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Upper Cambrian at Gudhem in Västergötland, Sweden**

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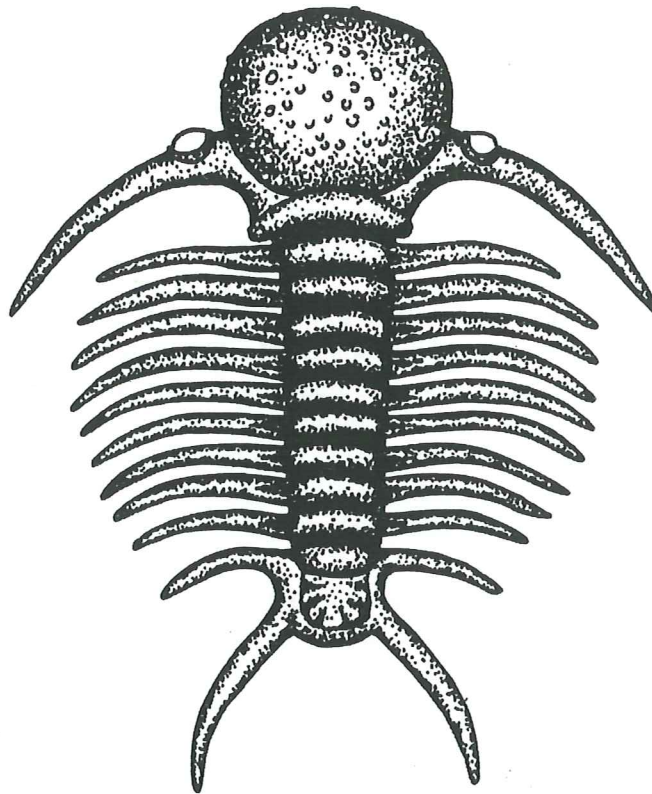
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Abstract: Middle and basal Upper Cambrian strata are well exposed in an old quarry at Gudhem in the Falbygden area of Västergötland, south-central Sweden. The exposures consist of finely laminated alum shale with scattered stinkstone (orsten) lenses, up to 2.3 m in diameter. Four sections have been measured and sampled in order to establish the succession of trilobite species. Fossils are generally preserved only in the stinkstone, and not in the shale. Trilobites, including agnostids, and bradoriid arthropods are generally common, whereas lingulate brachiopods and hyoliths are minor faunal constituents.

In the northeastern wall of the quarry the rock sequence is about 3.6 m thick, and includes the Middle-Upper Cambrian boundary. The lower and middle part of this section contains agnostids indicative of the *Lejopyge laevigata* Zone. These include, e.g., *Lejopyge laevigata*, *Diplagnostus planicauda*, and *Peronopsis insignis*. A bradoriid arthropod, *Anabaroichilina primordialis* (Linnarsson, 1869), is common throughout the *L. laevigata* Zone. Stinkstone lenses in the topmost part of the section contain *Agnostus pisiformis* in abundance, indicating the *A. pisiformis* Zone. A conglomeratic limestone (the Exporrecta Conglomerate) was previously exposed at the base of the section (Wallerius 1895, 1930).

In the southwestern wall of the quarry the rock sequence is 1-3 m thick. A fairly diverse fauna, including abundant *L. laevigata*, *L. armata*, *Hypagnostus sulcifer*, *Diplagnostus planicauda* and *Anabaroichilina primordialis* along with *Agnostus neglectus*, *A. pater*, *Acrocephalites stenometopus*, *Toxotis pusilla*, *Proceratopyge conifrons* and *Peronopsis insignis*, shows that this section is referable to the *L. laevigata* Zone. In the northwestern part of the quarry, this zone is overlain by the *A. pisiformis* Zone. As in the northeastern wall, unfossiliferous alum shales occur between stinkstones containing the *L. laevigata* and *A. pisiformis* faunas. Hence there is an interval (~70 cm) of uncertainty concerning the zonal and series boundaries.

At the northwestern entrance to the quarry there are exposures of the *Hypagnostus parvifrons* Zone. A section here consists of a more or less coherent limestone bed at the top, underlain by at least 4 m of unfossiliferous alum shales. The limestone bed has yielded *H. mammillatus* in abundance, as well as *H. parvifrons* and fragmentary specimens of *Paradoxides paradoxissimus*.

Keywords: Arthropoda, Trilobita, Bradoriida, taxonomy, biostratigraphy, Middle Cambrian, Västergötland, Sweden.

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Lower Palaeozoic deposits in Västergötland, south-central Sweden, occur in four main districts: Kinnekulle, Halle- and Hunneberg, Lugnåberget and Falbygden-Billingen. Between these districts Lower Palaeozoic beds are absent and the bedrock surface consists of Precambrian crystalline rocks. The Lower Cambrian of Västergötland form a western extension of the File Haidar Formation. In Västergötland this formation consists of the lower Mickwitzia Sandstone (about 10 m) and the upper Lingulid Sandstone (about 25 m). Body fossils are rare in these sandstones, but trace fossils are locally abundant (e.g. Jensen 1997; Jensen & Bergström 1995).

The Middle and Upper Cambrian of Västergötland consist predominantly of black alum shales with beds or lenses of stinkstone (orsten). Locally there are conglomerates and calcareous sandstones. The alum shale accumulated in a relatively deep (50-200 m) epicontinental sea. The net rate of accumulation was very low (1-10 mm/1000 years; Buchardt et al. 1997). The depositional environment was probably dysoxic during long periods of time, while anoxic episodes were short and rare (Buchardt et al. 1997). The pore water in the bottom sediment, was, however, constantly anoxic under very long periods of time.

