Trilobites of the Genus *Megistaspis* from the Vaginatum Limestone of Scandinavia

By

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ABSTRACT.—Eleven species of the asaphid genus *Megistaspis* JAANUSSON are described from the Lower Ordovician *Vaginatum* limestone of Sweden and one species from the corresponding beds of the Oslo region, Norway. Five new specific names are proposed. *Megalaspis rudis* ANGELIN is considered a nomen dubium, and the members of *Megistaspis* with a more or less smooth pygidium previously referred to this species are included in the new species *M. convexa* and *M. bombifrons*. The type material of *M. grandis* (SARS) is redescribed and considered to belong to a separate species hitherto known only from Norway. Examination of the types and additional material of *M. heros* (DALMAN) has shown that the specimens from Öland, Ingermanland, and Estonia previously referred to this species belong to *M. heroica* n.sp. Similarly, the material from Ingermanland and Estonia described by F. SCHMIDT (1906) as *Megalaspis acuticauda* ANGELIN is considered here as a separate new species, *M. spinulata*, which seems to occur also in Öland together with *M. acuticauda*. Eight of the species described belong to the subgenus *Megistaspis* (*Megistaspidella*) JAANUSSON, 1956, whereas *M. heros*, *M. heroica*, and *M. lawrowi* cannot at present be placed in any known subgenus of *Megistaspis*. A close examination of some well preserved pygidia has revealed that the boundaries between the segments in *Megistaspis* run in front of the ribs, and not in the rib furrows.

Contents

Introduction

The present paper is based chiefly on material collected by the author in Öland between 1939 and 1955. It comprises a great number of fragmentary cranidia and free cheeks and a still greater number of pygidia, in all more than 500 specimens. The cranidium is, in most cases, the part of the carapace which is best suited for a characterization of the species whereas the pygidia of some of them (e.g. *M. bombifrons* and *M. convexa*) obviously cannot be distinguished from each other, except, possibly, if a great material of perfectly preserved specimens were available. Often no attention can consequently be paid to material from localities where only pygidia have been found. In some species, on the other hand, the pygidium can be more distinctive than the cranidium, e.g. in the series of *M. bombifrons*, *M. obtusicauda*, and *M. gigas*. The present paper will deal only with material that can be referred to well defined species.

The species described are of great importance for the characterization of the faunas from different levels. Thus, for instance, it is evident that the upper part of the "*Raniceps*" limestone contains a distinctive species of *Megistaspis* not occurring in the lower part. This species, together with others, such as *Pseudoasaphus duplicatus* BOHLIN and *Homalopyge stacyi* (F. SCHMIDT), emphasizes the difference between the Upper "*Raniceps*" fauna and the faunas below, and possibly brings it nearer to the fauna of the *Gigas* limestone.

The material collected in Öland by the author, Dr. V. JAANUSSON, Dr. H. MUTVEI, and others is kept in the Palaeontological Museum at Uppsala; there is furthermore a collection from Öland, mainly by G. HOLM and G. VON SCHMALENSÉE, in the Museum of the Geological Survey (Sveriges Geologiska Undersökning) in Stockholm. The author has also had the opportunity of studying material from other parts of Sweden in the Palaeontological Museum, Uppsala (U.M.), the Museum of the Geological Survey (S.G.U.), the State Museum of Natural History (Naturhistoriska riksmuseets paleozoologiska avdelning = R.M.), Stockholm, and the Palaeontological Museum, Lund (L.M.).

ACKNOWLEDGEMENTS.—Thanks are due to Dr. F. BROTZEN of the Geological Survey, Dr. J. E. HEDE, Lund, and Dr. H. MUTVEI, State Museum of Natural History for kindly having put material from the museums at the author's disposal, and also to Dr. G. HENNINGSMOEN, Palaeontological Museum, Oslo (O.M.) who had the kindness to send the important type specimen of *M. grandis* and some other Norwegian material to Uppsala to be studied. The complete specimen of *M. heros* DALMAN (Pl. V, fig. 1) was kindly placed at the author's disposal by Lektor SVEN KILANDER, Skara.

The work proceeded under daily stimulating discussions with Dr. V. JAANUSSON and Dr. T. TJERNVIK to whom the author is greatly indebted for assistance with literature and much good advice.

The material was prepared by Mrs. MEIT LINDELL. The photographs were

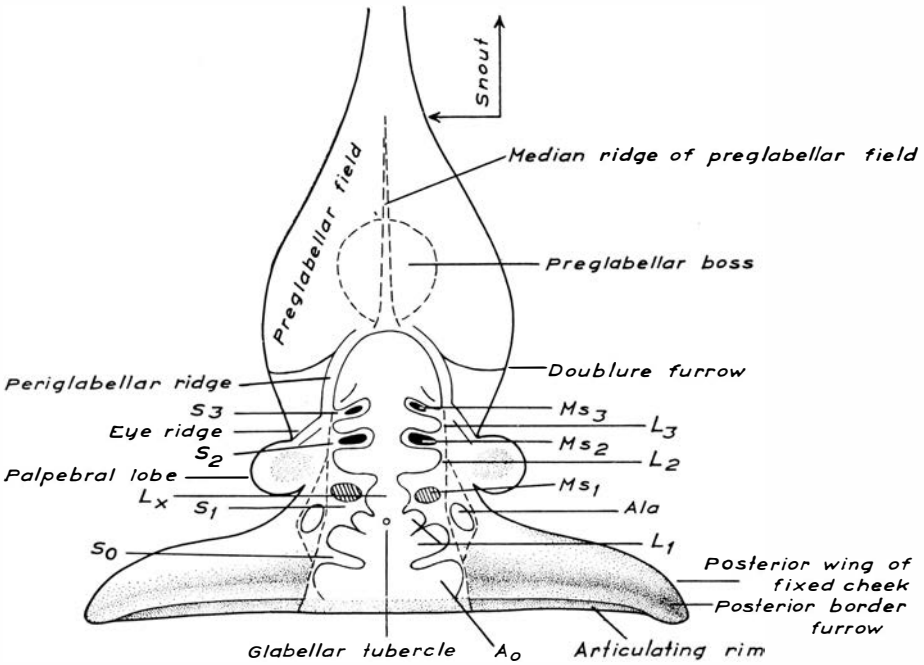
taken by Mr. N. HJORTH, and the drawings were made by Mr. E. STÅHL and Mrs. INGA THOMASSON. The typing of the manuscript was made by Mrs. EVA EKLIND. For their patient and skilful assistance the author wishes to express his sincere thanks. It may be especially mentioned that much of the structures seen in the photographs is hardly visible in ordinary light, and that almost every specimen has offered problems if its own.

Morphology and Terminology

SEGMENTATION OF THE GLABELLA.—It is not the author's intention to take sides in the discussion about the number and boundaries of the segments in the trilobite head. RAW (1953, p. 113) gives figures illustrating nine more or less sound theories, and yet all theoretical possibilities are not discussed. The following account of the segmentation of the *Megistaspis* glabella is purely topographical, and necessary for the comparison of the species *inter se*. The same details (Text-fig. 1) seem to occur, more or less distinctly, in all species, and thus, whatever the homologies of the lobes and furrows might be, when compared with other types of trilobites, the elements of the relief are the same in all species of the genus *Megistaspis*.

The frontal lobe is large, usually semicircular in outline, occupying about $\frac{1}{3}$ of the length of the glabella; at its posterior corners there are small elongate depressions which might indicate that the lobe represents two segments. The corners are drawn out backwards in the direction of the palpebral lobes. For the elements behind the frontal lobe the symbols proposed by JAANUSSON (1956b, p. 37) are used with some additions. L3 and L2 are narrow, in their medial part at right angles to the long axis of the glabella; laterally they curve backwards in the direction towards the eye (cf. Pl. VII, fig. 6). When S3 and S2 are shallow, they are occupied by low narrow ridges, Ms3 and Ms2, respectively, which may rise above the level of the surrounding lobes, Ms2 being the most distinct one. It is interesting to note that in species with flat, featureless glabella Ms2 may be more prominent than any other detail of the weak relief (cf. F. SCHMIDT, 1906, Pl. VIII, fig. 2, where the ridges are visible as two ovals at the mid-length of the glabella), and they are often the last to persist, when all other details have been effaced by weathering. As these ridges increase in size, the lobes shrink, and the result represents a kind of reversed segmentation (this is evidently what has happened in *Pseudoasaphus*, cf. BOHLIN, 1955, Pl. VI, fig. 4). The ridges may correspond to attachments of muscles on the internal surface of the test (cf. BRÖGGER, 1886, pp. 19 and 20). ÖPIK (e.g. 1929, p. 8) evidently thinks that the paired ridges in *Pseudoasaphus* correspond to segments.

S1 is very wide, and runs inwards and backwards. At its inner end, however, it branches round a projection from the medial part of the glabella (Lx). In forms with a very flat glabella S1 is almost entirely occupied by a flat, diffuse elevation (Ms1) evidently of the same origin as the ridges Ms2 and Ms3. In some

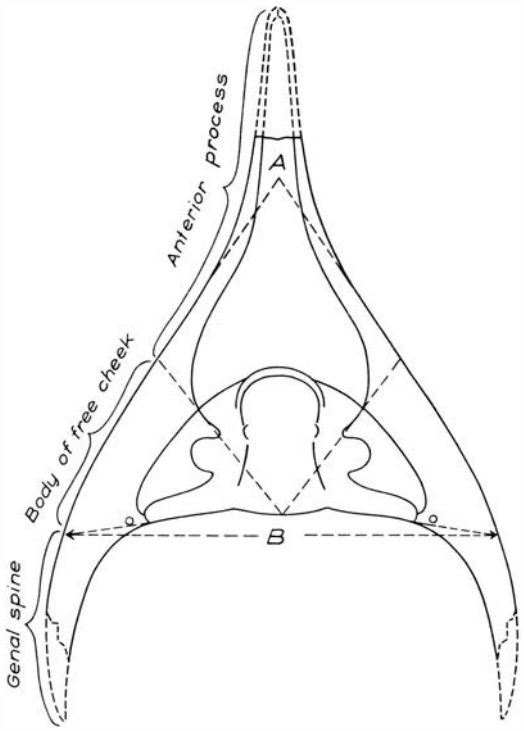


Text-fig. 1. *Megistaspis*, cranidium. Diagram. Terminology used in the descriptions.

specimens Ms1 is continuous with Lx. This might mean that these ridges could instead be interpreted as parts of a segment. Such a segment is, however, certainly not present in the more primitive type of glabella, e.g. in *Niobe*.

L1 is directed outwards and somewhat forewards. Between its distal end and the palpebral lobe there is a small oval swelling that may be homologous with the alae in *Harpes* (WHITTINGTON, 1950). A similar structural element is found in *Niobe* (cf. BOHLIN, 1955, Pl. VI, figs. 5–7) and in *Pseudoasaphus* (loc. cit. Pl. VI, fig. 4; in the text p. 144 erroneously identified with the occipital lobe as defined by WARBURG, 1925, Text-fig. 1). The alae are very variable in size but seldom entirely missing. In early species of e.g. *Niobe* and *Niobella* described by TJERNVIK (1956) the furrows separating the alae from L1 are very faint, in many specimens so faint that they were overlooked when the drawings were made (e.g. loc. cit. Fig. 37 A and B). In later species this furrow has become more marked, and in *Megistaspis* the alae may be so far removed from the main part of the glabella that they appear as small elevations within the dorsal furrow. The true dorsal furrows, however, still run between the alae and the palpebral lobes.

The occipital furrow (So) is usually very shallow, and in most species dealt with here only its lateral portions are distinguishable; in forms with a very flat glabella, or otherwise with poorly developed segmentation of the glabella, the furrow may be hardly visible at all. Therefore no distinction can be made



Text-fig. 2. *Megistaspis* (*M. acuticauda*), cephalon. Diagram. B, width. A–B, length used to give an approximate idea of the shape of the head in comparing different species. Terminology used in the description of the free cheek.

between the glabella and the occipital ring as defined by WARBURG (1925, p. 3; also HOWELL *et al.*, 1947, p. 74). Thus, in this paper, the term glabella is made to include the occipital ring (cf. WHITTINGTON, 1950, p. 533). For the latter the symbol *Ao* (*annulus occipitalis*) will be used.

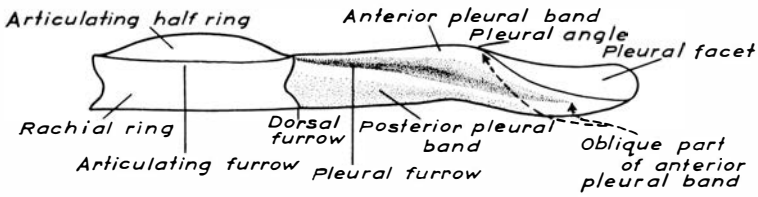
In most forms described here the posterior width of the glabella measured at the occipital ring is greater than that of the frontal lobe, and thus the glabella is more or less distinctly conical.

The glabellar tubercle is situated at the level of the posterior border of the palpebral lobes; it can be fairly large in *M. heroica* and *M. gigas*, but in the other forms described below, it is always very small. The distance from the posterior margin of the cranidium to the tubercle is about equal to that from the tubercle to the dorsal furrow (this is valid at least for all species dealt with in the present paper).

FREE CHEEKS.—On the dorsal surface of the free cheeks the following features can be distinguished:

(1) Narrow anterior processes embracing the preglabellar field in front of the doublure furrows and continuing along the sides of the snout.The very wide doublures of the processes meet below the preglabellar part of the cranidium in a median suture.

(2) A triangular middle portion of the free cheek may for descriptional



Text-fig. 3. Rachis and right pleura of a thoracic segment. Diagram. Terminology used in the descriptions.

purposes be delimited as shown in Text-fig. 2. It will here be designated as the body of the free cheek. The doublure furrow separates a median surface around the eye from a lateral surface. The former surface is in most (all?) species covered with a fine striation radiating from the base of the eye to slightly beyond the doublure furrow.

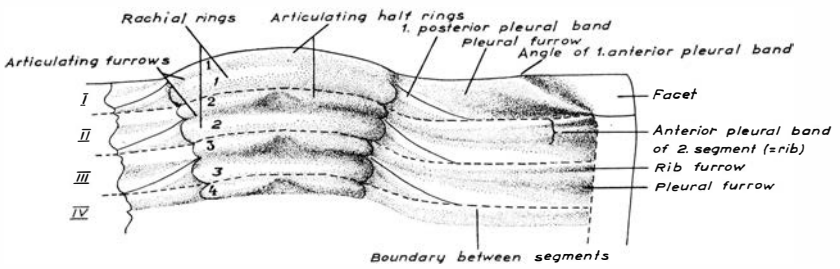
(3) Posterior processes forming the genal spines which are incomplete in most specimens, but evidently, at least in some species, are drawn out into a long, very fine point (cf. Pl. XII, fig. 4).

The external margin of the free cheek is raised as a very fine, sharply delimited marginal rim.

In most species described below the peripheral area of the free cheek is flattened, forming a border. This border is broad in *M. heroica* n.sp. but in others, e.g. *M. acuticauda*, it is narrow and indicated only by a slight concavity. In *M. gigas*, at least in the specimen figured on Pl. XII, fig. 4, no border can be distinguished. In *M. convexa* n.sp. a narrow zone with a steep outward slope is intercalated between the concavity of the border and the marginal rim (Pl. IX, figs. 1 and 2). These observations concern the body of the free cheek. In all species the border merges smoothly into the wide flattened area in front of the glabella.

Hypostoma.—Several specimens of the hypostoma are available, but none found in connection with the cephalon. For a high percentage of the specimens the exact stratigraphical level is unknown. It is therefore very uncertain to which species they belong, and a much larger material is needed before a description is worth while.

Thorax.—The complete thorax, or even isolated thoracic segments, is known only in a few of the species dealt with in this paper. In Öland, at least, there is very little hope of finding complete specimens of the species of *Megistaspis* in the *Vaginatum* limestone; isolated thoracic segments are seen now and then, but have only occasionally been collected. Evidently one ought to pay more attention to such finds than has hitherto been done as there are marked differences in the structure of the segments in the forms in which the thorax is known, e.g. differences in the relative width of the rachis and in its delimitation from the pleura, in the relief of the inner portion of the pleura, and



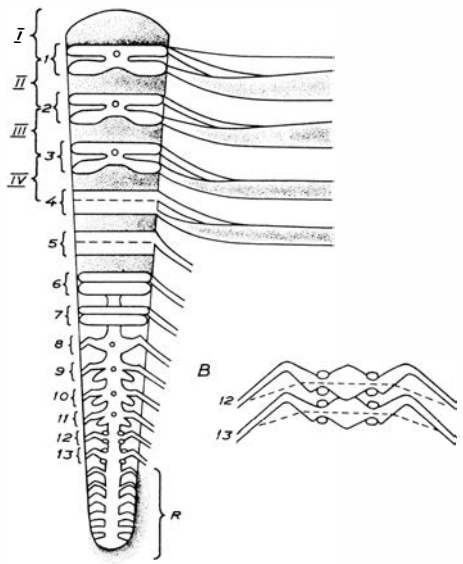
Text-fig. 4. Segmentation of the pygidium. Diagram. Terminology used in the descriptions.

in the position and the distinctness of the angle between the internal and the external portions. The terminology used for the description of the thorax is on the whole that used by WARBURG (1925), but it has been found convenient to introduce some new terms: *Pleural angle*, the angle on the anterior margin of the anterior pleural band, marking the boundary between the inner and the outer portions of the pleura (i.e. at the fulcrum); the pleural facet has its inner end at the pleural angle. The *oblique part of the anterior pleural band* is the part extending from the pleural angle to the lateral end of the pleural furrow. Further the term rachial ring will be used instead of "axial ring" (Text-fig. 3).

THE SEGMENTATION OF THE PYGIDIUM.—The anterior half of the first segment (BARRANDE, 1852: *demicôte articulaire*) agrees in all details with that of the thoracic segments though the pleural furrow is wider than in these, and extends further laterally than in the last thoracic segment. Farther back the fusion of the segments has made it difficult to trace their separate elements, but a study of minute details on some well preserved moulds has led to the interpretation given in Text-figs. 4 and 5.

The articulating half ring of the pygidium is followed behind by an articulating furrow.

The next ring (*1+2* in Fig. 4) is double. It consists of an anterior, more prominent part and a lower posterior part that is more or less distinctly divided by a small median depression extending forwards from the furrow behind the ring. Often the anterior and posterior portions of the ring join in front of this depression so as to form a small median tuberosity (Text-fig. 5). The same details can usually be distinguished also on the second (*2+3*) and third (*3+4*) ring. Complications in the structure of the rings are, however, present all along the rachis. In the 4th to 7th rings the anterior and posterior portions are usually confluent, farther back the rings start again to break up into elements (Text-fig. 5; Pl. I, fig. 2). An often striking feature are three rows of minute tuberosities which stand out clearly in very oblique light, either the middle row or the side rows being most prominent. The middle row is formed by the median tuberosities mentioned above, and may in the posterior third of the rachis fuse to form a low median keel. The lateral rows consist of small elevations at



Text-fig. 5. *A*, development of the rings in different parts of the pygidial rachis. Diagram. 1 to 13, rings. I to IV, segments (between anterior border of articulating half rings). *R*, elevated posterior end of rachis. *B*, detail of the twelfth and the thirteenth rings.

the sides of the small depressions entering the posterior portion of the rings. Posteriorly the lateral rows seem to merge into the sides of the keel formed by the median tuberosities. Finally, the external ends of the anterior portions of the rings may be slightly protuberant. This description is based, especially as far as the posterior half of the rachis is concerned, on a couple of well preserved specimens. In other equally well preserved pygidia all the finer details are not visible, which possibly depends on how far the fusion of the segments has proceeded, a process that is undoubtedly subject to individual variation. Further, if the rings stand out in strong relief, as for instance in *M. gigas* (ANG.), the details are more likely to be obscured than in forms with a very flat rachis (e.g. *M. bombifrons* n.sp.).

The double rings can be considered to correspond to the rachial rings of the thoracic segments. The peculiar differentiation of the rings may then be due to the fact that the articulating half ring extended underneath, and fused with the posterior half of the ring. It is even possible that the articulating half ring supplanted the posterior portion of the rachial ring or at least the median part of it, and thus came to occupy a small area on the external surface of the test. The structures described are best seen on internal moulds but are plainly visible also in specimens with well preserved tests (Pl. II, fig. 3). In Text-fig. 4, the boundaries between the segments of the rachis have been drawn at the supposed anterior margin of the articulating rings.

Within the dorsal furrow the anterior portion of a ring has connection with a narrow ridge that curves backwards and outwards to the anterior side of the corresponding rib. In the anterior segments, where the ribs are usually strong, even in forms with otherwise an almost smooth pygidium, the ridge is lower

than the rib, and delimited from this by a furrow for a distance equalling half the length (*tr.*) of the rib or more, before it merges into the anterior side of the rib (Pl. I, fig. 1). The furrow has no connection with the rib furrow. In a small specimen, evidently of *M. bombifrons*, very fine furrows with sharp raised edges run along the anterior side of the ribs from the inner border of the doublure (Pl. I, fig. 3; running in the direction of the arrows). The inner end of the ribs proper lies opposite the external end of the posterior part of the rachial ring. The only possible interpretation of this fact is that the ribs are homologous with the anterior band of the thoracic pleura, and that the boundaries between the segments run in front of the ribs. The posterior band is represented by the oblique rudimentary ridge behind the pleural furrow.

