pleural furrows are wide and shallow, adaxially moderately impressed. Ribs and furrows terminate at inner margin of the doublure which is slightly less than twice as wide as the almost flat border. Border is rather well-defined despite absence of border furrow, inclined anterolaterally, levelling off in posterior direction, horizontal and slightly concave behind the axis. Doublure (only preserved as internal mould of impression in the pygidium) is concave in dorsal view; terrace lines are not preserved. Articulating facets are large, rather steeply inclined.

Dimensions. Length of pygidium 24 mm, width 32 mm.

Remarks. – C. POULSEN (1936) referred the pygidium to *Megalaspis limbata* SARS & BOECK. JAANUSSON (1956a), when erecting the subgenus *Megistaspidella* and introducing the name *Megistaspis* to replace *Megalaspis*, also revised a number of species previously assigned to *Megalaspis*. It has been shown that *Megistaspis* (*Megistaspis*) *limbata* is restricted to the Lepidurus limestone, and the pygidium from Skelbro seems to be identical with *M. lata* in all respects. The pygidium represents a young individual, and as the cephalon is not known, the pygidium is referred to *M.* cf. *lata*. This assignment, however, seems to be consistent with the age of the assemblage, as *Megistaspis lata* is restricted to the lowermost part of the Volkhov Stage. *Megistaspis* (*Megistaspis*) sp. cf. *elongata* (SCHMIDT) = *Megistaspis* "*limbata*" occurs at a higher level in the "Limbata" limestone, and this species is not likely to be expected in the Skelbro Limestone assemblage. In order to establish the true relation of the pygidium the examination of a larger material appears necessary.

Megistaspis (*Megistaspis*) sp. no. 1.
Pl. 1, fig. 8.

1936 *Megalaspis stenorhachis* ANG. – C. POULSEN: Ordovizium von Bornholm, pp. 49–50. (Listed, vertical distribution discussed).

Material. – Internal mould of pygidium (MMH no. 9423).

Horizon and locality. – *Cyclopyge stigmata* Zone; quarry 400 metres east of Skelbro.

Description. – Pygidium is moderately convex, length probably about three-fifths the width. The low axis is about five-sixths the length of the pygidium and about one-sixth the width at anterior margin, only slightly elevated above the level of the inner portion of pleural fields, moderately tapering to axial ring no. 8, then slightly expanding, posteriorly swelling to a low knob;

there are about fourteen axial rings (including terminal piece), separated by wide and shallow ring furrows which become progressively fainter in posterior direction. Axial furrows are wide and moderately impressed.

Pleural fields are more convex anteriorly than posteriorly, showing nine very distinct pleural ribs (half rib not preserved) with wide and well-impressed pleural furrows throughout; interpleural furrows are narrow, but distinct. Ribs and furrows terminate at inner margin of the doublure which is somewhat wider than the border. Doublure is strongly concave in dorsal view; traces of terrace lines (probably about 10 per 5 mm) are preserved at inner margin. Only at little fragment of inner portion of the border is preserved; this fragment and the concavity of the doublure indicate that the pleural fields are elevated well above the level of the border which is apparently essentially flat, rather strongly inclined anteriorly, probably less so posteriorly.

Dimensions. – Length of pygidium 25 mm, width (estimated) about 40 mm.

Remarks. – The state of preservation prevents an assignment to species. The most remarkable feature is the strongly accentuated segmentation of the pleural fields, and no species from the Volkhov Stage or the Billingen Substage seem to have the same type of pleural fields. The specimen definitely belongs to *Megistaspis*, but the assignment to subgenus is less certain. The pygidium is probably less parabolic in outline than customary for subgenus *Megistaspis*, and the two anterior axial rings are not notably better defined than the posterior ones.

C. POULSEN (1936) referred the pygidium to *Megalaspis stenorhachis* ANGELIN = *Borogothus stenorhachis* (ANGELIN). This species, which occurs in the *Megistaspis planilimbata* Zone, has a pygidium with a prominent, evenly tapering and descending axis. The first axial ring is conspicuously convex and delimited by a deep transverse furrow, whereas the segmentation of the remainder of the axis is indicated by lateral pits and knobs only. The axial morphology of the Skelbro pygidium, as described above, indicates that it cannot be assigned to *Borogothus stenorhachis*.

Megistaspis (*Megistaspis*) sp. no. 2
Pl. 2, fig. 1

Material. – Internal moulds of two pygidia; figured pygidium MMH no. 9425.

Horizon and locality. – *Cyclopyge stigmata* Zone; quarry at Skelbro, Risebæk.

Description. – Pygidium is moderately convex, rounded triangular in outline, length two-thirds the width, with acutely rounded antero-lateral corners. Axis is lightly more than five-sixths the length of the pygidium and about one-fourth the width at anterior margin, only slightly elevated above the inner portions of the pleural fields, moderately tapering to axial ring no. 8, then slightly expanding, posteriorly swelling to a low knob which is softly

rounded; there are fourteen axial rings (including terminal piece), separated by wide ring furrows which are well-impressed laterally, shallower mesially, becoming progressively fainter in posterior direction. Axial furrows are wide and moderately impressed.

Pleural fields are rather strongly convex anteriorly, moderately so posteriorly, showing half rib and seven pleural ribs with wide and shallow pleural furrows throughout; interpleural furrows are faint and narrow. Ribs and furrows terminate at inner margin of the doublure which is probably somewhat less than twice as wide as the border. Doublure is concave in dorsal view; terrace lines (about 10 per 5 mm) are imperfectly preserved. Border is gently convex and steep anteriorly, levelling off in posterior direction, becoming slightly concave behind the axis. Articulating facets are large, rather steeply inclined.

Dimensions. – Length of figured pygidium (including articulating half ring) 43 mm, width 64 mm.

Remarks. – The pygidium cannot be assigned to any of the known species, but in some respects it resembles *Megistaspis* (*Megistaspis*) *polyphemus* (BRÖGGER, 1882). However, the segmentation of the pleural fields in the Skelbro pygidium seems to be more pronounced. TJERNVIK has found similar pygidia in the lower part of the *Megistaspis lata* Zone. SKJESETH (1952) has reported *Megistaspis polyphemus* from the upper part of the Lower *Didymograptus* Zone. This species would then be the only representative of *Megistaspis* (*Megistaspis*) from levels belov the Volkhov Stage. It is possible, however, that the uppermost part of the Lower *Didymograptus* Zone is equivalent to the *Cyclopyge stigmata* Zone (see p. 59). It is less probable that the species *polyphemus* crosses the boundary between the *Megistaspis estonica* Zone and *M. lata* Zone.

Subfamily Niobinae JAANUSSON, 1959

Genus *Niobella* REED, 1931

Type species: *Niobe homfrayi* SALTER, 1866.

Niobella imparilimbata (BOHLIN, 1955)

Pl. 2, figs. 2–5; pl. 3, figs. 1–2

1936 *Niobe explanata* ANG. [partim.]. – C. POULSEN: Ordovizium von Bornholm, pp. 49–50. (Listed, occurrence discussed).

1936 — *frontalis* (DALM.) [partim]. – C. POULSEN: Ordovizium von Bornholm, pp. 49–50. (Listed, occurrence discussed).

1936 — *laeviceps* (DALM.). – C. POULSEN: Ordovizium von Bornholm, pp. 49–50. (Listed, occurrence discussed).

1936 — *lindströmi* SCHM. – C. POULSEN: Ordovizium von Bornholm, pp. 49–50. (Listed, occurrence discussed).

1952 — *laeviceps* (DALMAN). – SKJESETH: Lower Didymograptus Zone, p. 169, pl. 2, figs. 5, 12, 13. (Description and figs. of cranidium and pygidia).

1952 — sp. aff. *laeviceps* (DALMAN). – TJERNVIK: Lägsta Ordov. lagren i Närke, p. 57, text-fig. 4B. (Remarks on species, drawings of cranidium and pygidium).

1955 — *imparilimbata* BOHLIN: Lower Ordov. limestones, Böda Hamn, p. 149, pl. 6, figs. 11–12. (Description and figs. of librigena and pygidium).

1956 *Niobella imparilimbata* (BOHLIN). – TJERNVIK: Early Ordovician of Sweden, p. 232, pl. 5, fig. 10. (Description and fig. of pygidium).
1956 — sp. aff. *imparilimbata* (BOHLIN). – TJERNVIK: Early Ordovician of Sweden, p. 233, text-fig. 37C, pl. 5, figs. 11–14. (Description and figs. of cranidia, pygidia, librigena, and hypostomata).

Material. – Internal moulds of two fragmentary cranidia; nine pygidia, and two hypostomata.

Horizon and locality. – *Cyclopyge stigmata* Zone; quarries at Skelbro, Risebæk, and 400 metres east of Skelbro.

Description. – Cranidium is of low convexity. Glabella is about four-fifths the length of cranidium, expanded forward to anterior one-third line across glabella; at this level a characteristic blunt angle is produced, as the glabella then tapers forwards to a rounded front. There are four pairs of ill-defined lateral glabellar furrows, separated from the axial furrows; anterior pair is short, directed inward-forwards, situated opposite the blunt antero-lateral corners of glabella; second pair is long, transverse, situated immediately behind anterior pair; third and posterior pair are shallow round pits. A small median tubercle is situated between the posterior pair of lateral glabellar furrows. Occipital ring is flat, moderately long and wide; the narrow occipital furrow is almost effaced laterally, adaxially deepening, curving slightly backwards. Axial furrows and preglabellar furrow are narrow and shallow.

Frontal area is entirely occupied by the flat, horizontal anterior border; border furrow is confluent with preglabellar furrow.

Anterior area of fixigenae tapers out in posterior direction. Palpebral area of fixigenae is about one-fourth the width of adjacent portion of glabella, flat, slightly down-sloping laterally; palpebral lobes are short, strongly arcuate, situated on posterior one – third line across glabella; the anterior extremities of the palpebral lobes join glabella at the middle; palpebral furrows are extremely shallow. Posterior area of fixigenae is rather long (sag.), of unknown width, as only the proximal part is preserved.

Anterior sections of facial suture are strongly diverging forwards, then curve inward-forwards, meeting at a distinct angle in front of glabella.

The hypostoma is moderately large, rather long. The median body is rounded sub-rectangular, reaching the strongly curved anterior margin. The anterior wings are well-developed, bent down at a steep angle to the main body. The lateral border is flat, upturned, and tapers out in anterior direction; the posterior border is wide, provided with a deep notch in the posterior margin. The lateral furrows are narrow and shallow anteriorly, then they widen backwards, where they end in deep triangular depressions.

The elliptical outline of the transverse pygidium is rather varying, with a length from half to three-fifths the width; antero-lateral corners are gently rounded. The rather prominent axis is about five-sixths the length of the pygidium and one-fourth the width at anterior margin; well elevated above the level of the pleural fields; axis is gently tapering to axial ring no. 8 which swells to a low knob, the portion behind axial ring no. 8 is more strongly tapering and descends to an acuminate terminal axial piece. The eight anterior axial rings are separated by undulating, shallow and narrow ring furrows

which become progressively fainter in posterior direction; the posterior axial portion, which forms a low ridge, does not show any trace of segmentation. Axial furrows are moderately impressed.

Pleural fields are gently convex, showing a prominent half rib and four or five low pleural ribs with narrow and extremely shallow pleural furrows; interpleural furrows are narrow and moderately impressed. Ribs and furrows, which are very faint in the portion overlying the doublure, terminate at the border. The almost flat, slightly down-sloping border is delimited by a wide and well-defined border furrow; maximum width of border is at midline across axis. Articulating facets are very long (tr.), moderately inclined. Doublure is wide, extending forwards along the posterior one-third of the axis.

Uniform terrace lines, which are well-defined only on the pygidial border, are arranged in a Bertillon pattern (about 13 per 5 mm in the largest specimen). The terrace lines on the doublure (about 10 lines per 5 mm in the largest specimen) are coarser, running parallel to the lateral and posterior margin of the pygidium.

Terrace lines on the hypostoma are prominent, arranged in a Bertillon pattern (about 20 lines per 5 mm).

Dimensions. – Length of the largest pygidium (MMH no. 9429) about 28 mm, width about 50 mm.

Affinities. – The four species of *Niobe* listed from the Skelbro Limestone (= "Umbonata" limestone) by C. POULSEN (1936) must evidently be assigned to *Niobella*. As pointed out by TJERNVIK (1956) differences in the pygidium present excellent criteria for separating the two genera. In *Niobe* the distal ends of the pleural ribs are prominent and bulging in such a way as to give an undulating course to the boundary line between the pleural fields and the flattened border. The pygidium of *Niobella* is distinguished by its low, flattened pleural ribs and an evenly curved boundary line between pleural fields and border. In agreement with the emended diagnosis the pygidia from the Skelbro Limestone must belong to *Niobella*.

Niobella imparilimbata was mainly based on a transverse pygidium, about twice as wide as long, originating from the lowermost part of the "Limbata" limestone on Öland (BOHLIN, 1955). A supposedly very closely related form from the Billingen Substage and lower part of the Volkhov Stage ("Limbata" limestone) was described by TJERNVIK (1956) as *Niobella* sp. aff. *imparilimbata*. According to TJERNVIK the pygidium of that species varies in outline, being evenly or obtusely rounded posteriorly. He stated that the pygidium was always longer than that of *N. imparilimbata*. He included the species described by SKJESETH (1952, p. 169, pl. 2, figs. 5, 12–13) as *Niobe laeviceps* (DALMAN).

The pygidia from Bornholm match the description *Niobella* sp. aff. *imparilimbata* very well, and, consequently, the four species listed by C. POULSEN are united into one.

TJERNVIK's species, however, should undoubtedly be included in *Niobella imparilimbata* which, in the present writer's opinion, was established on a pygidium that represents the extreme transverse end of the range of variation. There does not seem to be any other notable difference. Some of the pygidia from Bornholm closely approach a width:length ratio of 2:1, and the specimens are referred to *Niobella imparilimbata*.

The two hypostomata and fragmentary cranidia are in all preserved details identical to the specimens figured by TJERNVIK (1956, pl. 5, figs. 11–12). The lateral glabellar furrows of *Niobe*-type, not described by TJERNVIK, are very faint, and this is possibly a constant feature, the same way the segmentation of the pleural fields in the pygidium of *Niobella* is much effaced as compared to that of *Niobe*.

Remarks. – In agreement with the discussion above the vertical range of *Niobella imparilimbata* should be extended to comprise also the zones of *Megalaspides dalecarlicus* and *Megistaspis estonica* of the Billingen Substage.

Subfamily Symphysurininae KOBAYASHI, 1955

Genus ***Symphysurina*** ULRICH, 1925

Type species: *Symphysurina woosteri* ULRICH, 1924.

Symphysurina? sp.
Pl. 3, figs. 3–6

Material. – Internal mould of one cranidium (MMH no. 9452).

Horizon and locality. – *Cyclopyge stigmata* Zone; quarry at Skelbro, Risebæk.

Description. – Cranidium is sub-rectangular in outline, moderately convex transversely and highly convex longitudinally, anterior and posterior portions being approximately perpendicular to each other. Posterior portion of glabella is well-defined, gently expanding forwards, anterior portion is ill-defined and low, tapering forwards, gently rounded anteriorly. Glabella is about four-fifths the length of the cranidium (measured along curvature), profile is highest posteriorly; faint median tubercle is situated far back, slightly behind posterior end of the palpebral lobes; in front of the tubercle a faint median ridge is situated; otherwise glabella is quite smooth. Occipital ring is extremely short (sag.), simple; occipital furrow is effaced mesially, moderately deepening and widening in abaxial direction, joining axial furrows. Axial furrows are well-impressed posteriorly, shallowing up in anterior direction, ill-defined in front of palpebral lobes; preglabellar furrow is barely discernible.

Frontal area is entirely dominated by the preglabellar field which is convex, about one-fifth the length of the cranidium (measured along curvature); anterior border furrow is not defined; anterior border is narrow, only consisting of the thickened anterior margin which is slightly curved. Anterior area of fixigenae is moderately long and wide, strongly inclined anteriorly and anterolaterally; anterior border and furrow are ill-defined. Palpebral area of fixigenae is gently convex both ways, strongly down-sloping in lateral direction, about two-fifths the width of adjacent portion of glabella; palpebral lobes are long and narrow, about one-third the cranidial length, their midpoint situated on posterior one-third line across glabella, delimited by a faint palpebral furrow. Posterior area of fixigenae is incomplete, does not extend beyond palpebral lobes, down-sloping laterally; posterior border and border furrow are ill-defined.