This is evident from the high content of pyrite (FeS_2) and organic carbon (2-28%) in the alum shale (Buchardt et al. 1997). The alum shale successions are also enriched in metals, such as uranium and vanadium.

The Middle Cambrian (the Paradoxides Series) of Scandinavia is subdivided into the *Acadoparadoxides oelandicus* Stage (which is missing in Västergötland), the *Paradoxides paradoxissimus* Stage and the *Paradoxides forchhammeri* Stage. The thickness of the Middle Cambrian in Västergötland varies between 6 and 11 m (Westergård 1946). The boundary between the Middle and the Upper Cambrian is placed between the *Lejopyge laevigata* and the *Agnostus pisiformis* Zones. There are two distinct conglomeratic levels in the Middle Cambrian. The lower level is the *Acrothele granulata* conglomerate which occurs at the base of the *Paradoxides paradoxissimus* Stage. The *A. granulata* conglomerate has a varying lithologic character. It is made up of a dark-green conglomerate or a light-green sandstone rich in phosphorite and glauconite. The conglomerate is covered by a thin layer of greenish grey shale (Westergård 1946). This shale is overlain by black alum shale with stinkstone lenses.

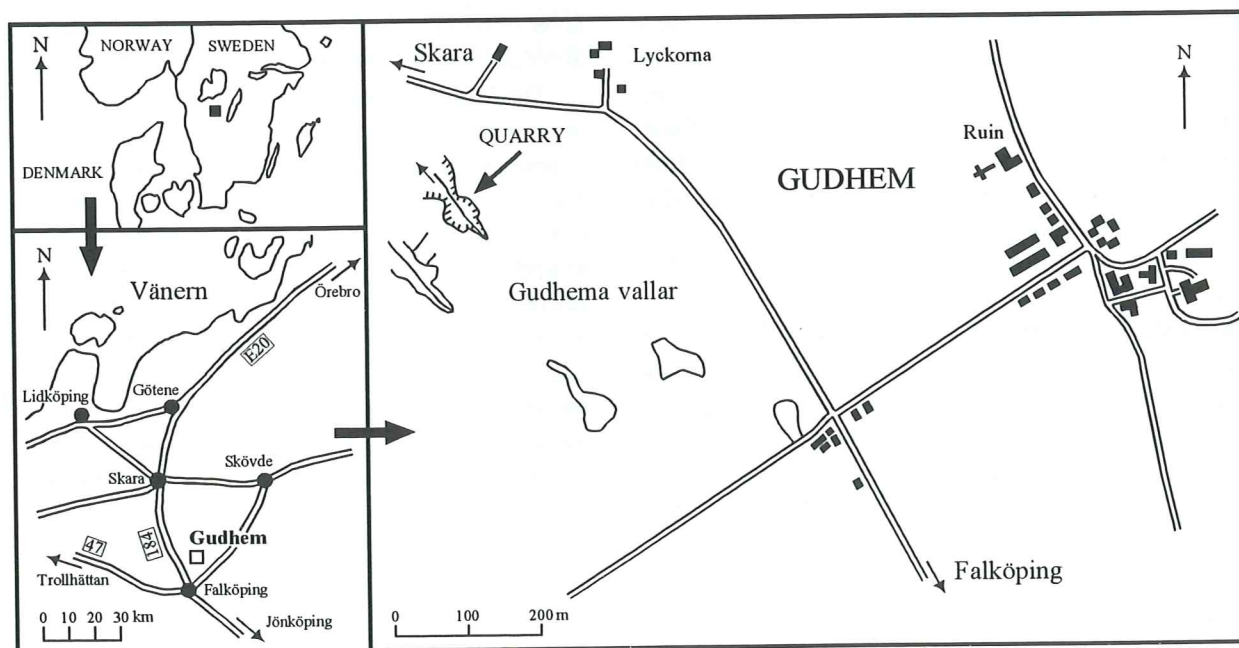


Fig. 1. Map showing the position of the Gudhem quarry.

The thickness of the *P. paradoxissimus* Stage in Västergötland varies between 3.5 m (Kinnekulle) and 9.0 m (eastern Falbygden). The *P. paradoxissimus* Stage comprises four biozones, of which the uppermost is present only on Hunneberg and at Djupadalen in the Falbygden area (Westergård 1946).

The upper conglomerate level occurs in the *P. forchhammeri* Stage and is called the Exporrecta conglomerate after the brachiopod *Billingsella exporrecta*. This conglomerate is generally thin or missing. The Exporrecta conglomerate is overlain by alum shale with scattered stinkstone lenses. This alum shale belongs to the *Lejopyge laevigata* Zone. The thickness of the *L. laevigata* Zone in Västergötland varies between 2.5 m and 4.0 m (Wallerius 1895). The *P. forchhammeri* Stage is more organic-rich than the *P. paradoxissimus* Stage (Westergård 1946). The Middle Cambrian faunas of Scandinavia are well diversified and dominated by trilobites, which form the basis for the zonation.

