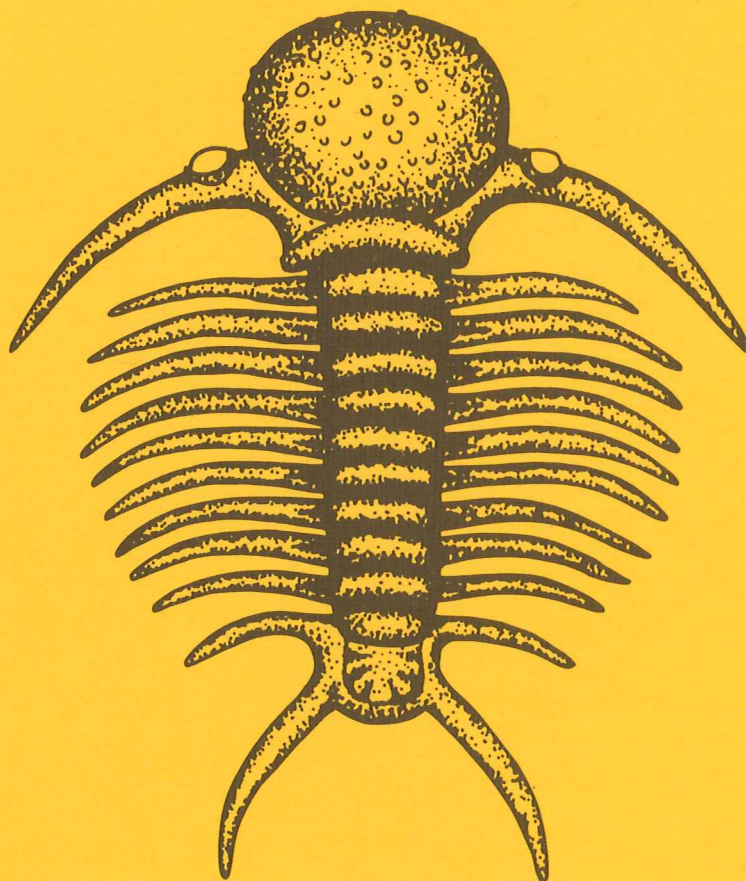


EXAMENSARBETEN I GEOLOGI VID LUNDS UNIVERSITET

Historisk geologi och paleontologi



TRILOBITES AND STRATIGRAPHY OF THE MIDDLE ORDOVICIAN KILLERÖD FORMATION, SCANIA, SWEDEN

KRISTINA MÅNSSON

LUND 1993

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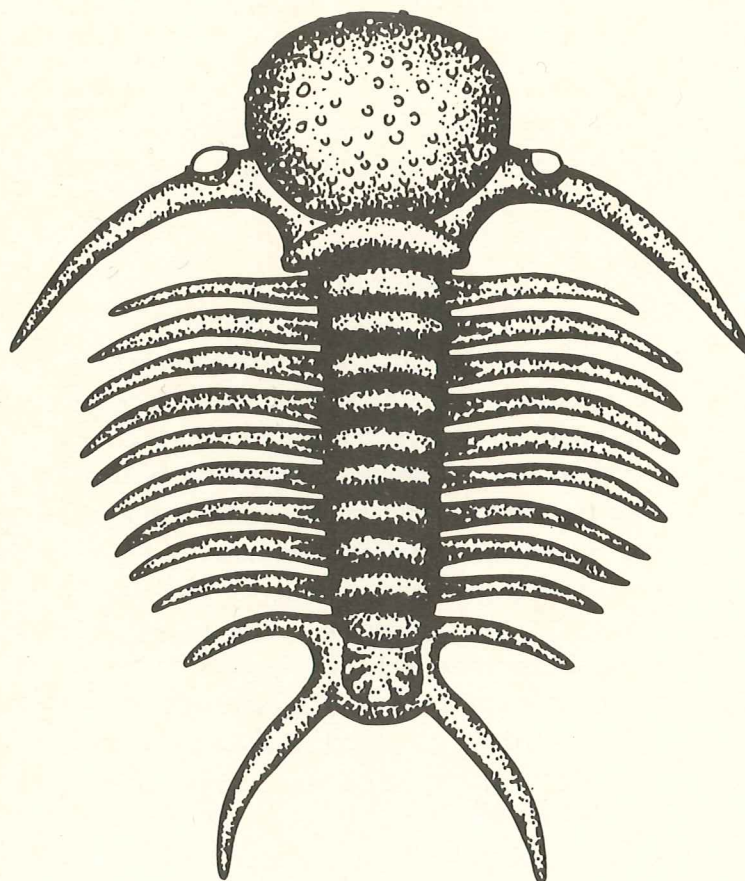
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KRISTINA MÅNSSON

Månsson, K., 1993 11 18: Trilobites and stratigraphy of the Middle Ordovician Killeröd Formation, Scania, Sweden. *Examensarbeten i geologi vid Lunds Universitet*. 20 poäng. Nr 50, pp. 1 - 22.

The Killeröd Formation ("Bronnii beds or Coscinorrhinus limestone") is a thin, but distinctive formation in the Middle Ordovician, upper Uhakuan Stage, of southeastern Scania, the southernmost province of Sweden. It is about 70 cm thick and consists of alternating grey microcrystalline limestone and blue-grey shaly mudstone. The Killeröd Fm is richly fossiliferous and has yielded a fairly extensive fauna that mainly consists of trilobites, but also includes brachiopods, conodonts and ostracodes.

The trilobite fauna is dominated by trinucleid trilobites. These include *Botrioides bronnii* (Boeck, 1838), *B. efflorescens* (Hadding, 1913) and *B. impostor* Owen, 1987. Other trilobites are *Arthrorhachis* sp., *Bronteopsis holtedahli* Skjeseth, 1955, *Lonchodomas rostratus* (Sars, 1835), *Nileus platys* Schrank, 1972, *Platycalymene dilatata* (Tullberg, 1882), *Platycalymene*? sp., *Pseudomegalaspis patagiata* (Törnquist, 1884), *Remopleurides* sp., and *Telephina* aff. *granulata* (Angelin, 1854). The trilobite fauna of the Killeröd Formation bears a close resemblance to those found in the lower Andersö Shale in Jämtland, central Sweden, and the upper Elnes Formation in the Oslo Region of Norway. It is concluded that the trilobite fauna of the Killeröd Formation is indicative of the *Hustedograptus teretiusculus* Zone. This is in accordance with the conodont-based correlations provided by Bergström (1973). □ *Trilobita, Middle Ordovician, Uhakuan Stage, stratigraphy, correlations, taxonomy, Killeröd Formation, Killeröd, Scania, Sweden.*

Kristina Månsson, Department of Geology, Historical Geology and Palaeontology, Sölvegatan 13, S-223 62 LUND, Sweden.

The Ordovician of Scania belongs to a south-western Baltoscandian confacies belt, characterized by graptolite shales. The Ordovician sequence is normally some 150 - 200 m thick (Bergström 1982). Exposures of Ordovician rocks are generally both rare and small in Scania. The widest distribution of Ordovician in the bedrock surface occurs in the south-eastern part of the province. In this area the graptolite shale is generally thinner than in western Scania, and some parts of the sequence are more or less missing. The Ordovician of southeast Scania contains a number of limestone or mudstone sequences (Fig. 1). Some of these units are more or less local, with a limited extension to the west. The various limestone and mudstone units are the Ceratopyge Limestone, the Komstad Limestone, the Killeröd Formation, the Skagen Limestone and the Jerrestad and Tommarp Mudstones (Fig. 1). The Ceratopyge Limestone is a grey microcrystalline limestone, about 0.25 - 1.0 m thick and rich in pyrite (Regnéll 1960). The Komstad Limestone, which may be considered as a tongue of the northern and north-eastern orthoceratite limestone, is thinning in a westerly direction from about 10-15 m in south-eastern Scania to 4-6 m at Fågelsång (Bergström 1982; Nielsen 1989). The Killeröd Formation is a thin sequence, about 0.7 m thick, in south-eastern Scania, consisting of alternating limestone and mudstone beds. The Skagen Limestone is a thin unit bounded by shales. This limestone has previously been termed Ampyx Limestone, but is actually a tongue of the Skagen Limestone developed to the north (Bergström 1982). The Jerrestad and Tommarp Mudstones form a lithological unit representing the top of Ordovician. The thickness is estimated at 45 m in the Fågelsång area and from there decreases to 9 m or less in north-west Scania, where the Jerrestad Mudstone appears to be missing. This may lead to the conclusion that the Ordovician graptolite shale was brought in from the Caledonian

geosynclinal zone mainly from a westerly direction, so that they first reached W and NW Scania (Regnéll 1960). On the other hand, the Baltic transgression (Regnéll 1960), characterized by deposition of carbonate sediments and a shellbearing fauna, did not penetrate far enough in a westerly direction to be registered all over Scania.