STRUCTURE OF THE TEST.—The test of *Megistaspis* has terrace lines only on the doublure, on the facets of the thoracic segments and of the pygidium, and on the genal spines. In forms with a long snout there are lines on the doublure only at the base of the snout (Pl. XI, fig. 7), a few lines may occur on the upper surface along the margin of the free cheek and the pygidium. Otherwise the test has been considered to lack surface structures.

On closer examination, however, very small pits (on the internal surface indicated by small tubercles) have been found to occur in all species, sometimes closely spaced (Pl. II, fig. 1), sometimes sparse. The pits may be of two sizes, and in this case the smaller ones form a densely punctuated background over which the larger ones are scattered; on the pygidial border of *M. heroica* n. sp. a fine furrow extends from each pit towards the edge (Pl. II, fig. 2). The pits can as a rule be seen only if the surface of the test has not suffered from weathering or corrosion. In the species considered here the density of pits is not the same in all parts of the test; thus the pits may be sparse in the central parts and more crowded at the borders. It must be pointed out, however, that the scarceness of suitable material prevents at present the distinction of patterns characteristic of different species. Pits of this kind were observed by TJERNVIK (1956) in *Megistaspis planilimbata.*

It is interesting to note that in some specimens in which the test has peeled off a thin, perfectly smooth lamella is left which evidently also belongs to the test (cf. STØRMER, 1930, Pl. 12). On this lamella the pits are as distinct as on the surface of the shell. Finally the pits can be seen on the mould if the sediment is fine enough to reproduce almost microscopic details.

A peculiar structure that seems to derive from the texture of the test is seen in Pl. II, fig. 3. In the pygidial rachis it consists of fine striae diverging from the middle forwards and outwards to the dorsal furrow, where they suddenly turn outwards and somewhat backwards. This structure is entirely independent of the relief of the pygidium, traversing rachial rings and ribs at acute angles. Where the relief is weak, it may be superseded by the striation, as for instance the weak ribs in the posterior part of the pygidium. In the anterior ribs the

distal end of the part behind the rib furrow may become diffuse, and merge into a network formed by the striae. The striation stands out in relief on both external and internal surfaces of the shell and may be preserved on the internal mould of the pygidium (Pl. II, fig. 4). It was observed in pygidia of *M. heros*, *M. acuticauda*, *M. curvispina*, and *M. gigas*, but only in a few specimens with weathered test (BOHLIN, 1955, p. 150); indications of it can be seen in other species. It is not restricted to the pygidium, as the striation in the cranidium of *M. lawrowi* and *M. heros* shows (Pl. VII, fig. 8; cf. diagram Text-fig. 13). The striation probably occurs in all species of *Megistaspis* and perhaps also in other asaphid genera.

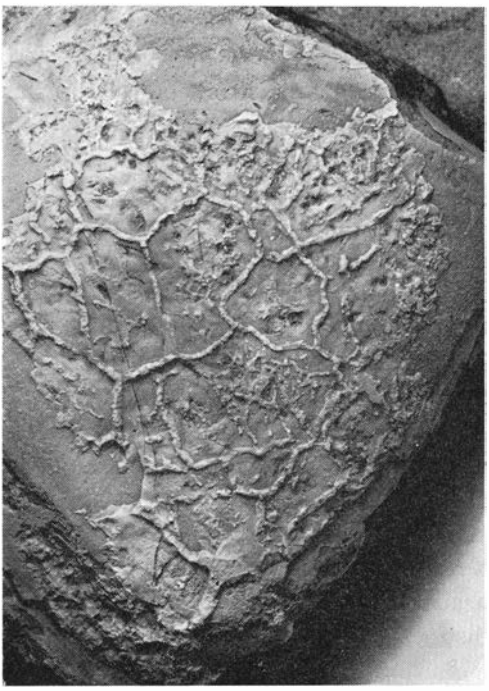
MEASUREMENTS.—Several species were measured, and tables of measurements prepared. The measurements were of some help when characterizing the species, but on account of the deficiency of the material the tables contain so many gaps and uncertainties that they do not bring our biometric knowledge of the species of *Megistaspis* much further than do statements about ratio between length and width etc. in the text. Even in well preserved specimens measurements may be difficult to define, as for instance length and width of the glabella, as the glabella is marked by a change in the slope of the dorsal surface and not by distinct furrows. Measurements are therefore given only for the smallest and largest available specimens of the species.

Organisms Boring in the Trilobite Test?

The exuviae were evidently rapidly destroyed in case they were not embedded immediately after moulting. The seawater is probably to some degree responsible, but judging from a greater number of specimens it was aided by some organisms which were attached to the corroded test. There are on the surface branching, winding, and anastomosing ridges (Text-figs. 6 and 7), semicircular in cross-section, and where these are attached to the test, its substance seems to be altered underneath; no structures (like pores or striae) can be seen. Such ridges are never seen in specimens in which the surface of the test is smooth, and their formation seems to have contributed to the destruction. They are here supposed to be calcite fillings of tubes bored in the test or superficially built. They are undoubtedly primary in so far as they were products of organisms contemporary with the trilobite fauna. This is apparent from the fact that a colony of a bryozoan is seen attached to a specimen strongly influenced by such corrosion (Pl. IV, fig. 1). What kind of organisms produced the "tubes" will perhaps never be discovered.

STØRMER (1931) has described traces of boring organisms from the test of various trilobites, but quite different from those described here. Structures evidently more similar to those described above were mentioned by REGNÉLL (1945, p. 56).

Text-fig. 6. *Megistaspis obtusicauda* (BOHLIN). Pygidium. Destruction of the test, probably by boring organisms.



Text-fig. 7. *Megistaspis bombifrons* n. sp. Same phenomenon as in Text-fig. 6.

Genus *Megistaspis* JAANUSSON, 1956

The fundamental facts respecting the genus were discussed by JAANUSSON (1956). The old well-known name of thegenus (*Megalaspis*) was altered, and a new diagnosis given. It may be necessary to alter the latter in one point owing to discoveries made after the appearance of JAANUSSON's paper. He mentions in his diagnosis that the lateral parts of the cephalon are "ganz oder teilweise konkav, einen deutlichen Limbus bildend". In an adult specimen of *M. gigas* there is no such concavity, and in some other species of the same group the concavity and thus also the border are not very distinct (see also p. 160). It is, however, evident that in earlier forms a border is always present. It shrank as the head became more elongated and the body of the free cheek in consequence narrower.

JAANUSSON has distinguished two subgenera of *Megistaspis*, but mentions that such forms as *M. heros* and *lawrowi* have only tentatively been referred to one of these subgenera (*Megistaspidella*) which implies that in the future yet more subgenera will probably have to be distinguished.

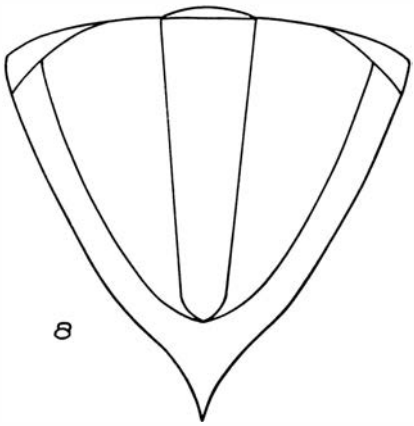
The present paper deals exclusively with species of the subgenus *Megistaspis* (*Megistaspidella*) as defined by JAANUSSON, and no attempt is made here to carry the subdivision further than was done by him. A grouping of the species is, however, possible.

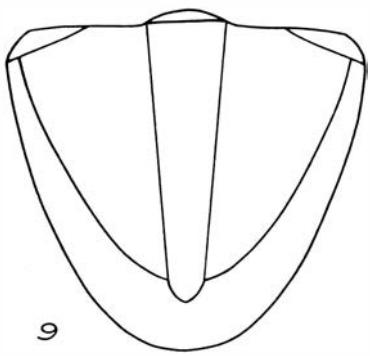
(A) SUBGENUS UNCERTAIN.—(1) *Megistaspis lawrowi* (F. SCHMIDT) differs from all others by its strongly convex and almost perfectly smooth glabella, and its comparatively short preglabellar field. Pygidium triangular with a short spine; width of doublure the same anteriorly and posteriorly.

(2) *Megistaspis heros* (DALMAN) and *M. heroica* n. sp. The sides of the head meet forwardly in a broad point, accentuated by slight concavities of the outline on each side. Glabella convex, its segmentation marked by deep furrows. Pygidium triangular with a terminal spine. Pygidial doublure of uniform width (Text-fig. 8).

(B) SUBGENUS MEGISTASPIDELLA.—(3) *M. acuticauda* (ANGELIN) has a pygidium with a terminal spine, and a doublure somewhat narrower in front than behind; the snout is long and the glabella very flat. The forms from the lowermost "*Raniceps*" limestone of Öland are imperfectly known, but suggest that *M. acuticauda* should be connected with *M. curvispina* and related species rather than with *M. heroica*. About *M. acuticauda* sensu F. SCHMIDT, see p. 186. As, however "*M. acuticauda*" in Sweden as well as in the East Baltic area is very variable, and probably comprises more than one species it will here for greater clarity be kept apart as a species group of its own.

(4) *Megistaspis convexa* n. sp., *M. curvispina* n. sp., *M. bombifrons* n. sp., *M. obtusicauda* (BOHLIN), and *M. gigas* (ANGELIN) agree in many respects: The head is drawn out in front into a long snout, the glabella is flattened and with distinct but not very prominent segmentation. The pygidium is rounded





Text-fig. 8. Pygidium of the *heros* type. Width of doublure uniform. Text-fig. 9. Pygidium of the *bombifrons* type. Doublure narrower in front than behind.

posteriorly, and the doublure is distinctly broader behind than in front (Text-fig. 9).

Megistaspis (*Megistaspidella*) *extenuata* (WAHLENB.) and related species are not treated in the present paper.

Megistaspis acuticauda belongs to the *Expansus* fauna. The lower "*Raniceps*" limestone (in N. Öland roughly the part with plenty of glauconite) has yielded a form resembling *M. convexa* from Dalarne. The middle division—that without macroscopical grains of glauconite or of any other substance—evidently has the same fauna as the upper division; *M. bombifrons* n. sp., *Pseudoasaphus duplicatus* BOHLIN and *Homalopyge stacyi* (F. SCHMIDT) were collected at Norra Udden (north-westernmost point of Öland) in limestone of that division.

Table I. Stratigraphic distribution of the species of *Megistaspis* in the *Vaginatum* limestone of Sweden.

	Expansus limestone	Lower "*Raniceps*" limestone	Middle and Upper "*Raniceps*" limestone	*Obtusi-cauda* limestone	*Gigas* limestone
Megistaspis lawrowi (F. SCHMIDT)	?	×	—	—	—
Megistaspis heros (DALMAN)	—	×	—	—	—
Megistaspis heroica n. sp.	—	×	×	—	—
Megistaspis acuticauda (ANGELIN)	×	—	—	—	—
Megistaspis spinulata n. sp.	×	—	—	—	—
Megistaspis convexa n. sp.	—	×	—	—	—
Megistaspis curvispina n. sp.	—	×	—	—	—
Megistaspis bombifrons n. sp.	—	—	×	—	—
Megistaspis obtusicauda (BOHLIN)	—	—	—	×	—
Megistaspis gigas (ANGELIN)	—	—	—	—	×

Megistaspis heroica n. sp. has been found all through the "*Raniceps*" limestone, especially abundantly in the lower division at Hälludden, Öland. *M. lawrowi* (F. SCHMIDT) is at present known only from the lower division of the "*Raniceps*" limestone where evidently also *M. convexa* n. sp. belongs (*M. lawrowi* possibly occurs also in the *Expansus* limestone).

Subgenus uncertain

Megistaspis lawrowi (F. SCHMIDT, 1906).

Pl. III, figs. 2–4; Text-figs. 10 and 11.

1898 *Megalaspis lawrowi* n. sp. — F. SCHMIDT, p. 41 (*nomen nudum*).
1906 *Megalaspis lawrowi* n. sp. — F. SCHMIDT, p. 61 f.; Text-fig. 33; Pl. VI, Fig. 7.
? 1951 *Megalaspis* cf. *heros* DALMAN — JAANUSSON & MUTVEI, faunal list, p. 633.

LECTOTYPE.—Cranidium. F. SCHMIDT, 1906, Text-fig. 33.

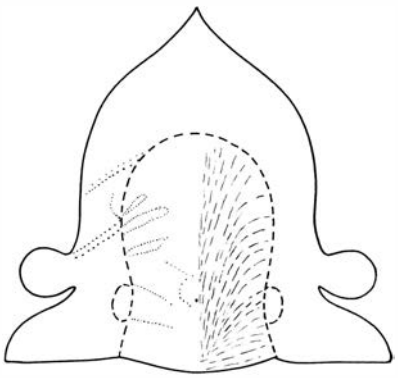
LOCUS TYPICUS.—Bylščina, Ingermanland (Leningrad district).

STRATUM TYPICUM.—$B_{III}\gamma$ (LAMANSKY).

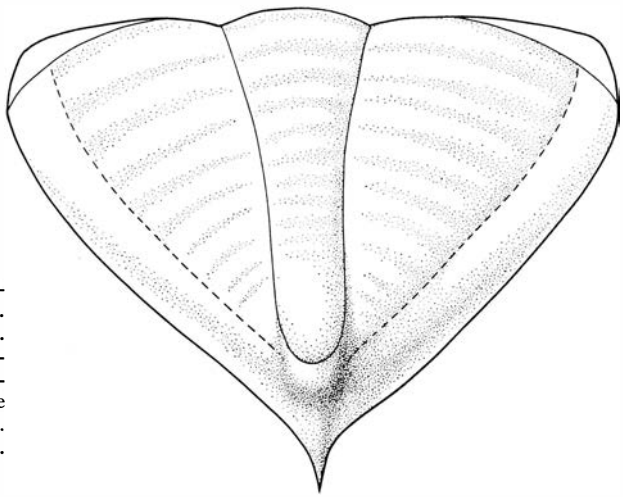
DIAGNOSIS.—Cranidium short and broad; glabella strongly convex both transversely and longitudinally, length less than twice the width, sides parallel; segmentation indistinct; preglabellar field about half as long as the glabella, slightly convex transversally, slightly concave longitudinally, ending in front in an acute angle. Eyes small; exsagittal diameter of palpebral lobe about half the distance from eye to posterior border. Pygidium broad and short with short terminal spine; doublure of uniform width; ribs few, rather prominent.

MATERIAL.—11 cranidia from Öland and the Siljan area, one of those from Öland almost complete. To the species are referred, with some hesitation, 3 almost complete and 2 fragmentary pygidia.

DESCRIPTION.—Length of cranidium about equal to its posterior width; length of glabella about 1.7 times its width. Glabella strongly convex transversely and longitudinally. The segmentation can be seen only in strongly oblique light. Glabellar tubercle small. As a whole the arrangement of the faint relief is that typical of *Megistaspis*. There is evidently no periglabellar ridge. Preglabellar field narrow (its width about 1.5 times that of the glabella), short (median length only $\frac{1}{2}$ of length of the glabella), in some specimens divided by a fine ridge extending forwards from the frontal lobe; other specimens have a faint furrow instead of a ridge and some specimens have a wide, shallow depression halfway between the glabella and the anterior end of the preglabellar field. A shallow triangular depression on either side behind the doublure furrow. As a whole the preglabellar field is saddle-shaped, though the concavity (in exsagittal direction) may be obsolete in large individuals. Opposite the middle part of the glabella the cheeks rise steeply towards the eyes so that the palpebral lobes reach the level of the back of the glabella. The palpebral lobes are small, their upper surface almost flush with the slope of the cheek medially to them. The posterior wing of the free cheek is comparatively short (*tr.*) and attached with a broad base, in



Text-fig. 10. *Megistaspis lawrowi* (F. SCHMIDT). Outline of cranidium. Upon the glabella to the left traces of segmentation, to the right orientation of the fine striation of the test. Lower "*Raniceps*" limestone.



Text-fig. 11. ? *Megistaspis lawrowi* (F. SCHMIDT). Pygidium. Rather strongly asymmetrical. Rachis and furrows partly reconstructed. ? "*Raniceps*" limestone. Tjusby, Gärdslösa (the locality is subject to some doubt). $\frac{2}{3}$ nat. size. U.M. No. Öl. 491.

old individuals about twice as broad (*sag.*) as the exsagittal diameter of the palpebral lobe. Posterior border furrows shallow; behind them a faint blunt ridge delimits a narrow articulating rim.

The dorsal surface of the test (preserved as impression on the mould) shows a striation of fine ridges arranged approximately as in the diagram Text-fig. 10. Actually it is more like a network, since the ridges anastomose frequently, and branch round small pits. In the posterior half there even seems to be two intersecting systems of ridges.

The pygidium resembles that of *M. acuticauda*, but is comparatively broader, length less than $\frac{3}{4}$ of the width. Rachial rings about 16, ribs 12 (or less?), rather prominent, indistinctly divided. Doublure of uniform width in its whole extension.

MEASUREMENTS.—Length of glabella 16 mm–43 mm.—Length of pygidium 51 mm–87 mm, width of pygidium 87 mm–120 mm.

REMARKS.—*M. lawrowi* was first mentioned by F. SCHMIDT in 1898. No

figure was given and no other description than a mention of a similarity to *M. grandis* (pygidium, referred to the species by mistake [F. SCHMIDT, 1906]) and *M. heros* (glabella), but nothing that can give an idea of the appearance of the specimens. It is true that SCHMIDT mentions as a synonym *Megalaspis* sp. LAWROW, 1858, but there is no doubt that the name is intended to designate his own material. The name was evidently not valid before 1906, when F. SCHMIDT figured two cranidia (Text-fig. 33 and Pl. VI, fig. 7).

The Swedish material agrees perfectly with SCHMIDT's figures, and there is no doubt as to its reference to *M. lawrowi*. The glabella in SCHMIDT's Fig. 33 is somewhat narrower behind the eyes; such specimens occur also among the Swedish material though in the young specimen figured in the present paper the sides of the glabella are apparently strictly parallel. No alae are seen in the specimens figured by SCHMIDT, and they are missing in practically all his figures. As their presence is an almost constant feature in *Megistaspis*, their absence in SCHMIDT's figures must be due to the retouching of the photographs. (In the Swedish material of *Megistaspis* the alae are entirely missing only in one specimen of *M.* cf. *gibba* but is present in another cranidium of the same species).

Three of the pygidia referred to *M. lawrowi* were found at the localities, where cranidia were collected, one at Hälludden (Öland) and two at Vikarbyn (Dalarna), where the same beds have yielded a fragment of a cranidium which undoubtedly belongs to the species. Their shape is such as one would expect in a species with a short and probably broad cephalon. They are distinct from other pygidia from the same localities, and there is just as good a reason for associating them with the cranidia of *M. lawrowi* as there is in many other cases for associating cranidium and pygidium with each other, when these were found separately.

In Öland *M. lawrowi* was found only in the lowermost "*Raniceps*" limestone, one specimen possibly even in beds just below that limestone (uppermost *Expansus* limestone).

OCCURRENCE.—*Siljan district.* Lindgården, Sjurberg, Vikarbyn, Silvberg (only a pygidium).

Öland. Böda: Hälludden, Hagudden. ? Gärdslösa: Tjusby (pygidium).

Estonia and Ingermanland: see F. SCHMIDT, 1906.

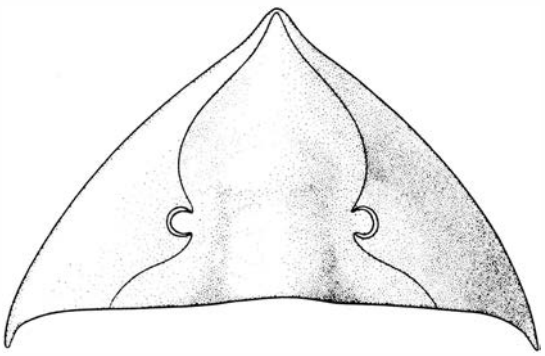
Megistaspis heros (DALMAN, 1828)

Pl. IV, fig. 3; Text-figs. 12, 13, and 16A, C.

1828 *Asaphus heros* n.sp. — DALMAN, p. 35.
partim 1837 *Asaphus heros* DALM. — HISINGER, p. 13.
partim 1852 *Megalaspis heros* DALM. — ANGELIN, p. 16, Pl. XIII.
1869 *Megalaspis heros* — LINNARSSON, p. 73 and 87.
1901 *Megalaspis heros* DALM. — HOLM, p. 49, Fig. 52.

LECTOTYPE.—Pygidium R.M. No. Ar. 14412 (selected here).