The Upper Cambrian (the Olenid Series) consists almost exclusively of alum shale with lenses or beds of stinkstones. A stinkstone bed of considerable persistence occurs in the *Agnostus (Homagnostus) obesus/Olenus* Zone and is called the "Great Stinkstone Bed", because it has a thickness of about 1 m. The Upper Cambrian trilobite faunas are generally dominated by olenids except in the *Agnostus pisiformis* Zone, the lowest zone of the Upper Cambrian (Westergård 1922). The alum shale in the Upper Cambrian is characterized by intervals with abundant, but low-diversity trilobite faunas. Brachiopods and bradoriid arthropods are occasionally common. The Upper Cambrian of Västergötland is about 15 m thick and well exposed in many old quarries. Middle Cambrian strata are also exposed in many of these quarries, one of them located at Gudhem in the Falbygden area (Fig. 1). The *Hypagnostus parvifrons*, *Lejopyge laevigata* and *Agnostus pisiformis* Zones are well exposed in this quarry. The aim of this paper is to describe and document the succession of trilobite species in the quarry at Gudhem.

Description of the quarry

In an old quarry 1.7 km west of Gudhem Church and about 9 km NW of Falköping, the *Lejopyge laevigata* Zone and the lower part of the *Agnostus pisiformis* Zone are well exposed (Fig. 1). This quarry was first investigated by Wallerius (1895, 1930). In 1998 I measured and sampled four sections in the quarry. Three of these (sections A-C) are largely concerned with the *L. laevigata* Zone, except for the uppermost part (0.0-0.8 m) which belongs to the *A. pisiformis*

Zone. The three sections are respectively 15, 16 and 60 m long and 1.0-3.6 m thick. They are well exposed with three to four stinkstone levels, which are restricted to particular horizons in the shale (Figs. 2-4). According to Wallerius (1895, 1930) the Exporrecta conglomerate was previously exposed at the base of section A. The fourth section (section D) is 25 m long and 4-5 m thick and has a more or less coherent limestone bed at the top. The limestone bed is probably situated approximately 0.5-1.0 m below the base of the *Lejopyge laevigata* Zone. It belongs to the *Hypagnostus parvifrons* Zone.

The diagenetic carbonate nodules (stinkstones or anthraconites) consist of micritic to coarse sparitic calcite with a low content of pyrite. The micritic and finely sparitic anthraconite consists of dark grey to black calcite with a large amount of clay and organic material. The stinkstones are generally more or less structureless, but can show some traces of bedding, which is traces from the concretion it is grown from (Buchardt et al. 1997).

The growth of the anthraconite started during an early diagenetic stage before the compaction of the surrounding mudlayer. This precipitation occurred in the pore space where carbonate precipitated between the clay and silt particles just under the sea bottom. The precipitation was connected with oxygen deficient conditions (Buchardt et al. 1997).

The amount and the size of the stinkstones vary between the sections and also between various levels. Each section in the quarry contains 11-21 stinkstones which have been formed at different levels. The size of the stinkstones is between 0.20 and 2.30 m in length and between 0.05 and 0.60 m in height. The most prominent stinkstone level in the quarry is level two in sections A and B. This level is exposed as a distinct unit, which can be followed laterally.

The large stinkstones are often surrounded by an outer coarse-grained prismatic crystalline layer. This coarse sparitic anthraconite consists of rod-shaped, brown calcite crystals. The crystals are often without contamination and diverge out from a fine sparitic anthraconite core. This coarse sparitic lining can occupy between 0%-100% of a concretion. It can enclose the fine sparitic, central part of the concretion, or only exist below or above the concretion (Buchardt et al. 1997). The thickness and placing of the prismatic layer in the sections vary from nodule to nodule (0.01-0.20 m). This outer prismatic lining was formed long after the growth of the fine sparitic core (Buchardt et al. 1997).

These large stinkstones often have a zone of horizontal cracks through the centre of the nodule. The horizontal cracks are sometimes disrupted by smaller

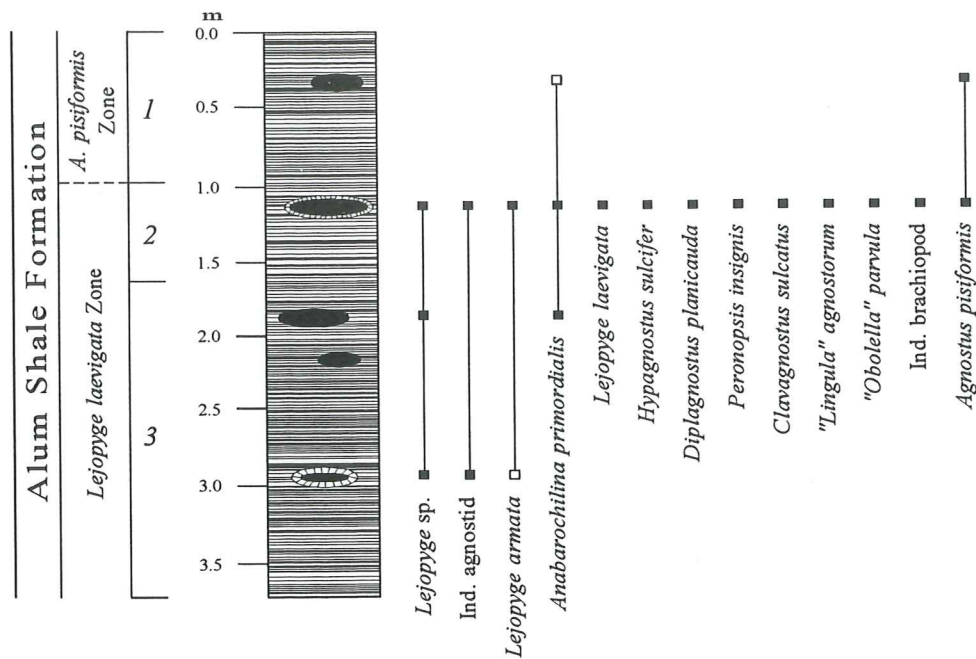


Fig. 2. Section A, northeastern part of the Gudhem quarry. Stratigraphic ranges of agnostids, bradoriid arthropods and brachiopods in the middle and upper part of the *Lejopyge laevigata* Zone and in the basal part of the *Agnostus pisiformis* Zone. An open symbol indicates uncertain identification.