Anterior sections of facial suture are only slightly diverging forwards, describing a faintly sigmoidal curve to anterior margin which is cut moderately out at sides. The suture continues on the ventral side as a rostral suture which leaves anterior part of the doublure as a uniformly narrow band. Posterior sections of facial suture are directed obliquely backwards, cutting posterior margin not far from occipital region.

Dimensions. – Length of cranidium (measured along curvature) about 5 mm, width at base about 3.5 mm, distance between the eyes 4.5 mm; length of glabella about 4 mm, width of glabella at base 1.5 mm.

Affinities. – The cranidium shows much resemblance to that of *Symphysurina? oriens* (MOBERG & SEGERBERG, 1906), but the cranidium alone does not permit an assignment to species.

MOBERG & SEGERBERG (1906) assigned two cranidia from the *Apatokephalus serratus* Zone at Ottenby, Öland, to *Illaenus oriens*. This would then be the earliest representative of *Illaenus* in Sweden.

TJERNVIK (1956, pp. 216–218) transferred MOBERG & SEGERBERG's species to *Symphysurina?*, and he included a few pygidia which had been figured previously by von POST (1906, indeterminable species, pl. 13, figs. 6–7). TJERNVIK was well aware that the species differs from the type species of *Symphysurina* in having long palpebral lobes and a median tubercle in a more posterior position. The pygidia figured by TJERNVIK may show some resemblance to that of some species of *Symphysurina*.

The cranidium of *Symphysurina? oriens* differs from *Symphysurina* in having a glabella which tapers forwards in front of the eyes, and the facial suture is not marginal anteriorly but ventral-intramarginal. Based on the same criteria the species *Symphysurina? perseverans* TJERNVIK (1956, pp. 218–219, pl. 3, figs. 19–22) should also be assigned to a new genus.

The present writer believes that a new genus will have to be erected to comprise the Skelbro species, *Symphysurina? oriens*, *S.? perseverans*, and a small species from the "Limbata" limestone in Närke (Dr. TJERNVIK, oral communication). The forward-tapering glabella and the ventral intra-marginal position of the facial suture anteriorly even makes the assignment to subfamily doubtful. On the other hand TJERNVIK has found a hypostome which may belong to *Symphysurina? oriens*. The hypostome in some ways resembles that of *Bellefontia* ULRICH, 1924, but differs in being more rectangular and parallel-sided.

More material is needed to characterize the new genus, and information about the thorax and hypostome would be especially valuable.

As a symphysurinine affinity is still a possibility, the assignment to *Symphysurina?* is sustained for practical reasons.

Family **Nileidae** ANGELIN, 1854

Genus *Nileus* DALMAN, 1827

Type species: *Asaphus* (*Nileus*) *armadillo* DALMAN, 1827. Designated by MILLER, 1889.

Nileus exarmatus TJERNVIK, 1956

Pl. 3, figs. 7–10, pl. 4, fig. 1

1936 *Nileus armadillo* DALM. [partim]. – C. POULSEN: Ordovizium von Bornholm, pp. 48, 50. (Listed, occurrence discussed).
1952 — *armadillo* (DALMAN). – SKJESETH: Lower Didymograptus Zone, p. 170, pl. 2, figs. 7–8, 11. (Occurrence, figs. of enrolled specimen, cranidium, pygidium).
1956 — *exarmatus* TJERNVIK: Early Ordovician of Sweden, pp. 209–210, pl. 2, figs. 16–21, text-fig. 33B. (Description, figs. of complete specimens, cranidia, pygidia, hypostoma).

Material. – Internal moulds of two complete dorsal exoskeletons, two cranidia, one pygidium, one hypostoma, internal mould of one transitory pygidium.

Horizon and locality. – *Cyclopyge stigmata* Zone; quarry at Skelbro, Risebæk.

Description. – The species is smaller and has a somewhat narrower dorsal exoskeleton than the type species.

Cephalon is reniform, highly convex both ways, with a strongly curved margin and rounded genal angles, the cephalic length is about two-thirds the width. Glabella is tapering forwards to anterior end of the eyes, then strongly expanded, anteriorly rounded so as to become parallel to anterior margin of cephalon; the width of glabella at base is about four-fifths the length. There is a small median tubercle situated on posterior one-fourth line across glabella; in front of it appears on the internal moulds a long and low median ridge, otherwise the glabella is quite smooth. Occipital ring is extremely short (sag.); occipital furrow is narrow and shallow, almost effaced on the outside of the test. Axial furrows are deeply impressed except opposite the central portion of the palpebral area.

Frontal area consists only of the extremely narrow (sag.) anterior border.

Anterior area of fixigenae is not discernible due to the indistinctly defined frontal glabellar lobe and the course of facial sutures. Palpebral area of fixigenae is about half the width of adjacent portion of glabella, flat and almost horizontal; palpebral lobes are about two-fifths the cranidial length, they are strongly arcuate, situated slightly behind midline across glabella; the anterior extremities of the palpebral lobes join the axial furrows well behind anterior one-third line across glabella; palpebral furrows are lacking. Posterior area of fixigenae is very short (tr.), slender, pointed distally; posterior border is very narrow, only faintly furrowed.

Holochroal eyes are large and semicircular, anteriorly and posteriorly joining the axial furrows.

Librigena is narrow, strongly curved, and has gently rounded, spineless genal angles. A low eye platform rises steeply up to the base of the visual surfaces

of the eyes. Lateral border is narrow; posterior border is more prominent, convex, and accentuated by a moderately deep and wide border furrow.

Anterior sections of facial suture are strongly diverging forwards, then turn inward-forwards, joining each other in front of glabella, describing an evenly rounded curve. Posterior sections of facial suture are short and straight, extend obliquely backwards to cut posterior margin well within the genal angles.

Hypostoma is moderately large, the length is about two-thirds the width. The median body is broadly ovate, yet narrower than in the type species, reaching the straight anterior margin; posterior lobe is short and triangular. The anterior wings are bent down at a steep angle to the main body, and are separated from lateral border by deep notches. The lateral border is of uniform, considerable width, essentially flat and almost horizontal, abaxially strengthened by a thread-like thickening of the lateral margin. Narrow posterior border is provided with a wide and shallow notch in the posterior margin. Lateral border furrows are deep and wide, terminating in deep, oblique depressions; posterior border furrow is effaced mesially, otherwise well-impressed.

Thorax is parallel-sided, consisting of eight segments. The axis is wide, a little more than half the thoracic width, almost parallel-sided and only slightly elevated above the pleural regions. Axial rings are short and simple, delimited by shallow axial furrows. Pleural regions are gently convex, rather steeply down-sloping laterally, consisting of moderately long pleurae with bluntly rounded extremities; pleural furrows are oblique, narrow and well-impressed in the proximal half of the pleurae, effaced in the distal half.

Pygidium is semicircular in outline, about twice as wide as long, gently convex both ways, has gently rounded antero-lateral corners. Axis is indistinct on outside of test, well-defined on internal mould, more than half the pygidial length, tapering backwards, truncated at rear end; there are possibly three axial rings and a terminal piece. Pleural fields are gently convex, smooth and unfurrowed. Border is indistinctly defined, flat, moderately wide, less inclined than pleural fields.

Terrace lines on the exoskeleton are uniform, and may be shorter or longer, not anastomosing.

Terrace lines on the hypostoma at hand are only preserved on parts of the lateral border; the lines are roughly transverse (about 6 per 5 mm).

Terrace lines on outside and internal mould of pygidium are extremely fine (up to 100 per 5 mm), parallel to outer margin. Terrace lines on pygidial doublure are coarser (15–20 lines per 5 mm), parallel to posterior margin, at which they are more closely spaced. Cephalic and thoracic doublures seem to be lined the same way as that of the pygidium.

The internal mould of a transitory pygidium (pl. 3, fig. 7) shows two anterior thoracic segments and articulating half segment. The thoracic segments are almost completely developed axially. In other respects the transitory pygidium is like the holaspid one. Terrace lines are not preserved.

Dimensions. – Internal mould of complete, outstretched specimen (MMH no. 9432, pl. 3 figs. 8–10): Length of dorsal exoskeleton 26.5 mm, width 16 mm; length of cephalon 10 mm, width 16.5 mm, width of glabella at base 7.5 mm, distance between the eyes 12 mm; length of thorax about 11 mm; length of pygidium 9.5 mm, width about 17 mm.

Length of hypostoma (MMH no. 9433, pl. 4, fig. 1) 4.5 mm, width 6 mm. Length of transitory pygidium (MMH no. 9434, pl. 3, fig. 7) 3 mm, width 4.5 mm.

Affinities. – The specimens from Skelbro match the description of *Nileus exarmatus* perfectly. It is especially significant that the axial furrows in the cranidium converge forwards, and glabella is considerably narrower than in the type species. The hypostoma is equally characteristic by the short, triangular posterior lobe. The specimens from the Skelbro Limestone were originally included in *Nileus armadillo*, when C. POULSEN (1936) discussed the vertical distribution of that species.

According to TJERNVIK (1956, p. 208) *Nileus armadillo* makes its first appearance in the Hunderum Substage (*Asaphus expansus* Zone).

SKJESETH (1952, p. 170) reported that *Nileus armadillo* is one of the most common trilobites in the subzone $3b_\delta$ which is equivalent to the zone of *Megistaspis estonica*. However, the cranidia figured by SKJESETH (1952, pl. 2, figs. 7–8) clearly show a narrow glabella and axial furrows converging forwards as in *N. exarmatus*, and, consequently, SKJESETH's specimens must be assigned to *Nileus exarmatus*.

Remarks. – *Nileus exarmatus* ranges from the uppermost part of the *Megistaspis planilimbata* Zone to the "Limbata" limestone (TJERNVIK 1956, p. 210). All the Latorp Stage specimens are characterized by the presence of a few scattered terrace lines which are developed in the lateral portions of the cephalon and pygidium. Specimens from the *Megistaspis lata* Zone are according to TJERVIK (oral communication) distinguished by the extremely fine and very closely situated terrace lines covering cephala and pygidia. The finely striated specimens from Bornholm are important for the discussion on the stratigraphical position of the Skelbro Limestone (see p. 58).

Genus *Symphysurus* GOLDFUSS, 1843

Type species: *Asaphus palpebrosus* DALMAN, 1827. Designated by BARRANDE, 1852.

Symphysurus (*Symphysurus*) *dorsatus* n. sp.

Pl. 4, figs. 2–7

1936 *Symphysurus palpebrosus* (DALM.) [partim]. – C. POULSEN: Ordovizium von Bornholm, pp. 49–50. (Listed, occurrence discussed).

Derivation of name. – Latin *dorsatus* = high-backed.

Holotype (here selected). – Cephalon (MMH no. 9435), pl. 4, figs. 2–4.

Other material. – Internal mould of a complete, enrolled specimen (imperfectly preserved), two cephala, ten cranidia, and internal moulds of eight pygidia.

Horizon and locality. – *Cyclopyge stigmata* Zone; quarries at Skelbro, Risebæk, and 400 metres east of Skelbro.

Diagnosis. – Dorsal exoskeleton in most respects as that of the type species. Glabella with steep sides forming a pseudocarinate arch. Cephalic doublure sagitally swollen into a round boss.

Description. – Cephalon is broadly semicircular, transversely convex, with rounded spineless genal angles, the length is about half the width. Glabella is highly convex both ways, expanded forward, flatly rounded anteriorly, reaches anterior margin of cephalon, the width at base is about three-fourths the length, profile is highest at midpoint. The sides of glabella are rather steep and together form a pseudocarinate arch. There is a small median tubercle situated slightly behind midpoint of glabella; in front of it appears a faint, long and low median ridge, otherwise the glabella apart from the presence of terrace lines is quite smooth. Occipital structures are completely effaced. Axial furrows are wide and deeply impressed throughout.

Frontal area and anterior area of fixigenae are not developed. Palpebral area of fixigenae is flat, about one-third the width of adjacent portion of glabella, somewhat down-sloping in lateral direction; palpebral lobes are about two-fifths the length of the cephalon, strongly arcuate, and situated on midline across glabella; anterior extremities of the palpebral lobes join the axial furrows at anterior one-third line across glabella, posterior extremities join the furrows at posterior one-third line across glabella; palpebral furrows are very shallow and indistinct posteriorly, disappearing completely in anterior direction. Posterior area of fixigenae is very stubby, pointed distally; posterior border and border furrow are not defined on outside of test, but on internal moulds a narrow posterior border and a shallow border furrow, which joins the axial furrows in pit-like depressions, are visible.

Holochroal eyes are large and semicircular, joining the axial furrows anteriorly, but not posteriorly.

Librigena is rounded triangular, essentially flat, down-sloping laterally, has acutely rounded genal angles. A prominent eye platform, which is delimited by a wide and rather deeply impressed furrow, rises vertically up to the base of the visual surface of the eyes. Lateral and posterior border are not defined.

Anterior sections of facial suture are diverging forwards, then turn inward-forwards, reaching anterior margin at antero-lateral corners of glabella. Posterior sections of facial suture are short and run almost straight backwards to posterior margin which is cut fairly close to axial furrows.

Doublure is prominent, strongly convex in ventral view, upturned, and is partly visible in frontal view. A low, round boss is formed sagitally by swelling of the doublure.

Thorax is tapering, consists of eigth segments. Axis is wide and gradually tapering, only sligthly elevated above the pleural regions; axial rings are short and simple, delimited by wide and moderately impressed axial furrows. Pleural regions are convex, down-sloping laterally, consisting of moderately sized pleurae, the extremities of which are not preserved; pleural furrows are short, wide, and shallow.

Pygidium is sub-semicircular in outline, its length varying from half to nearly two-thirds the width, moderately convex both ways, with acutely rounded antero-lateral corners. Axis is flat and only slightly elevated above

the pleural regions, about three-fourths the length of the pygidium, tapering and truncately rounded posteriorly; the internal moulds show a prominent articulating half ring, four axial rings, and a terminal piece which are separated from each other by wide and shallow ring furrows. Axial furrows are wide and well-impressed. Pleural regions are convex; the furrow behind the articulating half segment is wide and deep, traces of pleural furrows may be seen next to the axial furrows, otherwise the pleural regions are quite smooth. Articulating facets are long (tr.) and slender, moderately inclined. Border is not developed. Doublure is convex in dorsal view, anteriorly about half the width of the pleural regions.

Terrace lines on cephalon are well-defined on outside of test, very faint on internal moulds; the lines, which cover the entire cephalon, are arranged in a Bertillon pattern (about 25 lines per 5 mm). Terrace lines on the cephalic doublure are a little coarser (about 20 lines per 5 mm), running parallel to anterior margin.

Lines are not preserved on the thorax of the enrolled specimen.

Terrace lines are not seen on internal moulds of the pygidia, but are distinct on the doublure (10–15 lines per 5 mm), parallel to lateral and posterior margin.

The cephala appear to be densely covered with minute granules, whereas internal moulds seem to be smooth. Internal moulds of the pygidia are densely pitted. Presence or absence of this feature may depend upon the state of preservation.

Dimensions. – Length of holotype cephalon (MMH no. 9435, pl. 4, figs. 2–4) 17 mm, estimated width about 29 mm. Length of figured cranidium (MMH no. 9436, pl. 4, fig. 5) 16 mm, width 22 mm. Length of largest pygidium (MMH no. 9437, pl. 4, fig. 6) 17 mm, width 27 mm. Length of other figured pygidium (MMH no. 9438, pl. 4, fig. 7) 12.5 mm, width 23 mm.

Affinities. – *Symphysurus* (*S.*) *dorsatus* n. sp. appears to be intermediate between *S. angustatus* (SARS & BOECK) and *S. palpebrosus* (DALMAN) with regard to size and the length:width ratio of the glabella. *Symphysurus angustatus* is a common Tremadocian species in Norway and Sweden, and TJERNVIK (1956, p. 212) has demonstrated that the species also commonly occurs in the Hunneberg Substage in Västergötland. According to TJERNVIK the later representatives are distinguished by their wider glabella and pygidium. The large *Symphysurus palpebrosus* is characteristic of the Langevoj and Hunderum Substages.

The terrace lines on the test of the new species resemble those seen in *S. palpebrosus*. However *S. dorsatus* n. sp. differs from the other two species in possessing a cephalic doublural boss and in the glabellar cross-section being distinctly arched and pseudocarinate. The corresponding sections of the other species are low and evenly curved.