LOCUS TYPICUS.—Västerplana, Kinnekulle.



Text-fig. 12. *Megistaspis heros* (DALMAN). Reconstruction of the cephalon.

STRATUM TYPICUM.—Red? "*Raniceps*" limestone, see below.

DIAGNOSIS.—Cephalon broad, triangular, length about $\frac{2}{3}$ of width, with very short, sharply pointed genal spines. The whole cranidium rather strongly convex. Glabella slightly broader behind than in front, its width about $\frac{2}{3}$ of its length. Preglabellar field twice as broad as frontal lobe. Angle between anterior and posterior branches of facial suture at eye about 90°. Rachis moderately convex, wider than inner part of pleura. Pygidium broad, triangular, with a terminal spine and a border which is distinct posteriorly and absent or very shallow anteriorly; rachis comparatively broad, flattened posteriorly; pleural ribs 12 to 14, anterior ones prominent, broad and flattened.

MATERIAL.—Some poorly preserved "complete" specimens and several more or less fragmentary pygidia.

DESCRIPTION.—Cephalon broad, triangular, length about $\frac{2}{3}$ of the width; outline on both sides somewhat convex except most anteriorly, where it is concave for a short distance at the short snout. Genal spines very short and sharply pointed.

Glabella convex with almost parallel sides, width about $\frac{2}{3}$ of length. Segmentation of glabella indistinct: the elements in the anterior half can be seen in oblique light in spite of poor state of preservation. In the posterior half of the glabella the segmentation is almost effaced; in Text-fig. 12 the structures in this part have been exaggerated.

Preglabellar field twice as broad as the glabella, rather strongly vaulted (Text-fig. 16C *2*), ending anteriorly in a very short, pointed snout. No median ridge in front of glabella. Palpebral lobes not preserved, but to judge from what is preserved of the facial suture the eyes were small. Exsagittal section passing between glabella and fixed cheek strongly arched in exsagittal direction (Text-fig. 16A *2*). The border furrow on the posterior wings is wide and very shallow; the ridge delimiting the furrow behind is faint, and the articulating rim faces almost directly upwards.

In the thorax (Text-fig. 13) the rachis is in the first segment $1\frac{1}{2}$ times as wide (*tr.*) as the inner part of the pleura, and the width of this is $\frac{3}{4}$ of the width of the lateral part; the rachial ring is flattened, especially in its middle part, and

Text-fig. 13. *Megistaspis heros* (DALMAN). Thorax. Kinnekulle. Nat. size. U.M. No. Vg. 689.

the articulating furrow shallow. In the posterior segments the difference in the width of rachis and of inner pleural part is less pronounced; the relief of the rings becomes gradually more marked so that already from the fourth segment onwards the articulating furrow is deep, sharply delimiting the strongly convex articulating half ring posteriorly.

On the fourth thoracic segment of R.M. No. Ar. 47123 the right panderian organ is exposed (P. IV, fig. 2). Its internal opening is small and circular; the external opening is directed backwards, and in front of it there is a tubercle with semicircular base.

Length of pygidium less the spine about $\frac{3}{4}$ of width; outline approximately an equilateral triangle; sides slightly convex. Width of the doublure about uniform along its whole extension. Border narrow, forming a shallow concavity in the area of the doublure (Pl. VI, fig. 1); almost obsolete anteriorly. Rachis with about 20 rings and with a broad ridge that continues for some distance behind the rachis proper (Pl. II, fig. 4; Pl. VI, fig. 1), twice as broad at the anterior end as in the posterior half, where the sides run approximately parallel. In side view the rachis is straight or somewhat elevated at both ends; in two specimens it is, however, slightly bent down at its anterior extremity. Specimen R.M. No. Ar. 47123 with twelwe ribs, the most posterior ones very weak; other specimens with up to 14 ribs. The anterior eight ribs are broad (*sag.*), proximally flattened or slightly convex; the distal third divided by a broad and shallow furrow

into two branches the anterior one of which is the strongest, the posterior one, from the third rib backwards, disappearing before reaching the inner border of the doublure. In most specimens of the pygidium examined the posterior end is damaged; there is, however, a broad ridge extending backwards across the doublure from the posterior end of the rachis, as for instance in *M. acuticauda*, and there is no doubt that the posterior extremity was sharply pointed. The posterior termination is only preserved in a small fragment comprising the posterior end of the pygidium.

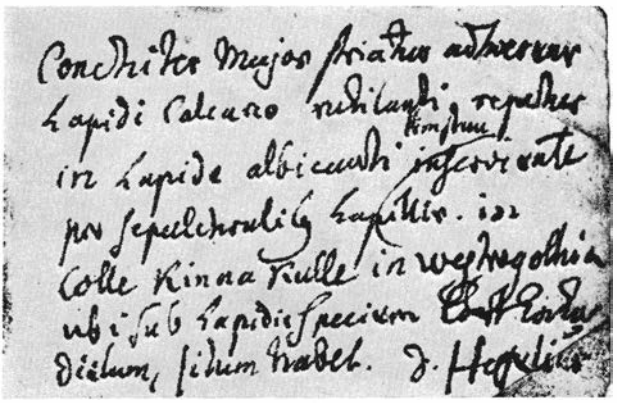
All specimens are approximately of the same size. Average length of pygidium 12,5 cm; average width 16 cm.

REMARKS.—The bulk of the material comes from Kinnekulle from a sequence of grey limestone, the so called Täljsten (1.3 m), and red beds above and below this. The matrix of the lectotype is red. The beds are probably contemporaneous with the Lower "*Raniceps*" limestone in Dalarna, where typical *Megistaspis heros* seem to occur (only the pygidium is known from there). The limestone at Kinnekulle is poor in fossils, apart from a layer that is crammed with *Sphaeronites pomum* GYLLENHAAL, and well preserved specimens are rare. Much work remains to be done before this part of the section will be properly known, but quite obviously the boundary between the "*Limbata*" limestone and the *Vaginatum* limestone does not coincide with the boundary between Lower Red and Lower Grey limestone as supposed by HOLM (1901, p. 54).

The best specimens of *M. heros* from Kinnekulle were found in the grey limestone. None of them is in a perfect condition; they are fragmentary and some of them have been deformed after the embedding. It is remarkable, however, that very fine structures of the test have been preserved on the mould (Pl. II, fig. 4). From the red limestone only pygidia are known, and these are so badly corroded that the ribs are only occasionally distinguishable. Specimens from red and grey limestone were first thought to belong to different species. Those from the red limestone gave the impression of being flatter than the grey ones; further the doublure is on an average somewhat wider in the former than in the latter. The red specimens are, however, on the whole somewhat larger than the grey ones. As specimens were found in red limestone both below and above the grey one, it is safest to assume that we have to do with a single species.

The structure of the posterior end of the rachis also varies, the rachis proper being strongly convex in some specimens. Such differences may be due to a difference in size of the specimens or to a difference in the thickness of the test.

The oldest specimen of *M. heros* in the Uppsala Museum is a specimen from red limestone in the BROMELL collection, 17th century; it is labelled: "Conchites Major striatus adhaerens Lapidi Calcareo rubicundi. repertur in Lapide albicundi limsten inserviante pro sepulchrulites Lapillis. in Colle Kinnakulle in westrogothia ubi sub Lapidis speciem Cartkaka dictum situm habet. D. Hesselius" (Text-fig. 14). "Limsten" is an old Swedish word for limestone. The limestone used for tomb stones forms part of the Täljsten and is called "likhall";



Text-fig. 14. Label of a specimen of *Megistaspis heros* DALMAN (p. 173). Late 17th century.

above this and intercalated with it are beds called "kart", those above forming the "Övre Rödsten" (Upper Red limestone). The term "kaka" ("cake") is used to designate a bed of limestone (see LINDSTRÖM, 1887, p. 39).

OCCURRENCE (only localities from which specimens have been available to the author).—*Siljan district.* Utby Lindgården. *Västergötland.* Kinnekulle, Ranten. *Närke.* "Hällebråten".

Megistaspis heroica n. sp.

Pl. VII; Text-figs. 15, and 16B, D, E.

1898 *Megalaspis heros* DALM. — F. SCHMIDT, p. 44, Figs. 15, 16.
1906 *Megalaspis heros* DALM. — F. SCHMIDT, pp. 51–54; Text-fig. 29, Pl. VII, figs. 4–7.
1949 *Megalaspis heros* (DALM.) — BOHLIN; faunal lists pp. 539, 547, 555, 556, 566.
1951 *Megalaspis* cf. *heros* ANG. — JAANUSSON & MUTVEI; faunal list p. 632 (non p. 633).
1955 *Megalaspis heros* — BOHLIN, pp. 129, 137.

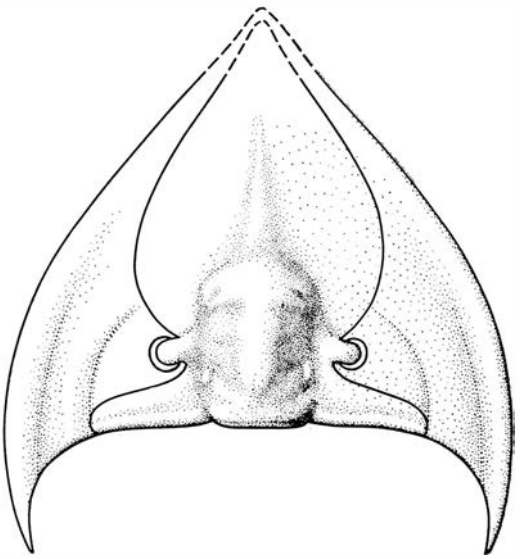
HOLOTYPE.—Almost complete specimen. F. SCHMIDT, 1906, Pl. VII, figs. 4, 4a.

LOCUS TYPICUS.—Pulkovka, Ingermanland.

STRATUM TYPICUM.—B_3b.

DERIVATIO NOMINIS.—The specific name is the adjective corresponding to *heros* and was chosen to emphasize that the species belongs to the *Heros* group of *Megistaspis*.

DIAGNOSIS.—Cephalon somewhat broader than long, triangular with strongly convex sides; genal spines short, flattened, curved inwards; distinct border postero-laterally. Glabella convex, its length about $1\frac{1}{2}$ its anterior width; sides almost parallel; segmentation distinct. Preglabellar field in adult specimens $2\frac{1}{2}$ to 3 times as wide as frontal lobe, divided by a distinct median ridge extending forwards from glabella. Angle between branches of facial suture at the eye ca. 70°. Posterior border furrows broad and very shallow, indistinctly delimited anteriorly. Eyes small. Pygidium broad, triangular, with broad border and pointed termination; rachis very narrow posteriorly, strongly convex, in cross-section



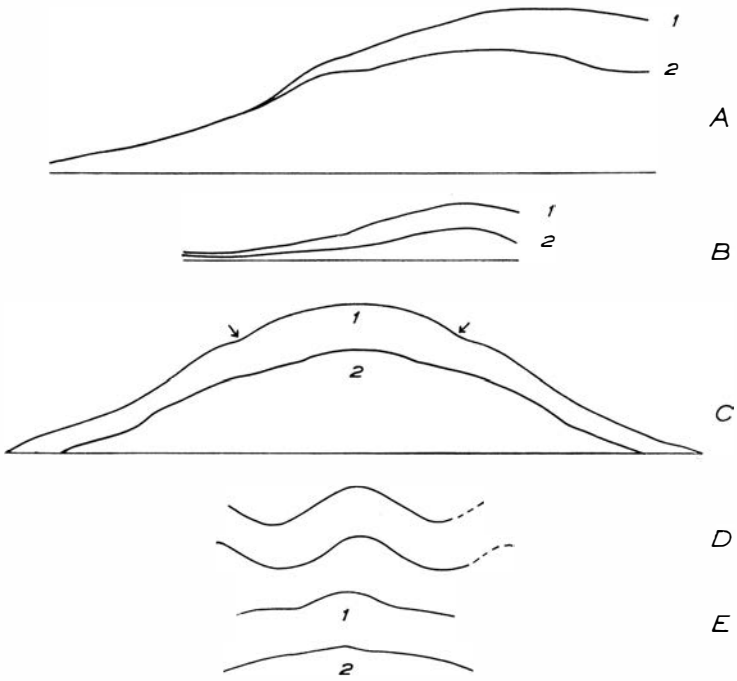
Text-fig. 15. *Megistaspis heroica* n.sp. Reconstruction of cephalon.

evenly rounded; pleural ribs 12 to 14, the anterior ones strong, and usually flattened. Panderian organs (at least on free cheek) very small, slit-like.

MATERIAL FROM ÖLAND.—About 20 more or less fragmentary cranidia, 4 fragments of the free cheek, and more than 30 complete or fragmentary pygidia.

DESCRIPTION OF MATERIAL FROM ÖLAND.—Cephalon broad, length less than $\frac{9}{10}$ of width, triangular with convex sides; broad border postero-laterally; comparatively short and strongly flattened genal spines; tips of spines curved inwards. Glabella moderately convex (Fig. 16 D), elongate, about $1\frac{1}{2}$ as long as wide; sides almost parallel (slightly broader behind than in front); segmentation better developed than in other species from the "*Raniceps*" limestone. Glabellar tubercle prominent. The features of the glabella vary considerably, especially the part between the frontal lobe and L3. In some specimens L3 and L2 together are almost as large as the lateral portions of the frontal lobe, and S2 deep (Pl. VII, fig. 6; cf. F. SCHMIDT, 1906, Pl. VII, figs. 4–6). In other specimens L3 and L2 are much less prominent than the frontal lobe, in one specimen (Pl. VII, fig. 5) very weak, so that the whole glabella appears to be only half as wide at the mid-length as at the ends.

The preglabellar field widens rapidly from the eyes forwards, and narrows rapidly anteriorly, evidently to form a somewhat elongated point, but only the basal part of this is preserved in the material treated. It was, however, probably short (Text-fig. 15). From the frontal lobe a ridge extends forwards. At the proximal end this ridge is broad and bordered by a pair of depressions occupying the corner between the ridge and the frontal lobe. The ridge tapers rapidly forwards, and at last becomes so faint that it can be seen only in strongly oblique light. In one specimen, with a preglabellar width of 70 mm, the ridge can be distinctly traced to a point 40 mm in front of the glabella. The ridge is, however,



Text-fig. 16. Sections through the cranidium. *A* and *C*, *Megistaspis heros* (DALMAN) (Pl. V, fig. 1). A_1, sagittal section. A_2, exsagittal section passing through lowest point between palpebral lobe and glabella. C_1, transverse section through frontal lobe (dorsal furrow at the arrows); C_2, at anterior end of glabella. *B*, *D*, and *E*, *Megistaspis heroica* n.sp. B_1 and B_2 (U.M. No. Öl. 332) as A_1 and A_2 above. *D*, transverse section at palpebral lobes; two specimens. E_1 and E_2 (U.M. No. Öl. 332) as C_1 and C_2. $\frac{2}{3}$ nat. size.

very variable (in one specimen it disappears 1 cm in front of the glabella), but always present. The frontal lobe may be encircled by a low and flat periglabellar ridge or by a simple preglabellar furrow, both indistinct or obsolete in the middle, where the base of the median ridge may be so strong that it forms a broad continuation of the glabella (Pl. VII, fig. 5). Where the periglabellar ridge is well developed, it seems to be connected with the well developed eye ridges at the posterior corner of the frontal lobe. The anterior furrow delimiting the periglabellar ridge evidently partly marks the posterior margin of the preglabellar portion of the doublure, and from it a pair of doublure furrows branch off at some distance in front of the eye ridges, and run laterally and slightly backwards to the facial suture. Between these impressions of the doublure and the eye ridges there are marked depressions with a more or less convex bottom bordered internally by the frontal lobe and externally by the facial suture. Palpebral lobes very small, circular; their diameter about $\frac{1}{10}$ of the width of the cranidium between their external borders. Section passing between glabella and free cheek only in young specimens arched in antero-posterior direction (Text-fig. 16B *2*); in large specimens it is straight or even slightly concave. Posterior border furrows form a

broad (*exsag.*) concavity occupying the anterior $\frac{2}{3}$ or more of the posterior wing of the fixed cheek behind the eye. Posteriorly this depression is bordered by a ridge behind which the narrow articulating rim faces upwards and backwards.

The outer margin of the free cheek on each side forms, as far as it is preserved (e.g. Pl. VII, fig. 2), part of a perfect circle with a diameter about twice the width of the head. What the outline is like in its most anterior part is unknown, but undoubtedly the head ended in an acute angle or, possibly, a short snout (cf. description of cranidium). The body of the free cheek forms a broad triangular area, its sides forming an angle of about 70° at the eye. The anterior branch is narrow, in its foremost half with almost parallel sides (not completely preserved in any of the specimens). The border is broad, but merges medially without distinct limit into the inner, elevated parts of the cheek and anteriorly into the wide preglabellar field. The genal spines are inserted with broad, strongly flattened base and taper rapidly to thin points. The internal margin of the doublure is marked on the dorsal surface by a distinct furrow running about halfway between the eye and the external margin, in its posterior part parallel to the latter. The eye is preserved in two specimens, in two other ones the outline of its base. It is small (cf. above) with vertical sides (in one specimen bulging outwards anteriorly). The openings of the panderian organs below the external ends of the posterior marginal furrows are small and elongate without a distinct tubercle (Pl. VII, fig. 1).

Pygidium triangular with slightly convex sides, length about $\frac{4}{5}$ of the width (F. SCHMIDT, 1906, p. 53; measurements on fragmentary specimens from Öland suggest approximately the same proportions). Border broad, extending all around the pygidium; broader and more distinctly delimited than on the free cheeks. Doublure with about uniform width in its whole extension; about twice as broad as the border, in small specimens carrying the distal ends of the ribs which fade out when reaching the border. Rachis with about 20 rings, narrow, at its anterior end twice as broad as in the posterior half, tapering backwards to about the 9th ring, from there approximately parallel-sided; posterior part strongly convex, almost semicircular in cross section. As a whole the rachis is raised at both ends and depressed in its middle part, further it is somewhat lowered between the pleurae, in some specimens so much so that a straight edge laid across the middle part does not touch the rachis. 13 to 15 ribs can be easily counted: in a small specimen there are as many as 18 ribs, 13 distinct ones and behind these traces of 5. The ribs are strongly convex; in very large specimens they are rounded, but in most specimens flattened or even divided by a shallow furrow that may become wider and deeper at the distal ends, so that the ribs are there double, the anterior and posterior portions being about equal. Behind the rachis a blunt ridge traverses the border, and ends in a short spine at the posterior end of the pygidium.

MEASUREMENTS.—Length of glabella 6.5 mm (No. Öl. 365)–45 mm (No. Öl. 359). Width of frontal lobe 4.5 mm (No. Öl. 372)–18 mm (No. Öl. 332).

Width of preglabellar field 10.5 mm (No. Öl. 372)–45 mm (No. Öl. 332). Length of pygidium 8 mm–129 mm, width 12 mm–166 mm.

REMARKS.—*Megistaspis heroica* n.sp. is common in Öland, at Hälludden even commoner than any other species of the genus. It belongs to the "*Raniceps*" limestone and, at least as far as can be concluded from the material now available, there is no difference between specimens from lower levels, e.g. Hälludden, and those from higher levels, e.g. the Upper "*Raniceps*" limestone at Föra. The species has, on the other hand, not been found in beds which belong with certainty to the *Gigas* limestone. A find mentioned by the author from Vedby, Högsrum (BOHLIN, 1955, p. 129), may come from the Upper "*Raniceps*" limestone as *Pseudoasaphus perstriatus*—which was thought to be confined to the *Gigas* limestone— possibly occurs also below this limestone.

It is beyond doubt that *M. heroica* is distinct from *M. heros*. F. SCHMIDT was not quite satisfied with his identification of the East Baltic material with material from Sweden, and noted the difference in the segmentation of the glabella (1906, p. 52). To this can be added that the cephalon of *M. heros* is broader than that of *M. heroica*, the cranidium as a whole more convex, the preglabellar field comparatively narrower, and the border of the pygidium less developed. The difference in the development of the ribs noted by SCHMIDT is, on the other hand, less evident, though SCHMIDT is probably right in assuming that Swedish specimens in which the ribs are "kaum angedeutet" do not belong to what he means is *M. heros* (l.c. p. 54).

The material from Öland was not known, when SCHMIDT wrote his monograph. It comes very close to *M. heros sensu* F. SCHMIDT. Small specimens differ from those figured by F. SCHMIDT (Pl. VII, figs. 4 and 7) in having a much broader border; the very large specimen in SCHMIDT's Text-fig. 29 agrees, however, in this respect with large specimens from Öland. The segmentation of the glabella is exactly the same in specimens from both regions; no alae are seen in SCHMIDT's Pl. VII, fig. 5, but distinctly in fig. 4. The preglabellar field is flat also in the East Baltic cranidia, and there is a triangular field between the frontal lobe and the facial suture of exactly the same appearance as in the cranidia from Öland. The similarity is in fact so great that possible small differences can at most suffice to distinguish races of the species.