The Killeröd Formation is of Middle Ordovician age, and has only been found in SE Scania. The formation consists of alternated limestones and shaly mudstones and has yielded a rather extensive fauna. This paper documents

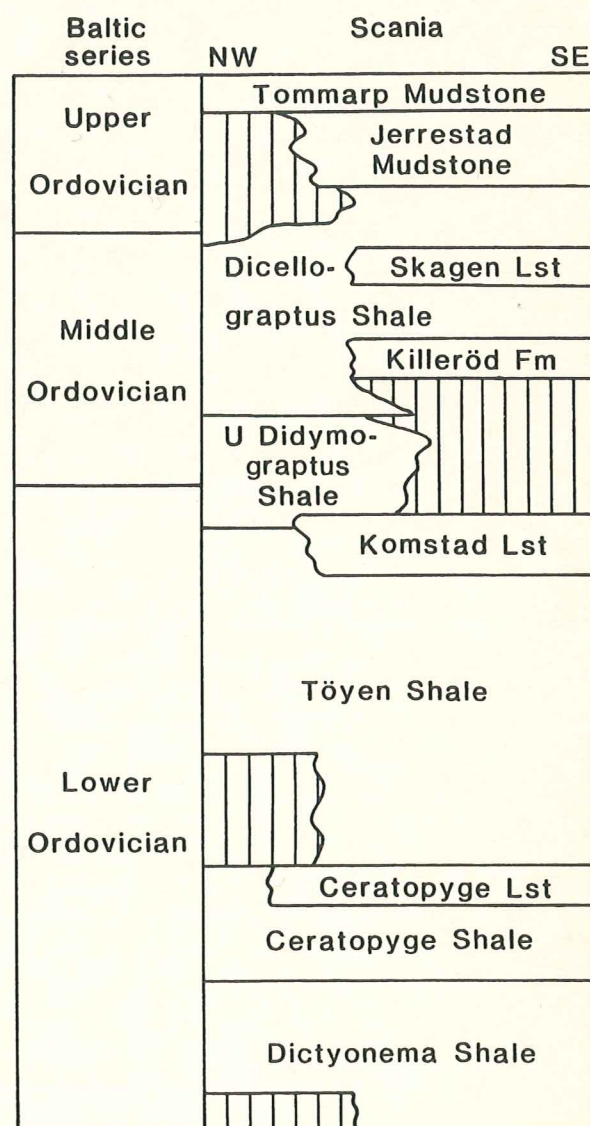


Fig. 1. The Ordovician of Scania. After Bergström (1982).

the trilobite fauna of the Killeröd Fm, and on the basis of the fauna conclusions about stratigraphy and correlations with sequences outside Scania are drawn. A great deal of the material on which the investigation is based, was gathered by Dr Ragnar Nilsson, Lund, during the 1940s. To this and other material housed at the Geological Institute of Lund, I have added more material through fieldworks in the autumn of 1992.

Historical review

The Killeröd Fm has not previously been discerned as a formation of its own, but was considered as a unit belonging to the Lower Dicellograptus Shale. However, the Killeröd Fm differs widely from the Dicellograptus Shale both with regard to the lithology and the fossil content. Therefore it has to be separated from the Dicellograptus Shale, and should be considered as a formation of its own. Bergström (1982) was the first to use the term Killeröd Formation. Earlier names were Bronnii beds or Coscinorrhinus Limestone, because the trilobite species *Botrioides bronnii*, formerly called *Trinucleus coscinorrhinus*, frequently occurs throughout the formation.

Many geologists have tried to determine the age of the Killeröd Fm, but they have not come to the same conclusion. They all had their own opinion, how to correlate and where to place the formation in the stratigraphic system. One could almost say that there have been as many opinions about the stratigraphic position of the Killeröd Fm as there have been geologists working with the unit. In 1749 Carl von Linné visited the limestone quarries at Tommarp (Linnaeus 1751), and he was probably the first to correlate the sequences with units outside Scania. Linné suggested that the geological units at Tommarp were equivalent to those in Västergötland. Tullberg (1882, 1883) summarized the stratigraphy of Scania and placed the Killeröd Fm just above the *Dicranograptus clingani* Zone (Fig. 7). Through the investigations of Moberg (1892) it was clear that the limestones characterised by *Trinucleus coscinorrhinus* (= *Botrioides bronnii*; Killeröd Fm) occurred bet-

ween the orthoceratite limestone (Komstad Limestone; equivalent to the upper *Didymograptus hirundo* and the lower *Didymograptus "bifidus"* Zone) and the clingani shale. Olin (1906) precised the stratigraphic position to the lowermost part of the Chasmops Series i.e. belonging to the graptolite zone of *Diplograptus multidentatus* (Fig. 7). In 1907 Moberg published a paper on the Dicellograptus Shale of Scania, and paralleled beds with *Trinucleus coscinorrhinus* with the graptolite zone of *Didymograptus muchisoni* (Fig. 7). Three years later (1910) Moberg revised his earlier opinion in a new survey and placed the Killeröd Fm further down in the system, just on top of the Komstad Limestone. The Killeröd Fm continued its stratigraphic journey when Funkquist (1919) was of the opinion that it should be placed between the *N. gracilis* and *Climacograptus putillus* (equivalent to the conodont zone of *Pygodus serra*) Zones. Nilsson (1952), however, thought that the formation ought to be placed higher up in the stratigraphic system. In his paper on the Ordovician in Scania, Regnéll (1960) considered that the Killeröd Fm belongs to the *N. gracilis* Zone. In 1973 the Killeröd Fm got its present stratigraphic position by Bergström. He placed it in the upper part of the graptolite zone *Glyptograptus teretiusculus* (= *Hustedograptus teretiusculus*; see Fig. 7 herein), equivalent to the conodont zone of *Pygodus anserinus* (Bergström 1973).

Distribution

The Killeröd Formation has, as mentioned above, only been found in the south-eastern part of Scania. At the end of the 19th century and in the beginning of the 20th century, there were several localities where the Killeröd Fm could be found (Funkquist 1919). These localities were Bollerup, Gislövshammar, Järrestad, Killeröd, Tommarp, Tosterup and Virrestad (Fig. 2). Killeröd is the locality after which the formation was named. Today the Killeröd Formation is only to be found at three localities, at Killeröd, Järrestad and Gislövshammar (Fig. 2). The former locality is the most complete and accessible one. This is also the locality where I have

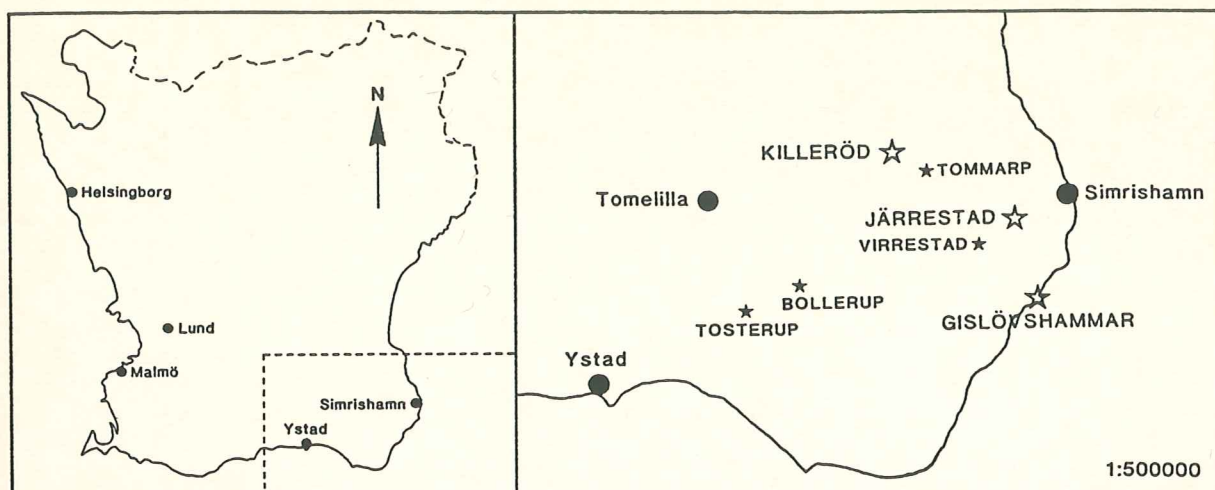


Fig. 2. Map of Scania showing the localities where the Killeröd Formation has been found. The localities where the Killeröd Fm is accessible is marked with empty stars. The filled stars represent old sites where the Killeröd Fm is no longer accessible.

carried out my fieldwork. The sequence is here about 70 cm thick. Nielsen (1989) described the Killeröd Fm from a locality at Järrestad, situated in a brook close to the old shut down shoe factory (locality J11 of Moberg 1910, p. 93). The thickness is here about 50 cm, but not very accessible since the outcrop is covered by water. At Gislövshammar there is a nearly 20 cm thin sequence of the Killeröd Fm (A.-T. Nielsen, Copenhagen, personal communication March 1993). The outcrop is here located by the shore. Almost all material I have examined is from the section at Killeröd, but some specimens, however, are from Bollerup, Tommarp and Tosterup.

The Killeröd section

The Killeröd section is located just by the entrance of an old limestone quarry at Killeröd, about 500 m south-east of Flagabro (Fig. 3). The quarry is commonly named "the old limestone quarry of Killeröd", and has earlier been quarried for orthoceratite limestone (Komstad Limestone). At the entrance, which is located to the east, the limestone is bounded by a 27 m wide Permo-Carboniferous dolerite dyke (Nilsson 1952). The dolerite dyke is in the eastern direction in contact with a small, partly earthcovered condensed shaly and limy sequence with a dip of 10 degrees to the south. This sequence comprises the Killeröd Fm and it can be followed for 6 m, then it is covered by till. Nilsson (1952) has studied and described the

Killeröd section thoroughly. In his essay he listed and named the different layers of the formation, which I have used in this paper. The section is as follows (cf. Fig. 4):

At the base 1.20 m of Upper *Didymograptus* Shale (layer *a*, *b* and *c*) is overlain by 0.12 m of similar Lower *Dicellograptus* Shale (layer *d*). The top of the sequence is formed by 0.73 m of alternating limestones and shaly mudstones (layers *e* - *p*). These beds are recognized as the

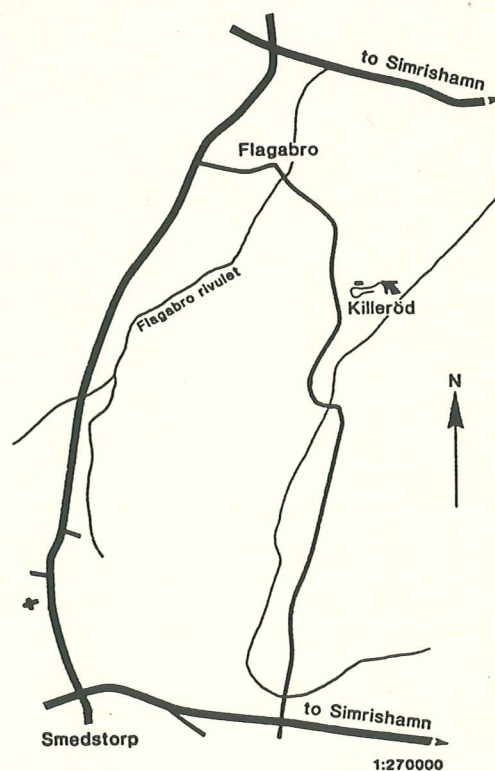


Fig. 3. Map of the Flagabro - Killeröd area. The arrow indicates the location of the Killeröd section. Based on Regnéll (1960, fig 4).