vertical cracks. The small and middle sized stinkstones are generally more compact, homogeneous and not surrounded by an outer prismatic layer.

Between the stinkstones there is a black, finely laminated and fine-grained alum shale. It is quite similar throughout the four sections. The obvious lamination, which can be clearly seen in the quarry, is partly due to erosion and weathering. Samples which have not been exposed are more coherent and homogeneous. The uppermost parts (0.0-0.5 m) in the sections are not as homogeneous as the underlying shale. The colour of the alum shale varies from black/grey-yellow in the lower part to a more black/red-yellowish colour at the top.

Biostratigraphy

Fossils are generally preserved only in the stinkstones, and not in the alum shale. The fossils are often preserved in two different ways, either as a horizontal layer throughout the centre of the stinkstone, or along the boundary between the fine sparitic core and the coarse sparitic anthraconite. In some rare instances fossils are scattered throughout the entire stinkstone. The coarse sparitic anthraconite are unfossiliferous.

The alum shale sequence in the quarry is covered by Quaternary strata. The thickness of the Quaternary deposits generally varies from one to two metres. These strata contain coarse-grained stinkstones derived from the *Agnostus pisiformis* Zone in sec-

tions A, B and C, while in section D they belong to the *Lejopyge laevigata* Zone.

Section A is situated in the northeastern part of the quarry, and it contains three to four stinkstone levels (Fig. 2).

Level one. - This level belongs to the *Agnostus pisiformis* Zone, which contains the very common zonal fossil *Agnostus pisiformis* and probably fragments from the bradoriid arthropod, *Anabarochilina primordialis*. Stinkstones from this level have yielded thousands of specimens of *A. pisiformis*.

Level two. - The fauna in this level is diverse and characteristic of the *Lejopyge laevigata* Zone. The zonal index fossil *Lejopyge laevigata* is common. It is generally associated with *A. primordialis* in abundance (>200 valves). Other common species are *Diplagnostus planicauda*, *Peronopsis insignis*, *A. pisiformis*, *Lejopyge* sp., an indeterminate brachiopod and an indeterminate agnostid. Rare species are *Lejopyge armata* (one pygidium), *Hypagnostus sulcifer* (one cephalon) and *Clavagnostus sulcatus* (one cephalon). This level has also yielded two lingulate brachiopod species, "*Lingula*" *agnostorum* and "*Obolletta*" *parvula*, which are fairly common.

Level three. - The fossil content in this level is very poor. Incomplete or fragmentary specimens of *A. primordialis* and *Lejopyge* sp. have been found. One stinkstone occurs near the base of the section. It probably belongs to a "fourth level" (Wallerius 1895). The stinkstone consists almost completely of coarse