At a preliminary revision of some Norwegian material a well preserved cranidium was discovered which is so similar to *M. heroica* n.sp. that it must be referred to this species (BOHLIN, 1955, p. 137: "*M. heros*"). The specimen is of interest as it shows a similar fine striation on the glabella as in *M. lawrowi* and a continuation of this striation onto the preglabellar field as a fan of small elongate tubercles radiating from the eye ridge and the furrow in front of the glabella towards the margins of the preglabellar field (Pl. VII, fig. 8). Traces of such structures are seen in two small specimens from Öland (U.M. Nos. Öl. 354 and Öl. 369).

OCCURRENCE.—*Siljan area*. Vikarbyn (U.M. No. D.535, fragment of a pygidium).

Öland. Böda: Hälludden, Byxelkrok, Tokenäs hamn, Haget. Högby: Byerums sandvik. Persnäs: Gunnarslund, Jordhamn, Sandvik. Föra: Hjälmestad, Föra kanal, Uggletorp. Alböke: Stacketorp. Högsrum: 1 km N Nyttorp, Vedby. Gärdslösa: Sättra. Glömminge: Ryd, Övetorp. Torslunda: Lenstad. Gårdby: Torp.

Estonia and Ingermanland: see F. SCHMIDT, 1906.

Norway. Hadeland: Gran, the road N of Grinaker.

Subgenus *Megistaspis (Megistaspidella)* JAANUSSON, 1956

Megalaspis rudis ANGELIN, 1854, nomen dubium.

1854 *Megalaspis rudis* n. sp.—ANGELIN, Pl. XVII, fig. 5.

The type of this species was found at Husbyfjöl in Östergötland, and is said to be characterized by a semielliptic abdomen, very faint rachis and no ribs. ANGELIN's original material could not be traced. The name was adopted by F. SCHMIDT for material from the East Baltic area. SCHMIDT's material and a large material from Öland are undoubtedly of the same type as the specimen figured by ANGELIN (Pl. XXVII, fig. 5), and in earlier papers by the present author the name has been used without reservation. The present revision has, however, shown that pygidia of the "*rudis*" type occur all through the "*Raniceps*" limestone in Öland, where at least two types of cranidia occur together with them. The species from the "*Raniceps*" limestone belonging to this group can simply not be determined with the aid of the pygidium, and *Megalaspis rudis* ANGELIN must therefore be considered a nomen dubium. An attempt to save the name for one of the species can lead to endless confusion.

Megistaspis (Megistaspidella) grandis (SARS, 1835)

Pl. III, fig. 1.

1835 *Asaphus grandis* n.sp. — SARS, p. 337, Pl. IX, fig. 6.
1882 *Megalaspis grandis* SARS — BRÖGGER, p. 80, ? Text-fig. 4.
1940 (*Asaphus grandis*=*Megalaspis centaurus* (DALMAN)). — STØRMER, p. 134, Text-figs. 4, 6a, 6b.
?1955 *Megalaspis grandis* SARS — BOHLIN, p. 137.

LECTOTYPE (selected here).—Fragmentary "complete" specimen. O.M. No. 20139. COTYPE.—Fragmentary pygidium O.M. No. 56340.

LOCUS TYPICUS.—Akersbakken, Oslo. Norway.

STRATUM TYPICUM.—3cγ. Black limestone.

DIAGNOSIS.—Glabella convex, length about twice the width, only slightly broader behind than in front; segmentation distinct. Angle between anterior and posterior branch of facial suture at eye less than 90°. No posterior border furrow. Rachis of thorax rather strongly convex, distinctly delimited; width about equal to that of inner part of pleura. Rachis of pygidium convex, narrow. Ribs low, double along their whole length. Posterior end broadly rounded.

MATERIAL.—The type and cotype figured by SARS.

DESCRIPTION.—To the characters given in the diagnosis may be added: All details in the segmentation typical of *Megistaspis* can be distinguished. The glabellar furrows are fairly deep, and L1 and L2 somewhat depressed so that the median part of the glabella stands out as a ridge which widens in front, since S2 penetrates farther inwards than S3. The glabellar tubercle is small and hardly distinguishable with the eye, but its position can be felt with the finger. The distance between the tubercle and the posterior border is $\frac{1}{4}$ of the length of the glabella. The anterior branches of the facial suture diverge strongly from each other in front of the eyes (their prolongations backwards converge approximately towards the middle point of the posterior border). The preglabellar field was probably originally broader, as the specimen is somewhat compressed from the sides, a pressure that has evidently not influenced the glabella, but which is, on the other hand, probably to a great extent if not wholly responsible for the broad border seen in SARS' drawing (1835, Pl. IX, fig. 6a). The posterior wings of the fixed cheek are flat without even an indication of a furrow. The articulating rim is narrow (*sag.*), but well marked; it continues with the same development across the posterior part of the occipital ring.

In the thorax the rachis is narrow, its width equal to the inner part of the pleura, distinctly wider in front than behind, rather strongly convex and sharply delimited on the sides. The rings are flattened, but well separated from the articulating half rings by broad and rather deep furrows. The preserved part of the thorax is evidently not deformed.

The pygidium of the type and the cotype are so deformed by tectonic movements that a detailed description would be of little value. It may be enough to state that the rachis also in unpressed condition must have been narrow and elevated above the side portions, and distinctly delimited from these by deep dorsal furrows.

REMARKS.—The type specimen of *M. grandis* comes from black limestone, and has been subject to some deformation by tectonic movements. Allowance was made for this in the description above, and it seems possible at last to throw some light on the confusion which the insufficient knowledge of *M. grandis* has caused. The name appears in synonym lists, but has evidently never been used as a valid name outside Norway.

In 1955 the author had a chance to see some Norwegian material, but unfortunately not the type. The short discussion (p. 137) was only a "first impression" as only little was known about the Swedish species at that time. The conclusion in the Summary that *M. grandis* may be different from anything hitherto known from Sweden, can now be repeated with more confidence. It must be stressed, however, that the material on which this statement was based in 1955, may not belong to *M. grandis*, but this question cannot be answered until all Norwegian material can be revised.

An identity of *M. grandis* with *M. gigas* is out of question, and has never been

presumed. F. SCHMIDT's synonym list (1906, pp. 55 f.) comprises, however, *M. longicauda* (v. LEUCHTENBERG) which may be identical with *M. gigas*. There are, in fact, cranidia of *M. gigas* from Öland which have a long glabella similar to that of *M. grandis*, but which differ in other important respects as, for instance, in having marked posterior border furrows. Attention must further be paid to the characteristic pygidium in *M. gigas*.

Megistaspis obtusicauda is still the species that seems to resemble *M. grandis* most closely. The cranidium is not sufficiently known to allow of a comparison. A specimen from Tokenäs hamn which probably belongs to *M. obtusicauda* has a shorter, less convex glabella, and well developed posterior border furrows. The distinctly delimited convex rachis in the pygidium of *M. grandis* is, however, quite different from the very flat rachis in *M. obtusicauda*. It is true that the type of *M. grandis* is deformed, but the deformation cannot have produced deep straight furrows with rounded bottom which separate the rachis on either side from the pleurae. The two species cannot be identical.

Megistaspis bombifrons has a broad flattened glabella tapering forwards and a pygidium with the same type of rachis as in *M. obtusicauda*. *M. curvispina* also has a flattened glabella, and deep posterior marginal furrow. The pygidium has a convex rachis, but the whole pygidium is triangular. *M. convexa* has a short glabella, deep posterior marginal furrows and a pygidium that cannot with certainty be distinguished from that of *M. bombifrons*.

In less well known forms from Öland and Östergötland we meet everywhere with very flat glabellae and pygidia of the *bombifrons* type. Pygidia with a well defined rachis are, however, found in the Siljan area and at Kinnekulle.

The study of the large material from Öland has shown that the genus *Megistaspis* is rich in species, and thus it is in no way surprising to find that *M. grandis*, which evidently lived on mud bottoms (preserved in black calcilutite), differs from species living in quite different surroundings.

OCCURRENCE.—Known with certainty only from the type locality.

Megistaspis (*Megistaspidella*) *acuticauda* (ANGELIN, 1854).

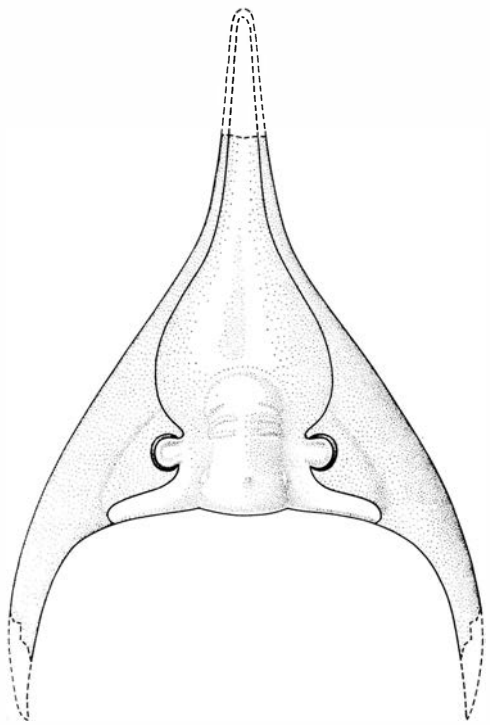
Pl. VIII; Text-figs. 17–20.

1854 *Megalaspis acuticauda* n.sp. — ANGELIN, p. 50; Pl. 27, fig. 4.
?1882 *Megalaspis acuticauda* ANG. — BRÖGGER, p. 82 ff.; Fig. 5; Pl. II, fig. 1; Pl. VI, figs. 1, 1a.
1949 *Megalaspis acuticauda* ANG. — BOHLIN, pp. 543, 545, 549, 567.
1955 *Megalaspis acuticauda* ANG. — BOHLIN, p. 116.
non 1906 *Megalaspis acuticauda* ANGEL. — F. SCHMIDT, p. 42; Pl. V, figs. 1–8; Pl. VI, figs. 1–6 (=*Megistaspis spinulata* n. sp.).

LECTOTYPE.—Pygidium R.M. No. Ar. 21763 (Pl. VIII, fig. 6).

LOCUS TYPICUS.—Öland. Exact locality unknown.

STRATUM TYPICUM.—Unknown for the type specimen. The known specimens have been found exclusively in the *Expansus* limestone.



Text-fig. 17. *Megistaspis* (*Megistaspidella*) *acuticauda* (ANGELIN). Reconstruction of cephalon.

DIAGNOSIS.—Cephalon broad; the outline, except snout and genal spines, almost an equilateral triangle, constricted at the base of the long snout which is strongly bent upwards; genal spines long and thick. Glabella very flat, indistinctly delimited, slightly narrower in front than behind; its length is about $1\frac{1}{2}$ its posterior width; segmentation faint. There is a slight depression in front of the glabella. Width of preglabellar field twice the width of the frontal lobe. Angle between the branches of the facial suture at the eye less than 90°. No posterior marginal furrows.

Pygidium triangular, ending posteriorly in a short spine, without border or with a slight concavity around its posterior half. Doublure widening somewhat backwards. Rachis low but distinctly defined. Ribs faint.

MATERIAL.—Several fragmentary cranidia, two incomplete free cheeks, and several pygidia.

DESCRIPTION.—Cephalon triangular with long snout and long genal spines. Distance between tips of genal spines evidently somewhat shorter than the total length of the head. Outline strongly concave at the base of the snout, convex at the base of the genal spines.

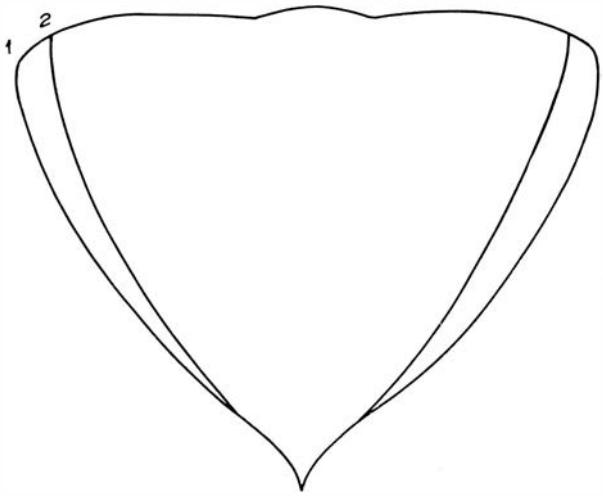
Glabella broad and flattened, very indistinctly delimited, slightly wider at its posterior end than in front; length about $1\frac{1}{2}$ times the posterior width. Segmentation faintly marked: area between frontal lobe and L1 depressed, structures of both sides in this region separated by a narrow median ridge.

Text-fig. 18. *Megistaspis* (*Megistaspidella*) *acuticauda* (ANGELIN). U.M. No. Öl. 424. A, profile of cranidium. B, transverse section at palpebral lobes. ⅔ nat. size.

The preglabellar field widens rapidly in front of the eyes with the greatest width at the anterior end of the glabella; then it narrows as quickly towards the base of the snout, the sides of which run practically parallel as far as they are preserved. The snout is broken off, probably at about half of its length, strongly bent upwards (Text-fig. 18). In front of the glabella there is a shallow longitudinal depression extending forwards to the base of the snout. In its posterior half this depression is divided by a hardly discernible ridge extending forwards from the frontal lobe. Periglabellar ridge distinct in some internal moulds. Eye ridges low but distinct, continuous with the anterior end of the elevated rim of the palpebral lobes (Pl. VIII, fig. 1). On either side of the frontal lobe there is a triangular area which is slightly depressed between this lobe and the eye ridge, the doublure furrow, and a swelling of the margin of the cranidium in front of the eyes; on the whole, however, the preglabellar field slopes evenly down to the facial suture in the part between the eye and the base of the snout. There are thus no marked depressions opposite the anterior end of the glabella as in *M. bombifrons* n.sp. Palpebral lobes circular with a deep depression in their centre (distinct on the mould). No posterior border furrows. A faint ridge, parallel to the posterior margin marks the anterior boundary of the articulating rim.

The anterior process of the free cheek is narrow with subparallel margins from a point somewhat in front of the greatest width of the preglabellar field to the base of the snout, where the process curves rather abruptly forwards (Pl. VII, fig. 3). The specimen is broken off a little in front of the bend. The body is large in relation to the very slender anterior part; its greatest width is about ⅔ of the width of the cranidium at the palpebral lobes; it is somewhat concave along the outer margin forming a very indistinct border. At the eye the anterior and posterior branches of the facial suture meet at an angle of less than 90°. What remains of the fragmentary genal spines suggests that their cross-section was lenticular at their base and rounded triangular in more distal parts; they were fairly long and probably bent inwards. A comparison with a specimen of *M. bombifrons* suggests that about half of their length is missing. Panderian organ small and elongate; the tubercle prominent, situated so that the opening turns backwards and outwards.

Pygidium triangular with somewhat convex sides meeting behind in a short spine; width greater than length (in the type specimen ca. 97 mm and 85 mm, respectively). Small specimens with border all round the pygidium, in large specimens the border obsolete or confined to a narrow concavity around the



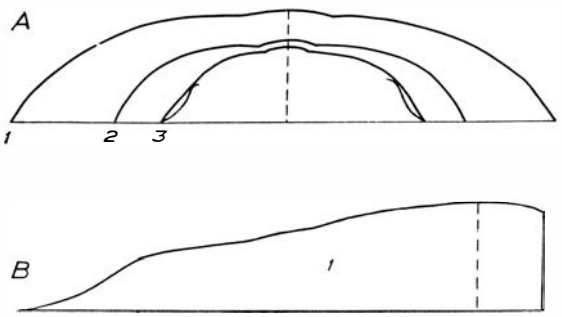
Text-fig. 19. *Megistaspis* (*Megistaspidella*) *acuticauda* (ANGELIN). Outlines of pygidia. 1, U.M. No. Öl. 509; 2, R.M. No. Ar. 21763 (Lectotype; reconstructed). Approximately $\frac{2}{3}$ nat. size.

posterior half of the pygidium. Rachis with about 20 rings, narrow, width at its anterior end almost twice that of its posterior end. Dorsal furrows deep, slightly curved inwards; rachis somewhat lowered between the pygidial pleurae, but its highest part always visible in strictly lateral view. Sagittal profile of rachis in the lectotype and some other specimens straight, in others slightly concave or slightly bent downwards in front. Posterior end of rachis protruding, continuing in posterior direction into a marked elevation that extends into the terminal spine. Ribs 11 to 14 (12 in the type specimen), very low, double; the anterior ridge of each rib more prominent than the posterior, the only one visible upon the external surface of the test, and the only one which reaches the inner border of the doublure upon the internal moulds. The posterior ridges dissolve into a net work at their distal ends. Furrows between the ribs very shallow, the two or three anterior ones, however, deeper than those further back.

MEASUREMENTS.—Length of glabella 27 mm–39 mm.—Length of pygidium 26.5 mm–93 mm, width 33.5 mm–102 mm.

REMARKS.—*Megistaspis acuticauda* was first described from Öland (ANGELIN 1854; second edition 1878, p. 50; Pl. XXVII, fig. 4). The specimen from which ANGELIN's drawing was made is preserved, and it is evident that this pygidium is much broader than in ANGELIN's reconstruction.

The shape of the whole pygidium and of the rachis, the development of the ribs, etc. are so characteristic that there has been no difficulty in recognizing the species among the material collected by the author. The material of the species from Öland exhibits a rather high variability. There are flattened pygidia like the lectotype; there are strongly vaulted ones (Text-fig. 20). Fortunately the collections from the richest localities (in the parish of Räpplinge) comprise pygidia which closely agree with the lectotype. The description above deals



Text-fig. 20 *Megistaspis* (*Megistaspidella*) *acuticauda* (ANGELIN). Sections of pygidia. — A, transverse sections. 1 and 2, between posterolateral corners of facets. 3, between external ends of 6th ribs. — B, sagittal section of same pygidium as "1" above. All $\frac{2}{3}$ nat. size. Korntorp (Alböke). 1, U.M. No. Öl. 425; 2 and 3, U.M. No. Öl. 426.

almost exclusively with this material. No small specimens were found at the Räpplinge localities; those mentioned are from localities in the parishes of Köping and Högsrum.

A form from the *Expansus* limestone of Dalarna seems to differ from *M. acuticauda* from Öland in certain respects. As the material fram the two provinces is not equivalent, that from Dalarna coming chiefly from small individuals, that from Öland from comparatively large ones, it was thought best to postpone the description of the form from Dalarna until more material is available.

BRÖGGER has described *M. acuticauda* from Norway, and distinguishes two varieties. In one of these the length of the pygidium surpasses the width, in the other the width is greater than the length, as is the case in all specimens from Öland. The Norwegian specimens are undoubtedly much more like those from Öland than those from Ingermanland and Estonia (see below). The border of the pygidium is, e.g., weakly developed or absent, but before sufficient material has been obtained from Swedish localities outside Öland the Norwegian material should be treated as *M.* cf. *acuticauda.*

A large material was referred by F. SCHMIDT to *M. acuticauda.* He distinguishes a *forma typica* and three varieties, *obtusa*, *lamanskii*, and *triangularis.* These all differ from the species from Öland in having a more convex and usually more distinctly segmented glabella, a distinct border on cephalon and pygidium, and prominent ribs on the pygidial pleurae. These are undoubtedly specific characters. To them can, possibly, be added differences in the hypostoma which in SCHMIDT's specimens (loc. cit. Pl. V, figs, 6 and 7) is shorter, has a distinct middle furrow and an oval anterior lobe, whereas in *M. acuticauda* the anterior lobe is pear-shaped and the middle furrow a wide and shallow depression. These hypostomata belong, however, to quite small specimens, and the hypostoma might undergo changes with the growth of the individual.

Thus the species described by F. SCHMIDT must have a new name. *M. centron* (LEUCHTENBERG) is perhaps in part referable to *M. acuticauda* sensu F. SCHMIDT, but some differences pointed out by F. SCHMIDT (no crest between the posterior end of the rachis and the terminal spine of the pygidium, and an earlier appear-

ance in the sequence of beds) make this very uncertain. The cephalon of *M. centron* may belong to a *Megistaspis*, but as the material is poor, it is better to leave it out of the discussion at present. However, if LEUCHTENBERG's Pl. I, fig. 1 is correct, or at least nearly so, the very broad preglabellar field in the specimen and the broadly triangular cephalon with its strongly convex sides are quite different from *M. acuticauda*, sensu F. SCHMIDT. The cephalon of *M. centron* rather suggests *M. heroica* than *M. acuticauda typica*. The specimen of *M. acuticauda* var. *lamanskii* in SCHMIDT's Text-fig. 27 (op. cit.) would probably give an equilateral triangle if properly reconstructed and the ratio: Width of frontal lobe/width of preglabellar field, is the same as in *forma typica*.

OCCURRENCE of *M. acuticauda* in Öland.—Persnäs: Gillberga. Föra: Lundtorp. Alböke: Korntorp, Ormöga. Köping: Pinnekulla, Klinta, Kolstad, Borgholm. Räpplinge: Tryggestad, Greby. Glömminge: Österskog.