Superfamily **Cyclopygacea** RAYMOND, 1925

Family **Cyclopygidae** RAYMOND, 1925

Genus ***Cyclopyge*** HAWLE & CORDA, 1847

Type species: *Egle rediviva* BARRANDE, 1846

The occipital region in cranidia of *Cyclopyge* possesses remarkable pit-like depressions, and at least some species also display papilla-like elevations which are situated adaxially to, or intrude upon the aforementioned depressions.

MAREK (1961, p. 10) suggested that the posterior depressions most probably correspond to remnants of the occipital furrow. However, *Cyclopyge stigmata* n. sp. shows traces of an occipital furrow behind the occipital depressions, and the present writer believes that the nature of the occipital structures indicates a function as muscle attachments.

In many trilobites muscles have been attached to apodemes projecting downwards from different pits and the glabellar furrows, representing infoldings of the integument. In other trilobites, particularly in those with smooth glabellas, no apodemes were developed, and muscles must have been attached directly to certain areas of the ventral surface of cephalon. These areas appear in the fossils as paired "dark markings" which are best known in the Illaenidae.

The present writer believes that the paired, composite occipital structures in *Cyclopyge* consisting of depressions and low, papilla-like elevations with regard to size, position and morphology may well be places of muscle attachments. Accordingly, notable differences in these structures in *Cyclopyge* are considered important criteria for specific distinction.

Cyclopyge stigmata n. sp.
Pl. 5, figs. 1–7

1936 *Cyclopyge umbonata* (ANG.). – C. POULSEN: Ordovizium von Bornholm, pp. 48, 50–51. (Listed, occurrence discussed).
1936 — *umbonata* n. var. C. POULSEN: Ordovizium von Bornholm, p. 48. (Listed).

Derivation of name. – Latin *stigmatus* = branded. The name alludes to the remarkable occipital structures.

Holotype (here selected). – Internal mould of cranidium (MMH no. 9439), p. 5, figs. 1–3.

Other material. – Internal moulds of about twenty cranidia, about ten pygidia, and numerous detached eyes which are seen in majority of samples of the Skelbro Limestone.

Horizon and locality. – *Cyclopyge stigmata* Zone; quarries at Skelbro, Risebæk, and 400 metres east of Skelbro.

Diagnosis. – Cranidium slightly tapering forwards. Median tubercle situated well in front of glabellar midpoint. Large and round postero-lateral depressions surrounded by a raised rim. Between the depressions and close to the sagittal axis are situated round, papilla-like elevations with central depressions.

Pygidium about twice as wide as long, rounded triangular in outline. Axis consisting of articulating half ring, three axial rings, and terminal piece. Postaxial ridge absent.

Description. – Cranidium is entirely dominated by the glabella, the fixigenae being reduced to narrow, diminutive bands which follow the glabellar contour. Glabella is slightly longer than wide, tapering forwards, gently rounded and inflated anteriorly, overhanging preglabellar furrow and anterior portion of axial furrows; posterior half of glabella is almost flat, moderately convex transversely, whereas anterior half is highly convex both ways. There is a single, wide and shallow pair of lateral glabellar furrows curving inward-backwards, fading out a little short of sagittal axis, separated from the axial furrows, situated on posterior one-third line across glabella, immediately in front of the occipital elevations. A median tubercle is situated well in front of midpoint of glabella on a narrow and low median ridge which dies out at anterior one-fourth portion of glabella, and posteriorly between the occipital elevations. An exsagitally elongate, shallow depression is situated in each postero-lateral corner of glabella; the depressions, which are about one-sixth the length of the cranidium, are surrounded by a raised rim. Between these depressions are situated two small and round, papilla-like elevations which have a distinct central depression, and which touch the median ridge adaxially and abaxially the postero-lateral depressions, intruding upon the rim around the latter. Occipital furrow is extremely faint, situated immediately behind the occipital depressions and elevations. Axial furrows and preglabellar furrow are well-impressed; a small pit is formed, where axial furrows join the occipital furrow.

Frontal area is non-existant. Palpebral area of fixigenae is reduced to narrow bands which follow the glabellar contour from the front to the occipital depressions. Posterior area of fixigenae is short (tr.) and triangular, truncated distally.

Visual surface of holochroal eyes is convex, vertical, tapering forwards. The acutely rounded anterior extremities of the eyes do not meet. The distance between them anteriorly is about one-fourth the cranidial width.

Librigenae are reduced to narrow, strongly curved bands which run along the posterior three-fourths of the outer margin of the eyes. The librigenae are expanded posteriorly to fit posterior area of fixigenae.

Facial sutures follow the glabellar contour closely in posterior direction to about posterior one-fourth line across glabella, then run almost straight to posterior margin which is cut close to glabella.

The anterior portion of glabella shows faint terrace lines (about 25–30 per 5 mm) which are transverse, curving slightly forwards; the lines are somewhat better defined in the vicinity of the preglabellar furrow.

Pygidium is about twice as wide as long, rounded triangular in outline

partly due to the inconstant width of the border; it is moderately convex both ways and has acutely rounded antero-lateral corners. Axis is about three-fifths the length of the pygidium and about one-fifth the width at anterior margin, well elevated above the pleural fields, and tapers to a rounded terminal piece. There are three axial rings and terminal piece separated by ring furrows, the anterior of which is deeply impressed, the second moderately impressed, the posterior extremely faint. Axial furrows are moderately wide and moderately impressed.

Pleural fields are gently convex, showing half rib which is delimited by a deep and wide furrow; articulating facets are narrow, inclined. The pleural fields are indistinctly segmented, but about three pleurae, which are separated by shallow furrows, may be seen in some specimens; pleural furrows are wide and extremely faint. Each pleura is outlined by very thin, raised lines which run along the interpleural furrows, crossing half of the border; the lines represent the anterior and posterior edge of the individual pleurae. In this way the pleural fields possess three pairs of striae, the adjoining edges of two pleurae forming one pair. No postaxial ridge is developed.

Border is prominent, wide and almost flat antero-laterally, narrower and more convex behind the axis, delimited by a wide moderately impressed border furrow. Between the striae, which represent the anterior and posterior edges of the pleurae, are situated other thin raised lines which pass between the pairs of pleural striae into the pleural fields for a short distance. The border striae are also discernible behind the region with pleural striae, but become progresseively fainter in posterior direction.

Dimension. – Length of holotype cranidium (MMH no. 9439, pl. 5, figs. 1–3) 8.5 mm, width 7.5 mm. Length of largest pygidium 2.6 mm, width 6 mm.

Affinities. – *Cyclopyge stigmata* n. sp. is a very important member of the fauna, and as the species has been chosen to name a new zone, the affinities will have to be discussed in some detail.

C. POULSEN (1936) referred the specimens from Bornholm to *Cyclopyge umbonata* (ANGELIN). Specimens of a supposed "new variety" by careful preparation turned out to be conspecific.

The present writer has had the opportunity of studying the Scanian specimens of *Cyclopyge umbonata umbonata*, including the ones figured by MOBERG (1907). It is quite evident that the specimens from Bornholm cannot be conspecific with the Scanian form or represent a new subspecies of *C. umbonata*, but must be regarded as belonging to a new species.

The cranidium of *Cyclopyge stigmata* n. sp. differs from that of *C. umbonata umbonata* (ANGELIN, 1854) in being more strongly tapering forwards, in the more advanced position of the median tubercle, in possessing postero-lateral occipital depressions, and in the papilla-like elevations being situated close to sagittal axis.

The pygidium of the new species differs from that of *C. umbonata umbonata* in the rounded triangular outline; the axis contains four rings insteads of three, and finally a postaxial ridge is missing.

Despite the differences the two species are probably fairly close relatives.

TJERNVIK (1956) erected the early Ordovician species *Cyclopyge latifrons*

and *C. gallica* which both differ from *C. stigmata* n. sp. in the shape of glabella and absence of occipital elevations.

Cyclopyge umbonata bohemica MAREK, 1961 resembles *C. umbonata umbonata* in many respects, but the cranidium tapers more strongly, and the median tubercle is closer to the occipital region. The pygidial axis in the Bohemian subspecies is slightly shorter (see also discussion in MAREK, 1961, p. 23).

The distinctions, which serve to separate the new species from *C. umbonata umbonata*, also apply to *C. umbonata bohemica*.

As stated above the marked differences found in the occipital region warrant a distinction at the specific level, and no other species of *Cyclopyge* are known to possess similarly situated elevations and depressions.

R. & E. RICHTER (1954) included in *Cyclopyge* several subgenera which had previously been regarded as independent genera. The subgenera were later (MAREK, 1961) reinstated as separate genera.

R. & E. RICHTER (1954) also reduced ANGELIN's species *umbonata* to a subspecies of *Cyclopyge rediviva* (BARRANDE), and the same authors assigned a complete exoskeleton from the Herscheider beds in the Ebbe anticline to *Cyclopyge* (*Cyclopyge*) *rediviva umbonata*?

However, the present writer believes that the degree of flattening and distortion in the Herscheider specimen prevents a reliable assignment to species.

From the *Didymograptus bifidus* Zone of the Ebbe anticline JENTSCH & STEIN (1961) described a fairly well-preserved specimen of *Cyclopyge* (*Cyclopyge*) cf. *rediviva umbonata*. It resembles the Scanian subspecies in several respects, including the position of the plainly visible occipital elevations (not described). However, major differences indicate that the specimen discussed represents a separate species. The thoracic pleurae end in long backward-directed spines, whereas some Scanian specimens examined by the present writer show the pleural extremities with minute spines which are barely indicated. The pygidium of the German species differs in possessing four axial segments which taper more strongly, and the postaxial ridge is too prominent.

Remarks. – *Cyclopyge stigmata* n. sp. is very characteristic of the lower part of the "Orthoceras limestone" on Bornholm, and it has been believed that a stratigraphical equivalent might be found at Fågelsång and Röstånga in Scania (C. POULSEN 1936, p. 51; REGNÉLL 1960, p. 19). The present writer has carefully studied MOBERG's collections from his locality E21a (= E21b, MOBERG 1910) which is a now inaccessible limestone quarry. It was hoped that some of the specimens assigned to *C. umbonata* in fact might belong to *C. stigmata* n. sp., but this was not so.

The Fågelsång specimens were found associated with *Pterygometopus* (*Pterygometopus*) *sclerops* (DALMAN), *Selenoharpes* sp., and *Nileus armadillo* (DALMAN). Thus *Cyclopyge umbonata umbonata* probably originates from the *Asaphus expansus* Zone, and the Skelbro Limestone then is considerably older than the Fågelsång beds.

Suborder Illaenina JAANUSSON, 1959

Superfamily **Illaenacea** HAWLE & CORDA, 1847

Family **Styginidae** VOGDES, 1890

Genus ***Hallanta*** n. gen.

Type species (by monotypy): *Hallanta modesta* n. sp.

Derivation of name. – Bornholm dialect *Hallanta* (f.) = a halfwit.

Horizon and locality. – Lowermost part of the Volkhov Stage (*Cyclopyge stigmata* Zone); quarry at Skelbro, Risebæk. – ? Komstad Limestone; Komstad, Scania.

Diagnosis. – Cranidium sub-quadrate, convex. Glabella almost reaching anterior margin of cephalon, well-defined, expanded forward, truncate anteriorly, with elongate median pit at anterior end. Posterior pairs of lateral glabellar furrows on each side united into elongate pits. Eye ridges double, very prominent. Anterior sections of facial suture sub-parallel posteriorly, slightly converging anteriorly.

Affinities. – A cranidium figured by FUNKQUIST (1919, "head of trilobite", pl. 2, fig. 8) may belong to the new genus. FUNKQUIST's specimen from the Komstad Limestone at Komstad, Scania, differs somewhat from the Skelbro species which has a more truncate glabella.

The nature of the glabella and the fixigenae indicates that *Hallanta* n. gen. must be grouped with the Styginidae, but in some respects the new genus differs from all other styginids. Thus the glabella is better defined than in the majority of styginids, and it has a remarkable pit-like impression at the anterior end. Eye ridges are more prominent, and the course of anterior sections of facial suture is different.

The well-defined glabella suggests a relationship to *Raymondaspis*, but the glabella of the new genus differs in having a low anterior profile, and in being more truncate. Also, the bicomposite structure of the eye ridges is more distinct, the eyes are farther apart, and the course of facial sutures is different.

Hallanta n. gen. is distinguished from *Stygina* SALTER, 1853 by the shape of glabella, the greater distance between the eyes, and the entirely different curvature of anterior sections of facial suture.

The new genus differs from *Bronteopsis* NICHOLSON & ETHERIDGE, 1879 by having a less forward-expanded glabella, the eyes are situated more anteriorly, and the curvature of the facial sutures is different.

Hallanta n. gen. is distinguished from *Protostygina* PRANTL & PŘIBYL, 1948 by the better defined glabella and different course of facial suture.

Hallanta modesta n. sp.
Pl. 5, figs. 8–12. Text-fig. 3

1936 N. gen. et n. sp. C. POULSEN: Ordovizium von Bornholm, p. 49. (Listed).

Derivation of name. – Latin *modestus* = modest.

Holotype (here selected). – Internal mould of cranidium (MMH no. 9446), pl. 5, figs. 8–10.

Other material. – Internal mould of one cranidium.

Horizon and locality. – *Cyclopyge stigmata* Zone; quarry at Skelbro, Risebæk.

Diagnosis. – See that of genus.

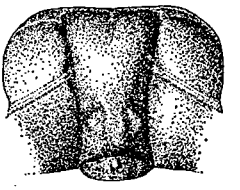

Fig. 3. *Hallanta modesta* n. gen. et n. sp. About × 2. *Cyclopyge stigmata* Zone; Skelbro, Risebæk.

Description. – Cranidium is sub-quadrate in outline, rather highly convex sagitally. Glabella, which is four-fifths the length of the cranidium, is rather highly convex sagitally, less so transversely, hardly rises above the level of the fixigenae; it almost reaches anterior margin of cephalon, profile is highest at midpoint. The posterior one-fourth of glabella is parallel-sided and angular in cross section, then glabella expands forwards to a truncated front. There are three pairs of lateral glabellar furrows showing; anterior pair is short and very shallow, forming small rounded pits, joining the axial furrows at anterior one-third line across glabella; second and posterior pair are on each side closely situated on posterior one-fourth line across glabella, converging to meet just inside of axial furrows; the two posterior pairs in this manner form one shallow, elongate (exsag.), slightly triangular pit on each side of glabella. The front of glabella has a shallow median impression which is elongate (sag.), about one-fifth length of glabella, and slightly expanded posteriorly. Occipital ring is moderately long and slightly wider than glabella at base, forming a pointed arch which carries a small node anteriorly; occipital furrow curves forwards mesially, is narrow and moderately impressed sagitally, becoming wider and shallower laterally, and does not reach the axial furrows. Axial furrows are narrow, but well-impressed, with distinct fossulae just behind antero-lateral corners of glabella; preglabellar furrow is ill-defined.

Frontal area is reduced to a straight, thread-like anterior border which should rather be regarded as a thickening of the upturned, gently curved

anterior margin of the cranidium. Anterior area of fixigenae is moderately convex, down-sloping anteriorly and laterally; anterior border furrow is wide and shallow; anterior border is constituted by the thickened rim of anterior margin. Palpebral area of fixigenae is convex, down-sloping in posterior direction, about five-thirds the width of adjacent portion of glabella; palpebral lobes are not preserved, but are presumably short, situated on posterior one-fourth line across glabella, anteriorly continuing into prominent, curved and oblique eye ridges which join axial furrows slightly anterior to midline across glabella. The eye ridges are double, each ridge consisting of two raised lines, the anterior of which is somewhat less prominent. Only the proximal portion of posterior area of fixigenae is preserved; posterior border and border furrow are ill-defined.

Anterior sections of facial suture are only slightly diverging forwards, running parallel to glabella, at anterior one-third line across glabella curving gently inward-forwards, cutting anterior margin moderately out at sides. The course of posterior sections of facial suture is unknown.

Small remains of the test on one of the two specimens show faint terrace lines (about 25–30 per 5 mm). The lines are transverse at the anterior end of glabella and concentric on the occipital ring, with the centre situated somewhat behind posterior margin.

The internal moulds show faint traces of genal caeca on anterior area and palpebral area of fixigenae.

Other parts of the dorsal exoskeleton are unknown.

Dimensions. – Length of holotype cranidium (MMH no. 9446, pl. 5, figs. 8–10) 11 mm, distance between the eyes (estimated) 14 mm; length of glabella 8.5 mm, width of glabella at base 3.5 mm. Length of other cranidium (MMH no. 9447, pl. 5, figs. 11–12) 12.5 mm, distance between the eyes (estimated) 16 mm; length of glabella 9.5 mm, width of glabella at base 4 mm.