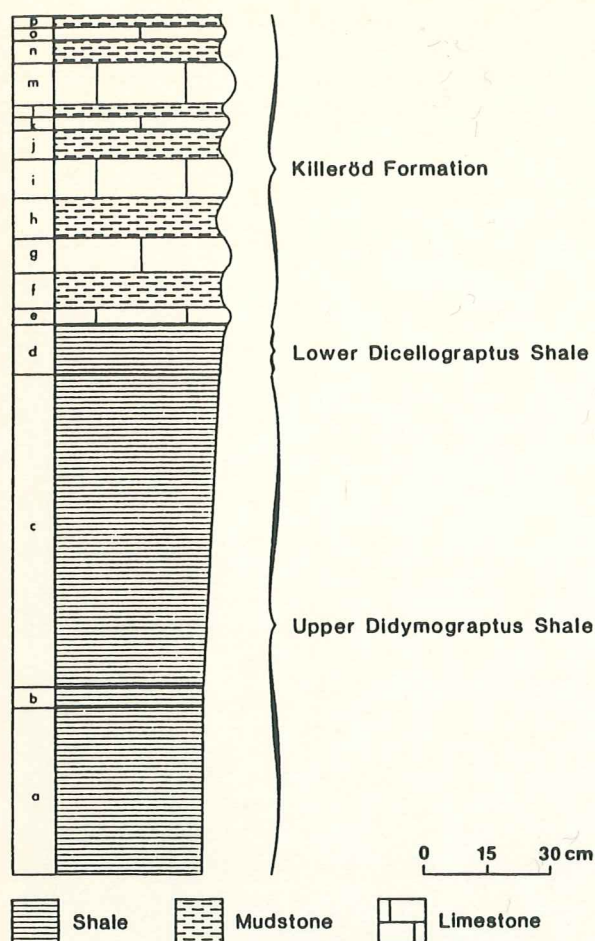


Fig. 4. The Killeröd section, showing general lithologic succession. a - p indicate divisions of Nilsson (1952).

Killeröd Formation (Bergström 1982; Fig. 5 herein). On top of them there is about 0.3 m of till. The Killeröd Fm is richly fossiliferous and has yielded a fairly extensive fauna consisting of trilobites, brachiopods, conodonts and ostracodes, of which the trilobites are the most abundant fossils. Previously the conodont fauna and the trilobite species *Botrioides bronni* and *B. efflorescens* have been described from the Killeröd section (Bergström 1973; Owen 1987). Part of the trilobite fauna has also been described by Nilsson (1952) and Funkquist (1919). The layers e - p are 3 - 10 cm thick, and consist of two varying lithologies, which were alternately deposited (Fig. 4). The layers g, i, k, m and o consist of a dense, light grey microcrystalline limestone, which sometimes can be very pyritic. The layers f, h, j, l, n and p consist of blue grey, pyritic and phosphoritic shaly mudstones. Both the mudstones and the limestones can sometimes be coated by a very thin calcitic

crust. Trilobites are found more or less frequently throughout the whole section, except in layer e. The trilobites are rather poorly preserved and generally disarticulated. This makes the identification somewhat difficult. The trilobite fauna of the mudstones is more diverse than that of the limestones. It is important to point out that the fossils which occur in the limestones are similar to those in the mudstones, but they are more abundant and diverse in the latter. The trilobite fauna from the different layers is otherwise quite similar and they are apparently of closely similar age (Bergström 1973). Layer e differs somewhat from the other layers concerning the lithology, and a lot concerning the fossil contents. This layer consists of an almost black, microcrystalline limestone. It is in the upper and lower part rich in deformed ostracodes, some of which belong to the genus *Conchoprimitia* (Nilsson 1952), whereas the middle part seems to be unfossiliferous. Ostracodes are the only fossils found in layer e. The mudstone layer f also contains a lot of badly preserved ostracodes in the lowermost part. Otherwise this layer is similar to the other mudstone layers, and the fauna resembles those in the higher part of the formation. Ostracodes occur in the rest of the formation but they are not in any way as common as in layer e and f.

It might be questioned if layer e really belongs to the Killeröd Fm, as it differs from the other limestone layers, which are all very similar. The ostracodes, which are found in layer e do not necessarily indicate a relationship to the Killeröd Fm, as they occur in the underlying Dicellograptus Shale as well. However the change from graptolite shale into limestone shows that this layer certainly does not belong to the underlying Dicellograptus Shale, and it may be considered as the basal bed of the Killeröd Fm.

The rhythmic changes in the sequence between richly fossiliferous mudstones and almost unfossiliferous limestones, most likely depend on continuing oscillational sea level changes, which are connected to the epeirogenic movements that occurred during the Ordovician, not only in Scandinavia but in other parts of the world as well (Nilsson 1952).

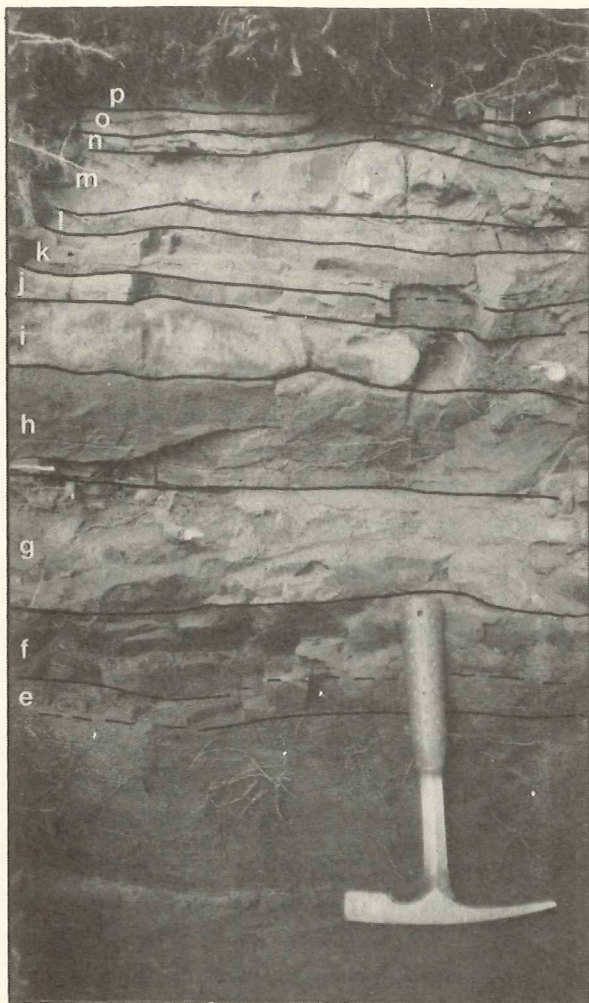


Fig. 5. Photograph showing the Killeröd Formation at Kille-röd with the different layers indicated (cf. Fig. 4).

Systematic palaeontology

Terminology. - On the whole I follow the terminology suggested in volume O of the Treatise on Invertebrate Paleontology (Moore 1959). The term rhachis is preferred to axis, and the terminology used concerning the genus *Botrioides* is that advocated by Hughes *et al.* (1975).

Repository. - All illustrated specimens are deposited in the collections of the Department of Geology, University of Lund, Sweden.

Family Trinucleidae Hawle and Corda, 1847

Genus *Botrioides* Stetson, 1927

Type species. - *Trinucleus coscinorinus* Angelin, 1854, p. 65, pl. 34, fig. 4, from the Killeröd

Formation of Scania, Sweden (= *B. bronni* (Boeck 1838)).

Botrioides bronni (Boeck, 1838)

Plate I: 1 - 7.

Synonymy. - □1838 *Trilobites Bronnii* - Boeck, p. 144. □1854 *Trinucleus coscinorinus* - Angelin, p. 65, pl. 34, fig. 4. □1854 *Trinucleus bucculentus* - Angelin, p. 84, pl. 41, fig. 1. □1919 *Trinucleus coscinorrhinus* - Funkquist, pp. 34 - 35, pl. 1, figs. 7 - 9, 11 - 22. □1927 *Botrioides bucculentus* - Stetson, pl. 1, fig. 11. □1930 *Trinucleus bucculentus* - Störmer, pp. 21 - 24, pl. 2, figs. 8 - 15. □1930 *Trinucleus bronni* - Störmer, fig. 6. □1940 *Trinucleus bronni* - Störmer, p. 147, pl. 1, fig. 18. □1940 *Trinucleus bronni* - Grorud, p. 160. □1958 *Trinucleus bronni* - Hadding, pp. 217 - 218. □1975 *Botrioides? bronni* - Hughes *et al.*, p. 561. □1975 *Botrioides bucculentus* - Hughes *et al.*, p. 562. □1987 *Botrioides bronni* - Owen, pp. 81 - 85, pl. 11, figs. 1 - 17 (see for a more complete synonymy).