In this list are entered localities which yield material closely agreeing with the type. At other localities further collecting is desirable.

Megistaspis (*Megistaspidella*) *spinulata* n.sp.

1906 *Megalaspis acuticauda* ANG. var. *typica* — F. SCHMIDT, pp. 42–49, Text-figs. 19, 22, 23; Pl. V, figs. 1–4.

HOLOTYPE.—Carapace figured by F. SCHMIDT (1906) as Pl. V, fig. 1.

LOCUS TYPICUS.—Obuhovo on the Volhov, Ingermanland.

STRATUM TYPICUM.—$B_{III}\alpha$ (*Expansus* beds).

DIAGNOSIS.—A species resembling *M. acuticauda* in many respects, but glabella more convex and more distinctly segmented. Cephalon and pygidium with a distinct border. Strong ribs on the pygidium.

Megistaspis (*Megistaspidella*) *convexa* n.sp.

Pl. IX; Text-figs. 21 and 22.

1884 *Megalaspis grandis* SARS var. *lata* n. var. — TÖRNQUIST, p. 77.
1884 *Megalaspis grandis* SARS var. *rudis* ANGELIN — TÖRNQUIST, p. 78 (partim).
1951 *Megalaspis rudis* ANG.—JAANUSSON & MUTVEI, faunal list p. 633 (not *M.* aff. *rudis*, p. 632).

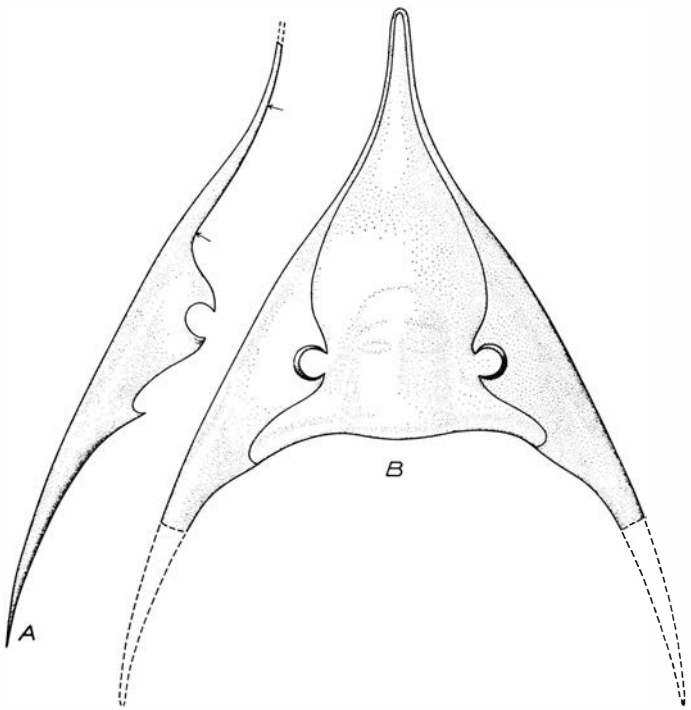
HOLOTYPE.—Cranidium, R.M. No. Ar. 9324.

LOCUS TYPICUS.—Skattungbyn, Siljan district.

STRATUM TYPICUM.—Lower "*Raniceps*" limestone.

DERIVATIO NOMINIS.—The name alludes to the even vaulting of the preglabellar field immediately in front of the glabella.

DIAGNOSIS.—Medium-sized. Cephalon triangular, distinctly constricted at the base of the snout. Genal spines long, slender, almost straight. Snout and genal spines bending strongly upwards. Glabella flattened, length $1\frac{1}{2}$ of the posterior width, segmentation only partly distinguishable. Preglabellar field in front of glabella evenly (though not strongly) vaulted; often with shallow



Text-fig. 21. *Megistaspis* (*Megistaspidella*) *convexa* n. sp. Reconstruction of cephalon.

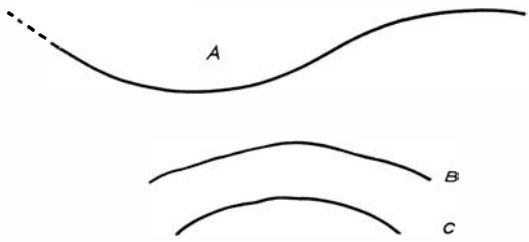
median depression; greatest width somewhat more than twice the width of frontal lobe. Angle between anterior and posterior branches of suture at the eye about 90°. Posterior border furrow narrow, well defined. Pygidium flattened, semi-elliptical; rachis poorly delimited in its middle part; rings and ribs faint.

MATERIAL FROM THE SILJAN DISTRICT.—About 20 fragmentary cranidia, 5 fragments of the free cheek, and about 25 more or less fragmentary pygidia.

DESCRIPTION.—Cephalon triangular, rather abruptly constricted to a narrow snout; width between the bases of genal spines greater than median length except snout (cf. Fig. 2). Outline behind snout somewhat convex, continuing, with only very slight constriction at the base of the genal spines, in the external sides of these. Snout and genal spines with a strong upward curvature.

Glabella strongly flattened, in some specimens so low that it can be clearly distinguished only in oblique light; length less than $1\frac{1}{2}$ of posterior width. Segmentation indistinct, especially in posterior half (behind S2). In the type specimen the Ms2 are more prominent than other details. In some specimens a median ridge extends from the very weak glabellar tubercle to the beginning of the frontal lobe. Alae small and diffuse.

Preglabellar field broad, rapidly narrowing to a fairly distinct constriction at the base of the narrow snout; evenly convex along a transverse line touching



Text-fig. 22. A and B, *Megistaspis* (*Megistaspidella*) *convexa* n. sp. *A*, Sagittal section of cranidium. *B*, transverse section at anterior end of glabella. Nat. size. Utbyn, Lindgården, Siljan area. U.M. No. D. 517. *C*, ? *M. convexa* n. sp.; transverse section at anterior end of glabella. Nat. size. Hälludden (Böda). U.M. No. Öl. 521.

the anterior border of the glabella (Text-fig. 22C). In most specimens a shallow and narrow median depression separates a pair of low diffuse swellings in the posterior part of the field (cf. *M. curvispina*). There may also be a fine median ridge running forwards for some distance from the frontal lobe. A very low periglabellar ridge is distinguishable in some specimens. Palpebral lobes medium-sized, their diameter (*sag.*) about half of the distance from their posterior side to the posterior margin of the cranidium. Posterior wing of free cheek short (*tr.*), triangular, with comparatively broad (*sag.*) base. Posterior border furrow narrow, distinctly delimited also in front.

The free cheek is slender; its greatest width at right angles to the outer margin is less than half the width of the cranidium between the eyes. In side view the lateral margin is perfectly straight in its middle part, but bent rather abruptly upwards at the genal spines and the snout (Pl. IX, fig. 3). The anterior and posterior branches of the facial suture meet at the eye at approximately right angles. From the eye the anterior branch runs forwards for a short distance before turning strongly outwards. The body of the free cheek has a distinct border; its concave internal part is separated from the fine marginal ridge by a narrow zone sloping steeply outwards. Such a development of the border has not been observed in other species. The genal spine is slender, and was evidently drawn out into a very long fine point. In the specimen, Pl. IX, figs. 2 and 3, at least 1 cm is probably missing (cf. Pl. XII, fig. 4).

None of the fragmentary free cheeks available fits well with the cranidia. The margin at the facial suture turns strongly outwards in front of the eye, then rather abruptly forwards and inwards; the preglabellar field in the cranidia to which the cheeks belonged must therefore have had its greatest width far back at a fairly well marked angle (Text-fig. 21): Fig. 21 A is drawn from a single specimen lacking the portion of the anterior process between the arrows in the drawing and most of the genal spine (cf. Fig. 21 B). The cheek belonged to a comparatively small individual, and there is at least one small cranidium that has a sharper angle posteriorly on the preglabellar margin than the holotype, though the part of the margin further forwards is too convex for the free cheek. This has, however, been used, with corrections, for the reconstruction of the cephalon.

The material of pygidia varies in many respects, and may belong to more than one species. For the following description three specimens, one of them

from the type locality, have been used; these agree well with each other, and except for probably unessential differences from other specimens, they are representative of the most common type, and most likely they are those which should be associated with the cranidia described above. These pygidia are roundedly triangular, width anteriorly greater than the length, and the border is developed only for a short distance at the posterior end. Width of doublure in front about $\frac{2}{3}$ of that behind. The posterior half of the rachis is in profile concave, a character that is evidently due to an under-development of the whole posterior half of the pygidium. The anterior end of the rachis is pressed down between the side lobes, and thus the anterior broader part of these lobes gives the impression of being in some way inflated. In *M. bombifrons* the profile of the rachis is slightly bent downwards anteriorly, otherwise it is straight; only in some of the quite small specimens a development as in *M. convexa* is found. The resemblance with *M. bombifrons* is, however, striking, and in BOHLIN, 1955, pygidia of both species were used for Text-fig. 7C ("*M. rudis*").

MEASUREMENTS.—Length of glabella 25 mm–46 mm.—Length of pygidium 59 mm–93 mm.

REMARKS.—A material of *Megistaspis* from the Siljan district was described in 1884 by TÖRNQUIST. His specimens are kept in Lund, and have kindly been put at the author's disposal by Dr. J. E. HEDE. TÖRNQUIST considers what is here described as *M. convexa* as varieties of *M. grandis*. He calls one of these *M. grandis* var. *lata*, a name that was discussed by JAANUSSON in 1956 (p. 72), and declared a nomen nudum. The name *M. grandis* var. *rudis* is a nomen dubium (see above). TÖRNQUIST is evidently right, however, in assuming that there might be more than one species (rather than variety) in his material from the grey "*Raniceps*"-beds in Dalarna. There are a few small cranidia that differ from the larger ones in the development of the preglabellar field, though they are not well enough preserved to form a reliable basis for description. There are also some pygidia which differ too much from the more common type to be considered as mere aberrant specimens of a single species. Some of the pygidia found in Dalarna have tentatively been referred to *M. lawrowi* (p. 168).

OCCURRENCE.—*Dalarna* (Siljan district): Leskusängen, Skattungbyn; Furudal; Gulleråsen; Osmundberg; Silverberg (=Silfberg); Lindgården, Utbyn; Sjurberg; Nittsjö; Vikarbyn.

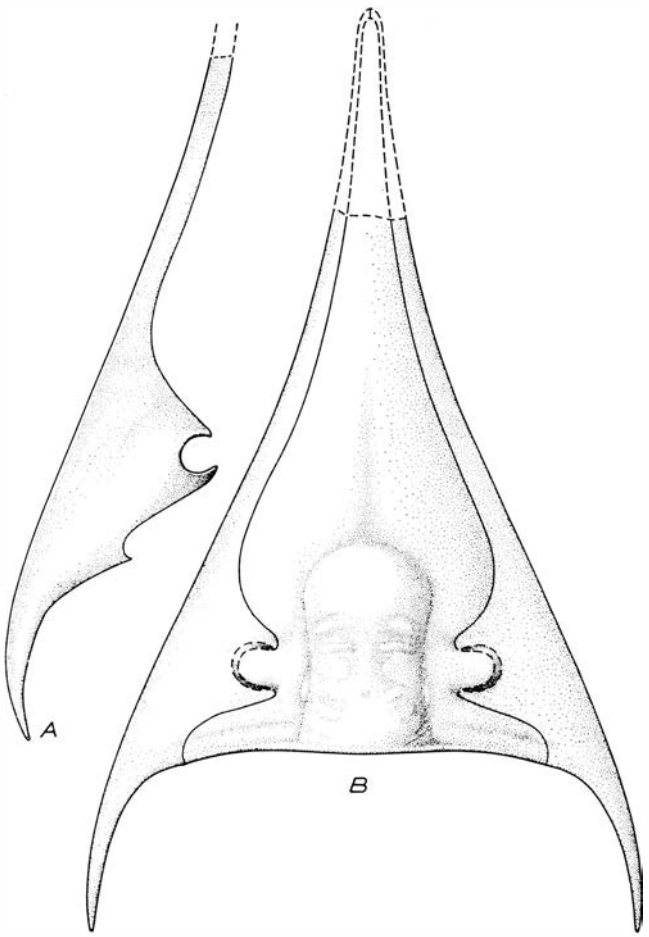
M. convexa is possibly present also in the material from Västergötland, Östergötland, and Öland.

Megistaspis (*Megistaspidella*) *curvispina* n. sp.

Pl. II, fig. 3; Text-figs. 23 and 24.

1949 *Megalaspis* sp. — BOHLIN, Pl. I, fig. 3.
1955 *Megalaspis* sp. — BOHLIN, Text-fig. 7D.

HOLOTYPE.—Cranidium U.M. No. Öl. 481.



Text-fig. 23. *Megistaspis* (*Megistaspidella*) *curvispina* n.sp. *A*, free cheek. Same as Pl. X, fig. 1. × ¾. *B*, reconstruction of cephalon.

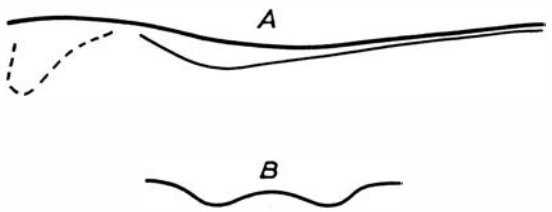
Locus Typicus.—Torslunda, drainage ditch from Lenstad Mosse, S of the railway, about 500 m W of the railway stop at Lenstad.

Stratum Typicum.—Red Lower "*Raniceps*" limestone.

Diagnosis.—Large species. Cephalon broad, triangular, slowly tapering to a long snout. Genal spines short, strongly curved inwards. Glabella 1½ times as long as wide, moderately convex, somewhat saddle-shaped between the eyes. Elongate depression in front of the glabella. Preglabellar field twice as wide as glabella. Angle between branches of facial suture less than 90°. Pygidium triangular with rounded posterior end. Rachis distinctly convex along its whole length. Ribs moderately strong, flattened or with shallow furrows.

Material.—About a dozen more or less fragmentary cranidia, an almost complete free cheek, and about a dozen more or less fragmentary pygidia.

Description.—Cephalon broad, triangular. Length to the constriction at the base of the snout about equal to width between the bases of the genal spines (cf. Text-fig. 2). Sides sinuous, concave at the base of the snout, otherwise convex



Text-fig. 24. *Megistapis* (*Megistaspidella*) *curvispina* n. sp. *A*, profile of cranidium. *B*, transverse section at palpebral lobes. Nat. size. U.M. No. Öl. 481 (Holotype).

and passing with an even curvature into sides of genal spines which are strongly curved inwards (or, where the cheek is in juxtaposition, upwards and inwards).

Glabella moderately convex; length 1½ times the width. Width of frontal lobe equal to, or less than, width of the occipital ring, but greater than smallest width between eyes. Segmentation distinct in oblique light. Elements between frontal lobe and L1 in a saddle shaped depression; Ms2 prominent, L3 and L2 weak, L2 penetrating farther towards the middle than L3. Lx not distinguishable, evidently continuous with Ms1. Behind the "saddle" three about equal lobes are marked on the sides of an otherwise even convexity: the two branches of L1, and A0. The glabellar tubercle is very small.

The preglabellar field widens rapidly from the eye ridges, and has its greatest width opposite the anterior end of the glabella. Its margins then converge, and pass with only slight constriction into the cranidial portion of the snout. Snout of unknown length, but may have been as long as shown in the reconstruction (Text-fig. 23 B). There is a broad and rather deep elongate depression extending forwards from the frontal lobe for a distance of nearly the length of the glabella; on the sides of the depression the preglabellar field is convex with its highest points close to the median depression (distance from this about ½ of the distance from outer margins). The convexities are less prominent in the holotype, which is medium-sized, than in the larger specimens. In two specimens, both with the test, one of them the holotype, a very fine ridge extends for some distance (about ⅓ of the length of the glabella) into the posterior part of the depression. On the internal mould of one specimen only a small rudiment of a ridge is present at the anterior border of the frontal lobe. In oblique light a faint periglabellar ridge can be seen in a more or less marked depression between the frontal lobe and the preglabellar field. The eye ridges are low and flat. Doublure furrow best developed in the holotype, but all specimens have a somewhat depressed triangular field in front of the eye ridges. Palpebral lobes of moderate size; distance from posterior margin about 1½ times their diameter. Posterior border furrow present but not deep. Articulating rim flattened, facing upwards and only slightly backwards, separated from the furrow by a faint ridge.

The sides of the narrow anterior process of the free cheek run parallel at least to the base of the snout. The body of the cheek is rather broad, its greatest width at right angles to the outer margin about ½ of the width of the cranidium at the eyes. The angle between the anterior and posterior branches of the facial suture at the eyes less than 90°. The doublure furrow faint. A border, only a

couple of mm broad, extends from the base of the genal spine forwards, and merges anteriorly into the upper surface of the anterior process.

The thorax is represented by a fragmentary segment, probably one of the foremost ones (Pl. X, fig. 5). The rachis is very flat, with broad (*sag.*) and very shallow articulating furrow. Width of the rachis twice that of inner pleural part.

The pygidium (BOHLIN 1949, Pl. I, fig. 3) is triangular with rounded posterior end, its length about equal to its width. There is no border except for a slight concavity behind the rachis. Doublure, measured at posterior end of the rachis at right angles to the margin, twice as broad as opposite the first rib. Rachis with about 27 rings, tapering backwards in its anterior half, in its posterior half with almost parallel sides; distinctly convex and delimited by marked dorsal furrows. The anterior part of the rachis, from the 4th or 5th ring, is somewhat bent downwards; in the remaining part the profile of the rachis may be slightly concave. The pleural lobes rise somewhat outwards from the dorsal furrows so that their highest point lies at a distance about half the width of the rachis from the dorsal furrow. There are 14 or 15 distinct ribs and behind them a small area in which no structures can be seen on the available material. The ribs are low and flat, but distinct also in specimens with the test. The rib furrows almost reach the dorsal furrow.

MEASUREMENTS.—Length of glabella 18 mm–54 mm.—Length of pygidium 41 mm–116 mm, width 43 mm–115 mm.

REMARKS.—Until now *M. curvispina* has been found only in the red "*Raniceps*" limestone of Central and Southern Öland. It has not yet been possible to correlate the sections in these parts with those in N. Öland, but it seems as if the beds with *M. curvispina* belonged to a lower level than those that have yielded such a rich harvest of *M. bombifrons* in N. Öland.

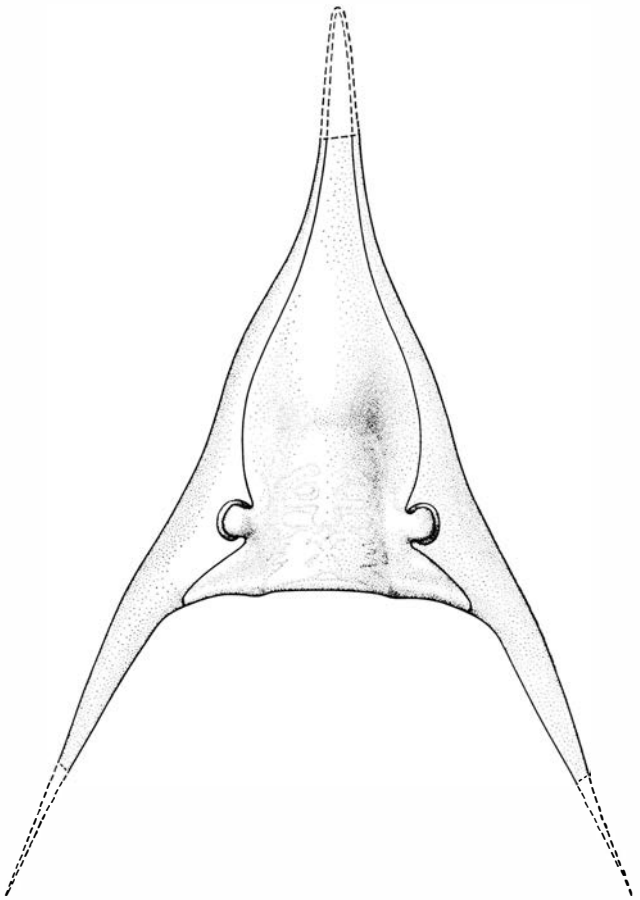
M. curvispina is a large species like *M. bombifrons*, but is easily distinguished from the latter by the elongate depression in front to the glabella, the smaller angle between the anterior and posterior branches of the facial suture, the triangular pygidium, and the well demarcated pygidial rachis. The species somewhat resembles *M. acuticauda* which has, however, a marked restriction at the base of the snout and a terminal spine on its pygidium. There is also some similarity with *M. convexa* which has, however, a pygidium closely resembling that of *M. bombifrons*.

OCCURRENCE.—Högsrum: W of the main road 1 km NE of Nyttorp; the alvar about 200 m N of the church. Torslunda: Drainage ditch about 500 m W of Lenstad. Hulterstad: A couple of hundreds of metres W of "Tingstads flisor".

Megistaspis (*Megistaspidella*) *bombifrons* n. sp.

Pl. XI; Text-figs. 25 and 26.