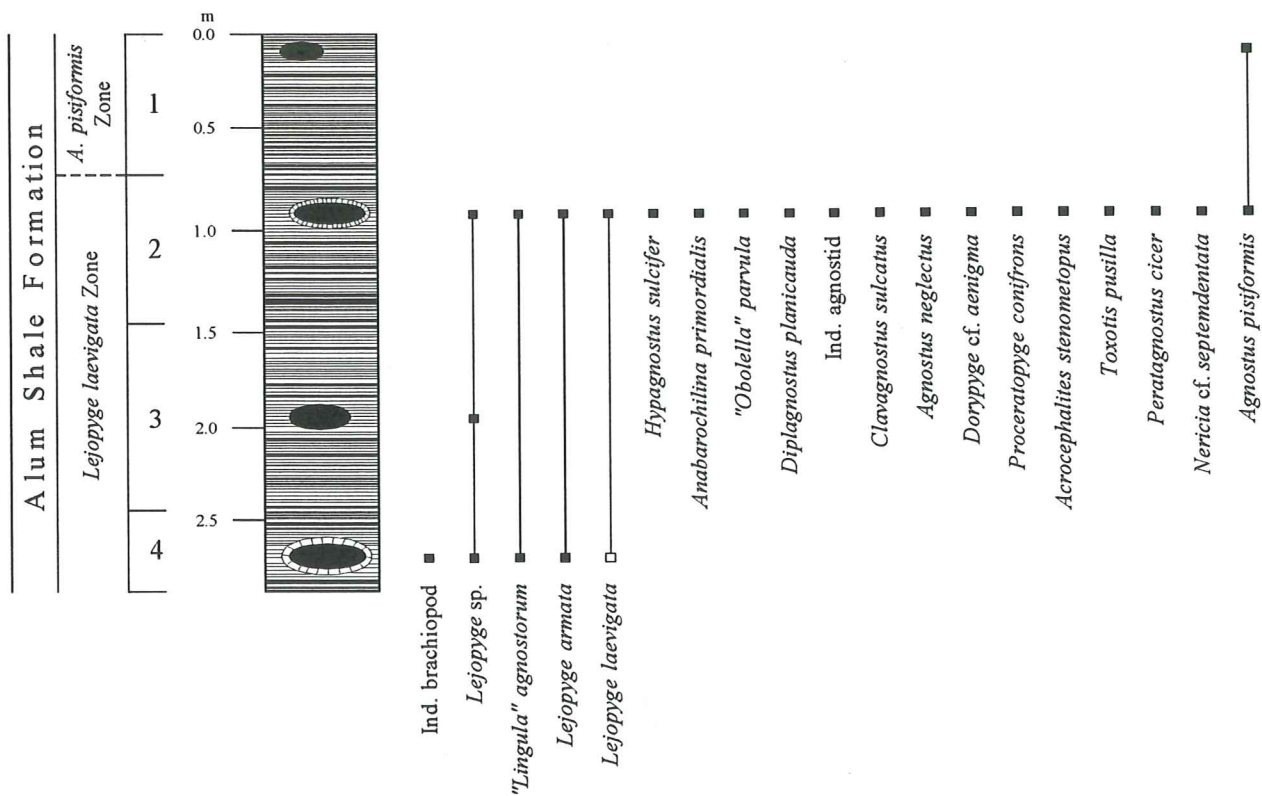


Fig. 3. Section B, northwestern part of the Gudhem quarry. Ranges of trilobites, brachiopods and bradoriid arthropods in the middle and upper part of the *Lejopyge laevigata* Zone and in the basal part of the *Agnostus pisiformis* Zone. An open symbol indicates uncertain identification.

sparitic calcite. The fossil content in this stinkstone is very sparse, but fragments of *L. armata*?, *Lejopyge* sp. and an indeterminate agnostid could be identified.

Section B is situated in the northwestern part of the quarry. This section contains four stinkstone levels (Fig. 3).

Level one. - This level contains only one stinkstone. It belongs to the *Agnostus pisiformis* Zone. The only occurring species is the zonal index fossil *A. pisiformis*, which is common.

Level two. - The fauna is very diverse and dominated by *Hypagnostus sulcifer* (>100 cephalae and pygidia), *L. laevigata*, *L. armata*, *D. planicauda* and *A. primordialis*. *A. pisiformis* is fairly common. More rare trilobites are *C. sulcatus*, *Agnostus neglectus* (one pygidium), *Acrocephalites stenometopus* (two cephalae), *Toxotis pusilla*, *Proceratopyge conifrons*, *Dorypyge* cf. *aenigma* (one hypostome), *Nericia* cf. *septemdentata* (one cephalon) and *Peratagnostus cicer*. *Lejopyge* sp., an indeterminate agnostid and the brachiopods "*L.*" *agnostorum* and "*O.*" *parvula* are fairly common in this level.

Level three. - The fossil content in this level is extremely poor. The stinkstones are solid and homogeneous. Only two specimens of *Lejopyge* sp. have been found.

Level four. - These stinkstones occur in the basal part of the section. They are generally richly fossiliferous. The fossils occur at the boundary between the coarse and fine sparitic anthraconite, and at several horizons within the stinkstones. Many of the specimens seem to be deformed due to compression. Therefore it is difficult to identify some of the species. *Lejopyge* sp. is very common (>100 cephalae and pygidia). *L. armata* is known from thirty specimens. A few specimens of *L. laevigata*?, "*L.*" *agnostorum* and an indeterminate brachiopod have also been collected.

The third section (section C) is a continuation at right angle from section B (Fig. 4). It is situated in the southwestern part of the quarry. The different levels in this section are difficult to separate from each other. The stinkstones are more irregularly spaced, and the section is partially collapsed.

Level one. - This level is like level two in section B. The fauna is very diverse and the level contains only two stinkstones. The most common fossils are *L. laevigata*, *L. armata*, *H. sulcifer*, *A. pisiformis*, *Lejopyge* sp., an indeterminate agnostid, and "*L.*" *agnostorum* and "*O.*" *parvula*. *A. primordialis* is not as common in this level as in the other sections. The following species are very rare and known only from a few specimens: *D. planicauda*, *P. insignis*, *A. ne-*