Affinities. – The present writer has had the opportunity of examining the above mentioned cranidium figured by FUNKQUIST. As pointed out it may represent a separate species, but the state of preservation does not justify any conclusions. The Komstad specimen has a slightly less truncate glabella.

Genus *Raymondaspis* PŘIBYL, 1948

Type species: *Holometopus limbatus* ANGELIN, 1854. Designated by MILLER, 1889. *Raymondaspis* to replace *Holometopus* (preoccupied MILNE EDWARDS, 1853) and *Warburgella* RAYMOND, 1937 (preoccupied REED, 1931).

Raymondaspis limbata (ANGELIN, 1854)

Pl. 6, figs. 1–4

1854 *Holometopus limbatus* ANGELIN: Palaeont. Scandinavica, p. 58, pl. 33, figs. 7–7a. (Description and figs. of cephalon and pygidium).

1906 — *limbatus* ANGELIN. – WIMAN: Paleont. Notizen, pp. 293–294, pl. 29, figs. 21,? 22. (Remarks; figs. of two pygidia, fig. 22 incorrectly drawn or misidentified).

1936 — n. sp. C. POULSEN: Ordovizium von Bornholm, p. 48. (Cranidium, listed).

1936 *Stygina*? n. sp. C. POULSEN: Ordovizium von Bornholm, p. 49. (Pygidium, listed).

1950a *Raymondaspis limbatus* (ANGELIN, 1854) [partim]. – WHITTINGTON: Sixteen Ordov. Genotype Trilobites, pp. 549–550. (Changes of generic name cited. Pyg. redescribed and discussed. Figured pygidia, pl. 72, figs. 11–14 are probably not identical with type species).

1952 — *limbatus* (ANGELIN, 1854). – SKJESETH: Lower Didymograptus Zone, pp. 171–172, pl. 4, figs. 16–17, 19–21. (Description and figs. of cranidia and pygidia; occurrence disc.).

1955 — *limbatus* (ANGELIN, 1854). – SKJESETH: Trilobite Family Styginidae, pp. 21, 24, 26; pl. 4, figs. 2, 4–9, pl. 5, figs. 6, 8. (Description and figs. of cranidia and pygidia; phylogeny and vertical distribution disc.).

?1956 — sp. no. 2 TJERNVIK: Early Ordovician of Sweden, p. 263. (Short description of pygidium).

Material. – Eight cranidia (six internal, one external mould, and one ventrally exposed cranidium), internal mould of one pygidium.

Horizon and locality. – *Cyclopyge stigmata* Zone; quarry at Skelbro, Risebæk.

Description. – Cranidium is sub-trapezoidal in outline, highly convex sagitally, moderately so transversely. Glabella is about two-thirds the length of the cranidium, almost reaching anterior margin, highly convex sagitally, rising above the level of the fixigenae, profile highest at midpoint. Posterior one-fourth of glabella is slightly tapering forwards, then glabella expands forwards to a truncately rounded front. There are four pairs of lateral glabellar furrows; anterior pair is short and shallow, forming small pits situated on anterior one-fourth line across glabella; second pair forms almost transverse, shallow, oblong pits situated on midline across glabella, behind anterior extremities of the eye ridges; two posterior pairs are more deeply impressed, situated on posterior one-fourth line across glabella, they are converging to form a triangular depression on each side of glabella with the apex of the triangle touching the axial furrow. In all specimens the front of glabella has an extremely faint wide median impression. Occipital ring is moderately long and wide, carries a simple median node; occipital furrow is wide and deeply impressed mesially, becomes narrower and shallows up in abaxial direction, and it is separated from the axial furrows. Axial furrows are moderately wide, well-impressed, with distinct fossulae situated just behind antero-lateral corners of glabella; preglabellar furrow is not defined.

Anterior margin of the cranidium is gently curved, thickened and slightly upturned, separated from glabella by a narrow border furrow. Anterior area of fixigenae is strongly inclined in anterior and antero-lateral direction; anterior border furrow is narrow and extremely shallow, almost parallel to anterior margin; anterior border is distinctly upturned. Palpebral area of fixigenae is convex, somewhat down-sloping in posterior direction, of approximately the same width as adjacent portion of glabella; palpebral lobes are not preserved, but must be situated on posterior one-fourth line across glabella, anteriorly continuing into distinct, oblique and almost straight eye ridges which join axial furrows slightly anterior to midline across glabella. The eye ridges are double, consisting of two raised lines, the anterior of which is more

weakly developed and almost completely fused to the posterior. Posterior area of fixigenae is only preserved proximally; posterior border and border furrow are ill-defined.

Anterior sections of facial suture are strongly diverging forwards, describing a gentle and even curve all the way to anterior margin which is reached well out at sides. The course of posterior sections of facial suture is unknown.

Terrace lines are not preserved.

Pygidium is about twice as wide as long, sub-semicircular in outline, with acutely rounded antero-lateral corners. Axis is about two-thirds the pygidial length and about one-sixth the width at anterior margin, slightly elevated above the pleural fields, gently tapering. There are a prominent articulating half ring and about seven axial rings (including terminal piece), separated by moderately and uniformly impressed ring furrows which become progressively fainter in posterior direction. Axial furrows are moderately deep and wide.

Pleural fields are gently convex, essentially horizontal, showing half rib which is delimited by a deep and wide furrow. The pleural fields are indistinctly segmented, in the anterior half showing three narrow and faintly indicated pleural ribs which terminate at the border. Border (only a fragment preserved) is concave, strongly down-sloping throughout, posteriorly slightly less than one-third the length of pygidium, delimited by an indistinct border furrow. Doublure is strongly concave in dorsal view, reaching the border furrow and posterior end of axis. Postaxial ridge is not preserved.

Terrace lines are not preserved on pygidium and doublure, but the internal mould shows a fine punctuation.

Dimensions. – Length of figured internal mould of cranidium (MMH no. 9448) 5.5 mm, distance between the eyes (estimated) 7.5 mm; length of glabella 3.5 mm, width of glabella at base 2 mm. Length of pygidium (internal mould, MMH no. 9449) 7 mm, width at anterior margin 14.5 mm; width of axis at anterior margin 2.5 mm.

Affinities. – The holotype of *Raymondaspis limbata* is probably lost, and when redescribing some type species WHITTINGTON (1950a, pp. 549–550) based his diagnosis on two pygidia from Fågelsång in Scania (collected by LUNDGREN, identified by MOBERG). The mentioned pygidia have a distinctly convex border, and for this reason WHITTINGTON rejected the pygidia from Öland with a concave border figured by WIMAN (1906, pl. 29, figs. 21–22), and he stated that WIMAN's specimens were not conspecific with *R. limbata*. SKJESETH (1952, p. 172), however, has pointed out that ANGELIN's original drawings (1854, pl. 33, figs. 7–7a) clearly show that the pygidium and the cephalon as well have a concave border. All the pygidia figured by SKJESETH (1952, pl. 4, figs. 16–17, 21; 1955, pl. 4, figs. 4, 9) demonstrate a concave, rather steep border. The present writer believes that the two specimens described and figured by WHITTINGTON (1950a, pl. 72, figs. 11–14) should not be referred to *Raymondaspis limbata*.

TJERNVIK (1956, p. 263) briefly discussed a *Raymondaspis* sp. no. 2, the pygidium of which is distinguished by a strongly concave border and by the convex pleural fields. He included the specimens which SKJESETH (1952) had previously referred to *R. limbata*. Undoubtedly SKJESETH's specimens are correctly assigned to species, and, consequently, TJERNVIK's species may well have to be included in *R. limbata*.

It is important that the glabella of *R. limbata* shows the same kind of frontal impression as in *Hallanta* n. gen., although the pit is very faint and less elongate than in the new genus. The double eye ridges, which are very conspicuous in the new genus, are also seen in *Raymondaspis limbata*. This feature may be commonly occurring in the Styginidae, as it is also demonstrated by *Bronteopsis holtedahli* SKJESETH (1955, p. 5, fig. 4).

The cranidium of *Raymondaspis limbata* in many respects resembles that of *Hallanta modesta* n. gen. et n. sp., but differs in having a more slender glabella which is less expanding, and less truncate anteriorly. The anterior cranidial margin is gently curved in *Raymondaspis* in contrast to the straight or even faintly concave margin in *Hallanta* n. gen.

Remarks. – *Raymondaspis limbata* is reported from the Lower *Didymograptus* Zone in Norway (subzones $3b_{\gamma-\delta}$, equivalent to the Billingen Substage). The species range into the "Limbata" limestone in Sweden but is undoubtedly most frequently occuring in the Billingen Substage.

Raymondaspis imparilis n. sp.
Pl. 6, figs. 5–6

1936 *Holometopus* n. sp. C. POULSEN: Ordovizium von Bornholm, p. 49. (Listed).

Derivation of name. – Latin *imparilis* = different.

Holotype (here selected). – Internal mould of pygidium (MMH no. 9451), pl. 6, fig. 6.

Other material. – Internal mould of pygidium (MMH no. 9450), pl. 6, fig. 5.

Horizon and locality. – *Cyclopyge stigmata* Zone; quarry at Skelbro, Risebæk.

Diagnosis. – Pygidium sub-semicircular in outline, length three-fifths the width. Border essentially flat, sligthly down-sloping. Posterior width of doublure is about half the length of pygidium.

Description. – Pygidium is sub-semicircular in outline, with obliquely truncated antero-lateral corners, the length is three-fifths the maximum width which is at anterior one-third line across axis. Axis is about three-fifths the pygidial length and about one-sixth the width at anterior margin, is slightly elevated above the pleural fields; it tapers rather strongly to the third axial ring, then more gently to the acuminate terminal piece which continues into a slender, narrowing postaxial ridge to the posterior margin. There are a prominent articulating half ring and about seven axial rings, of which only the three anterior are well-defined, delimited by moderately and uniformly impressed ring furrows. The segmentation is indistinct behind the third ring. Axial furrows are moderately deep and wide.

Pleural fields are gently convex, showing half rib which is delimited by a wide and shallow furrow; there are about four pleural ribs with narrow traces

of interpleural furrows, the ribs terminate at inner margin of doublure. Border is essentially flat, only slightly down-sloping, of uniform width which is about one-fourth the length of pygidium; inner limit of border is ill-defined due to the absence of a border furrow. Articulating facets are large, triangular, situated almost vertically at angle of about 45° to sagittal axis. Doublure is approximately twice as wide as border, gently concave in dorsal view, reaching posterior end of the axis.

Terrace lines are not preserved.

Dimensions. – Length of largest pygidium (pl. 6, fig. 5) 4.5 mm, width at anterior one-third line across axis 7.5 mm; length of axis about 2.8 mm, width of axis at anterior margin 1.3 mm.

Affinities. – The pygidium of *Raymondaspis imparilis* n. sp. differs from that of other species of *Raymondaspis* in outline and in possessing an unusually wide doublure.

The new species is probably closely related to *R. limbata*. Some pygidia of this species figured by SKJESETH (1955, pl. 4, figs. 9–10) approach that of the new species in outline and gentle concavity of the border, but *R. imparilis* n. sp. is distinguished by a still wider doublure, by being less transverse, and finally by the somewhat funnel-shaped axis.

The axial region in the pygidium of the new species resembles that of *Raymondaspis infundibularis* TJERNVIK, 1956, but TJERNVIK's species differs in being distinctly transverse and in having a narrower doublure.

Raymondaspis brevicauda TJERNVIK, 1956 differs in having a convex border, and the same argument applies to *R. nitens* (WIMAN, 1906).

The new species seems to be most closely related to an undescribed species collected by TJERNVIK from the *Megistaspis lata* Zone in Närke. However, the pygidium of the Närke species differs in outline and in morphology of the posterior part of the axis.

Superfamily **Proetacea** SALTER, 1864

Family **Celmidae** JAANUSSON, 1956

Genus ***Celmus*** ANGELIN, 1854

Type species: *Celmus granulatus* ANGELIN, 1854

Celmus? *longifrons* n. sp.

Pl. 6, figs. 7–9, pl. 7, fig. 1. Text-fig. 4

1936 N. gen. et n. sp. C. POULSEN: Ordovizium von Bornholm, p. 49. (Listed).

Derivation of name. – Latin *longifrons* = having a long front. The name alludes to the well-defined frontal area.

Holotype (here selected). – Cranidium (MMH no. 9453), pl. 6, figs. 7–9.

Other material. – One cranidium and external mould of same.

Horizon and locality. – *Cyclopyge stigmata* Zone; quarry at Skelbro, Risebæk.

Diagnosis. – Cranidium sub-trapezoidal, convex. Glabella prominent, tapering forwards, gently rounded anteriorly, overhanging preglabellar field.

Two pairs of lateral glabellar furrows; anterior pair short and shallow, transverse, situated on anterior one-third line across glabella; posterior pair deeply impressed, converging backwards from axial furrows, anterior end situated opposite midpoint of glabella. Occipital furrow deep and wide. Frontal area strongly inclined, almost vertical. Anterior border concave. Palpebral area of fixigenae narrow, rising at a steep angle. Posterior area of fixigenae triangular, with raised lateral edges; posterior border furrow deep and wide. Anterior sections of facial suture only slightly diverging forwards, posterior sections nearly straight, at right angles to each other. Test covered with rather coarse, closely spaced tubercles of varying sizes.

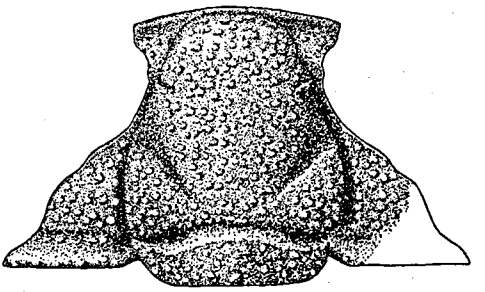

Fig. 4. *Celmus*? *longifrons* n. sp. About ×5. *Cyclopyge stigmata* Zone, Skelbro, Risebæk.

Description. – Cranidium is sub-trapezoidal in outline, highly convex sagitally, less so transversely, length is about two-thirds the width. Glabella, the length of which is somewhat more than half the cranidial length, is prominent, highly convex both ways, profile is equally high along posterior half. Glabella is slightly wider than long, distinctly tapering forwards, gently rounded anteriorly; it is inflated and overhangs the preglabellar field. There are two pairs of lateral glabellar furrows; anterior pair is short and shallow, transverse, situated on the almost vertical sides of glabella on anterior one-third line across glabella, reaching axial furrows; posterior pair is very long, deeply impressed, converging backwards from the axial furrows opposite midpoint of glabella, almost reaching occipital furrow. Occipital furrow is wide and very deeply impressed, communicating with axial furrows, adaxially curving in anterior direction; occipital ring is rather short (sag.) but wide, with a median node at posterior margin, narrowing in abaxial direction, as the posterior margin makes a slight forward turn. Axial furrows are wide and deeply impressed, shallowing up anteriorly and becoming effaced at antero-lateral corners of glabella; preglabellar furrow is not defined.

Frontal area is strongly concave, preglabellar field and anterior border being at almost right angles to each other. Preglabellar field is a narrow band which is directed vertically downwards, anteriorly delimited by the hardly raised posterior margin of anterior border. Anterior border is about twice as wide as preglabellar field, strongly concave, becoming horizontal in anterior direction; anterior margin of cranidium is parallel to posterior margin of border, making

a gentle turn forwards in front of glabella. Anterior area of fixigenae is strongly concave, inclined, narrowing in posterior direction; anterior border is slightly wider than in front of glabella, delimited posteriorly by three irregularly spaced tubercles, the proximal of which is smaller than the others; behind the distal tubercle follow in exsagittal direction two other tubercles. Palpebral area of fixigenae is reduced to a narrow, almost vertical band; palpebral lobes are imperfectly preserved, they appear to be moderately long and curved, situated slightly behind anterior one-third line across glabella. Posterior area of fixigenae is triangular, with acute lateral extremities, and a somewhat raised lateral edge; posterior border furrow is very deep and wide, close to posterior cephalic margin, communicating with axial furrows and occipital furrow.

Anterior sections of facial suture are nearly parallel, running almost straight to anterior margin. Posterior sections of facial suture are almost straight, at right angles to each other, cutting posterior margin well out at sides.

Other parts of the dorsal exoskeleton are unknown.