1949 *Megalaspis rudis* ANG. — BOHLIN (partim).
1955 *Megalaspis rudis* ANG. — BOHLIN (partim).



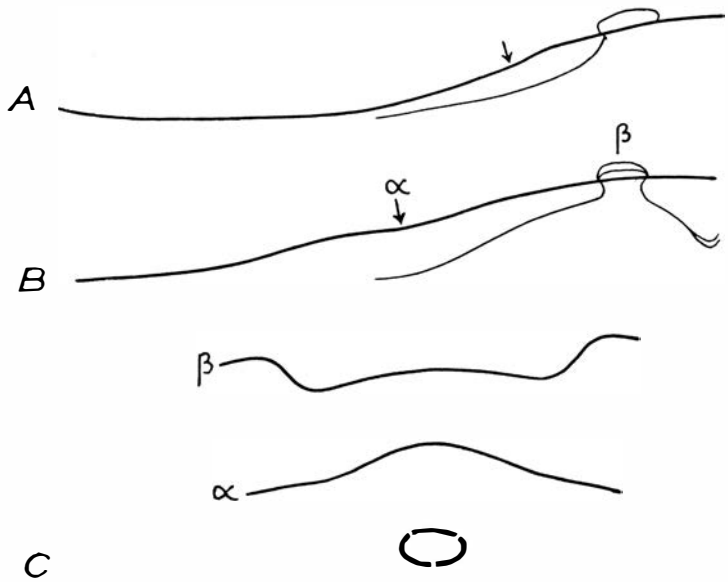
Text-fig. 25. *Megistaspis* (*Megistaspidella*) *bombifrons* n. sp. Reconstruction of cephalon.

HOLOTYPE.—U.M. No. Öl. 437. A mould of the external surface of the shell. Snout and left posterior wing partly missing.

LOCUS TYPICUS.—Vässby, at the drainage ditch from the small lake of Marsjö, 1 km E of the main road; parish of Föra, Öland.

DERIVATIO NOMINIS.—From the strong swelling in front of the glabella.

DIAGNOSIS.—Cephalon triangular. Width at base of genal spines equal to distance from posterior border to base of snout. Snout long, narrow, slightly bent upwards. Genal spines thick, straight or somewhat curved, diverging outwards. Glabella very flat, distinctly wider behind than in front, its length about $1\frac{1}{2}$ of its posterior width. Segmentation almost obsolete (distinguishable in very oblique light). Strong frontal boss delimited postero-laterally by marked triangular depressions. Greatest width of preglabellar field twice the width of frontal lobe. Angle between anterior and posterior branches of frontal suture at eye greater than 90°. Posterior border furrow broad and shallow, indistinctly delimited. Pygidium semi-elliptical, wider than long, broadly rounded posteriorly. No border. Rachis flat, in its middle portion flush with the side lobes.



Text-fig. 26. *Megistaspis* (*Megistaspidella*) *bombifrons* n. sp. *A* and *B*, profiles of cranidia. The arrows point at the anterior end of the glabella. *B* β and α, transverse sections in front of the glabella and at the palpebral lobes (see 26*B*). — *C*, transverse section of the snout at about mid-length. *A* and *B* nat. size, *C* sligthly enlarged. *A*, U.M. No. Öl. 427. *B*, U.M. No. Öl. 437 (Holotype). *C*, U.M. No. Öl. 523.

MATERIAL.—A great number of cranidia and pygidia; some fragments of free cheeks.

DESCRIPTION.—Cephalon elongate, triangular. Width at base of genal spines about equal to length excluding the snout (cf. Text-fig. 2). Total length including snout and genal spines probably more than 1½ of the distance between the tips of the genal spines. Length of snout unknown but probably approximately as in the reconstruction (Text-fig. 25). Genal spines long, almost straight in some specimens (Pl. XI, fig. 6), in others somewhat curved (Pl. XI, fig. 5).

Glabella broad and flat, its sides distinctly converging forwards; length about 1½ of posterior width. Segmentation just traceable, all elements characteristic of the genus recognizable. Ms2 often more prominent than any other detail in the relief. S3 penetrating as far towards the middle as S2, on either side occupying ⅖ of the width of the glabella. Alae elongate, narrow, hardly visible upon the external surface of the test. The relief distinguishable in the type specimen is entered in the reconstruction, but somewhat exaggerated.

The preglabellar field is elongate and comparatively narrow. Its sides form fairly even curves from the eye ridges to a point at a distance from the posterior margin of the cranidium about twice the length of the glabella; there, at a slight inward turn they pass into the almost straight sides of the long snout. The anterior extremity of the snout is not preserved in any of the specimens, but it is evident that the snout was slightly turned up anteriorly (Text-fig. 26A).

Immediately in front of the glabella there is a strong median boss, in the holotype seemingly extending over the entire width of the preglabellar field. In other specimens the boss proper is better delimited laterally. There are also specimens in which the boss is so vaguely delimited from the frontal lobe that it appears as an anterior continuation of the latter. In some specimens a blunt median ridge extends from the anterior margin of the frontal lobe over the boss, tapering forwards, and fading out in front of the boss, in one specimen in a shallow elongate depression in the anterior part of the preglabellar field. The periglabellar ridge is not always distinguishable. It is best seen in the holotype where at its ends it merges with the indistinctly delimited eye ridges. It is interrupted in front, where the boss is in contact with the frontal lobe. A characteristic feature of the species, by which it can be distinguished from related species from lower levels of the *Vaginatum* limestone, is a pair of large triangular depressions between the frontal boss, the frontal lobe, and the facial suture. These depressions may, however, be indicated also in *M. gigas* and *M. obtusicauda* as they evidently appeared as a consequence of the development of the frontal boss. In one specimen the depression is traversed by a doublure furrow; usually, however, there seems to be no impression of the posterior margin of the doublure upon the test of the cranidium. Eyes far back; anterior margins of palpebral lobes opposite the middle of the glabella. Palpebral lobes fairly large with almost flat upper surface, their antero-posterior diameter is about $\frac{1}{6}$ of the width of the cranidium at the eyes and $\frac{2}{3}$–$\frac{1}{2}$ of the distance from the lobes to the posterior border of the cranidium. Posterior wings triangular, delimited anterolaterally by almost straight posterior branch of facial suture. Posterior border furrow broad and shallow, delimited by a blunt ridge from the articulating rim.

The free cheeks are narrow throughout, greatest width somewhat more than $\frac{1}{3}$ the width of cranidium at palpebral lobes. In side view the margins of the cephalon curve downwards in a long even sweep from the tip of the genal spine to the tip of the snout. Along the narrow border, however, the surface of the body of the free cheek is concave in antero-posterior direction so that in top view the outline of the cephalon was concave in this region. The body is comparatively small. The anterior and posterior branches of the facial suture form at the eye an angle of about 105°, the anterior branch running straight forwards and outwards from the eye. There is an indistinctly delimited depression in the prolongation of the posterior border furrows. The anterior processes taper very slowly forwards, and their sides are evidently nowhere strictly parallel. On the sides of the snout they become very narrow, and face strongly outwards as the anterior part of the snout is oval in cross-section (Text-fig. 26 C). The doublure is closely adpressed to the lower surface of the frontal boss. The genal spines are long. At the base they are thick, their lower surface considerably more convex than the upper one. The surfaces meet in an outer and an inner edge the outer one of which is sharp and slightly turned upwards to form a marginal ridge. The internal edge disappears at a short distance from the base, towards

the tip also the external one, and the cross-section becomes almost circular.

The panderian organs are situated at the genal angle, below a point about halfway between the distal end of the posterior wing of the fixed cheek and the external cephalic margin. They have a large opening antero-medially surmounted by an elevation with semicircular base, so that the openings seem to have been directed backwards and outwards.

Thorax unknown.

Some large pygidia found at the same localities as the cranidia described above undoubtedly belong to *M. bombifrons*. Outline semielliptical; width somewhat greater than length (cf. BOHLIN, 1955, Text-fig. 7C). Posterior end broadly rounded, in some specimens with slight indication of a border. At the level of the posterior end of the rachis the zone entered by the doublure is flat with a gentle slope, but becomes increasingly steeper anteriorly. Doublure only half as broad anteriorly as opposite the posterior end of the rachis. Rachis with about 25 rings, with straight sides converging backwards so that the width at the posterior end is only half of that in front. The rachis is extraordinarily flat: the part carrying the 6 (5–7) foremost rings delimited by distinct dorsal furrows and more or less raised above the side lobes; further back, from the 7th (6th–8th) to about the 15th ring, the rachis is flush with the side lobes, from the 15th segment to the posterior end it is again slightly elevated but there are no distinct dorsal furrows. Ribs about 17. Rib furrows distinct but ending before reaching the rachis. Pleural furrows of varying depth but always comparatively shallow. This description is valid for internal moulds. In the few specimens in which the test is preserved the relief can be so faint as to be almost indistinguishable. This may, however, to a certain degree depend on the thickness of the shell.

MEASUREMENTS.—Length of glabella 12.5 mm–46 mm.— Length of pygidium 40 mm–145 mm, width 43 mm—146 mm.

REMARKS.—*M. bombifrons* is known at present only from Northern Öland. In earlier faunal lists (BOHLIN, 1949, 1955) it was entered as "*Megalaspis rudis*", a determination based exclusively on the pygidium. Since the cranidium has been properly studied, it has turned out that the material collected in the upper divisions of the "*Raniceps*" limestone is different from that collected in the lowermost, glauconitic part. In the list of 1949 the specimens from Tokenäse Hamn ("Tokenäs"), "Marsjö" (red limestone), and Persnäs ("Upper *Raniceps*") belong to *M. bombifrons*. Material, undoubtedly belonging to the same species was also found at "Norra udden" (S.G.U., coll. G. HOLM). The available material is large, and belongs without doubt to a single species. The frontal boss, from which the species derives its name, varies in its development, but is always present. Another characteristic feature are the depressions delimited medially by the boss and the frontal lobe and reaching the facial suture. By these characters *M. bombifrons* can be distinguished from the older forms of the *Vaginatum*

limestone. In later forms the cranidium resembles more that of *M. bombifrons*, though at least in *M. gigas* the depressions mentioned are far less pronounced or even lacking.

In 1955 the author briefly discussed ANGELIN's *M. latilimbata*. The cranidium figured by ANGELIN (Pl. XIV, fig. 1) has a boss in front of the glabella, and the locality (Sandvik, Öland) is one, where *M. bombifrons* can be expected to occur. The type of *M. latilimbata* is lost, the figure, if correct, differs in other respects so completely from *M. bombifrons* that an identification with this species is impossible. It seems further as if ANGELIN for his reconstruction had used material belonging to different species. The free cheeks show a distant resemblance to *M. heroica* (broad border and short sharply pointed genal spines), but again the differences are very great, and it can safely be stated that a form like *M. latilimbata*, whether the figured cephalon is combined from heterogenous material or not, does not occur in the large material at the author's disposal. The detail from a pygidium (loc. cit. Pl. IV, fig. 3) suggests in an equally uncertain way *M. heroica* (the broad border). *M. latilimbata* should thus be definitely regarded as a nomen dubium.

OCCURRENCE.—Böda: Norra udden, Hälludden (free cheek, pygidium), Tokenäse hamn. Högby: W. of Hornsjön (only pygidia). Persnäs: Gunnarslund, several localites in the area between Stenninge, Sandvik, and Knisa (only pygidia). Föra: Hjelmestad (only pygidia), Vässby (="Marsjö kanal" 1949). Köping: ?Pinnekulla (only pygidium).

Megistaspis (Megistaspidella) obtusicauda (BOHLIN, 1955).

Text-fig. 27 A.

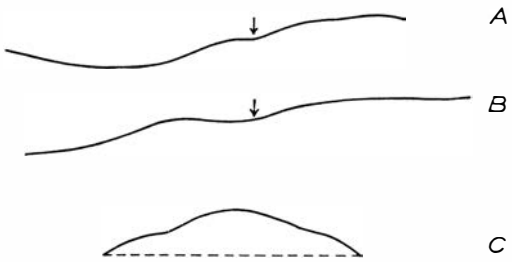
For synonyms, see BOHLIN, 1955, pp. 131 ff.

Of this species several well preserved pygidia were collected, but the cranidium is still insufficiently known. All that can be said about the latter at present is that it seems to resemble closely that of *M. gigas*, though the glabellar tubercle is evidently less pronounced. The hesitation is to a great part due to the fact that the type locality has yielded only a badly weathered fragmentary cranidium; a somewhat better specimen was found at Tokenäs Hamn (a negative), but the pygidia from there are not well enough preserved to prove with full certainty the presence of the species. In 1955, p. 135, the locality was entered with a question mark ("Enerum?").

MEASUREMENTS.—Length of pygidium 81 mm–118 mm, width 70 mm–105 mm.

Length and width of the extraordinarily long specimen, BOHLIN 1949, Pl. I, fig. 1, 123 and 98 mm, respectively.

OCCURRENCE.—Böda: Maderna, Tokenäs hamn? (=Enerum BOHLIN, 1955, p. 135). Högby: Horn. Persnäs: Gunnarslund. Föra: ca. 500 m E of Ö. Vässby.



Text-fig. 27. *A*, ?*Megistaspis* (*Megistaspidella*) *obtusicauda* (BOHLIN). Sagittal section of cranidium. U.M. No. Öl. 520. *B* and *C*. *Megistaspis* (*Megistaspidella*) *gigas* (ANGELIN). B, sagittal section of cranidium. *C*, transverse section at anterior end of glabella. U.M. No. D. 520. — All $\frac{2}{3}$ nat. size.

Megistaspis* (*Megistaspidella*) *gigas (ANGELIN, 1851).

Pl. XII; Text-figs. 27 B, C and 28.

For synonyms, see BOHLIN, 1955.

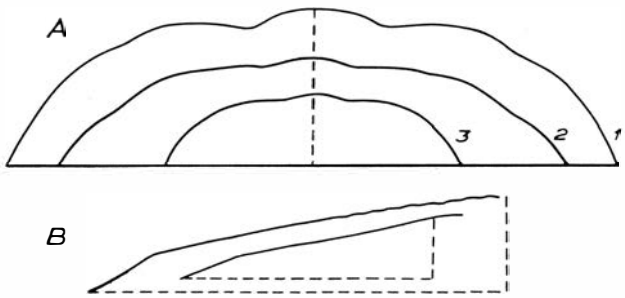
In 1955 (pp. 135–137) *M. gigas* was discussed, and a neotype designated and figured, but a detailed description of the species was postponed till other species of *Megistaspis* could be revised.

The material available at present is not quite satisfactory. There are several cranidia (all of them fragmentary and several of them badly weathered), some fragmentary free cheeks, a fragment comprising five thoracic segments and part of the pygidium, and a great number of pygidia, most of them fragmentary.

DESCRIPTION.—Cephalon triangular. Its exact form cannot be reconstructed from the remains, but was probably as in *M. bombifrons*, though the genal spines seem to have been slenderer than in that species.

The glabella is moderately convex, its sides roughly parallel, its length about $1\frac{1}{2}$ of its posterior width. Segmentation as in *M. bombifrons* though somewhat better marked. Prominent glabellar tubercle. Shallow occipital furrow, much wider (*sag.*) behind the glabellar tubercle than on the sides. Preglabellar field elongate, greatest width about twice that of frontal lobe, tapering gradually to a long snout which is distinctly bent upwards. Frontal boss varying greatly in size but always present; its width usually greater than its length. Some specimens with a fine median ridge extending from the frontal lobe over the boss onto the anterior part of the preglabellar field, at least to the point, where the snout begins to turn upwards. A cross-section in front of the glabella is more evenly convex than in *M. bombifrons*, and the depressions on the sides between the frontal boss and the glabella are indistinct. The palpebral lobes are large with a deep depression in their centre; distance from their posterior border to the posterior border of the cranidium in adult specimens $1\frac{1}{2}$ times the sagittal diameter of the lobes. Posterior marginal furrow well developed and fairly deep. Posterior wings slenderer than in *M. bombifrons*, with narrower (*sag.*) base.

The free cheeks in the material are fragmentary, and most of them belong to small individuals. The body is comparatively large, its greatest width about half the width of the cranidium at the palpebral lobes. The genal spine is, in adult specimens, very slender and drawn out in a long fine point (in the speci-



Text-fig. 28. *Megistaspis* (*Megistaspidella*) *gigas* (ANGELIN). *A*, sections of pygidia between postero-lateral corners of facets. $\frac{2}{3}$ nat. size. — *1*, U.M. No. Öl. 816; *2*, U.M. No. Öl. 522; *3*, U.M. No. Öl. 34. — *B*, sagittal sections of pygidia. $\frac{2}{3}$ nat. size. Large specimen: R.M. No. Ar. 21770 (Neotype). Small specimen: U.M. No. Öl. 34.

men Pl. XII, fig. 4 it is evidently not complete). In cheeks of young specimens the spines seem to be comparatively heavier.

In the thorax the relief of the segments is rather strongly pronounced (rachial rings prominent in relation to articulating half rings; pleural furrows deep). Internal portion of pleura narrow, in the posterior segments only $\frac{2}{3}$ of the width of the rachis.

Pygidium roundedly triangular; length somewhat greater than width (BOHLIN, 1955, Text-fig. 7). A narrow border may be present at the extreme posterior end. Width of doublure in front $\frac{2}{3}$ of width opposite posterior end of rachis. Rachis convex, distinctly delimited by deep dorsal furrows, more than twice as wide in front as at posterior end, lowered between side lobes, but its middle line forms the highest point in any cross-section; dorsal furrows slightly curved inwards. Rachial rings 24–27, their lateral portions prominent. About 18 ribs separated by deep pleural furrows; back of ribs, in most large specimens from Öland, rounded, and the rib furrows developed only distally; in small specimens (young individuals) and some large specimens that back of the ribs is flattened, or there are shallow furrows extending along the whole length of the ribs.

MEASUREMENTS.—Length of glabella 13 mm–47 mm.—Length of pygidium 49 mm–110 mm, width 46 mm–98 mm.

REMARKS.—The material referred here to *Megistaspis gigas* is rather variable. The description of the cranidium above is based mainly on large specimens, the description of the pygidium in first hand on the neotype. Some adult specimens show minor peculiarities. A fragmentary cranidium from Vässby (U.M. No. Öl. 502), for instance, has a small rounded depression in front of the large frontal boss. Some pygidia, among them the neotype, are more flattened than others, this being independent of the size of the specimen (Text-fig. 28 B). Slight postmortal deformation may be responsible for this difference though the specimens are apparently in a perfect condition.

Among the small specimens the variation is very pronounced. *M.* aff. *gigas* (U.M. No. ar. 4218, new number U.M. No. Öl. 31; BOHLIN, 1955, Pl. III, fig. 9) has a strongly convex frontal lobe divided anteriorly by a shallow longitudinal furrow (not visible in the figure, but identical with that in the large

specimen in Pl. XII, fig. 1 in the present paper); behind the frontal lobe the glabella is pinched, and a pair of depressions is formed which are bordered posteriorly by L1. As a whole the glabella resembles somewhat that of an *Asaphus*. The boss in front of the glabella is large and broad. Another slightly smaller specimen (U.M. No. Öl. 492) has a flattened glabella and a low frontal boss (Pl. XII, fig. 3). U.M. Nos Öl. 31 and 492 are fairly well preserved moulds of small cranidia. They agree with each other and with the adult specimens in having a marked glabellar tubercle and fairly large eyes situated at the same distance from the posterior border. There are a number of small pygidia which agree well with *M. gigas*, only that the rib furrows can be traced almost to the dorsal furrow (1955, Pl. IV, fig. 5; cf. above). It thus seems as if the rather variable cranidia all belong to individuals with a pygidium of the *Gigas* type. More material is needed in order to decide, whether the differences are due to individual variation or whether *M. gigas* comprises several closely related forms. About the very small specimen, U.M. No. Öl. 30 (= U.M. No. Ar. 4217; 1955, Pl. III. fig. 8), see below.

Three fragmentary cranidia and some pygidia are known from Dalarna (Siljan district). The cranidium in Pl. XII, fig. 2, differs from the specimens from Öland in having a very large cranidial boss, almost circular in outline and detached from the frontal lobe (Text-fig. 27 B). The specimen has a comparatively small glabellar tubercle which, however, may have been worn by weathering. In other specimens the tubercle is as strong as in any specimens from Öland. The available pygidia from Dalarna (4 specimens) have furrows on the ribs.

The pygidia from Ljung, Östergötland, are deformed, some even to such an extent that the ribs are almost effaced. No cranidia are known from that locality. The material was briefly dealt with in 1955 (BOHLIN, 1955, p. 134).

OCCURRENCE.—*Dalarna* (Siljan district). Orsa: Stenberg. Ore: Fjäcka. Boda. Rättvik: Vikarbyn. Leksand: Sollerön. *Östergötland*. Vreta kloster (erratic boulder), Ljung. *Öland* (see BOHLIN, 1955). Böda: Björnnabben, E of Byxelkrok, Enerums alvar. Byerums Sandvik. Högby: Binnerbäck. Persnäs: Gunnarslund, Södvik. Föra: Vässby ("Marsjö kanal").