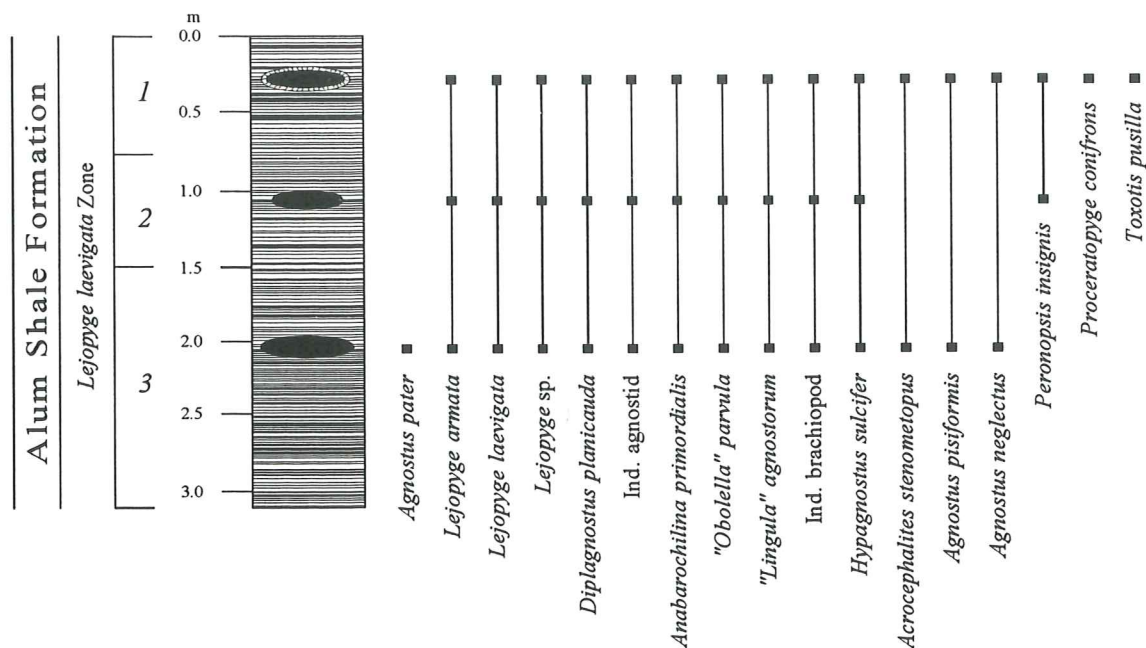


Fig. 4. Section C, southwestern part of the Gudhem quarry. Section through the middle and upper part of the *Lejopyge laevigata* Zone. A diverse fauna of trilobites, brachiopods and bradoriid arthropods occur.

glectus, *A. stenometopus*, *T. pusilla*, *P. conifrons* and an indeterminate brachiopod.

Level two. - This level has yielded only some fragmentary and generally poorly preserved fossils. The fauna is dominated by *Lejopyge sp.* and an indeterminate agnostid. *L. laevigata*, *L. armata*, *H. sulcifer*, *D. planicauda*, *P. insignis*, *A. primordialis*, "*L*". *agnostorum*, "*O*". *parvula* and an indeterminate brachiopod are very rare and known only from a few specimens.

Level three. - *Lejopyge sp.* (>100 cephalae and pygidia) and an indeterminate agnostid dominate the fauna. *H. sulcifer* is fairly common. *L. armata*, *D. planicauda*, *A. primordialis*, "*O*". *parvula*, "*L*". *agnostorum* and an indeterminate brachiopod also occur. Rare species are *L. laevigata*, *A. neglectus*, *Agnostus pater*, *A. stenometopus* and *A. pisiformis*.

Section D is situated at the northwestern entrance to the quarry (Fig. 5). The section here consists of a more or less coherent limestone bed in the uppermost part of the section. It is underlain by at least 4 m of unfossiliferous alum shales. The fossil content is not as high as in the other sections. The limestone bed has yielded trilobites indicative of the *Hypagnostus parvifrons* Zone. The zonal index fossil *Hypagnostus parvifrons* is rare, whereas *Hypagnostus mammillatus* is very common (>100 cephalae and pygidia). A few specimens of *Hypagnostus sp.*, an indeterminate agnostid and one incomplete cephalon of *Paradoxides paradoxissimus* have also been found. Stinkstones in the Quarternary deposits above the section

contain *Lejopyge armata*, *Lejopyge sp.*, *Agnostus pisiformis* (>100 cephalae and pygidia) and *Andrarina costata* (very rare).

The *Lejopyge laevigata* Zone exclusive Scandinavia

In the late middle Cambrian various species and subspecies of *Lejopyge* are important index fossils, especially in Sweden, North America (Utah), Australia (Queensland) and the former Soviet Union (Daily & Jago 1975).

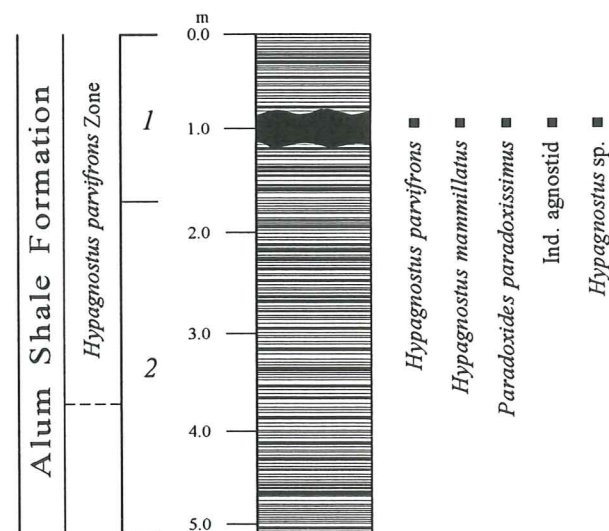


Fig. 5. Section D, northwestern entrance to the Gudhem quarry. The uppermost part of the section contains a more or less coherent limestone bed belonging to the *Hypagnostus parvifrons* Zone.