The ornamentation of the glabella and posterior area of fixigenae consists of somewhat coarse, closely spaced tubercles of varying sizes; they seem to be slightly coarser on posterior area of fixigenae than on glabella. Tubercles are absent in the furrows and on anterior border. There are five larger tubercles arranged in two lines at right angles in anterior area of fixigenae, and two additional, very faint ones are situated close to the tubercles which forms the apex of the right angle, and these three form a line parallel to antero-lateral portion of glabella.

Terrace lines, which are transverse, uniformly fine, are seen on internal mould of the occipital ring in one of the cranidia.

Dimensions. – Length of holtype cranidium (MMH no. 9453, pl. 6, figs. 7–9) 8 mm, width at posterior margin about 12 mm; length of glabella 5 mm, width of glabella at base 5.5 mm.

Affinities. – JAANUSSON (1956b) erected the family Celmidae with *Celmus* as the sole representative. Especially the glabellar morphology of *Celmus*? *longifrons* n. sp. resembles that of *Celmus* very much, and also some other parts of the cranidium are in good agreement. The new species very likely belongs to the Celmidae, but several significant dissimilarities prevent a definite assignment to *Celmus*, and a new genus will probably have to be erected for the Skelbro species.

In the diagnosis of the Celmidae JAANUSSON (1956b, p. 38) stated that the cephalon was surrounded by a distinct convex border. The cranidium of *C.*? *longifrons* n. sp. shows a distinctly concave anterior border. The glabella of the new species has a higher profile anteriorly and is more strongly tapering forwards, the frontal area is longer and more inclined, and the lateral margin of posterior area of fixigenae is upturned.

The differences pointed out above refer to the type species *C. granulatus*, but the same arguments may be applied to *C. barrandei* (VOLBORTH, 1858) which, according to JAANUSSON, may or may not be conspecific with *Celmus granulatus*.

JAANUSSON (1956b, p. 39) compared *Celmus* to members of the Glaphuridae, Dimeropygidae, Hystricurinae, Catillicephalidae, and Cheiruridae. He concluded that *Celmus* differed decisively in important respects, and that the family Celmidae had to be erected for *Celmus*.

The Glaphuridae differ from *Celmus*? *longifrons* n. sp. in the shape of glabella, in the position and direction of the lateral glabellar furrows which delimit bicomposite lateral glabellar lobes, whereas *Celmus*? and *Celmus* show lateral preoccipital lobes which are well-delimited from the anterior ones. The frontal area in *Glaphurus* RAYMOND, 1905 is long, but the anterior border is strongly convex.

The Dimeropygidae are smaller forms, the cranidia of which differ from *Celmus*? by having a convex border, faint or shallow lateral glabellar furrows, and the glabella is low anteriorly.

The Hystricurinae are distinguished from *Celmus*? by cranidia with faint lateral glabellar furrows, narrow and convex anterior border, and glabella with a low anterior profile; anterior sections of facial suture are more strongly diverging forwards.

The Catillicephalidae are Upper Cambrian forms from North America, and any relationship to the Celmidae is rather improbable. They differ from *Celmus*? in possessing a prominent, forward-expanded glabella which reaches the anterior cephalic margin in the majority of genera. The group appears to be inhomogeneous, and the genera shov a great variety of lateral glabellar furrows. Some of the genera do have lateral glabellar furrows which approach those of *Celmus*? and *Celmus*. The same genera, however, are easily separated from the celmids by means of the other, above mentioned criteria.

The Cheiruridae are proparian, the frontal area of the cranidium is at best poorly developed, and the glabella is usually forward-expanded. The celmids cannot in any way be grouped with the cheirurids, despite some similarities in the development of the thoracic pleurae.

In view of the similarities between the cranidia of *Celmus* and *Celmus*? *longifrons* n. sp. they presumably belong in the same family. On the other hand the differences pointed out indicate that considerable variation in preglabellar morphology, and therefore also in the morphology of the entire cephalic margin, may be characteristic of the Celmidae.

As nothing is known about the thorax and pygidium, the assignment of the new species to *Celmus*? and thereby to family Celmidae must be regarded as provisional.

Suborder Harpina WHITTINGTON, 1959

Family **Harpidae** HAWLE & CORDA, 1847

Genus ***Selenoharpes*** WHITTINGTON, 1950

Type species: *Harpes* (*Eoharpes*) *youngi* REED, 1914).

Selenoharpes excavatus (LINNARSSON, 1875)
Pl. 7, figs. 2–4

1875 *Harpes excavatus* LINNARSSON: Nerikes öfvergångsbildn., pp. 38–40, pl. 5, figs. 1–3. (Description and figs. of cephalon).

1950b *Selenoharpes excavatus* (LINNARSSON, 1875). – WHITTINGTON: Swedish Lower Ordivician Harpidae, pp. 303–305, pl. 1, figs. 1–3. (Redescription and figs. of LINNARSSON's original).

1956 — *excavatus* (LINNARSSON). – TJERNVIK: Early Ordovician of Sweden, p. 268. (Species reported from the *Megalaspides dalecarlicus* Zone).
1962 — *excavatus* (LNRS., 1875). – C. POULSEN: En ny trilobit fra Danmarks Ordovicium, p. 152. (Remarks).

Material. – Mould of one incomplete cephalon (MMH no. 9455). Glabella and genal regions appear as internal moulds, genal roll and most of the brim are absent. Lower lamella represented as mould of outer surface, a few patches show internal mould of brim and inner surface of upper lamella.

Horizon and locality. – *Cyclopyge stigmata* Zone; quarry at Skelbro, Risebæk.

Description. – Cephalon is sub-circular in outline, rather highly convex both ways, the height is about one-fourth the width, and the sagittal length is believed to be about five-eigths the width. Glabella is well elevated above genal regions, rather strongly convex both ways, probably one-third the cephalic length; it tapers gently forwards to a rounded front, the profile is highest slightly anterior to the occipital furrow. There is one pair of moderately deep and wide lateral glabellar furrows, delimiting slightly bulbous posterior lateral lobes, converging backwards, not reaching occipital furrow. Occipital furrow is deeply impressed, wide laterally, somewhat constricted mesially; occipital ring is imperfectly preserved, possibly provided with a node. Axial furrows are wide and shallow; preglabellar furrow is narrow but distinct, outlined by a curved, narrow (sag.) bulge around the front of glabella.

Preglabellar field is of equal width to the genal roll sagittally, and slopes forwards; laterally it merges into the transversely convex genae which slope gently down to the axial furrows, but with outer parts progressively more steeply down-sloping posteriorly. Eye tubercles are of moderate size, situated slightly behind the front of glabella, and the distance from glabella is two-thirds the width of adjacent portion of glabella; eye ridges are prominent, practically transverse, joining axial furrows in broad depressions. Genal ridges are extremely faint, arcuate, crossing the genal regions. Alae are semicircular in outline, about one-third the length of glabella, well-depressed, faintly convex, delimited by indistinct alar furrows. Posterior border furrow is wide and deep proximally, confluent with alae and occipital furrow, shallowing up abaxially; posterior border is narrow, convex.

Glabella, alae, and furrows are smooth. Genae and preglabellar field are ornamented with fine, anastomosing caeca. Between the individual ridges, which are radiating and becoming coarser distally, are situated small pits elongated in the radial direction.

Girder is not exposed, but the position is indicated by the corresponding inflexion of brim and a row of enlarged intercaecal pits. Genal roll must be broad, gently sloping anteriorly and antero-laterally, more steeply so posteriorly. Brim is wide, gently concave anteriorly, strongly so posteriorly; upper external rim is not preserved; lower external rim is flattened. Brim prolongations are not preserved.

The radiating caeca on genal roll and brim are continuous with those on the

preglabellar field and genae. The ridges are on the outer surfaces of the lamellae. The caeca then form tunnels traversing the fringe. The internal mould of the brim, left as small patches on the lower lamella, shows a very faint ridge pattern with minute, round closely situated pits between the ridges. Equally dimensioned and spaced pits are situated on the genal roll (about 50 per 5 mm).

Dimensions. – Length of cephalon (sagittally) about 14 mm, width at posterior margin 23 mm; length of glabella 5.0 mm, width of glabella at base 4.5 mm.

Affinities. – WHITTINGTON (1950b, p. 305) stated that *Selenoharpes excavatus* differs from the Middle Ordovician type species, *S. youngi*, in possessing a wider preglabellar field, concave brim crossed by radiating ridges, and in the absence of genal ridges.

The cephalon from Skelbro has genal ridges developed, but they are very faint, and LINNARSSON's imperfectly preserved holotype, which was refigured by WHITTINGTON, cannot be expected to show this feature.

In all other preserved details the Skelbro specimen is in perfect agrrement with the holotype. The ridge pattern on genal roll and brim is apparently less distinct than in the holotype, but that is probably related to the mode of preservation.

LINNARSSON's holotype of *Selenoharpes excavatus* originated from Lanna, Närke. The bed, in which it was found, was then believed to represent the Ceratopyge limestone. Now it is known that the holotype belongs to the *Megalaspides dalecarlicus* Zone of the Billingen Substage. TJERNVIK (1956, p. 268) has reported additional specimens from the same level.

Remarks. – C. POULSEN (1962, p. 152) stated that the presence of *Selenoharpes excavatus* in the basal part of the "Orthoceras limestone" on Bornholm emphasized the transitional nature of the assemblage.

A probably closely related species are found in the basal part of the "Orthoceras limestone" at Fågelsång, Scania associated with *Cyclopyge umbonata umbonata*.

Family **Harpididae** WHITTINGTON, 1950

Genus ***Harpides*** BEYRICH, 1846

Type species: *Harpides hospes* BEYRICH, 1846

Harpides nodorugosus n. sp.

Pl. 7, figs. 5–7

1936 *Harpides* n. sp. C. POULSEN: Ordovizium von Bornholm, pp. 48, 50. (Listed, remarks).

Derivation of name. – Latin *nodus* = node, and *rugosus* = wrinkled, alluding to the numerous, irregularly spaced nodes which are situated along the genal caeca, especially at points of furcation.

Holotype (here selected). – Internal mould of incomplete cephalon (genicranium) (MMH no. 9456), pl. 7, fig. 5.

Other material. – Internal moulds of three incomplete genicrania.

Horizon and locality. – *Cyclopyge stigmata* Zone; quarry at Skelbro, Risebæk.

Diagnosis. – Genicranium (cranidium) sub-semicircular. Glabella tapering forwards, with three pairs of lateral glabellar furrows, and with preoccipital median tubercle. Eye tubercles situated slightly behind front of glabella. Genal caeca very prominent, anastomosing, with irregurlarly spaced nodes, preferably at points of furcation.

Description. – Genicranium (sensu HENNINGSMOEN 1959, p. 155) is sub-semicircular in outline, of low convexity, about twice as wide as long. Glabella is prominent, probably between one-fourth and one-third the cranidial length, highly convex transversely, moderately so sagitally, unevenly tapering forwards to a flatly rounded front; its profile is highest posteriorly, where a prominent median tubercle is situated just in front of occipital furrow. There are three pairs of lateral glabellar furrows; anterior and second pair are very short and shallow, approximately transverse, closely situated behind the eye ridges; posterior pair is deeply impressed, converging backwards from axial furrows at posterior one-third line across glabella, delimiting somewhat bulbous posterior lateral lobes. Occipital furrow is moderately wide, well-impressed laterally, shallowing up adaxially, with a distinct forward-turn mesially; occipital ring is slightly expanded mesially, apparently without node. Axial furrows are well-impressed; preglabellar furrow is shallow.

Genae are sub-semicircular, gently convex in the proximal half, slightly concave and upturned distally. Eye tubercles are small, situated slightly behind the front of glabella, the distance from glabella is almost equal to width of adjacent portion of glabella; eye ridges are prominent, arcuate, almost transverse, joining glabella right behind antero-lateral corners. Genal ridges are absent. Alae are small, smooth, well-depressed. Posterior border is narrow, smooth, delimited by a well-impressed, abaxially widening border furrow which joins occipital furrow.

Genal caeca are very prominent, anastomosing, becoming progressively coarser when approaching the margin, ornamented with nodes of varying size, very often at points of furcation. Irregularly spaced tiny pits are situated between the caecal ridges in the marginal zone.

Glabella, eye ridges, and occipital ring are ornamented with irregularly spaced granules of varying size. Posterior border shows a single row of minute granules. Furrows and alae are smooth.

Dimensions. – Estimated length of holotype genicranium (MMH no. 9456, pl. 7, fig. 5) about 5 mm, estimated width about 10 mm, distance between the eye tubercles 4 mm; length of glabella 1.5 mm, width of glabella at base 2 mm.

Affinities. – The Skelbro specimens like all other harpidids evidently had a fragile test, and an imperfect state of preservation is to be expected. Only a few species of *Harpides* have been described, although harpidid fragments have been recorded from various levels. TJERNVIK (1956, p. 268) reported that species of *Harpides*, represented by small fragments, occur throughout the Latorp Stage.

The new species also occurs in the upper part of the *Megistaspis estonica* Zone in Sweden. The Swedish specimens show the same characteristic preoccipital tubercle and the nodes at points, where the caecal ridges furcate.

The type species, *Harpides hospes*, is apparently narrower than *Harpides nodorugosus* n. sp., and the position of the eye tubercles and eye ridges is somewhat different.

Harpides rugosus (SARS & BOECK, 1838) is known from the Tremadocian in Sweden and Norway. This species resembles the new species in many ways, and they are probably closely related.

H. nodorugosus n. sp. differs from *H. rugosus* by the absence of a preglabellar boss and genal ridges. Furthermore the eye tubercles are situated slightly more posteriorly in the new species, and the presence of a preoccipital median tubercle is very conspicuous. *H. rugosus* has a normal occipital tubercle which is absent in the new species. The ornamentation consisting of nodes, which are seen in both species, seems to be somewhat more prominent in the new species.

Harpides neogaeus HARRINGTON & LEANZA, 1957 differs from the new species in having comparatively small genae, narrower genicranium, well-developed genal ridges, and in the absence of a preoccipital node.

The Estonian *Harpides plautini* SCHMIDT, 1894 is only known from small fragments. The genicranium of this species is distinguished by a broad glabella which is quite unlike that of *H. rugosus* and *H. nodorugosus* n. sp.

RAW (1949, p. 511) has suggested that the Bohemian *Harpides grimmi* (BARRANDE, 1852) may be a junior synonym of *H. rugosus*. The same arguments, which serve to separate the new species from *H. rugosus*, may also be applied to *H. grimmi*.

Suborder Trinucleina SWINNERTON, 1915

Family **Dionididae** GÜRICH, 1908

Genus ***Trinucleoides*** RAYMOND, 1917

Type species: *Trinucleus reussi* BARRANDE, 1856.

Trinucleoides praecursor n. sp.
Pl. 8, figs. 1–4

1936 *Trinucleoides* n. sp. C. POULSEN: Ordovizium von Bornholm, p. 49. (Listed).

Derivation of name. – Latin *praecursor* = forerunner.

Holotype (here selected). – Internal mould of genicranium (MMH no. 9459), pl. 8, figs. 1–3.

Other material. – Internal moulds of two genicrania.

Horizon and locality. – *Cyclopyge stigmata* Zone; quarry at Skelbro, Risebæk.

Diagnosis. – Cephalon transverse, evenly rounded anteriorly and antero-laterally. Genal angles well-advanced. Glabella expanded forward, gently

rounded anteriorly, with median spine in front of midpoint. Lateral glabellar lobes sub-reniform, accentuated by elongate, exsagittal pits which are very deeply impressed parts of posterior pair of lateral glabellar furrows. Occipital region simple. Genae with short eye ridges, prominent eye tubercles, and faint transverse genal ridges. Surface of genae ornamented with closely set rows of pits which outline a faint caecal pattern. Pitted portion of fringe narrow.

Description. – Cephalon (and genicranium) transverse, evenly rounded anteriorly and antero-laterally, with well-rounded metagenal angles, rather highly convex both ways. Genal spines, of which only the base is preserved as mould of ventral side, are well-advanced, situated on midline across glabella, directed outward-backwards. Glabella is pyriform, expanded forward, bulbous anteriorly, with a gently rounded front; its profile is highest slightly in front of midpoint, and a slightly forward-tilted median spine arises from the highest point. There are two pairs of lateral glabellar furrows; anterior pair is short and moderately impressed, directed inward-backwards from a point just behind the eye ridges, separated from axial furrows; posterior pair is very deeply impressed, forming deep crescentic pits which are almost parallel to sagittal axis, connected with the anterior pair by shallow furrows at inner ends; the composite furrows thus delimit sub-reniform lateral glabellar lobes. Occipital furrow is straight, narrow and shallow; occipital ring is narrow (sag.), simple, moderately wide. Axial furrows are narrow and well-impressed anteriorly, expanded posteriorly so as to form depressions along posterior half of the lateral glabellar lobes; preglabellar furrow is narrow, but distinct.