Type data. - The lectotype is an internal mould of a slightly crushed cephalon (PMO 61752) from the Oslo area. From what unit is not known.

Material. - Ten cephalata and internal moulds of cephalata from layers *h*, *j* and *n*, five cephalata from layers *f*, *h*, *j*, *l* and *n*, and nine pygidia from layers *h*, *l*, and *n* from Killeröd, and one almost complete internal mould of a *B. bronni* from Tommarp. Smaller fragments of *B. bronni* are frequently present in all the mudstone layers.

Description. - The pseudofrontal lobe is sub-spherical and is overhanging the fringe anteriorly. A median tubercle is located a short distance behind the mid-point of the pseudofrontal lobe. The genal lobe is quadrant in shape and bears a very subdued eye tubercle. The fringe is narrow, and contains E1, E2 and In arcs over the whole fringe. In some specimens an I1 arc is developed anterolaterally (Owen 1987). The external surface of the glabella and genal lobes

bears a fine reticulation. Larger specimens also show concentric ridges superimposed on the reticulation of the pseudofrontal lobe. Internal moulds are completely smooth. The pygidium is smooth with four segments on the rhachis, and up to four pleural ribs are present.

Remarks. - Typical of *B. bronni* is the anterior overhang of the glabella. This feature does not show on Angelin's illustration of *T. coscinorhinus* (Angelin 1854, pl.34, fig.4), but his illustration may have been based on a crushed specimen in which this feature was not preserved. Such material is fairly common among samples from the Killeröd Formation.

Botrioides efflorescens (Hadding, 1913)
Pl. II: 1 - 4.

Synonymy. - □1913 *Trinucleus coscinorhinus* Hadding, pp. 74 - 75, pl. 7, figs. 18, 20. □1913 *Trinucleus efflorescens* - Hadding, p. 75, pl. 7, figs. 21a - c. □1927 *Trinucleus efflorescens* - Stetson, pl. 1, fig. 4. □1927 *Botrioides coscinorhinus* - Stetson, pl. 1, fig. 12. □1930 *Trinucleus foveolatus* - Störmer, p. 18, text-fig. 2d. □1982 *Botryoides efflorescens* - Karis, p. 58. □1982 *Botryoides coscinorhinus* - Bergström, p. 190. □1987 *Botrioides efflorescens* - Owen, p. 91, pl. 13, figs. 5 - 13.

Type data. - The holotype is an external mould of a cranidium (LO 2543T) from the Andersö Shale in Jämtland, Sweden.

Material. - Three internal moulds of cephalon from layer *h* and *j*, and two pygidia from *h* and *k* at Killeröd. Other fragments like cheeks or fringe parts are found in layer *h*, *j*, *k* and *n* at Killeröd.

Description. - The cephalon is broad and rather wide. The glabella is pear-shaped with moderately swollen pseudofrontal lobe, which overhangs the fringe very slightly. The fringe has a complete set of E1, In, I1 and I2 arcs all round, while E2 and I3 only are present anteriorly. The surface is smooth on the anterior and lateral

part, but is reticulated on the top. 3 pairs of glabellar furrows are visible. The pygidium is broad and triangularly rounded, with a narrow rhachis. The rhachis has 7 - 9 segments (Owen 1987).

Botrioides impostor Owen, 1987
Not figured.

Synonymy. - □1857 *Trinucleus Bronnii* - Kjerulf, p. 94. □1887 *Trinucleus bucculentus* - Brögger, p. 17. □1930 *Trinucleus bronni* - Störmer, pp. 19 - 21, figs. 1 - 5 and 7. □1934 *Trinucleus bronni* - Störmer, p. 331. □1953 *Trinucleus bronni* - Störmer, pp. 61 and 83. □1975 *Botrioides? bronni* - Hughes *et al.*, p. 561, pl. 4, fig. 44. □1987 *Botrioides impostor* sp. nov. - Owen, pp. 85 - 86, pl. 11, figs. 18 - 20.

Type data. - The holotype is the external mould of a cranidium and first thoracic segment (PMO HO 566) from the upper Elnes Fm between Håkavik and Bjerkåsholmen, Asker, Norway.

Material. - Two cephalon and one rather well preserved external mould of a cranidium, all three from layer *l* at Killeröd.

Description. - The pseudofrontal lobe is oval and very slightly overhanging the narrow fringe, which comprises E1 and In arcs and in some specimens also I1 arcs. External surface is only slightly reticulated.

Remarks. - *B. impostor* differs from *B. bronni* primarily in its much less swollen pseudofrontal lobe, which lacks concentric ridges even in the larger specimens, and perhaps more important and characteristic is the absence of the E2 arc.

B. impostor has not earlier been described from the Killeröd Formation.

Family Telephinidae Marek, 1952
Genus *Telephina* Marek, 1952

Type species. - *Telephus fractus* Barrande, 1852, from the Upper Ordovician of Bohemia.

Telephina aff. *granulata* (Angelin, 1854)
Pl. III: 1 - 5.

Synonymy. - □1919 *Telephus granulatus* - Funkquist, p. 39, pl. 2, fig. 9. □1952 *Telephus granulatus* - Nilsson, pp. 684, 688.

Material. - Two rather well preserved cranidia, from a loose boulder at the Killeröd section, and one poorly preserved cranidia from a loose boulder at Rödmölla in the Tosterup area.

Description. - The cranidium is wider than it is long. The glabella is subparabolic in outline, tapering moderately forwards and well rounded. The glabella is granulated and provided with two wart-like tubers, which according to Nikolaisen (1963) are bases of broken, long spines. The occipital ring is as wide as the posterior end of the glabella. The occipital ring is also granulated. There is no granulation or any other kind of ornamentation on the narrow fixigenae and these are completely smooth. The outer somewhat downbent part of the cheeks are surrounded by a narrow palpebral lobe of uniform breadth. The anterior border is prolonged into a pair of small spines in front of the glabella.

Remarks. - The cranidium is very much like that of *Telephina granulata* but differs in having a slightly longer glabella, which is truncated in the front. In addition the spines on the glabella are in a slightly posterior position and closer together than in typical specimens of *Telephina granulata*.

Family Metagnostidae Jaekel, 1909
Genus *Arthrorhachis* Hawle & Corda, 1847

Type species. - *Battus tardus* Barrande, 1846, from the Králuv Dvur Formation of Libomysl near Zdice, Bohemia.

Arthrorhachis sp.
Pl. II: 5 and 7.

Material. - One poorly preserved internal mould

of a cephalon from a loose boulder and one just as poorly preserved internal mould of a pygidium from layer j, both from Killeröd. A small part of a rhachis has also been found.

Description. - The cephalon and the pygidium are moderately convex, and each part is equal in length and width. The glabella is occupying about 57 % of the total cephalic length. The rhachis is occupying 61 % of the pygidium. The external exoskeletal surface bears no visible marks of any kind of ornamentation.

Remarks. - The preservation is bad. This makes it impossible to determine what species they belong to. However, the short rhachis suggests that the species belongs to the genus *Arthrorhachis*, and I consider they are best identified under open nomenclature as *Arthrorhachis* sp.

Family Asaphidae Burmeister, 1843
Genus *Pseudomegalaspis* Jaanusson, 1953

Type species: *Megalaspis formosa* Törnquist, 1884, from the Folkeslunda Limestone in the Siljan district, Dalarna, Sweden.

Pseudomegalaspis patagiata (Törnquist, 1884)
Pl. IV: 5 and 6.

Synonymy. - □1884 *Megalaspis patagiata* n. sp. - Törnquist, p. 82, pl. 3, figs. 15 - 17. □1887 *Megalaspis* n. sp. - Brögger, p. 16. □1909 *Megalaspis patagiata* - Hortedahl, pp. 7, 28. □1913 *Megalaspis patagiata* - Hadding, pp. 69 - 70, pl. 6, figs. 20 - 21. □1953 *Pseudomegalaspis patagiata* - Störmer, pp. 58, 83, 90, 97, 103, 109. □1953 "*Megalaspis*" sp. - Störmer, p. 109. □1953 *Pseudomegalaspis patagiata* - Jaanusson, p. 456, pl. 9, figs. 4 - 7, pl. 10, fig. 1. □1953 *Pseudomegalaspis formosa* - Jaanusson, p. 452. □1960 *Pseudomegalaspis patagiata* - Henningsmoen, p. 248 - 250, pl. 12, figs. 1 - 7.

Type data. - The holotype (by monotypy) is an

enrolled dorsal shield from the Lasnamägian Stage at Kårgärde in the Siljan district, Dalarna, Sweden.

Material.- Five internal moulds of pygidia, all rather poorly preserved, from layers *g*, *h*, *j* and *l*, at Killeröd.

Description.- The pygidium is spherical triangular or almost semicircular in outline. The rhachis is broadest at the anterior, tapering rather fast to the middle part, and then more slowly to the margin. The rhachis is about 4/5 of the length of the pygidium. The rhachial furrows are poorly marked, but can be counted to at least 10. The border has weakly marked terrace lines. The size of the pygidium can vary a lot, but the relation between length and width will always remain 3:5 (Henningsmoen 1960). The pygidium of *P. patagiata* has terrace lines concentrated in a zone along the paradoublur line.

Family Remopleurididae

Hawle & Corda, 1847

Genus *Remopleurides* Portlock, 1843

Type species.- *Remopleurides colbii* Portlock, 1843 from the Killey Bridge Formation (Ashgill) of Co. Tyrone, Northern Ireland.