Young specimens

In 1955 two cranidia from the *Gigas* limestone were figured (BOHLIN, 1955, Pl. III, figs. 8 and 9). They differ considerably from each other, and were mentioned in the faunal lists as *M.* aff. *gigas* and *M.* sp. (p. 128). The most striking feature in the latter is the very narrow snout that could as well be called a spine. The glabella is strongly convex, and the eyes are large. In all these respects it differs from the adult *M. gigas*. The outline of the cranidium is roughly as in *M. gigas*, and as in this species there is a marked swelling in front of the glabella.

At Högsrum, in red beds with *M. curvispina*, a small cranidium was found.

Again the spine-like snout, the convex glabella, and the comparatively large eyes as compared with fully grown specimens of *M. curvispina*. There is a slight depression in front of the glabella and no trace of a swelling.

Finally, there are two small specimens with a similar convex glabella from the Upper "*Raniceps*" limestone at Föra. There is a frontal boss, and the frontal lobe is delimited on either side by a deep depression separated from the margins of the cranidium by a broad flat ridge, a feature present also in large specimens of *M. bombifrons*, though much less pronounced. The snout in both small specimens is broken off, and the eyes are damaged or completely broken off.

All these specimens must belong to young individuals of respectively *M. gigas*, *M. curvispina*, and *M. bombifrons*. Otherwise there would have existed three small species differing from each other in roughly the same respects as do the associated large species.

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Explanation of the Plates

Plate I

Fig. 1. *Megistaspis* (*Megistaspidella*) *bombifrons* n. sp. Detail of pygidium (cf. p. 163). The arrow marks the position of the left dorsal furrow. Upper "*Raniceps*" limestone. Ca. 1 km W of Horn (Högsrum). × 2. U.M. No. Öl. 507.

Fig. 2. *Megistaspis* (*Megistaspidella*) cf. *bombifrons* n. sp. Detail of pygidium (cf. Text-fig. 5). Upper "*Raniceps*" limestone. × 2. U.M. No. Öl. 456.

Fig. 3. *Megistaspis* (*Megistaspidella*) cf. *bombifrons* n. sp. Part of small fragmentary pygidium (cf. p. 163). Upper "*Raniceps*" limestone. Ö. Vässby (Föra). × 2. U.M. No. Öl. 506.

Plate II

Fig. 1. *Megistaspis* (*Megistaspidella*) sp. (? aff. *convexa*). Pygidium. Structure of external surface of the test in the doublure zone (cf. p. 163). Lower (glauconitic) "*Raniceps*" limestone. Stenninge, quarry on the Alvar (Persnäs). × 8. Excursion collection 1947. U.M. No. Öl. 505.

Fig. 2. *Megistaspis heroica* n. sp. Pygidium. Structure of external surface of the test on the border (cf. p. 163). Upper "*Raniceps*" limestone. Ö. Vässby (Föra). × 8. U.M. No. Öl. 380.

Fig. 3. *Megistaspis* (*Megistaspidella*) *curvispina* n. sp. Pygidium. Striation of the test at anterior end of rachis (cf. p. 163). Red "*Raniceps*" limestone. Lenstad (Torslunda). × 2. U.M. No. Öl. 465.

Fig. 4. *Megistaspis heros* (DALMAN). Pygidium. Segmentation and structure of the test (mould) at posterior end of rachis. "Täljsten", Kinnekulle (? = Lower "*Raniceps*" limestone). × 2. R.M. No. Ar. 47123.

Plate III

Fig. 1. *Megistaspis* (*Megistaspidella*) *grandis* (SARS). Lectotype. 3cγ. Akersbakken, Oslo, Norway. Nat. size. O.M. No. 20139.

Figs. 2–4. *Megistaspis lawrowi* (F. SCHMIDT). Cranidium. Lower "*Raniceps*" limestone. Hagudden (Böda). × 2. U.M. No. Öl. 486. — Fig. 2, front view. — Fig. 3, left side view. — Fig. 4, dorsal view.

Plate IV

Fig. 1. *Megistaspis* (*Megistaspidella*) cf. *bombifrons* n. sp. Part of corroded test with the base of a bryozoan colony, and "tubes" filled with calcite (cf. p. 164).

Fig. 2. *Megistaspis heros* (DALMAN). Distal ends of the fourth and the fifth right thoracic pleurae. On the fourth pleura doublure and panderian organ. "Täljsten", Kinnekulle (? = Lower "*Raniceps*" limestone). × 2. R.M. No. Ar. 47123.

Fig. 3. *Megistaspis heros* (DALMAN). Lectotype. Red limestone, probably below the "täljsten". Västerplana, Kinnekulle. Coll. DALMAN 1827. Ca. $\frac{2}{3}$ nat. size. R.M. No. Ar. 14412.

Plate V

Fig. 1. *Megistaspis heros* (DALMAN). Plaster cast. "Täljsten." Kinnekulle (? = Lower "*Raniceps*" limestone). Coll. O. RAMSAY 1856. $\frac{1}{2}$ nat. size. Original in the School Museum, Skara, Västergötland.

Fig. 2. *Megistaspis heroica* n. sp. Cranidium. Internal mould. Right side view. 3c, uppermost part. Grinaker, Gran, Norway. Coll. TH. MÜNSTER 1893. × 2. O.M. No. 33199. Same specimen as Pl. VII, fig. 8.

Plate VI

Megistaspis heros (DALMAN). Pygidium. Probably from the "täljsten", Kinnekulle. U.M. No. Vg. 700. — Fig. 1, ⅔ nat. size. — Fig. 2, segmentation of anterior part of the rachis. ×2.

Plate VII

Megistaspis heroica n. sp.

Fig. 1. Free cheek. Doublure and panderian organ exposed. Upper "*Raniceps*" limestone. Vässby (Föra). Nat. size. U.M. No. Öl. 385.

Fig. 2. Free cheek, partly with test. Upper "*Raniceps*" limestone. Ö. Vässby (Föra). Nat. size. U.M. No. Öl. 383.

Fig. 3. Posterior part of free cheek with genal spine. Test partly preserved. Grey "*Raniceps*" limestone without glauconite. Sandvik (Persnäs). Nat. size. U.M. No. Öl. 382.

Fig. 4. Pygidium, partly with test. Upper "*Raniceps*" limestone. Vässby (Föra). Nat. size. U.M. No. Öl. 342.

Fig. 5. Cranidium. Right eye and right posterior wing complete. Upper "*Raniceps*" limestone. Byxelkrok (Böda). Nat. size. U.M. No. Öl. 361.

Fig. 6. Cranidium. Grey "*Raniceps*" limestone with glauconite. Hälludden (Böda). ×2. U.M. No. Öl. 352.

Fig. 7. Cranidium. Upper "*Raniceps*" limestone. Vässby (Föra). Nat. size. U.M. No. Öl. 332.

Fig. 8. Cranidium. Internal mould. ×2. See Pl. V, fig. 2.

Plate VIII

Megistaspis (Megistaspidella) acuticauda (ANGELIN)

Fig. 1. Cranidium with test. *Expansus* limestone. Power line, "pole VII", N. of the main road, Greby (Räpplinge). U.M. No. Öl. 424.

Fig. 2. Right free cheek. Incomplete genal spine. Doublure and panderian organ exposed. *Expansus* limestone. Tryggestad (Räpplinge). Nat. size. U.M. No. Öl. 411 b.

Fig. 3. Left free cheek with test. *Expansus* limestone. Tryggestad (Räpplinge). Nat. size. U.M. No. Öl. 411 a.

Fig. 4. Pygidium. *Expansus* limestone. Drainage ditch, Klinta (Köping). Nat. size. U.M. No. Öl. 405.

Fig. 5. Pygidium. *Expansus* limestone. Jordhamn (Persnäs). ⅔ nat. size. U.M. No. Öl. 509.

Fig. 6. Pygidium. Lectotype. Probably *Expansus* limestone, Öland. Nat. size. Coll. ? ANGELIN. R.M. No. Ar. 21763.

Fig. 7. Hypostome. *Expansus* limestone. Tryggestad (Räpplinge). Nat. size. U.M. No. Öl. 510.

Plate IX

Megistaspis (Megistaspidella) convexa n. sp.

Fig. 1. Cranidium. Holotype. ? Lower "*Raniceps*" limestone. Skattungbyn, Siljan district, Dalarne. Nat. size. Coll. F. J. BLOMQUIST. R.M. No. Ar. 9324.

Figs. 2–3. Left free cheek. ? Lower "*Raniceps*" limestone. Silverberg, Boda, Siljan district, Dalarne. Nat. size. Coll. P. THORSLUND. — Fig. 2, dorsal view. — Fig. 3, side view.

Figs. 4–5. Pygidium. ? Lower "*Raniceps*" limestone. Leskusäng, Skattungbyn. Siljan district, Dalarne. Nat. size. Coll. E. WARBURG. U.M. No. D519. — Fig. 3, dorsal view. — Fig. 5, from the left side.

Plate X

Megistaspis (Megistaspidella) curvispina n. sp.

Fig. 1. Left free cheek. Red "*Raniceps*" limestone. Lenstad (Torslunda). Nat. size. U.M. No. Öl. 484 c.

Fig. 2. Cranidium. Red "*Raniceps*" limestone. N. of the church of Högsrum. ×⅔. U.M. No. Öl. 480.

Fig. 3. Cranidium. Holotype. Red "*Raniceps*" limestone. Lenstad (Torslunda). Nat. size. U.M. No. Öl. 481.

Fig. 4. Cranidium. Red "*Raniceps*" limestone. N. of Nyttorp (Högsrum). Nat. size. U.M. No. Öl. 482.

Fig. 5. First (?) thoracic segment. Red "*Raniceps*" limestone. Lenstad (Torslunda). Nat. size. U.M. No. Öl. 511.

Plate XI

Megistaspis (Megistaspidella) bombifrons n. sp.

Fig. 1. Cranidium. Holotype. Photo of cast. Upper "*Raniceps*" limestone. Ö. Vässby (Föra). Nat. size. U.M. No. Öl. 437.

Fig. 2. Cranidium. Combined from specimen and a cast of mould (tip of the snout). Upper "*Raniceps*" limestone. Ö. Vässby (Föra). Nat. size. U.M. No. Öl. 427.

Fig. 3. Right free cheek. Upper "*Raniceps*" limestone. Ö. Vässby (Föra). Nat. size. U.M. No. Öl. 512.

Fig. 4. Left free cheek. Panderian organ. Upper "*Raniceps*" limestone. Hälludden (Böda). Nat. size. Coll. G. HOLM. S.G.U.

Fig. 5. Left genal spine. Curved. Dorsal surface. Upper "*Raniceps*" limestone. Ö. Vässby (Föra). Nat. size. U.M. No. Öl. 513.

Fig. 6. Left genal spine. Straight. Lower "*Raniceps*" limestone. Gunnarslund (Persnäs). Nat. size. U.M. No. Öl. 514.

Fig. 7. Free cheek. Anterior part of doublure. Lower surface. Upper "*Raniceps*" limestone. Excursion collection 1947. Ö. Vässby (Föra). Nat. size. U.M. No. Öl. 515.

Plate XII

Megistaspis (Megistaspidella) gigas (ANGELIN)

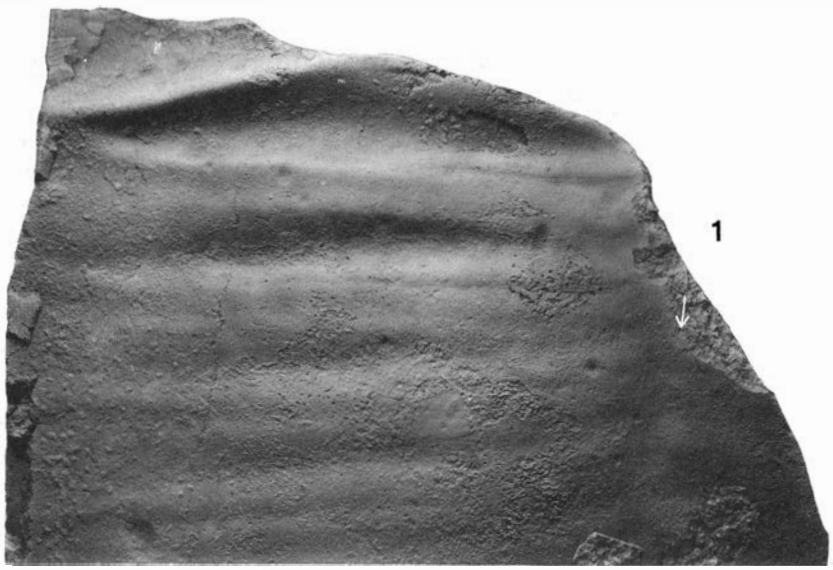
Fig. 1. Cranidium. Grey *Gigas* limestone. Byxelkrok (Böda). Nat. size. U.M. No. Öl. 493.

Fig. 2. Cranidium. *Gigas* limestone. Fjäcka, Siljan district, Dalarne. Nat. size. Coll. P. THORSLUND. U.M. No. D. 520.

Fig. 3. Cranidium. *Gigas* limestone. Enerum (Böda). Nat. size. Coll. KLING and EKSTRÖM. U.M. No. Öl. 492.

Fig. 4. Free cheek. *Gigas* limestone. Enerum (Böda). Nat. size. Coll. KLING and EKSTRÖM. U.M. No. Öl. 516.

Fig. 5. Fourth to eighth thoracic segments. *Gigas* limestone. Gunnarslund (Persnäs). Nat. size. U.M. No. Öl. 517.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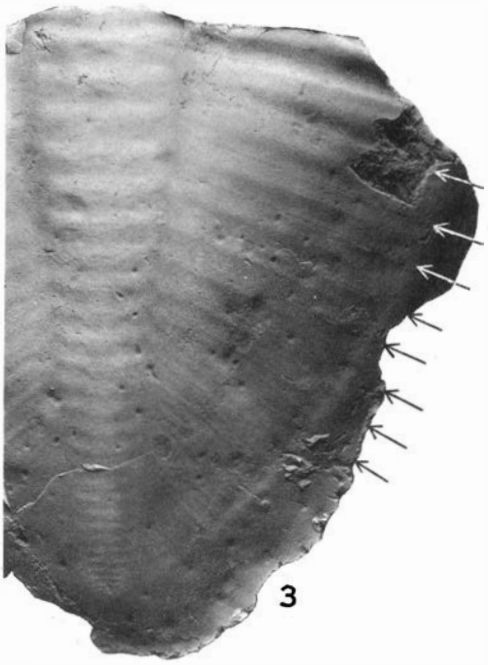
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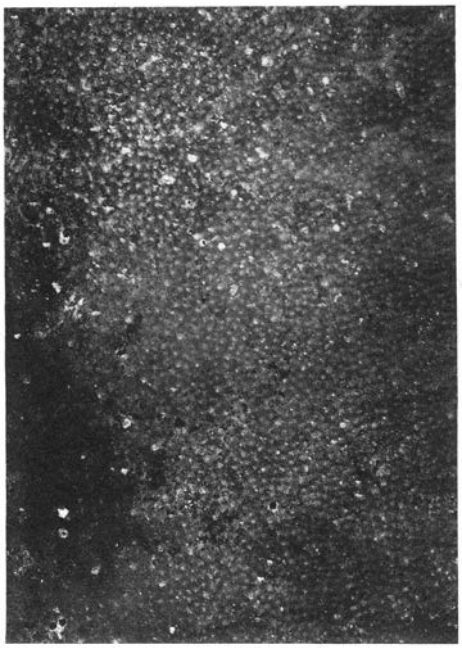

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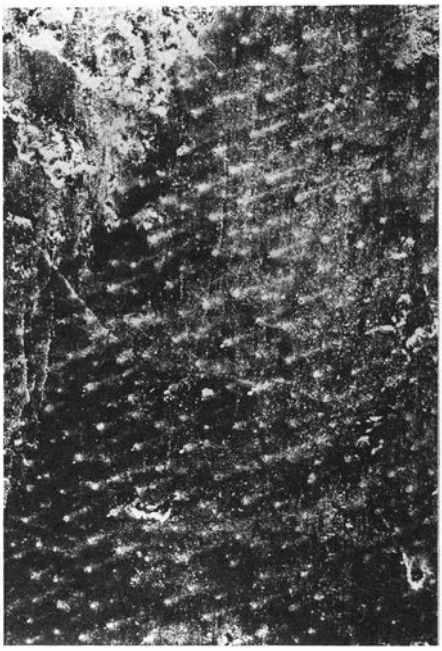

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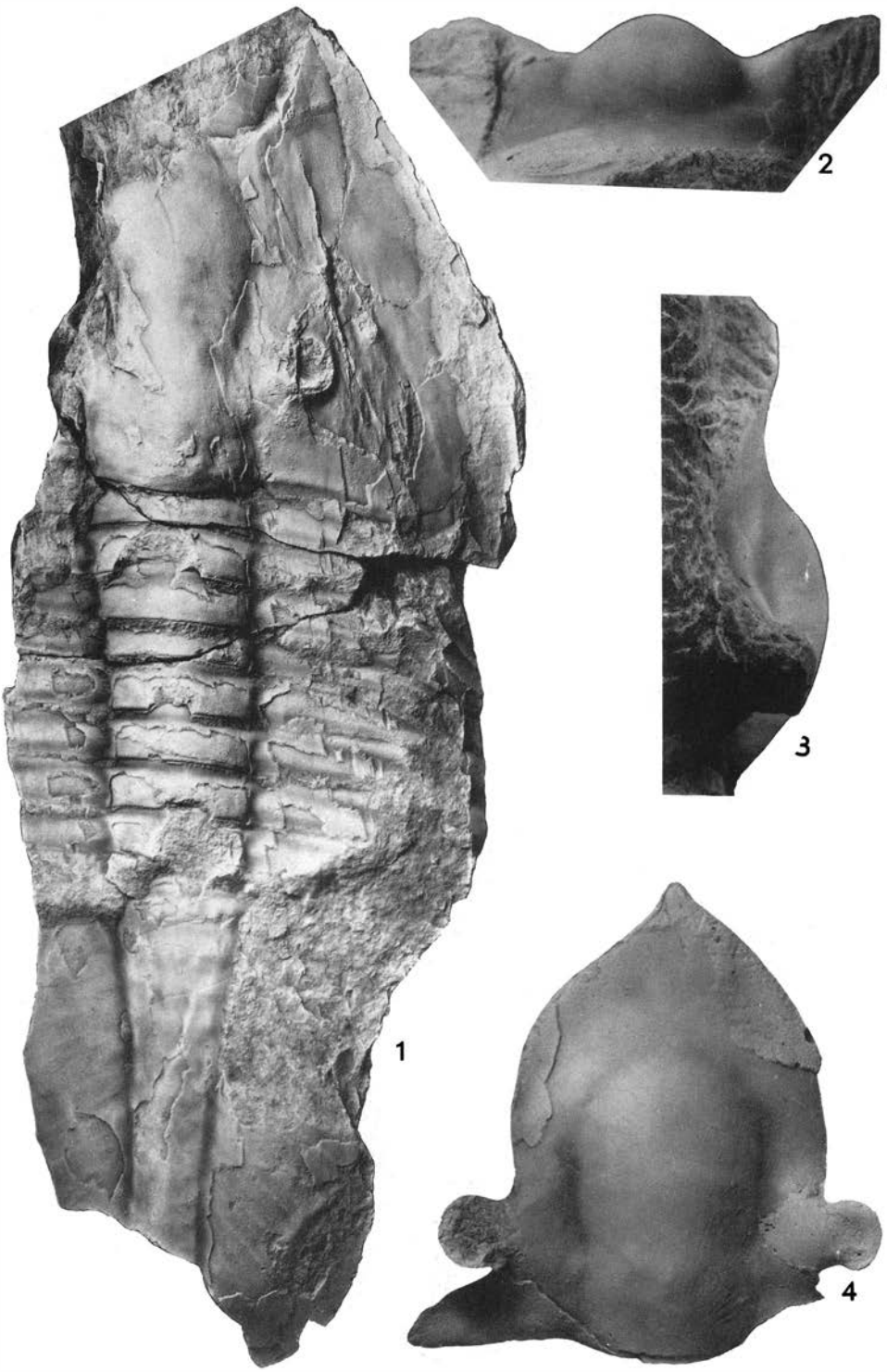
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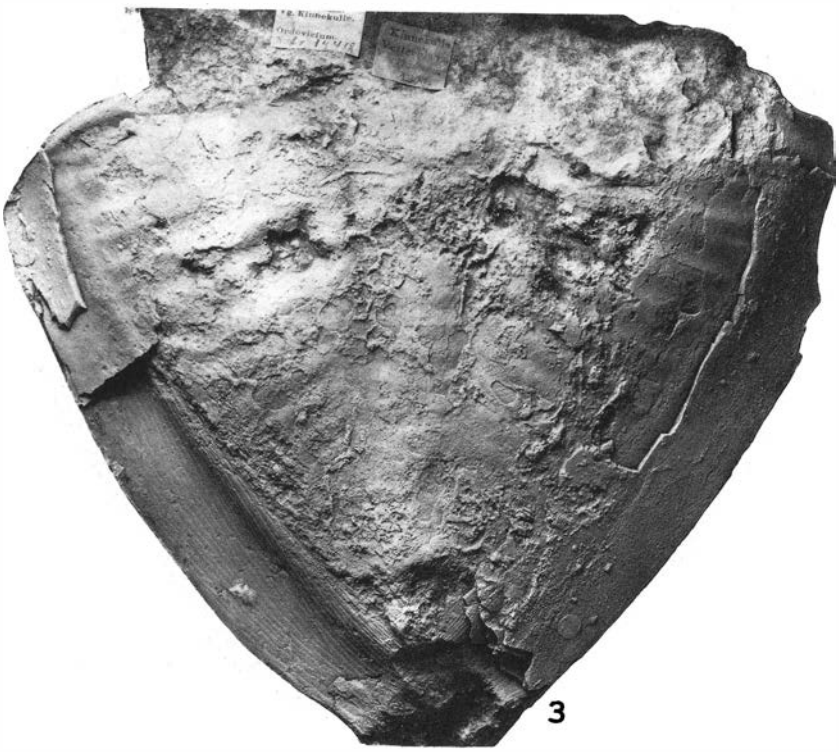