Fringe is narrow, dominated by the narrow, essentially flat upper external rim. One row of irregularly spaced, large pits are situated along the inner margin of the fringe; between the large pits are laterally a number of small pits in a quite irregular arrangement. Genae are convex, sub-triangular in outline, curving rather steeply down to expanded portion of axial furrows. Eye tubercles are fairly large, situated slightly behind anterior one-third line across glabella, the distance from glabella is less than one-fourth the width of adjacent portion of glabella; eye ridges are prominent, transverse, crossing axial furrows to join glabella just in front of anterior pair of lateral glabellar furrows. Genal ridges are extremely faint, slightly arcuate, almost transverse, crossing inner margin of the fringe, at which the pits are obliterated. Posterior border furrow is wide and rather well-impressed, separated from axial furrows, directed outward-forwards from occipital ring, then curving gently back behind middle portion of the genae, laterally turning outward-forwards; posterior border is convex, narrow proximally, then widening, slightly upturned laterally. Distally the border and border furrow make a forward-turn to meet base of the genal spines, forming a rounded metagenal angle.

The surface of the genae is ornamented with closely set rows of shallow pits which outline a faint caecal pattern.

Postero-laterally the marginal suture turns inwards obliquely across the fringe to posterior cephalic margin.

Thorax and pygidium are unknown.

Dimensions. – Length of holotype genicranium (MMH no. 9459, pl. 8, figs. 1–3) 1.3 mm, width 3 mm, distance between the eye tubercles 1.5 mm; length of glabella 1.1 mm, width of glabella at base 0.9 mm.

Affinities. – *Trinucleoides* has hitherto been represented only by the type species *T. reussi* (BARRANDE) which is of Llanvirnian age.

The writer considered erecting a new dionidid genus for the Skelbro species. However, it closely resembles *Trinucleoides reussi* in many respects, and at the same time it is very unlike the other dionidids.

The cephalon of *Trinucleoides praecursor* n. sp. resembles that of the type species with regard to general shape, the pyriform glabella with antero-median spine and prominent lateral glabellar lobes, the narrow pitted portion of the fringe, and the advanced genal spines.

On the other hand the genal spines in the new species are more advanced. The inner margin of the lateral glabellar lobes is parallel to outer margin, thus forming an almost reniform body. Eye ridges and eye tubercles are well-defined. Finally the new species does not exhibit bifurcate genal ridges like the ones supposedly present in the type species (WHITTINGTON 1940, p. 257).

Trinucleoides praecursor n. sp. is the only known dionidid representative with eye tubercles. In general the definite presence or absence of eyes would constitute valid criteria for a generic distinction, but in the present case the considerable age difference between the Danish and Bohemian species makes such a distinction questionable. The members of the Dionididae with the exception of the new species belong to the Middle or Upper Ordovician, and the writer believes that a gradual reduction of the eye tubercles has taken place during the late Lower Ordovician.

Trinucleoides reussi still shows short rudiments of the eye ridges.

RAYMOND (1917, p. 204) compared the lateral glabellar lobes of *T. reussi* with the alae of *Onnia ornata*. This was rejected by WHITTINGTON (1940, p. 256), who stated that the lateral glabellar lobes of *Trinucleoides* are anterior to the occipital furrow, while the alae of *Onnia ornata* seem to be connected with the occipital ring and are never crossed by the occipital furrow.

The present writer believes that WHITTINGTON is right, as the expanded portion of the axial furrows along posterior half of the lateral glabellar lobes in *Trinucleoides praecursor* n. sp. may possibly be referred to as alae.

Family **Raphiophoridae** ANGELIN, 1854

Genus ***Ampyx*** DALMAN, 1827

Type species: *Ampyx nasutus* DALMAN, 1827.

Ampyx glaber n. sp.

Pl. 8, figs. 5–11

1936 *Ampyx volborthi* SCHM. – C. POULSEN: Ordovizium von Bornholm, p. 48. (Listed).
1936 — n. sp. C. POULSEN: Ordovizium von Bornholm, p. 48. (Listed).
?1942 — *volborthi* F. SCHMIDT. – REGNÉLL: Remarks Lower Ordov. Öland, pp. 3–4. (Listed, remarks, fig. of pyg.).
1952 — *pater* HOLM [partim]. – SKJESETH: Lower Didymograptus Zone, p. 176, pl. 5, figs. 4b, 7; non figs. 2, 12–16. (Description and figs. of cranidium).

Derivation of name. – Latin *glaber* = smooth, alluding to the smooth glabella with only barely discernible muscle scars.

Holotype (here selected). – Internal mould of cephalon with spines broken off (MMH no. 9463), pl. 8, figs. 5–7.

Other material. – One cranidium, one pygidium; internal moulds of two cephala, ten cranidia, and two pygidia; external moulds of one cranidium and two pygidia.

Horizon and locality. – *Cyclopyge stigmata* Zone; quarries at Skelbro, Risebæk, and 400 metres east of Skelbro.

Diagnosis. – Cephalon rounded triangular, twice as wide as long. Glabella highly convex both ways, pseudo-carinate, pointed pyriform, overhanging anterior cephalic margin. Cephalic border flat and horizontal. Occipital ring and furrow curving backwards mesially, situated slightly posterior to posterior border respectively border furrow. Pygidium triangular, twice as wide as long; border flat, almost vertical.

Description. – Cephalon is rounded triangular in outline, about twice as wide as long (excluding spine). Cranidium is triangular. Glabella is highly convex both ways, pseudo-carinate, pointed pyriform, anteriorly overhanging anterior cephalic margin, triangular in frontal view, profile highest slightly in front of midpoint, well-elevated above genae; the front of glabella is drawn into a long upward-curving glabellar spine which is circular in cross section. There are four pairs of ovate muscle scars which are extremely faint in most specimens and absent in some, all separated from the axial furrows; anterior pair is small, situated almost opposite anterior ends of genal ridges; second pair is large; third pair is large, situated just in front of occipital furrow, in which the fourth transverse pair of muscle scars is situated close to the axial furrows. Occipital furrow is moderately deep and wide throughout, joining axial furrows; occipital ring is narrow (sag.) convex, simple, curving backwards mesially parallel to occipital furrow, indistinctly delimited from posterior border. Occipital ring is situated slightly posterior to posterior margin of cephalon. Axial furrows are narrow and shallow, with deep, elongate fossulae which are situated, where glabella attains its maximum width; preglabellar furrow is narrow and shallow.

Anterior border is narrow and flat. The genae are moderately convex, gently down-sloping in abaxial direction, meeting the flat lateral border at a sharp angle which is outlined by a narrow border furrow. Eyes are absent. Some specimens show very faint genal ridges, curving backward-outwards from axial furrows between anterior and second pairs of muscle scars to pass in front of genal angles. Posterior border is narrow (sag.), convex, delimited by a wide, moderately impressed border furrow which has a deep pit situated just inside genal angle.

The suture is marginal anteriorly, crossing the genae in a gentle curve, at genal angles turning inward-backwards to cross posterior border. Genal spines are not preserved in any of the specimens.

Pygidium is triangular in outline, twice as wide as long. Axis is gently convex, almost level with the pleural fields, about one-fifth the width of the pygidium at anterior margin, gently tapering to posterior border, with rounded terminal piece. Internal moulds show about twelve axial rings, of which only the anterior

eight are well-defined, separated by shallow ring furrows; articulating half ring is narrow (sag).). Round muscle scars are arranged in two rows which are situated in the ring furrows. Axial furrows are shallow.

Pleural fields are gently convex, showing about five pairs of pleurae with faint pleural furrows. Articulating half segment is depressed below level of pleural fields, delimited by a moderately deep furrow. Furrows terminate at inner margin of the border which is outlined by a narrow raised line. Border is flat, almost vertical, attaining its maximum width at midline across axis, with fine, closely situated terrace lines parallel to outer margin of the pygidium.

External surface of test is finely pitted.

Dimensions. – Length of largest cephalon (not figured) about 6 mm, width 11 mm; length of largest pygidium (not figured) about 6 mm, width 12.5 mm.

Affinities. – *Ampyx glaber* n. sp. is readily distinguished from other species of *Ampyx*.

The glabella does not reach the anterior cephalic margin in *Ampyx linnarssoni* SCHMIDT, whereas it clearly is overhanging in the new species. The glabella in *Ampyx pater* HOLM is less overhanging, and its profile especially posteriorly is much lower, the glabella is almost level with the genae. *A. costatus* BOECK MS. differs by its flattened lateral portions of glabella with deeply impressed muscle scars. *A. mammilatus* SARS has a glabella which is flatly rounded anteriorly.

The cephalic border in *Ampyx nasutus* is convex, whereas it is flat in the new species. *A. nasutoides* REGNÉLL differs in having a glabella with a flat front and by the indistinctly defined occipital ring.

Ampyx glaber n. sp. in many respects resembles *A. volborthi* SCHMIDT, but the glabella of the new species has a slightly different shape, and the occipital ring and furrow are curving backwards mesially. In *A. volborthi* the occipital ring is straight and continuous with posterior border on both sides.

The pygidia of the different species are somewhat less characteristic, but as all the cephalic material of *Ampyx* in the Skelbro limestone seems to belong to *A. glaber* n. sp., the associated pygidia are regarded as conspecific.

C. POULSEN (1936) listed a new species af *Ampyx* apart from *A. volborthi*, but the present writer is of the opinion that all specimens represent one species.

REGNÉLL (1942, p. 3) reported a pygidium of *Ampyx volborthi* from the "Limbata" limestone on southern Öland. An assignment to species of isolated ampyxid pygidia is probably not reliable, and the pygidium in question may in fact belong to *A. glaber* n. sp.

SKJESETH (1952, p. 178) transferred Norwegian specimens of the species *volborthi* to *Lonchodomas*. The material originated from the Lower *Didymograptus* Zone. He stated that it had a four-edged glabellar spine, However, the spine as well as the front of glabella are broken off in the figured cranidium (SKJESETH, 1952, pl. 5, fig. 1), and the section thus produced creates the impression of an angular cross section. The present writer has has the opportunity of studying the cranidium and corresponding mould which shows a glabellar spine with a rounded, noncarinate cross section. SKJESETH further emphasized the importance of the five thoracic segments which is the number previously indicated by SCHMIDT. The present writer believes that *Ampyx volborthi* probably possesses six thoracic segments. Only one of SCHMIDT's

figured specimens (1894, pl. 6, fig. 11) shows the thorax. In this specimen five thoracic segments are seen, but the position of the cranidium is such that the anterior thoracic segment may very well be missing.

The original Estonian collections of *Ampyx volborthi* described by SCHMIDT originated from a level corresponding to the *Asaphus expansus* Zone, and Latorpian specimens, which have been referred to *A. volborthi*, will probably have to be assigned to some other species.

One of the cranidia of *Ampyx pater* figured by SKJESETH (1952, pl. 5, figs. 4b, 7) must belong to *Ampyx glaber* n. sp. The Norwegian specimen shows identical occipital structures, the shape and height of glabella is the same, and quite different from the other figured specimens of *A. pater*.

Suborder and family uncertain

Genus et species indet.

Pl. 8, figs. 12–14

1936 *Ceratopyge* n. sp. C. POULSEN: Ordovizium von Bornholm, pp. 48, 51. (Listed, occurrence discussed).

Material. – Eight cranidia, some of which are represented by internal moulds.

Horizon and locality. – *Cyclopyge stigmata* Zone; quarry at Skelbro, Risebæk.

Description. – Cranidium is small, about as long as wide. Glabella is three-fourths the cranidial length and about half the width at base, expanded forward, gently rounded anteriorly, highly convex both ways, profile highest at midpoint. There are three pairs of short and shallow almost transverse lateral glabellar furrows. A faint median node, which is situated on posterior one-third line across glabella, may be seen in some specimens, otherwise glabella is quite smooth. Occipital ring is simple, short (sag.), relatively wide, delimited by a straight, wide and deeply impressed occipital furrow. Axial furrows and preglabellar furrow are narrow and moderately impressed.

Frontal area consists only of narrow, thread-like anterior border, delimited by a border furrow which is confluent with the preglabellar furrow; anterior margin is parallel to the front of glabella. Anterior area and palpebral area of fixigenae are reduced to narrow bands which follow the glabellar contour closely; palpebral lobes are not preserved in any of the specimens, but are supposed to be situated on posterior one-third line across glabella, joining the axial furrows; the distance between the eyes is probably about half the width of the cranidium. Posterior area of fixigenae is horizontal, moderately long and wide, triangular, pointed distally; posterior border furrow is wide and shallow; posterior border is rather prominent, gently convex; posterior margin is straight.

Anterior sections of facial suture are only slightly diverging forwards, closely following the glabellar contour, cutting anterior cephalic margin close to antero-lateral corners of glabella. Posterior sections of facial suture are

sinuous, strongly diverging backwards, turn in more posterior direction at border furrow, cutting posterior margin well out at sides.

Other parts of the dorsal exoskeleton are unknown.

Dimensions. – Length of cranidium (MMH no. 9444) pl. 8, figs. 12–13 2 mm, width 2.2 mm; length of glabella 1.5 mm, width of glabella at base 1.2 mm; distance between the eyes (estimated) 1 mm.

Remarks. – C. POULSEN (1936) assigned the cranidia to *Ceratopyge*, but in other regions the genus is restricted to the Tremadocian, and it is not likely to occur in the Volkhov Stage.

The small size of the cranidia indicates that they may possibly be meraspides (styginid?).

Order Phacopida SALTER, 1864

Suborder Cheirurina HARRINGTON & LEANZA, 1957

Family **Cheiruridae** SALTER, 1864

Subfamily Cyrtometopinae ÖPIK, 1937

Genus *Cyrtometopus* ANGELIN, 1854

Type species: *Calymene clavifrons* DALMAN, 1827. Designated by BARTON, 1920.

Cyrtometopus sp.
Pl. 8, figs. 15–16

1936 *Cyrtometopus* sp. C. POULSEN: Ordovizium von Bornholm, p. 48. (Listed).

Material. – Internal mould of a somewhat fragmentary, slightly distorted cranidium.

Horizon and locality. – *Cyclopyge stigmata* Zone; quarry at Skelbro, Risebæk.

Description. – Cranidium is sub-semicircular in outline, about twice as wide as long. Glabella is close to being elliptical in outline, gently rounded anteriorly, strongly convex both ways, well elevated above genal regions, its profile highest at midpoint; maximum width at second pair of lateral glabellar furrows is about two-thirds the length of glabella. There are three pairs of narrow, well-impressed lateral glabellar furrows which join axial furrows; anterior and second pair are short, directed but slightly backwards; posterior pair is longer, arcuate, converging backwards, apparently connected by shallow furrow or depression. Occipital ring is only preserved laterally, apparently narrow (sag.) and convex; occipital furrow is relatively wide and well-impressed. Axial furrows are deep but narrow, with deep fossulae situated slightly in front of anterior pair of lateral glabellar furrows; preglabellar furrow is wide and moderately impressed, slightly elevated above the level of the axial furrows.

Frontal area consists only of the narrow, convex anterior border, delimited by a border furrow which is confluent with preglabellar furrow. Anterior area of fixigenae is short, wholly dominated by the wide, moderately impressed

anterior border furrow. Palpebral area of fixigenae is imperfectly preserved; inner portions are gently down-sloping in adaxial and posterior direction; lateral portions of palpebral regions are not preserved; eye ridges are wide and low, slightly arcuate, joining axial furrows almost opposite anterior pair of lateral glabellar furrows. Posterior area of fixigenae is only preserved proximally, gently down-sloping in lateral and posterior direction; posterior border is narrow (sag.), convex, delimited by a wide and well-impressed border furrow.

Anterior sections of facial suture are converging forwards; posterior sections are not preserved.

Small patches of the test left on glabella show a fine granulation. Fixigenae are covered with small pits.

Dimensions. – Length of the cranidium (MMH no. 9465) 16 mm, width (estimated) 28–30 mm; length of glabella 14 mm, width of glabella at base 9 mm, maximum width at second pair of lateral glabellar furrows 10.5 mm.

Affinities. – TJERNVIK (1956, p. 267) chose a *Cyrtometopus*-like pygidium as holotype of *Cyrtometopus priscus*. The species was hesitantly assigned to this genus, because the cranidium differed in some respects.