Australia. - In northern Australia the *Lejopyge laevigata* Zone belongs to the Boomerangian Stage (late Middle Cambrian), which is especially characterised by species of *Lejopyge*, but other agnostids such as *Hypagnostus* and *Diplagnostus* are also common. *Lejopyge armata* ranges upwards into the overlying *Acmarhachis quasivespa* Zone, which is the middle zone in the Mindyallan Stage (Shergold 1995). Daily & Jago (1975) prefer to place the boundary between the Middle and the Upper Cambrian in the *A. quasivespa* Zone, between faunas with *L. armata* below and *Blackwelderia sabulosa* above. The upper range of *L. armata* is the same in Queensland as in Sweden. The lower part of the *A. quasivespa* Zone and the top part of the Swedish *L. laevigata* Zone are correlatives, and the upper part of the *A. quasivespa* Zone together with the overlying *Glyptagnostus stolidotus* Zone correlate with the Scandinavian *Agnostus pisiformis* Zone. The occurrence of *Diplagnostus planicauda* tends to support the correlation of the Australian *L. laevigata* II Zone with the upper part of the *Solenopleura brachymetopa* Zone in Sweden, but in Sweden *D. planicauda* also occurs in the overlying *L. laevigata* Zone. It appears that the *L. laevigata* III Zone is equivalent to the basal part of the Swedish *L. laevigata* Zone (Daily & Jago 1975).

Great Britain. - According to Daily & Jago (1975), *Lejopyge laevigata* has not been found in Great Britain, but the *Lejopyge laevigata* Zone is present within the Mancetter Grits and Shales in the Nuneaton district (Rushton 1978). The bradoriid arthropod, *Anabarochilina primordialis* (Linnarsson) has been described from the middle and lower part of this formation. In Sweden *A. primordialis* occurs throughout the entire *L. laevigata* Zone and also in the *Solenopleura brachymetopa* Zone. It is possible that the lower third of the Mancetter Grits and Shales partially belongs to the *S. brachymetopa* Zone, and the other two thirds belong to the *L. laevigata* Zone. The basal part of this formation in Great Britain consists of a conglomerate which could be comparable with the Exporrecta conglomerate of Sweden. The youngest fossil found near the top of the formation is *Hypagnostus sulcifer* (Wallerius). It is indicative of the upper part of the *L. laevigata* Zone in Sweden (Westergård 1946). The lower part of the overlying Outwoods Shales belongs to the *Agnostus pisiformis* Zone (Daily & Jago 1975; Rushton 1978).

North America. - The *Lejopyge laevigata* Zone is represented in western North America (Nevada and Utah). Such species as *Lejopyge armata*, *L. laevigata* and *Diplagnostus planicauda* are widespread and range throughout most of the *Lejopyge laevigata* Zone (Robison 1984). Robison (1984) subdivided the zone into an upper and a lower subzone. The upper sub-

zone contains, e.g., *Agnostus pisiformis*, *Clavagnostus sulcatus*, *Lejopyge calva*, *L. armata*, *Peronopsis ferox*, *Clavagnostus repandus* and *Hypagnostus sulcifer*. The lower subzone contains, e.g., *Agnostus neglectus*, *D. planicauda*, *L. lundgreni*, *Goniagnostus spiniger* and *Hypagnostus* sp.. It is also possible to subdivide the *L. laevigata* Zone in Sweden into an upper and a lower subzone, based on the ranges of the agnostids mentioned by Robison. According to Robison (1964) it is possible to correlate the faunas in Utah with the Baltic faunas. Both *Hypagnostus* and *Lejopyge* are represented in the Swedish *L. laevigata* Zone and in the North American equivalent. In Sweden *Hypagnostus* ranges from the *Tomagnostus fissus*/*Ptychagnostus atavus* Zone into the *Lejopyge laevigata* Zone, while in Utah it ranges from the middle *Bolaspidella* Zone (middle *Hypagnostus parvifrons* Zone of Sweden) and throughout the *Cedaria* Zone (*Lejopyge laevigata* Zone of Sweden). In Sweden *Lejopyge* ranges from the *Solenopleura brachymetopa* Zone to the *Lejopyge laevigata* Zone, while in Utah it is recognized in the uppermost *Bolaspidella* Zone and much of the *Cedaria* Zone. This makes the *Lejopyge laevigata* Zone correlatable with the uppermost part of the North American *Bolaspidella* Zone and much of the *Cedaria* Zone.

Greenland. - The Holm Dal Formation of central North Greenland closely correlates with the *Lejopyge laevigata* Zone of Scandinavia. Agnostids represented are among others *A. exsulatus*, *D. planicauda*, *L. laevigata* and *L. armata* (Robison 1984, 1988).

China. - The Chiangnan fauna in China is preserved in mainly black carbonaceous shales, which is similar to the Scandinavian alum shale and stinkstone facies. This fauna occurs in south-eastern China and in parts of South Korea (Daily & Jago 1975). *Proceratopyge conifrons* (Wallerius) has been reported from these areas. It appears in the upper part of the *Lejopyge laevigata* Zone. In the Chiangnan faunal belt *Lejopyge armata* has been reported from the upper part of the Yanglioukang limestone in West Chekiang Province. In south Anhwei *Lejopyge* occurs below strata with *Drepanura*, *Blackwelderia* and *Proceratopyge*. *L. armata* has also been reported in a sequence of the Kueichow-Hunan border region. It occurs here together with *Diplagnostus planicauda* (Daily & Jago 1975).