Remopleurides sp.

Not figured.

Synonymy.- □1919 *Remopleurides subquadratus* Hdg. - Funkquist, pl. 2, fig. 5.

Material.- One cranidium from Tommarp.

Remarks.- Funkquist (1919) figured a nearly complete cranidium (LO 2962t) from the Killeröd Fm at Tommarp, and assigned it to *Remopleurides subquadratus* Hadding, 1913 (*Sculptaspis subquadratus*). The wide glabellar tongue suggests that it does not belong to this species, and, as noted by Nikolaisen (1983, p. 283), it appears to be closer to *R. latus* Olin, 1906. The specimen has now weathered into pieces and is destroyed.

Family Raphiophoridae Angelin, 1854

Genus *Lonchodomas* Angelin, 1854

Type species.- *Ampyx rostratus* Sars, 1835, from the Vollen Formation of Bygdøy in Oslo, Norway.

Lonchodomas rostratus (Sars, 1835)

Pl. V: 1 - 3.

Synonymy.- □1835 *Ampyx rostratus* - Sars, pl. 8, fig. 3. □1940 *Lonchodomas rostratus* - Störmer, p. 128 - 130, pl. 2, figs. 1 - 4. □1950 *Lonchodomas rostratus* - Whittington, p. 556 - 557, pl. 74, figs. 11 - 15.

Type data.- The lectotype (PM no. 56407), selected by Störmer in 1940, is from the Vollen Formation (Ampyx Limestone) of Huk, Bygdøy, Oslo Region, Norway.

Material.- Internal moulds of three cephalae with a glabellar spine from layers *h* and *j*. One pygidium and two internal moulds of pygidia, from layers *f* and *h* in Killeröd.

Description.- The cephalon is triangular in outline. The width is slightly greater than the sagittal length (excluding the spine). The glabella is also triangular in outline, and the anterior portion is drawn out into a long spine. The length of the spine probably exceeds the length of the rest of the glabella (Whittington 1950). Three pairs of muscle scars occur on the glabella. The basal pair is situated in the occipital furrow. The cheeks are triangular in outline, and slope anterolaterally downward from the shallow axial furrows. Eyes are absent. The pygidium is wider than it is long. The posterolateral margin is forming a smooth curve. The rhachis is gently convex and the dorsal furrows very shallow. Two pairs of suboval muscle scars occur on each segment, the outer scar is prominent, the inner one fainter. The pleural lobes are flattened, with a broad, steeply sloping border, which is narrowest at the posterior. Two pairs of narrow pleural furrows are seen, curving outwards and forwards.

Family Scutelluidae Richter & Richter, 1955

Genus *Bronteopsis* Nicholson & Etheridge, 1879

Type species.- *Ogygia ? concentrica* Linnarsson, 1869 (pp. 75 - 76, pl. II, fig. 37 - 40), from the Skagen Limestone (Beyrichia Limestone), Ålleberg, Västergötland, Sweden.

Bronteopsis holtedahli Skjeseth, 1955
Pl. III: 6.

Synonymy.- □1919 *Ogygiocaris concentrica* - Funkquist, p. 23, pl. 2, fig. 10. □1955 *Bronteopsis holtedahli* - Skjeseth, pp. 17 - 18, pl. 5, figs. 4 and 7. □1963 *Bronteopsis holtedahli* - Skjeseth, p. 63. □1984 *Bronteopsis holtedahli* - Wandås, p. 233, pl. 2, figs E - F.

Type data.- The holotype (PMO no. 67011) is an incomplete cranidium from the lowermost Elnes Formation (*Ogygiocaris* Shale; 4 a) at Furnes church at Mjøsa, Norway.

Material.- One external mould of a complete pygidium, from a loose boulder at Tommarp.

Description.- The pygidium is subsemicircular in outline and the length is a little more than half the width. The rhachis has seven segments. The length of the rhachis is a little more than half the pygidial length. The rhachis continues as a postaxial ridge, which tapers towards the posterior margin of the pygidium. The doublure is broad and reaches to the posterior end of the rhachis. The inner doublure margin is marked by a shallow furrow parallel to the outer pygidial margin. The pleurae turn backwards and swell outside this furrow. The facets are nearly vertical and continue as pre-pygidial ridges towards the rhachis.

Family Nileidae Angelin, 1854
Genus *Nileus* Dalman, 1827

Type species.- *Asaphus (Nileus) armadillo*

Dalman, 1827, from the lower Holen Limestone (upper Arenig) at Borensberg (Husbyfjöl) in Östergötland, Sweden.

Nileus platys Schrank, 1972

Pl. IV: 1-4.

Synonymy.- □1919 *Nileus armadillo* - Funkquist, pl. 2, figs. 1-4. □1972 *Nileus platys* - Schrank, pp. 368 - 371, pl. 6, fig. 4, pl. 7, fig. 3, pl. 8, figs. 1 - 6, pl. 9, figs. 1-4, pl. 10, figs. 1, 2.

Type data.- The holotype is a complete specimen from an erratic boulder at Dwasiede, Rügen, Germany. Probably derived from the Dalby Limestone.

Material.- Two almost complete pygidia from Bollerup and Tommarp, and ten internal moulds from layers *f*, *h*, and *l*, and from a loose boulder at Killeröd. In addition there are three cranidia from loose boulders from Killeröd, Tommarp and Tosterup.

Description.- The pygidium is semicircular in outline, with an indistinct rhachis and with unfurrowed pleural fields. The pygidium has a distinct, broad, concave and flat border zone. The surface seems to be completely smooth, without any kind of ornamentation. On the inside of the exoskeleton, clearly visible on the internal mould, are well marked terrace lines. The cranidium is about 1.3 times as broad as it is long. Characteristic marks of the species is the mesial tubercle at the posterior end of the glabella, and a faint ridge running from the mesial tubercle to the anterior part of the glabella.

Remarks.- Moberg (1892) reported a *Nileus* species with an angulate librigena from the Killeröd Formation, which he named *Nileus armadillo* var. *cornutus*. But it is uncertain what this species actually looked like, since it was not figured, and can not be found in any collection.

Family Calymenidae Burmeister, 1943
Genus *Platycalymene* Shirley, 1936

Type species. - *Platycalymene duplicatus* (Murchison, 1839), from the Middle Ordovician of the Shelve district, Welsh Borderland.

Platycalymene dilatata (Tullberg, 1882)
Pl. II: 6.

Synonymy. - □1882 *Calymene dilatata* n. sp. - Tullberg, p. 18. □1906 *Calymene dilatata* - Olin, p. 56-57, pl. 2, figs. 10-12. □1979 *Platycalymene dilatata* - Siveter, pl. 3, figs. 3, 5.

Type data. - Tullberg's (1882) syntypes are deposited in the type collection of the Geological Survey of Sweden, Uppsala. They are from the Sularp Shale (*Diplograptus multidens* Zone) at Röstånga and other localities in Scania. The selection of a lectotype has to await a revision.

Material. - One internal mould of an almost complete cranidium, from layer *j* at Killeröd.

Description. - At the anterior margin of the cranidium there is a broad upbent straight border, which is separated from the glabella by a narrow deep furrow. The faintly vaulted glabella, which is somewhat narrowing anteriorly, is as long as it is broad (excluding the occipital-ring). The anterior end of the frontal lobe of the glabella is flat with rounded corners. The glabella has three pairs of lateral furrows. The anterior pair is rather weak and faint. The second pair is somewhat longer and much deeper and wider. The posterior pair is even deeper and wider, and runs inwards and backwards in a faint arch and ends at the posterior not far from the occipital furrow. The third pair of lateral glabellar lobes therefore becomes triangularly rounded in outline. The surface of the cranidium is densely granulated.

Remarks. - *P. dilatata* is previously known only from the Sularp Shale. The record of the species in the Killeröd Fm indicates that it is a fairly long-ranging species.

Platycalymene? sp.
Pl. II: 8.

Material. - Two moulds of pygidia, an external mould from layer *j* and an internal mould from a loose boulder, and some fragments from layer *h*. All material is from Killeröd.

Remarks. - The pygidia do not belong to the above described *P. dilatata*. They have rather few rhachial furrows and rhachial segments, and in this respect they come closer to *P. tasgarensis*. It might, however, be questioned if they really belong to the genus *Platycalymene*, because they have unusually few rhachial furrows and rhachial segments. It is possible that they could belong to *Flexicalymene*, or even to *Gravicalymene*.

Age and correlation

A total amount of twelve trilobite species has been discovered from the Killeröd Fm. These are: *Arthrorhachis* sp., *Botrioides bronnii* (Böeck 1838), *B. efflorescens* (Hadding 1913), *B. impostor* Owen 1987, *Bronteopsis holtedahli* Skjeseth 1955, *Lonchodomas rostratus* (Sars 1835), *Nileus platys* Schrank, 1972, *Platycalymene dilatata* (Tullberg, 1882), *Platycalymene?* sp., *Pseudomegalaspis patagiata* (Törnquist 1884), *Remopleurides* sp., and *Telephina* aff. *granulata* (Angelin 1854). The trilobite fauna is clearly dominated by trinucleid trilobites, in particular by *Botrioides bronnii* which is frequently present in every mudstone layer. The mudstone layers *j* and *h* are the layers that contain most trilobites, both regarding the number of individuals and the total amount of species. Unfortunately some of the trilobites from the Killeröd Fm, housed at the Department of Geology in Lund, are not labelled with a specific layer. This concerns much of the material collected before 1952, when Nilsson named the individual layers in the formation.