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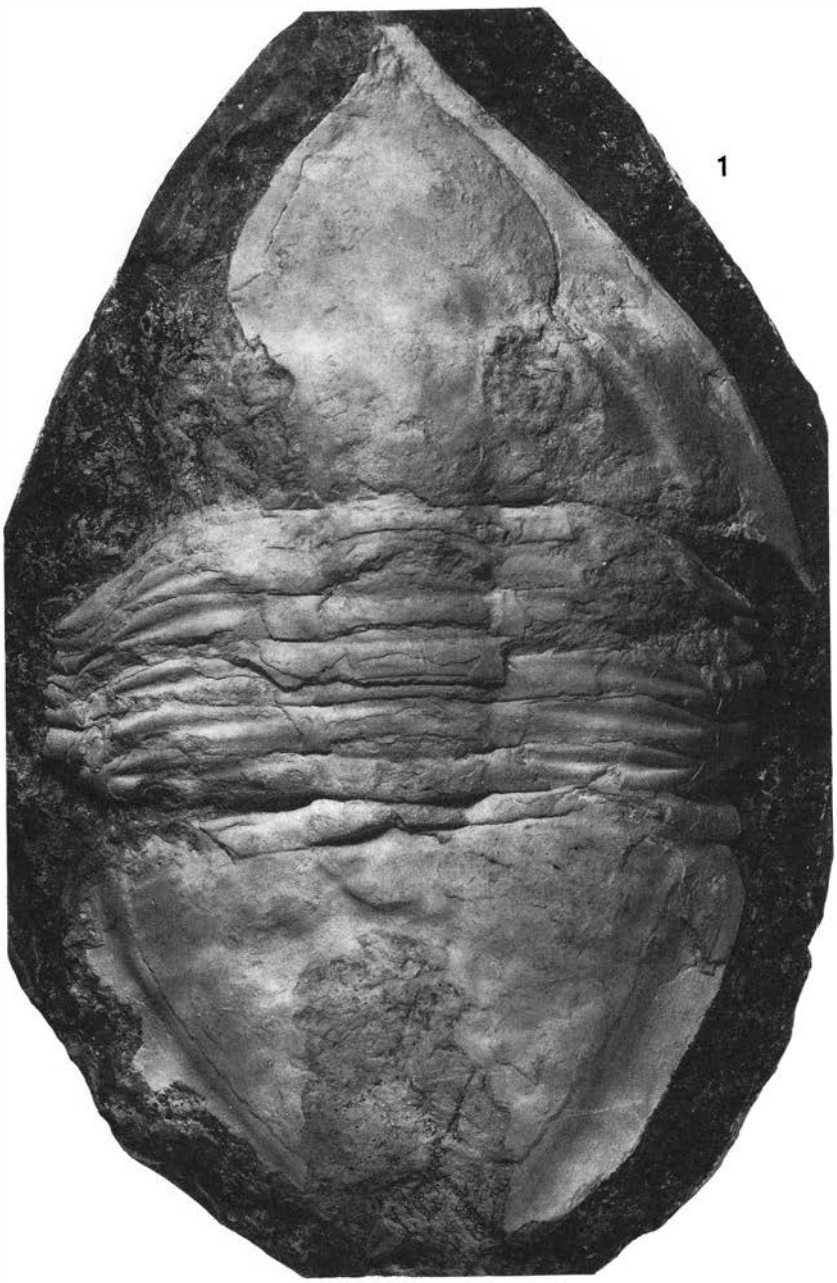
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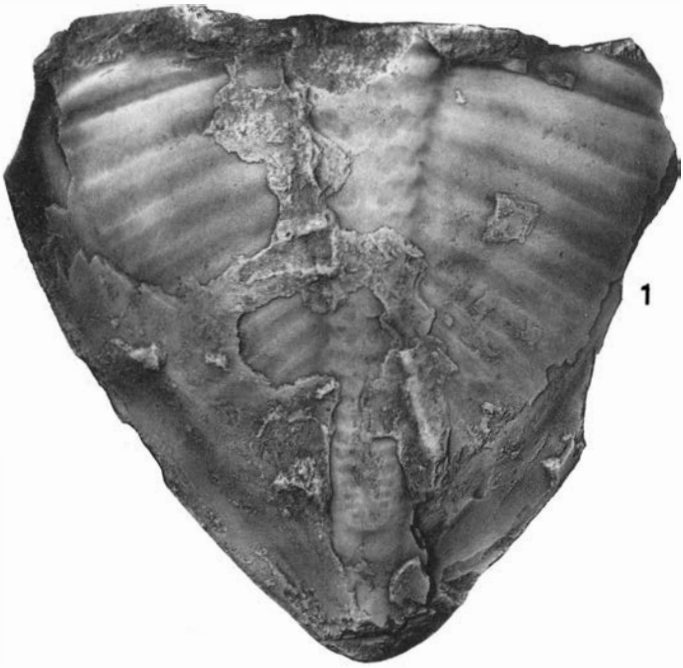

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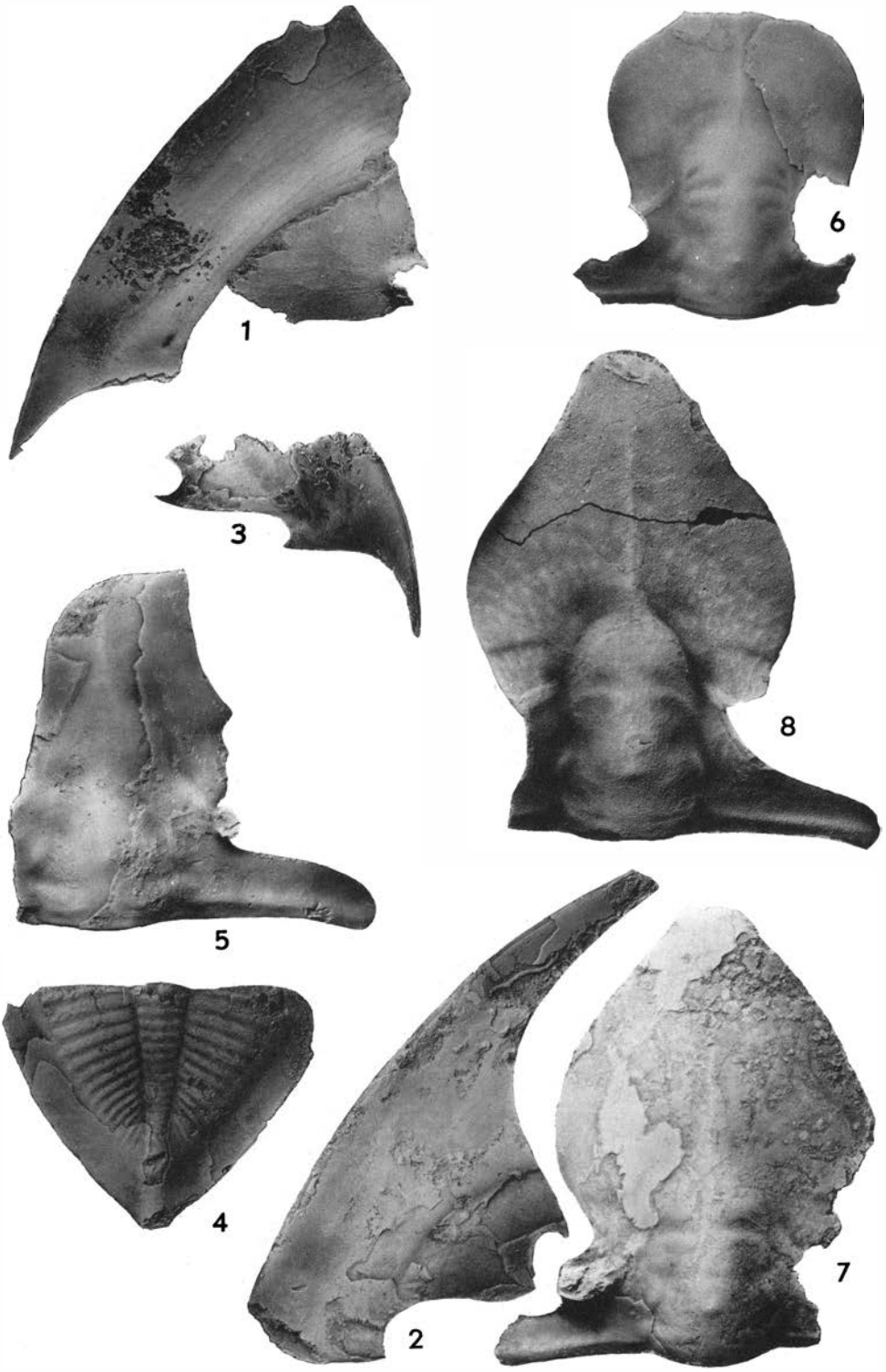
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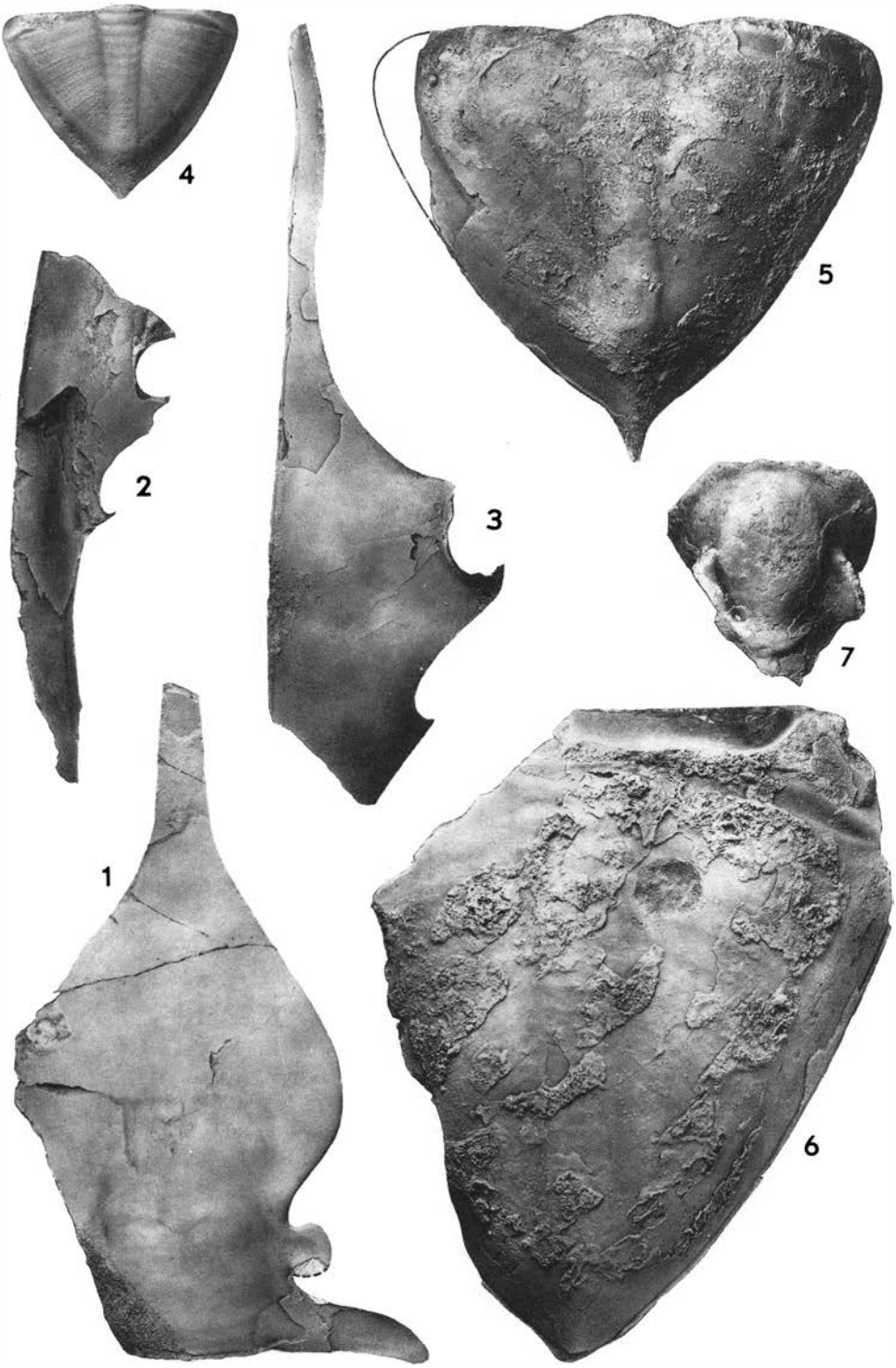
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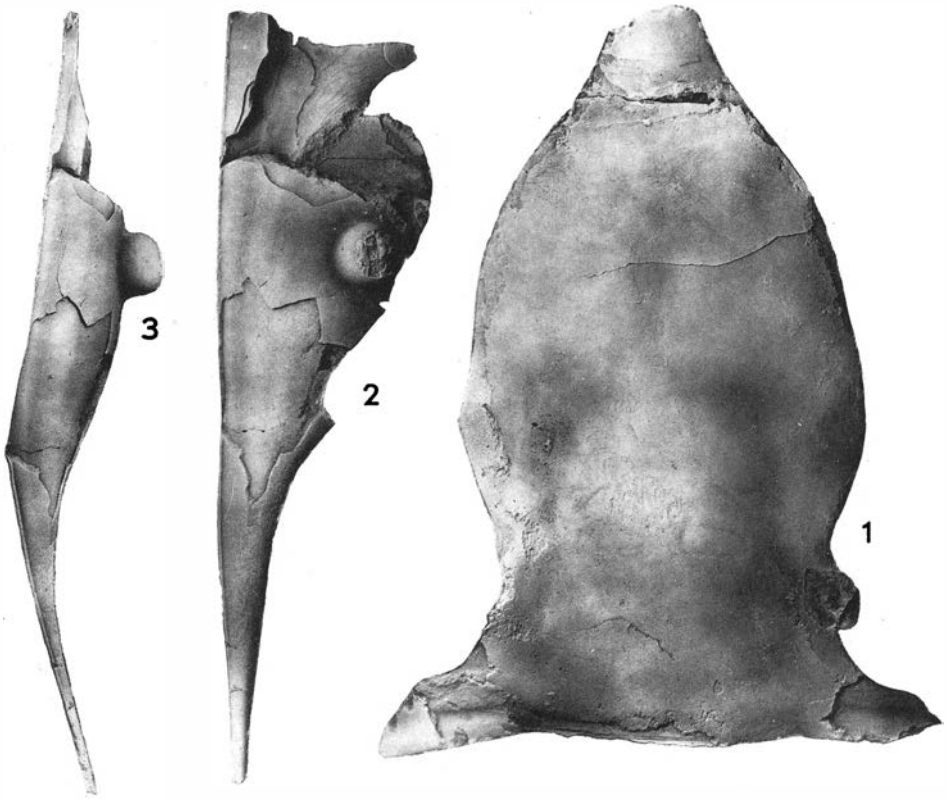
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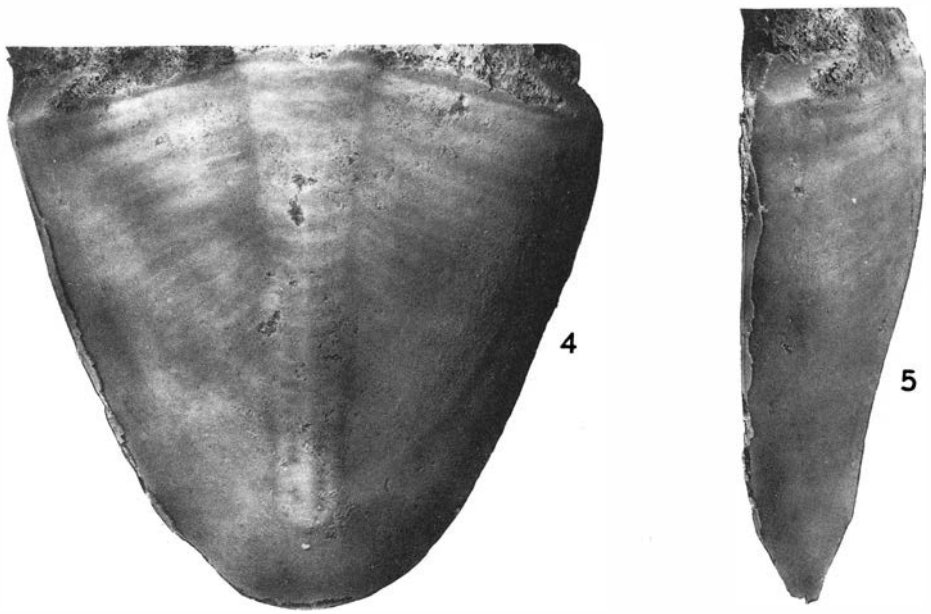
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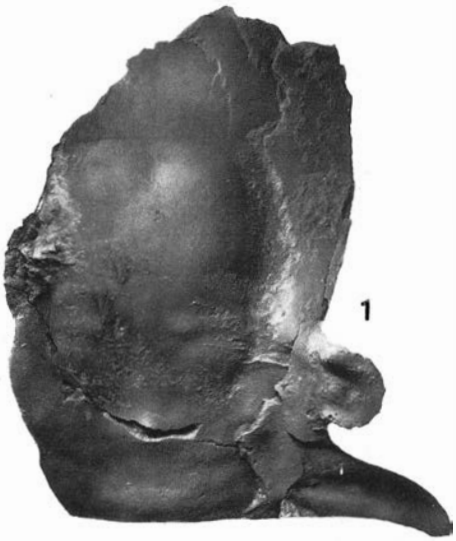
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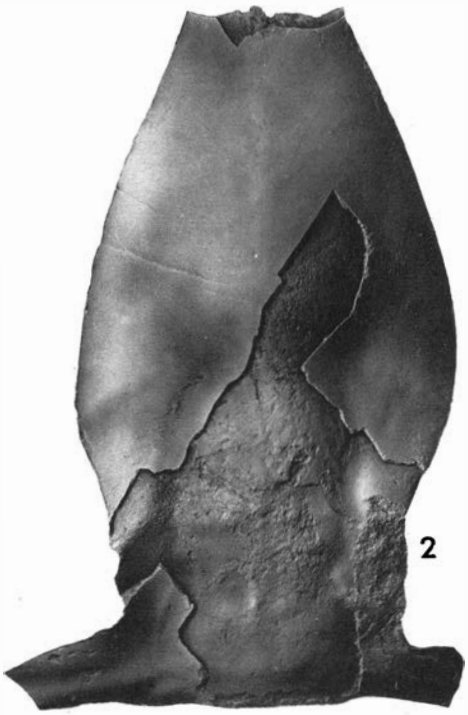
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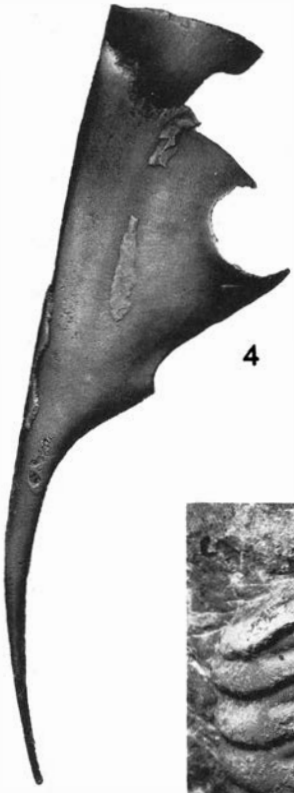
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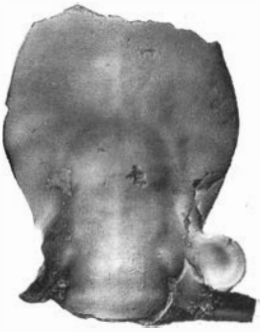
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