The present writer believes that the assignment to *Cyrtometopus* is absolutely valid. *C. priscus* is obviously an early, primitive form which still shows cranidial features characteristic of the ancestral Pilekiinae. Most important is the presence of true eye ridges or palpebro-ocular ridges (= true palpebral ridges, TJERNVIK 1956, p. 266).

The cranidium of *Cyrtometopus priscus* in many respects resembles that of *Pilekia anxia* SDZUY, 1955. The glabella on the other hand has a different outline, and the pygidia assigned to *Pilekia* are quite different, having eight slender, sub-equally dimensioned spines.

In most respects the cranidium from Bornholm seems to be identical with that of *C. priscus* from the *Megistaspis estonica* Zone, but TJERNVIK has found similar cranidia in the *Megistaspis lata* Zone in Närke, and a reliable specific assignment is not yet possible. It may be so that the species crosses the boundary between the two zones. The specimen from Skelbro is somewhat larger than the cranidium of *C. priscus* figured by TJERNVIK (1956, pl. 11, fig. 6), and the posterior border furrow is slightly widening in abaxial direction, whereas the furrow in *C. priscus* apparently is of constant width. However, the morphology of the furrow may to some extent be related to the absolute size of the individual.

Remarks. – According to ÖPIK (1937, p. 111) a sutural ridge was developed in the Cyrtometopinae to take the place of the eye ridges which had been reduced to obliteration, whereas the palpebral furrow remains as in *Pliomera*. Stages of the postulated reduction of the eye ridges then ought to show in some "Limbata"-level representatives of *Cyrtometopus*.

Genus ***Pseudosphaerexochus*** SCHMIDT, 1881

Type species: *Sphaerexochus hemicranium* KUTORGA, 1854. Designated by REED, 1896.

Subgenus ***Pateraspis*** PRANTL & PŘIBYL, 1947

Type species: *Cheirurus pater* BARRANDE, 1872

This subgenus is represented by two Scandinavian species: *Pseudosphaerexochus* (*Pateraspis*) *praecursor* REGNÉLL, 1940 from the *Megistaspis estonica* Zone on Öland and *P.* (*Pateraspis*) *inflatus* n. sp. from Bornholm. The two species are the first to be recorded apart from the Bohemian type species which belongs to late Lower Ordovician and early Middle Ordovician.

Pseudosphaerexochus (*Pateraspis*) *inflatus* n. sp.
Pl. 9, figs. 1–9

1936 *Cyrtometopus* n. sp. C. POULSEN: Ordovizium von Bornholm, p. 48. (Listed).

Derivation of name. – Latin *inflatus* = swollen, alluding to the strongly bulbous glabella.

Holotype (here selected). – Internal mould of cranidium (MMH no. 9466), pl. 9, figs. 5–8.

Other material. – Internal moulds of five cranidia; one pygidium, external moulds of two pygidia.

Horizon and locality. – *Cyclopyge stigmata* Zone; quarry at Skelbro, Risebæk.

Diagnosis. – Cranidium dominated by oval, strongly bulbous glabella which rises steeply, reaching its greatest height just behind second pair of lateral glabellar furrows. There are three pairs of lateral glabellar furrows. Eyes situated slightly behind midline across glabella. Pygidium exclusive of the spines rounded triangular, including the spines trapezoidal in outline. There are three axial rings and effaced terminal piece. Pleural regions projected into three pairs of lancet-shaped spines.

Description. – Cranidium is sub-trapezoidal in outline, about twice as wide as long. Glabella is very highly convex in both directions, strongly bulbous, rises steeply from surrounding furrows, forming two-thirds of a spheroid, oval in dorsal view, slightly longer than wide, four-fifths the cranidial length; its profile is highest just behind second pair of lateral glabellar furrows. There are three pairs of regularly spaced lateral glabellar furrows which join axial furrows; anterior and second pair are short and shallow, slightly arcuate, directed but slightly backwards, situated at anterior one-third line and midline across glabella; posterior pair is wide and deeply impressed, arcuate, converging in backward direction from axial furrows at posterior one-third line across glabella, not reaching occipital furrow. Occipital ring is short (sag.) but wide,

gently convex, simple; occipital furrow is wide and deeply impressed throughout. Axial furrows are deep but narrow; preglabellar furrow is wide and well-impressed, united with anterior border furrow.

Anterior border is narrow, convex, almost straight, thickening in abaxial direction, delimited by a wide and well-impressed border furrow. Anterior area of fixigenae is narrow (tr.), strongly down-sloping anteriorly, less so laterally. Palpebral area of fixigenae is imperfectly preserved, convex in both directions, less than one-fifth the width of adjacent portion of glabella; palpebral lobes, which are not preserved, must be situated slightly behind midline across glabella; palpebral furrows are short, narrow but distinct, curved, approaching glabella. Posterior area of fixigenae is moderately wide, strongly down-sloping abaxially; posterior border furrow is narrow but deep, communicating with occipital furrow and axial furrows; posterior border is narrow, convex.

Anterior sections of facial suture are converging forwards, gently curved, cutting anterior cephalic margin rather close to glabella. Posterior sections are strongly diverging backwards, cutting lateral margin fairly close to the genal angle.

Pygidium exclusive of the spines is rounded triangular in outline, including spines trapezoidal in outline. Axis is convex, slightly raised anteriorly, almost level with pleural regions posteriorly, strongly tapering backwards, about one-third the pygidial width at anterior margin. There are a narrow articulating half ring, three well-developed axial rings, terminal piece is obsolete; ring furrows are narrow but deep, the posterior ring furrow is reduced to two ill-defined shallow pits. Axial furrows are indistinct.

Pleural regions are projected into three pairs of long, flattened lancet-shaped spines which are elliptical in cross section; a line drawn through the distal ends of the spines is less curved than the pygidial margin between the spines.

Surface of the test of cranidia and pygidia with the exeption of furrows is densely covered with fine granules. In the cranidia irregularly spaced, coarser granules are seen.

Dimensions. – Length of holotype cranidium (MMH no. 9466, pl. 9, figs. 5–8) 2.5 mm, width 4 mm; length of glabella about 2 mm, width of glabella at base 1.5 mm, maximum width 2 mm. Length of largest cranidium (not figured) 6 mm, width 10–12 mm; length of glabella 5 mm, width of glabella at base 3 mm, maximum width 4 mm. Length of figured pygidium (MMH no. 9468, pl. 9, fig. 9) excluding spines 2.5 mm, including spines 5.5 mm, width at anterior margin 5.5 mm, maximum width between anterior spines 9 mm, width of axis at anterior margin 2 mm.

Affinities. – The subgenus *Pateraspis* has hitherto only been recorded from Bohemia. The new species matches the subgeneric diagnosis in most respects, but the cranidium differs from that of the type species in the more posterior position of the palpebral lobes, and in the highly bulbous glabella. The pygidium of the new species shows the appropriate number of spines characteristic of *Pateraspis*, but the spines differ somewhat in shape, size, and direction.

Pseudosphaerexochus praecursor REGNÉLL, 1940 undoubtedly belongs to

subgenus *Pateraspis*, and may be closely related to the new species. The cranidium of REGNÉLL's species differs from that of *P.* (*Pateraspis*) *inflatus* n. sp. with regard to the outline and profile of glabella. The Swedish species has an almost perfectly round glabella, the profile of which is lower and culminating more anteriorly than in the new species. The pygidium of the Swedish species is unknown.

Family uncertain

Genus et species indet.

Pl. 9, fig. 10

1936 *Cybele* n. sp. C. POULSEN: Ordovizium von Bornholm, p. 48. (Listed).

Material. – One external mould and two internal moulds of glabellar region.

Horizon and locality. – *Cyclopyge stigmata* Zone; quarry at Skelbro, Risebæk.

Description. – Glabella is sub-parallelsided posteriorly, with swollen frontal glabellar lobe, flatly rounded anteriorly, profile is highest at midpoint of frontal lobe. There are three pairs of short well-impressed lateral glabellar furrows which are separated from axial furrows; anterior pair is transverse, situated on midline across glabella; second and posterior pair are directed slightly backwards, widening and deepening in adaxial direction. Occipital furrow is moderately wide, well-impressed, making a slight forward-turn mesially, with transverse elongate pits laterally, joining posterior border furrow; occipital ring is simple, with a median node. Axial furrows are ill-defined.

Anterior and palpebral areas of fixigenae are not preserved. Posterior area of fixigenae is imperfectly preserved; inner portion is gently down-sloping towards the glabella; posterior border furrow is moderately deep and wide.

Surface of glabella is ornamented with scattered, coarse granules, at front of the glabella they form a single line.

Dimensions. – Length of figured glabellar region (MMH no. 9469, pl. 9, fig. 10) 1.5 mm, width at base 0.8 mm; width of frontal lobe 1.2 mm.

Remarks. – In some respects the fragments resemble *Atractopyge* HAWLE & CORDA, and especially with regard to the strongly expanded frontal glabellar lobe they resemble the Upper Ordovician *Atractopyge errans* ÖPIK (1937, p. 122, text-fig. 35 = *Cybele brevicauda* ANGELIN [partim]. – SCHMIDT, 1881, pl. 14, figs. 7a–b). The incompleteness of the material, however, prevents any assignment to genus.

The writer believes that the species must represent a young element in the fauna.

Order Lichida MOORE, 1959

Family **Lichidae** HAWLE & CORDA, 1847

Subfamily Lichinae HAWLE & CORDA, 1847

Genus ***Metopolichas*** GÜRICH, 1901

Type species: *Metopias hübneri* EICHWALD, 1842. Designated by REED, 1902.

Metopolichas? sp. indet.
Pl. 9, fig. 11.

Material. – Incomplete, slightly corroded external mould of pygidium (MMH no. 9470).

Horizon and locality. – *Cyclopyge stigmata* Zone; quarry at Skelbro, Risebæk.

Description. – The marginal region is not preserved, but the pygidial outline is probably elongated triangular. Axis is gently convex, slightly raised anteriorly, level with pleural regions posteriorly, slightly tapering, rounded posteriorly. Anterior half of axis is divided into an articulating half ring and four flat axial rings, delimited by moderately deep and wide ring furrows which are forward-expanded mesially; the furrows become progressively fainter in posterior direction, and the posterior one is interrupted at the middle by a gap equal to half the axial width on midline. Posterior half of the axis is unsegmented. Axial furrows are narrow but distinct.

Pleural regions are flat, showing three well-defined pairs of pleurae and a fourth posterior pair which is less distinct; interpleural furrows are narrow but well-impressed, faintly sigmoidal, directed obliquely backwards; pleural furrows are dimensioned very much like the interpleural furrows.

Surface of the test except furrows is densely covered with fine, uniform granules.

Dimensions. – Length of pygidium possibly about 30 mm, width possibly about 38 mm; width of axis at anterior margin 10 mm.

Affinities. – According to TRIPP (1957, pp. 108–109) the pygidia may differ strongly within the individual lichid genra, and even the presence of an extra segment in the pygidium does not appear to be of fundamental importance.

The pygidium from Skelbro resembles that of *Metopolichas*? sp. from the Billingen Substage or lower part of the Volkhov Stage on Öland (REGNÉLL 1942, *Lichas* s. l. sp.). The resemblance pertains to shape and segmentation of the axis. REGNÉLL's specimen, however, differs in the development of the third and fourth pair of pleurae which are more oblique; furthermore the pleural furrow is absent on the fourth pair in the Swedish specimen. The present writer is of the opinion that the pygidia probably represent two distinct but closely related species.

SKJESETH (1952, p. 174) recorded fragments of *Lichas* sp. from Ringsaker, Norway. A resemblance to REGNÉLL's specimen was pointed out, but the fragmentary material did not permit any closer comparison.

DANSK SAMMENDRAG

I det foreliggende arbejde beskrives en nedreordovicisk trilobitfauna fra Skelbrokalken (nyt navn) på Bornholm. Skelbrokalken udgør den nederste del af »Orthoceratitkalken«. Materialet stammer fra Mineralogisk Museums samlinger og er indsamlet i årene 1880–1958. Størstedelen af materialet er indsamlet af C. POULSEN 1922–1923.

Lokaliteter

Det beskrevne materiale stammer fra to lokaliteter: Skelbro ved Risebæk og 400 meter øst for Skelbro. Lokaliteterne er nu opgivne kalkbrud (kort, tekstfigur 1). Skelbrokalken er for tiden vanskeligt tilgængelig. Kalken kan let kendes i håndstykker ved dens indhold af op til tre cm store, kantede fosforitstykker.

Stratigrafi

Den stratigrafiske placering af Skelbrokalken diskuteres indgående på grundlag af trilobitfaunaen (side 55–59).

C. POULSEN (1936) udskilte den nederste del af »Orthoceratitkalken« på Bornholm som en separat enhed, der fik navnet Umbonatakalken efter den almindeligt forekommende *Cyclopyge umbonata*. Denne art optræder i den nedre del af »Orthoceratitkalken« ved Fågelsång i Skåne, og det blev fremhævet, at lagene ved Skelbro og Fågelsång kunne være stratigrafiske ækvivalenter. Grundlaget for en udskillelse af Umbonatakalken var trilobitfaunaens »blandede« karakter. Faunanen inkluderede elementer fra Planilimbatakalkens niveau foruden arter fra »Limbata«-kalken og nedre del af Asaphus-serien.

Forfatteren til det foreliggende arbejde påviser side 82, at *Cyclopyge umbonata* ikke optræder i Skelbrokalken. Alle eksemplarer tilhører en ny art *C. stigmata*. Alle *Cyclopyge*-eksemplarer fra Fågelsång tilhører *C. umbonata*, og de her associerede trilobitarter antyder, at de nedre Fågelsång-lag må være betydeligt yngre end Skelbrokalken.

Siden C. POULSEN's oversigt fra 1936 er der sket mange ændringer af stratigrafisk og systematisk art; men til trods herfor er faunaens blandede karakter lige slående, og en stratigrafisk placering af faunaen og dermed kalken kommer da til at afhænge af en vurdering af samtlige arters betydning.

Det stratigrafiske inddelingsgrundlag, som anvendes her, svarer til det svensk-baltiske standardprofil ifølge JAANUSSON (1960a, b). Den eneste forskel er, at en *Cyclopyge stigmata* Zone er blevet tilføjet som den ældste enhed i Volkhovetagen (se tekstfigur 2).

Skelbrokalken

JAANUSSON (1960a, p. 300) introducerede Komstad Formationen, som omfatter den skånske kalkfølge mellem Nedre- og Øvre Didymograptusskifer. Denne formation svarer til den øvre del af »Orthoceratitkalken« på Bornholm, og den nedre del opstilles i det foreliggende arbejde som en selvstændig formation – Skelbrokalken.

Skelbrokalken beskrives (side 53–55), dog er lithologien endnu kun ufuldstændig kendt.

Faunaens alder.

Skelbrokalkens 25 trilobitarter kan placeres i fire grupper. Den ene omfatter de ubestemmelige og nye arter, som ikke kan give oplysninger om alderen. Den anden gruppe rummer arter med affinitet til former fra Latorpetagen, og den tredie består af arter med affinitet til Volkhovetagens fauna. Endelig omfatter den fjerde gruppe arter, som i andre områder optræder på begge sider af grænsen mellem Latorp- og Volkhovetagen.

I øjeblikket kan følgende arter ikke give stratigrafiske oplysninger:

Celmus? *longifrons* n. sp.
Cyclopyge stigmata n. sp.
Genus et species indet. no. 1
– – – – no. 2
Hallanta modesta n. gen. et n. sp.
Metaptychopyge? sp. indet.
Metopolichas? sp. indet.
Symphysurina? sp.
Trinucleoides praecursor n. sp.

Celmus? *longifrons* n. sp. og *Trinucleoides praecursor* n. sp. repræsenterer slægter, hvis udbredelse endnu er ukendt. *Cyclopyge stigmata* n. sp. viser slægtskab med *C. umbonata*, men viser samtidig karakterer, som ikke kendes hos nogen anden cyclopygid slægt. Denne art er valgt til at karakterisere faunaselskabet som en ny zone – *Cyclopyge stigmata Zonen.*

Følgende arter kendes fra eller er nært beslægtet med former fra Latorpetagen:

Ampyx glaber n. sp.
Geragnostus danicus n. sp.
Harpides nodorugosus n. sp.
Pseudosphaerexochus (*Pateraspis*) *inflatus* n. sp.
Remopleuridiella groenwalli n. sp.
Selenoharpes excavatus (LINNARSSON, 1875).