Studies of the stratigraphical ranges of the different trilobite species place the Killeröd Fm in the upper part of the Uhakuan Stage, i. e. the lower part of the Llandeilo (Fig. 6). The species

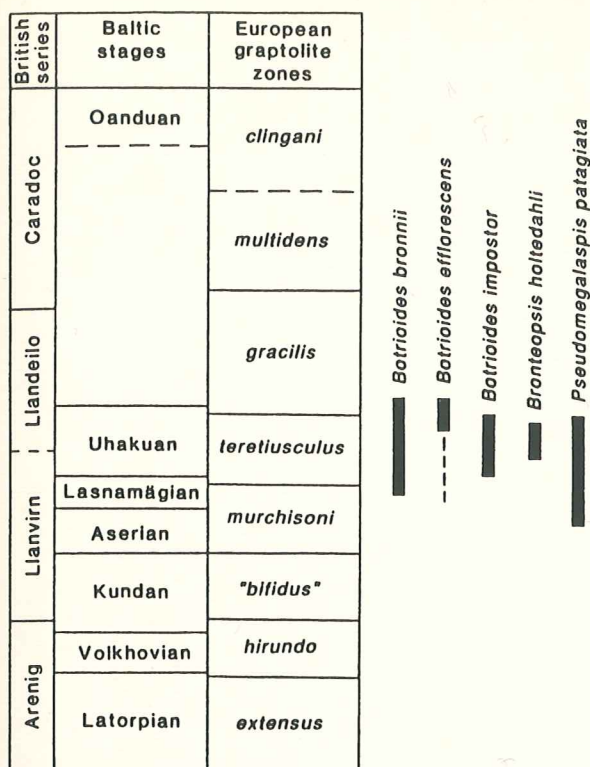


Fig. 6. Stratigraphical ranges of some of the trilobites found in the Killeröd Formation.

indicating this are *Botrioides bronnii*, *B. efflorescens*, *B. impostor*, *Bronteopsis holtedahli* and *Pseudomegalaspis patagiata*. The other trilobite species have a longer stratigraphic range, and therefore can not be used to precise the stratigraphic position of the Killeröd Fm.

The trilobites of the Killeröd Fm have several species and genera in common with the upper Elnes Formation in the Oslo Region of Norway (previously termed 4a Ogygiocaris shale) and with the lower Andersö Shale in Jämtland (this formation was also previously termed Ogygiocaris shale).

The lower Andersö Shale has the character of a mixed facies, that consists of 6 m of dark coarse shales with inclusions of limestone layers and limestone lenses (Karis 1982). Not only has the lower Andersö Shale the character of a mixed facies from a lithological point of view, but from a palaeontological one as well. The shale contains a graptolite fauna (rather poorly preserved; Hadding 1913) together with a rather extensive trilobite fauna, which higher up in the

sequence completely dominates in the limestones (Owen *et al* 1990). There are about 14 different species in the lower Andersö Shale, and *B. bronnii*, *B. efflorescens* and *P. patagiata* are species that also occur in the Killeröd Fm (Karis 1982). As described by Störmer (1953) the upper Elnes Fm consists of alternating calcarenites (up to 10 cm thick), bedded and nodular limestones (also up to 10 cm) and grey calcareous shales (up to 30 cm thick). Many of the calcarenites show cross and convolute lamination (Störmer 1953). The strata of this unit formed the basis for the *Trinucleus bronnii* Zone, introduced by Störmer (1953). Owen (1987), however, pointed out that the characteristic trinucleid is *Botrioides impostor*, not *B. bronnii*. The upper Elnes Fm contains a more diverse trilobite fauna than the Killeröd Fm. Species present in both formations are *B. bronnii*, *B. impostor*, *B. holtedahli*, *L. rostratus* and *P. patagiata* (see Henningsmoen 1960, Owen 1987, Störmer 1940 and Wandås 1984).

Both the lower Andersö Shale and the upper Elnes Formation have yielded rich graptolite faunas, which is totally lacking in the Killeröd Fm. The graptolite faunas indicate that the lower Andersö Shale and the upper Elnes Fm both belong to the upper part of the *Hustedograptus teretiusculus* Zone. The trilobite fauna of the Killeröd suggests that it is equivalent to these formations, and an assignment to the *H. teretiusculus* Zone seem well founded. This is also in accordance with a conodont-based stratigraphy provided by Bergström (1973). His investigation was based on material from the Killeröd Fm at Killeröd. Samples were taken from the limestone horizons *g* and *m*. It was concluded that these two horizons and probably all of the Killeröd Fm belong to the lower part of the conodont zone of *Pygodus anserinus*, corresponding to the *H. teretiusculus* Zone (Fig. 7). Thus, the trilobite stratigraphy and the conodont stratigraphy made on the Killeröd Fm correspond. A late Uhakuan age is therefore indicated and the Killeröd Fm most likely corresponds to the *Hustedograptus teretiusculus* Zone.

British chronostrat. series	Baltic chronostrat. stages	European graptolite zones	N. Atlantic conodont zones	OSLO	SCANIA NW	SE	JÄMTLAND Lower Allochton	
Caradoc	Oanduan	<i>clingani</i>	<i>superbus</i>	Solvang Fm			Kogsta Siltstone	
				Nakkholmen Fm	Skagen Lst			
				Frognerkilen Fm				
Llandeilo		<i>multidens</i>	<i>tvaerensis</i>	Arnestad Fm	Dicellograptus Shale		U. Dalby Beds	
		<i>gracilis</i>	<i>anserinus</i>	Vollen Fm				
		<i>teretiusculus</i>		Elnes Fm	Upper Didymograptus Shale	Killeröd Fm	Andersö Shale	
		<i>murchisoni</i>	<i>serra</i>					
Llanvirn	Kundan	<i>"bifidus"</i>	<i>suecicus</i>	Huk Fm	Komstad Limestone		Isö Limestone	
		<i>hirundo</i>	<i>variabilis</i>					
Arenig	Latorpian	<i>extensus</i>	<i>parva triangularis</i>	Tøyen Shale	Tøyen Shale		Tøyen Shale	
			<i>evae</i>					
			<i>elegans</i>					

Fig. 7. Correlation between the Arenig - Caradoc successions of Oslo, Scania and Jämtland. Equivalence of the units is based on Bergström (1982), Jaanusson (1982) and Owen *et al* (1990).

Acknowledgement

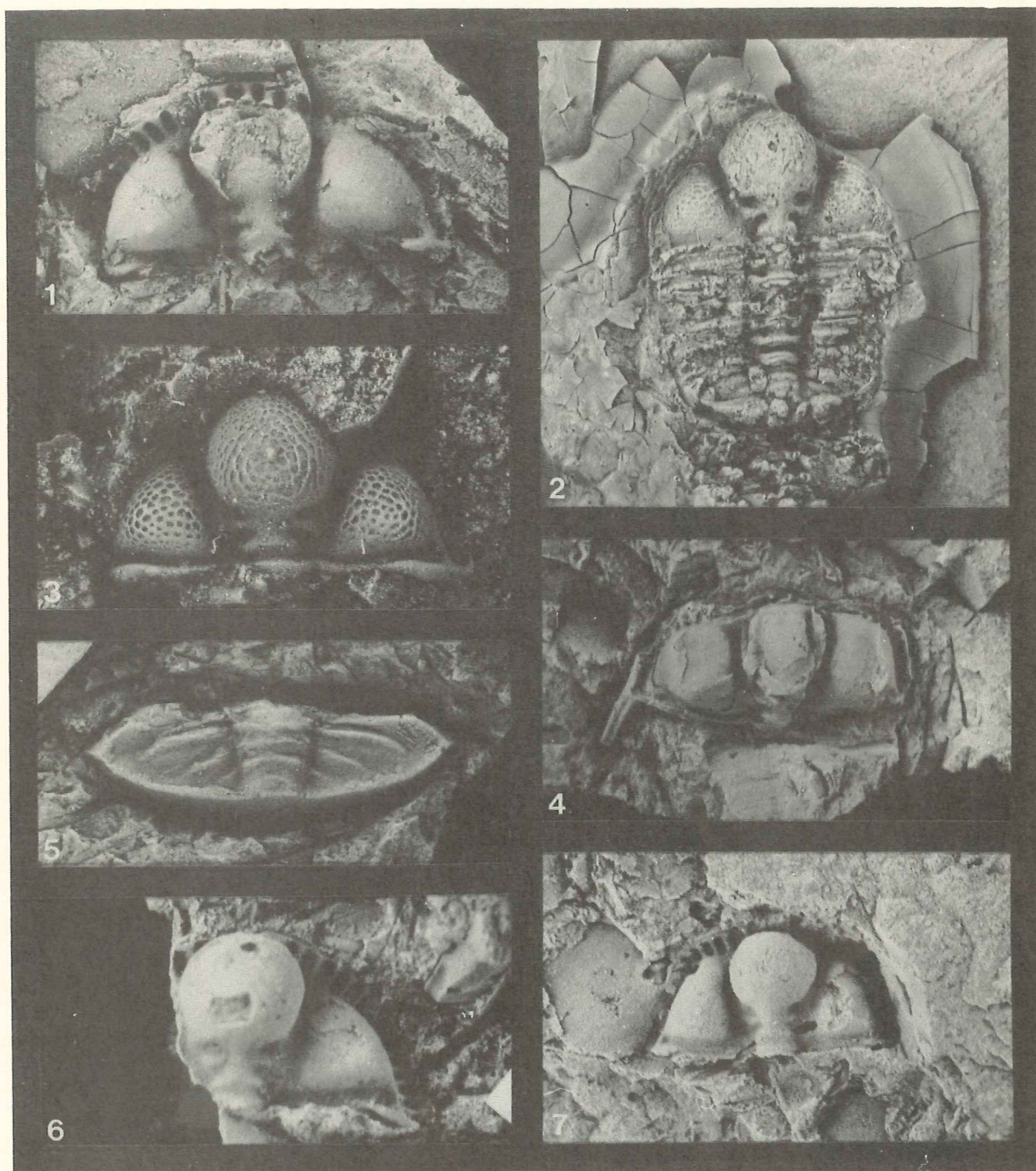
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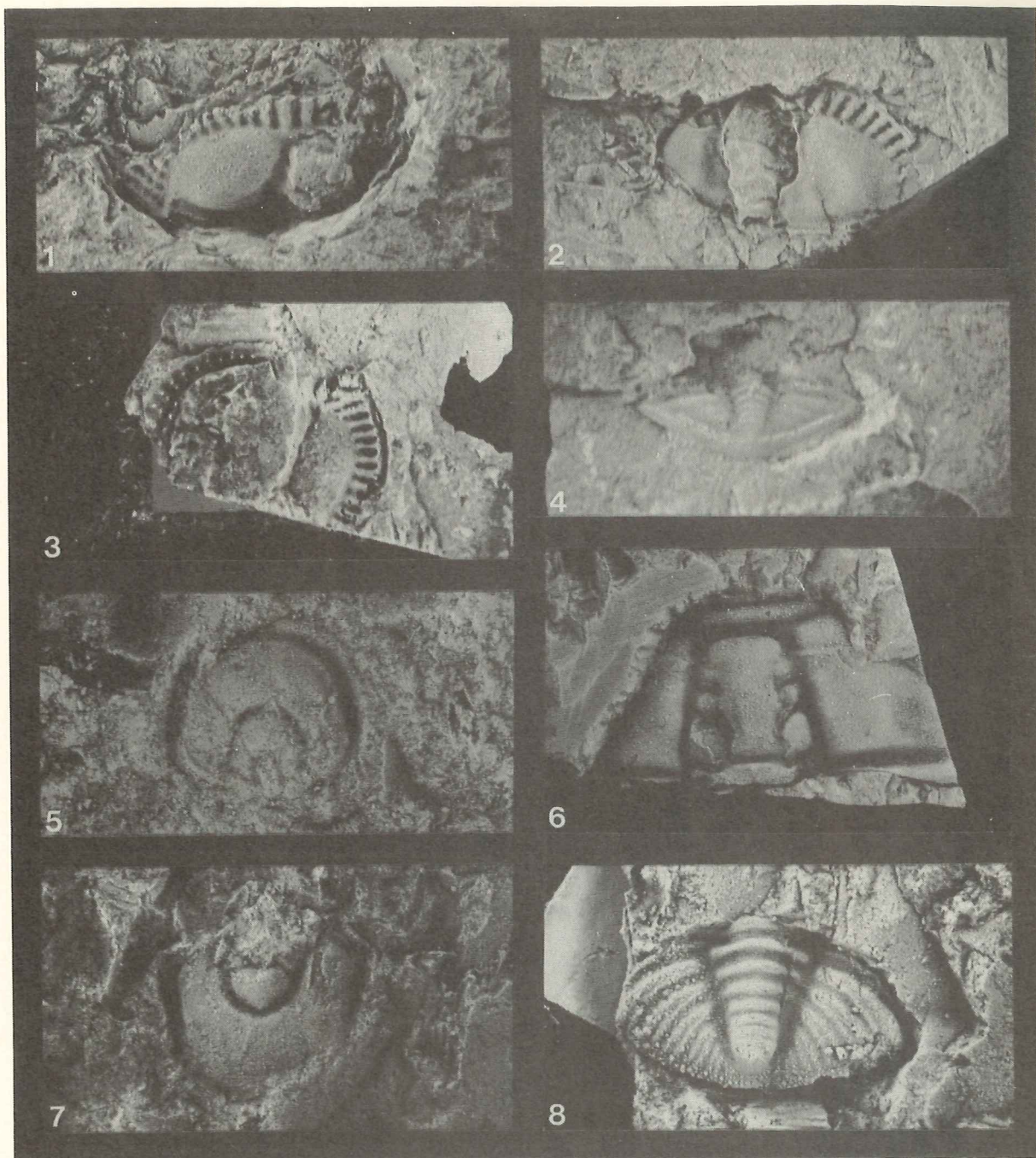
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Explanation of plate I

1-7. *Botrioides bronni* (Boeck, 1838). 1, dorsal view of a cephalon with a crushed glabella, layer unknown, Killeröd, x 5. 2, dorsal view of an almost complete *B. bronni*, loose boulder, Tommarp, LO 2949t, x 3, original of Funkquist (1919, pl. 2, figs. 20-21), also figured by Owen (1987, pl. 11, fig. 16). 3, dorsal view of latex cast of cranidium, loose boulder, Killeröd, LO 5717t, x 7, original of Owen (1987, pl. 11, fig. 5), who selected it as neotype for "*Trinucleus*" *coscinorrhinus* Angelin. 4, dorsal view of internal mould of a crushed cephalon, loose boulder, Tommarp, LO 2937t, x 3, original of Funkquist (1919, pl. 2, fig. 7), also figured by Owen (1987, pl. 11, fig. 17). 5, dorsal view of pygidium, layer *h*, Killeröd, x 6, original of Funkquist (1919, pl. 1, fig. 16), also figured by Owen (1987, pl. 11, fig. 14). 6, dorsal view of internal mould of half a cephalon, layer *j*, Killeröd, LO 5721t, x 6, original of Owen (1987, pl. 11, fig. 9). 7, dorsal view of a cephalon, layer *n*, Killeröd, x 5.

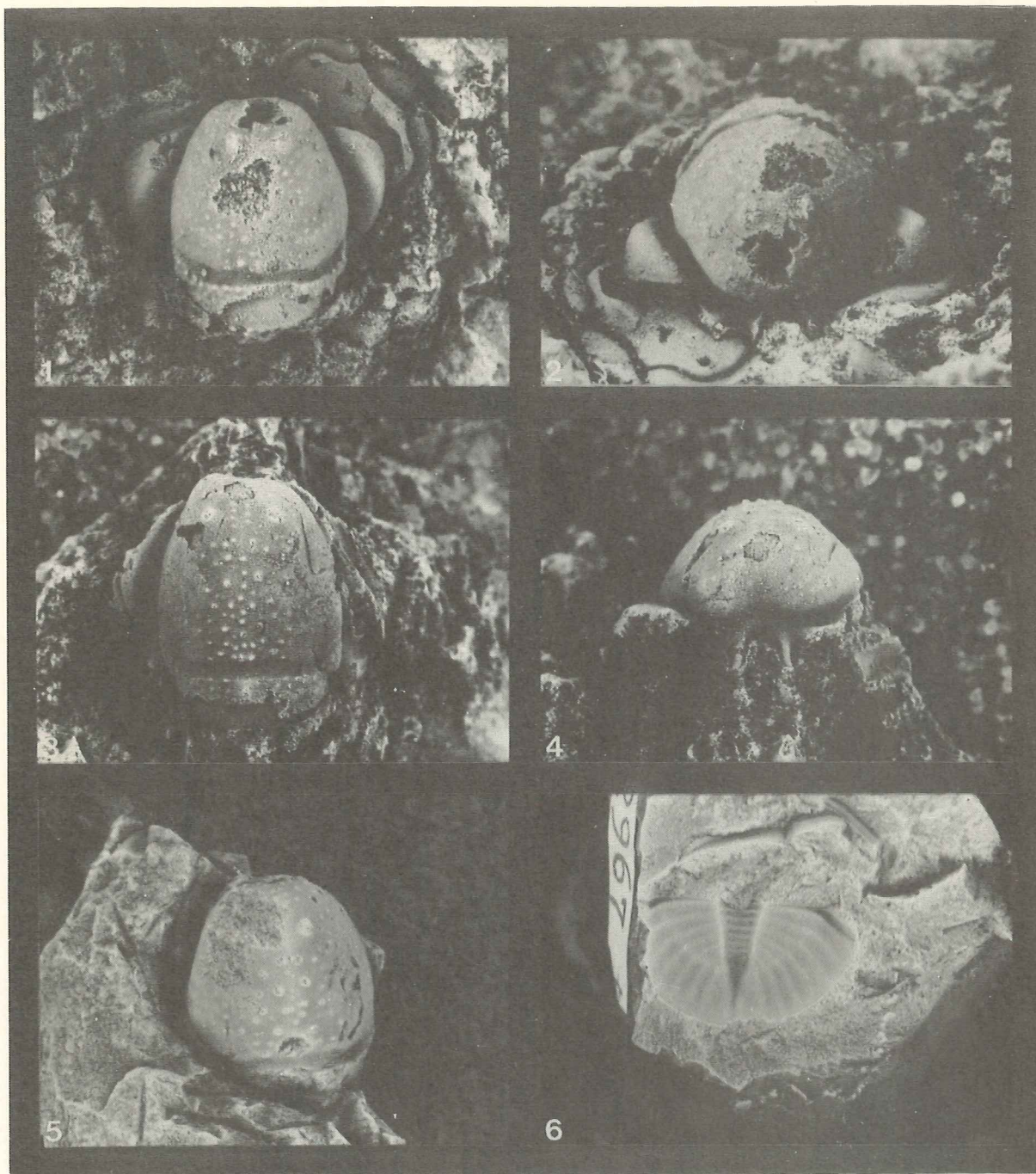
PLATE II



Explanation of plate II

1-4. *Botrioides efflorescens* (Hadding, 1913). 1, dorsal view of half a cephalon, layer *n*, Killeröd, x 4. 2, dorsal view of a cephalon with a crushed glabella, layer *h*, Killeröd, x 4. 3, dorsal view of a crushed cephalon, part of it being an internal mould, layer *j*, Killeröd, x 4. 4, dorsal view of pygidium, layer *k*, Killeröd, LO 5722t, x 4, original of Owen (1987, pl. 13, fig. 12). 5 and 7. *Arthrorhachis* sp. 5, dorsal view of cephalon, loose boulder, Killeröd, x 9. 7, dorsal view of internal mould of pygidium, layer *j*, Killeröd x 10. 6. *Platycalymene dilatata* (Tullberg, 1882). Dorsal view of an almost complete cranidium, layer *j*, Killeröd, x 3. 8. *Platycalymene?* sp. Dorsal view of a complete pygidium, loose boulder, Killeröd, x 7.