Ampyx glaber n. sp. optræder i øverste del af Nedre Didymograptusskifer i Norge, og det samme gælder måske *Geragnostus danicus* n. sp. og *Remopleuridiella groenwalli* n. sp. *Harpides nodorugosus* n. sp. er en nær slægtning til *H. rugosus* fra Ceratopygekalken og findes i øverste del af *Megistaspis estonica* Zonen i Sverige; men *Harpides*-arter kendes overhovedet ikke fra yngre niveauer andre steder. Holotypen for *Selenoharpes excavatus* stammer fra *Megalaspides dalecarlicus* Zonen i Närke.

Følgende arter kendes fra eller er nært beslægtet med former fra Volkhovetagen:

Megistaspis (*Megistaspis*) cf. *lata* (TÖRNQUIST, 1884)
– – sp. no. 1
– – sp. no. 2
Paraptychopyge sp.
Raymondaspis imparilis n. sp.
Symphysurus (*Symphysurus*) *dorsatus* n. sp.

Arter af *Megistaspis* (*Megistaspis*) er aldrig fundet i niveauer under *Megistaspis lata* Zonen, og *Paratychopyge* begynder i Volkhovetagen. *Raymondaspis imparilis* n. sp. synes at stå særlig nær svenske former fra *M. lata* Zonen. *Symphysurus dorsatus* n. sp. er muligvis en nær slægtning til *S. palpebrosus.*

Den sidste gruppe trilobitarter kendes både fra Latorp- og Volkhovetagen og omfatter:

Cyrtometopus sp.
Nileus exarmatus TJERNVIK, 1956
Niobella imparilimbata (BOHLIN, 1955)
Raymondaspis limbata (ANGELIN, 1854).

Det enlige *Cyrtometopus*-cranidium er af ganske samme type som cranidierne i

zonerne med *Megistaspis estonica* og *M. lata*. *Nileus exarmatus* er en vigtig art, som viser tætstillede fine terrasselinier på skal-ydersiden. Denne karakter mangler ganske hos eksemplarer fra niveauer under *M. lata* Zonen.

Ovenstående diskussion viser, at Skelbrokalkens trilobitfauna må høre hjemme et sted mellem zonerne med *Megistaspis estonica* og *M. lata*; men en korrelation med en af disse zoner er ikke mulig. Forfatteren lægger særlig vægt på *Megistaspis* (*Megistaspis*), *Paraptychopyge* samt den fint striérede *Nileus exarmatus*. Konklusionen bliver, at Skelbrokalken må placeres som den ældste enhed i Volkhovetagen snarere end som den yngste enhed i Latorpetagen. Enheden har rang som zone, som får navnet *Cyclopyge stigmata* Zonen efter den dominerende art.

I Sverige er faunaskiftet fra *M. estonica* Zonen til *M. lata* Zonen brat, og lakunen mellem de to zoner må repræsentere et betydeligt tidsrum, og *Cyclopyge stigmata* Zonen kan antagelig kun svare til en del af denne lakune.

Transgressionen, som kun nåede Bornholm, var kortvarig, og faunaselskabet var »blandet« bestående af tilbageværende former fra Latorpetagen samt de første nye former, som skulle komme til at præge Volkhovetagen. Derefter trak havet sig helt tilbage. Da det atter kom igen til det baltiske område, var de gamle former helt ude af billedet.

Forekomsten af *Trinucleoides* og *Pateraspis* antyder en tidlig ordovicisk havforbindelse mellem den baltiske region og Böhmen.

Milieu

I dette afsnit (side 59–61) er dannelsesbetingelserne for Skelbrokalken anskuet på baggrund af trilobitfaunaens bevaringstilstand og sedimentets karakter.

Det antages, at aflejringen af Skelbrokalken har fundet sted på temmelig lavt vand. Kalken er i betydelig grad allochton og formentlig aflejret hurtigt. Forud for en landhævning kan havbunden have fået en hældning på et par grader, og det løse materiale er blevet sat i bevægelse som en mudderstrøm. Derved kan fossilernes tilfældige orientering i kalken forklares.

Tilstedeværelsen af flere diskontinuitetsflader er interessant. JAANUSSON (1961) konkluderede, at sådanne flader dannedes over havniveau, mens LINDSTRÖM (1963) har udtalt, at lignende flader i »Orthoceratitkalken« i Västergötland og på Öland er udformet submarint efter en forudgående ligeledes submarin hærdning. LINDSTRÖM's undersøgelser syntes at vise, at den submarine opløsning på de svenske lokaliteter er foregået på betydelig dybde.

Skelbrokalkens fauna og lithologi tyder imidlertid på lavt vand. Den ordoviciske lagfølge på Bornholm er præget af lakuner, og vertikale bevægelser langs forkastninger i den fenno-skandiske randzone kunne have bragt Bornholm over havniveau ved flere lejligheder. Dette ville også være i overensstemmelse med et lavvandet milieu, og diskontinuitetsfladerne i Skelbrokalken kunne være udformet over havniveau.

Beskrivelse af slægter og arter

I dette afsnit (side 61–107) er beskrevet samtlige trilobitarter i Skelbrokalken. Da ordoviciske trilobiter fra Bornholm her for første gang beskrives fra dansk side, er allerede kendte arter omhyggeligt beskrevet. Faunaen omfatter 25 arter, hvoraf fire er kendt i forvejen, elleve er nye, og ti er af forskellige grunde ubestemmelige. Materialet rummer en ny slægt *Hallanta* (familie Styginidae).

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Plates 1–9

Trilobites from the Skelbro Limestone

Plate 1

Fig. 1–3. *Geragnostus danicus* n. sp. 61
1: Internal mould of pygidium (MMH no. 9417). Holotype. Skelbro ×9.
2: Internal mould of pygidium (MMH no. 9418). Skelbro. ×9.
3: Internal mould of cephalon (MMH no. 9419). Skelbro. ×9.

Fig. 4. *Remopleuridiella groenwalli* n. sp. 63
Internal mould of cranidium (MMH no. 9420). Holotype. Skelbro. ×9.

Fig. 5. *Metaptychopyge*? sp. indet. 65
Internal mould of fragment of pygidium (MMH no. 9422). Skelbro. ×1.

Fig. 6. *Paraptychopyge* sp. 65
Internal mould of pygidium (MMH no. 9421). Skelbro. ×1.

Fig. 7. *Megistaspis* (*Megistaspis*) *cf. lata* (TÖRNQUIST, 1884) 66
Internal mould of pygidium (MMH no. 9424). Skelbro. ×1.

Fig. 8. *Megistaspis* (*Megistaspis*) sp. no. 1 67
Internal mould of fragmentary pygidium (MMH no. 9423). 400 metres east of Skelbro. ×1.

Plate 2

Fig. 1. *Megistaspis* (*Megistaspis*) sp. no. 2 68
Internal mould of fragmentary pygidium (MMH no. 9425). Skelbro. ×1.

Fig. 2–5. *Niobella imparilimbata* (BOHLIN, 1955) 69
2: Internal mould of fragmentary cranidium (MMH no. 9427). Skelbro. ×2.
3: Internal mould of fragmentary cranidium (MMH no. 9426). 400 metres east of Skelbro. ×2.
4: Internal mould of fragmentary pygidium (MMH no. 9429). Skelbro. ×1.
5: Hypostoma (MMH no. 9428). Skelbro. ×2.

Plate 3

Fig. 1–2. *Niobella imparilimbata* (BOHLIN, 1955) 69
1: Internal mould of pygidium (MMH no. 9430). Skelbro. ×2.
2: Internal mould of pygidium (MMH no. 9431). Skelbro. ×2.

Fig. 3–6. *Symphysurina*? sp. 72
Internal mould of cranidium (MMH no. 9452); frontal, dorsal, oblique dorsal, and lateral view. Skelbro. ×9.

Fig. 7–10. *Nileus exarmatus* TJERNVIK, 1956 74
7: Internal mould of transitory pygidium (MMH no. 9434). Skelbro. ×6.
8–10: Internal mould of almost complete dorsal exoskeleton (MMH no. 9432); frontal, lateral, and dorsal view. Skelbro. ×1.8.

Plate 4

Fig. 1. *Nileus exarmatus* TJERNVIK, 1956 74
Internal mould of hypostoma (MMH no. 9433). Skelbro. ×9.

Fig. 2–7. *Symphysurus* (*Symphysurus*) *dorsatus* n. sp. 76
2–4: Internal mould of cephalon (MMH no. 9435); frontal, dorsal, and lateral view. Holotype. Skelbro. ×1.8.
5: Internal mould of cranidium (MMH no. 9436). Skelbro. ×1.8.
6: Internal mould of pygidium (MMH no. 9437). Skelbro. ×1.8.
7: Internal mould of pygidium (MMH no. 9438). Skelbro. ×1.8.

Plate 5

Fig. 1–7. *Cyclopyge stigmata* n. sp. 79
1–3: Internal mould of cranidium (MMH no. 9439); dorsal, lateral, and frontal view. Holotype. Skelbro. ×3.
4: Internal mould of fragmentary pygidium (MMH no. 9434). Skelbro. ×9.
5: Eye with librigena (MMH no. 9441). Skelbro. ×3.
6: Internal mould of cranidium (MMH no. 9442). Skelbro. ×3.
7: Internal mould of pygidium (MMH no. 9440). Skelbro. ×9.

Fig. 8–12. *Hallanta modesta* n. gen. et n. sp. 84
8–10: Internal mould of cranidium (MMH no. 9446); frontal, dorsal, and lateral view. Holotype. Skelbro. ×2.
11–12. Internal mould of cranidium (MMH no. 9447); frontal and dorsal view. Skelbro. ×2.

Plate 6

Fig. 1–4. *Raymondaspis limbata* (ANGELIN, 1854) 85
1–3: Internal mould of cranidium (MMH no. 9448); frontal, lateral, and dorsal view. Skelbro. ×6.
4: Internal mould of pygidium (MMH no. 9449). Skelbro. ×3.
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5: Internal mould of pygidium (MMH no. 9450). Skelbro. ×6.
6: Internal mould of pygidium (MMH no. 9451). Holotype. Skelbro. ×6.
Fig. 7–9. *Celmus*? *longifrons* n. sp. 89
Internal mould of cranidium (MMH no. 9453); frontal, lateral, and dorsal view. Holotype. Skelbro. ×5.

Plate 7

Fig. 1. *Celmus*? *longifrons* n. sp. 89
Internal mould of cranidium (MMH no. 9454). Skelbro. ×5.
Fig. 2–4. *Selenoharpes excavatus* (LINNARSSON, 1875) 92
Mould of incomplete cephalon (MMH no. 9455); dorsal, frontal, and lateral view. Skelbro. ×3.
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5: Internal mould of incomplete genicranium (MMH no. 9456). Holotype. Skelbro. ×6.
6: Internal mould of incomplete genicranium (MMH no. 9458). Skelbro. ×4.
7: Internal mould of incomplete genicranium (MMH no. 9457). Skelbro. ×4.

Plate 8

Fig. 1–4. *Trinucleoides praecursor* n. sp. 96
1–3: Internal mould of genicranium (MMH no. 9459); dorsal, frontal, and lateral view. Holotype. Skelbro. ×9.
4: Internal mould of genicranium (MMH no. 9460). Skelbro. ×9.
Fig. 5–11. *Ampyx glaber* n. sp. 98
5–7: Internal mould of cephalon (MMH no. 9463) (spines broken off); dorsal, lateral, and frontal view. Holotype. Skelbro. ×4.
8–9: Internal mould of pygidium (MMH no. 9461); dorsal and oblique dorsal view. Skelbro. ×4.
10: Internal mould of pygidium (MMH no. 9462). Skelbro. ×4.
11: Internal mould of incomplete cranidium (MMH no. 9464). Skelbro. ×4.
Fig. 12–14. Genus et species indet. 101
12–13: Internal mould of cranidium (MMH no. 9444); lateral and dorsal view. Skelbro. ×9.
14: Internal mould of cranidium (MMH no. 9445). Skelbro. ×9.
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Internal mould of incomplete, slightly distorted cranidium (MMH no. 9465); lateral and dorsal view. Skelbro. ×2.

Plate 9

Fig. 1–9. *Pseudosphaerexochus* (*Pateraspis*) *inflatus* n. sp. 104
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Glabellar region (MMH no. 9469). Skelbro. ×9
Fig. 11. *Metopolichas*? sp. indet. 107
Cast of external mould of incomplete pygidium (MMH no. 9470). Skelbro. ×1.

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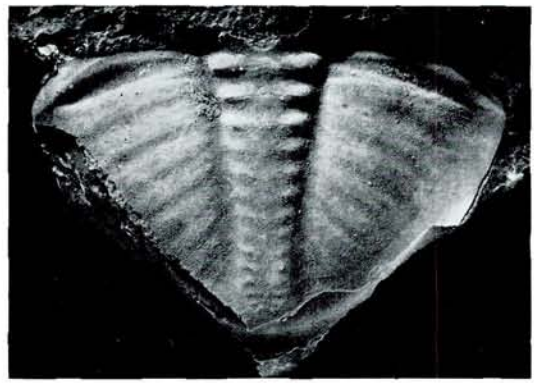

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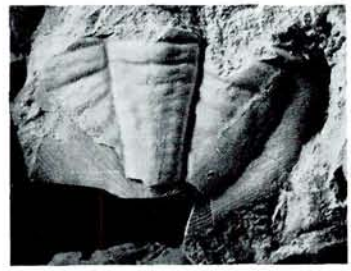

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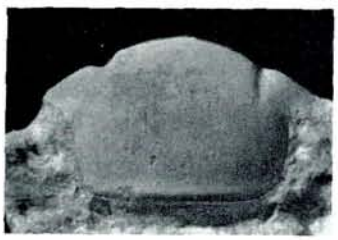

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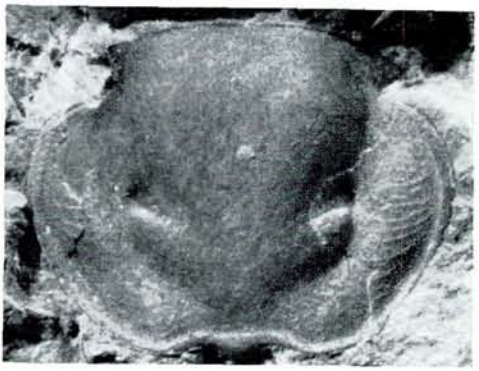

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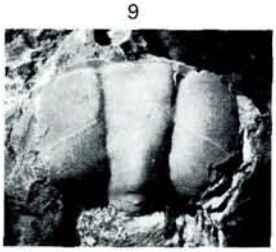

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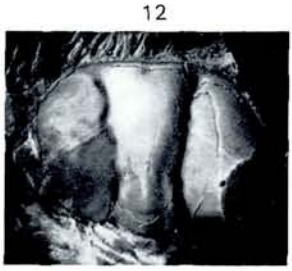

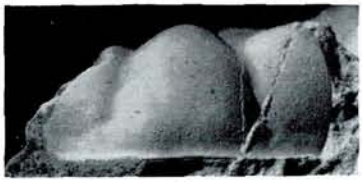

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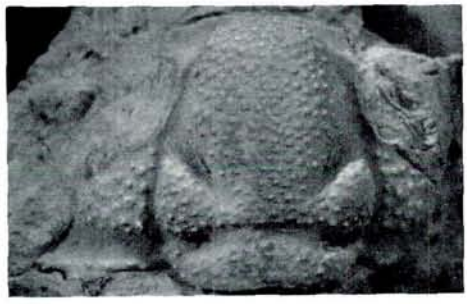

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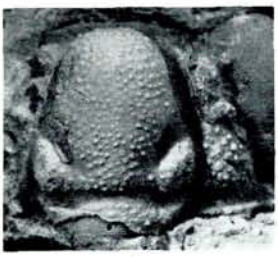

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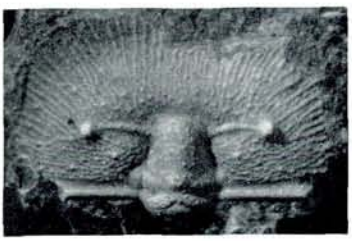

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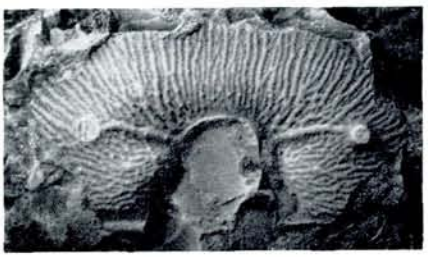

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