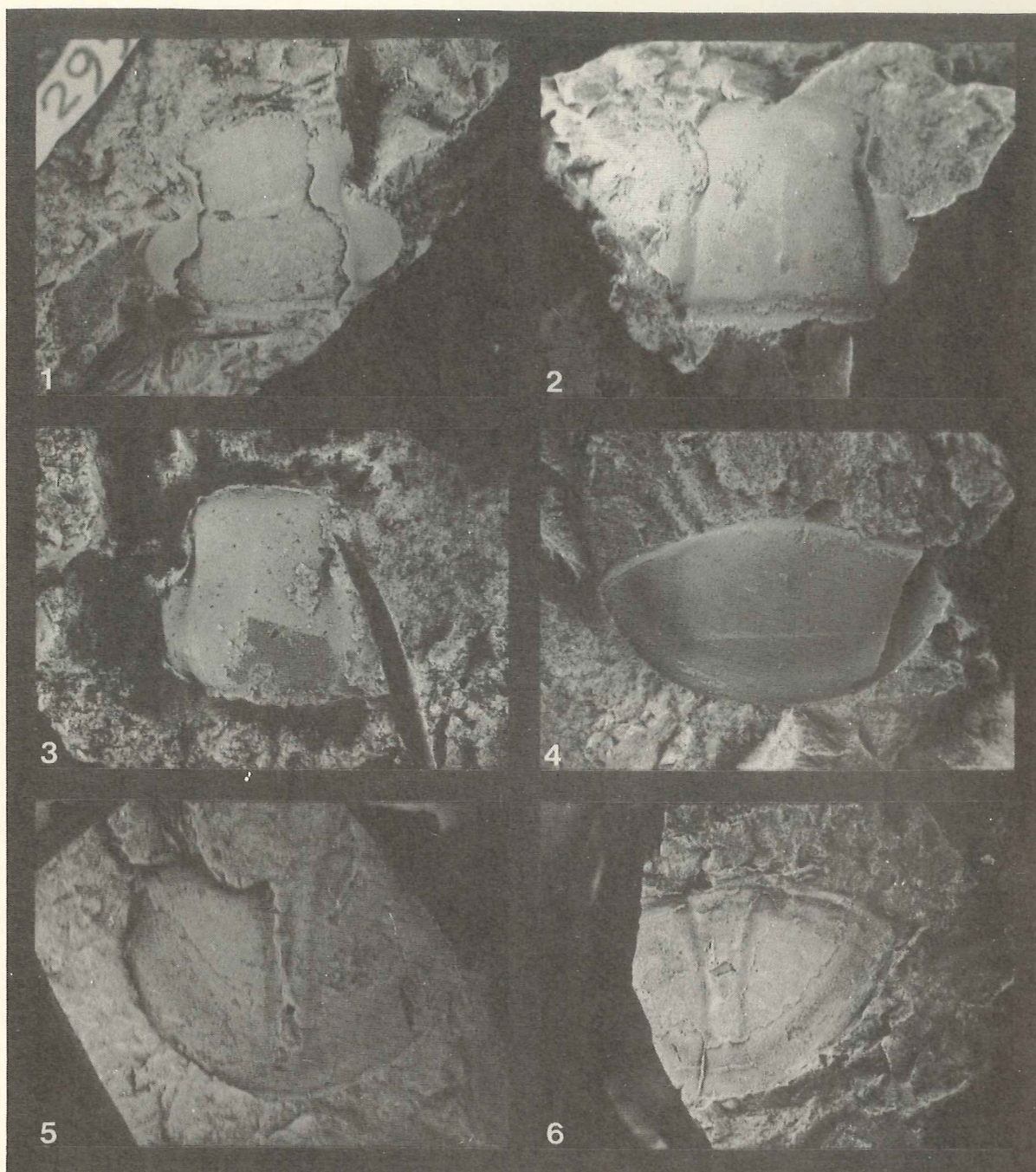
PLATE III



Explanation of plate III

1-5. *Telephina* aff. *granulata* (Angelin, 1854). 1-2, nearly complete cranidium in dorsal and anterior views, loose boulder, Killeröd, LO 6714t, x 5. 3-4, incomplete cranidium in dorsal and anterior views, loose boulder, Killeröd, LO 6713t, x 5. 5, dorsal view of fragmentary cranidium, loose boulder, at Röd mölla in the Tosterup area, LO 2966t, x 5, original of Funkquist (1919, pl. 2, fig. 9). 6. *Bronteopsis holtedahli* Skjeseth, 1935. External mould of a pygidium, loose boulder, Tommarp, LO 2967t, x 2, original of Funkquist (1919, pl. 2, fig. 10).

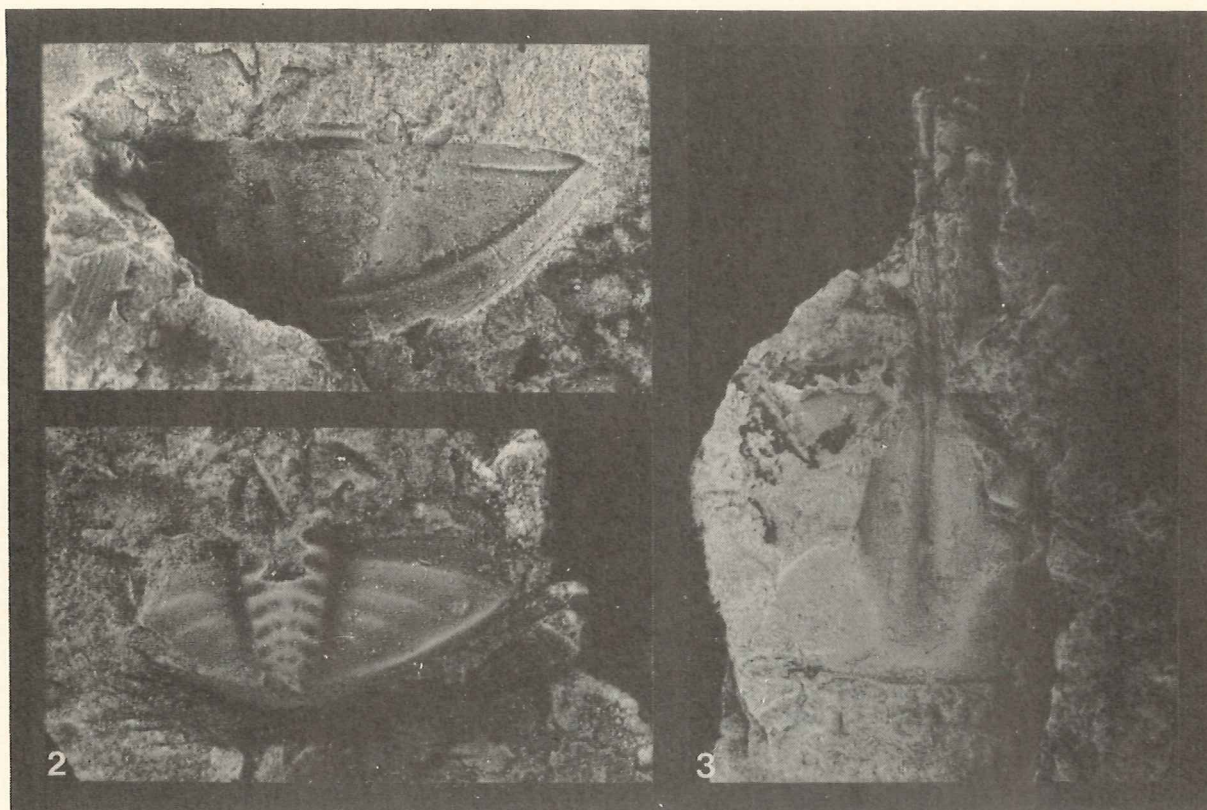
PLATE IV



Explanation of plate IV

1-4. *Nileus platys* Schrank, 1972. 1, dorsal view of internal mould of cranidium, with parts of the exoskeleton, loose boulder, Tommarp, LO 2958t, x 3, original of Funkquist (1919, pl. 2, fig. 1). 2, dorsal view of a cranidium, loose boulder, at Rödmölla in the Tosterup area, LO 2961t, x 3, original of Funkquist (1919, pl. 2, fig. 4). 3, dorsal view of internal mould of a cranidium, loose boulder, Killeröd, x 7. 4, dorsal view of pygidium, Bollerup, LO 2959t, x 5, original of Funkquist (1919, pl. 2, fig. 2). 5-6. *Pseudomegalaspis patagiata* (Törnquist, 1884). 5, dorsal view of internal mould of a poorly preserved pygidium, layer I, Killeröd, x 2. 6, dorsal view of a broken pygidium, layer J, Killeröd, x 2.

PLATE V



Explanation of plate V

1-3. *Lonchodomas rostratus* (Sars, 1835). 1, dorsal view of internal mould of a pygidium, layer *h*, Killeröd, x 6. 2, dorsal view of a broken pygidium, loose boulder, Killeröd, x 8. 3, dorsal view of internal mould of a cephalon, layer *h*, Killeröd, x 6.

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