Former Soviet Union. - The Siberian *Lejopyge laevigata*-*Oidalagnostus trispinifer* Zone in the uppermost part of the Mayan Stage correlates most closely with the *L. laevigata* Zone of Sweden. *Lejopyge armata* has been reported from many sections in the northern and north-western portion of the Siberian platform, within the upper part of the Mayan Stage. The *L. laevigata* Zone and lower part of the

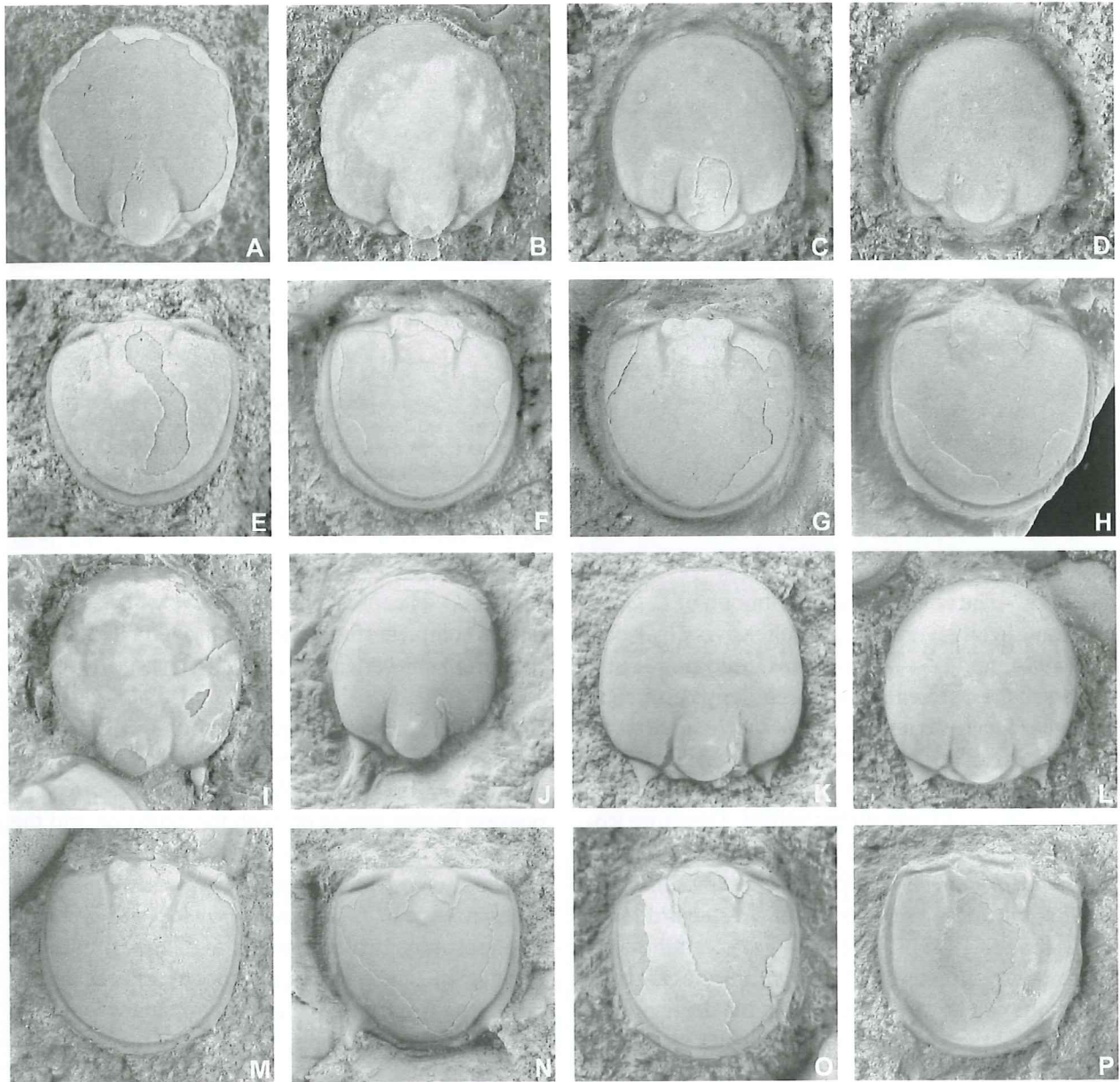


Fig. 6. All specimens from the *Lejopyge laevigata* Zone in the Gudhem quarry in the Falbygden area, Västergötland. A-H. *Lejopyge laevigata* (Dalman, 1828). A, cephalon; x8. B, cephalon; x8. C, cephalon; x7. D, cephalon; x7. E, pygidium; x8. F, pygidium; x7. G, pygidium; x8. H, pygidium; x8. I-P. *Lejopyge armata* (Linnarsson, 1869). I, cephalon; x7. J, cephalon; x7. K, cephalon; x7. L, cephalon; x7. M, pygidium; x7. N, pygidium; x7. O, pygidium; x8. P, pygidium; x7.

Komagnostus simplex Zone in Kazakhstan also correlate with the Swedish *L. laevigata* Zone (Daily & Jago 1975; Robison 1988).

Systematic palaeontology

Terminology. - The morphological terms used are those advocated by Kaesler (1997) and Shergold et al. (1990, pp. 8-16, figs. 1-6). In the description of the bradoriid, *Anabarochilina primordialis*, morphological terms for ostracods are used. The classification of the agnostids follows Kaesler (1997) and Shergold et al. (1990).

Repository. - Discussed and illustrated specimens are deposited at the Department of Geology, University of Lund.

Class Trilobita Walch, 1771
 Order Agnostida Salter, 1864
 Family Ptychagnostidae Kobayashi, 1939

Genus *Lejopyge* Hawle & Corda, 1847

Lejopyge laevigata (Dalman, 1828)

Fig. 6A-H

Material. - 45 cephalons and 126 pygidia. Several of these are more or less complete. The specimens vary in size.

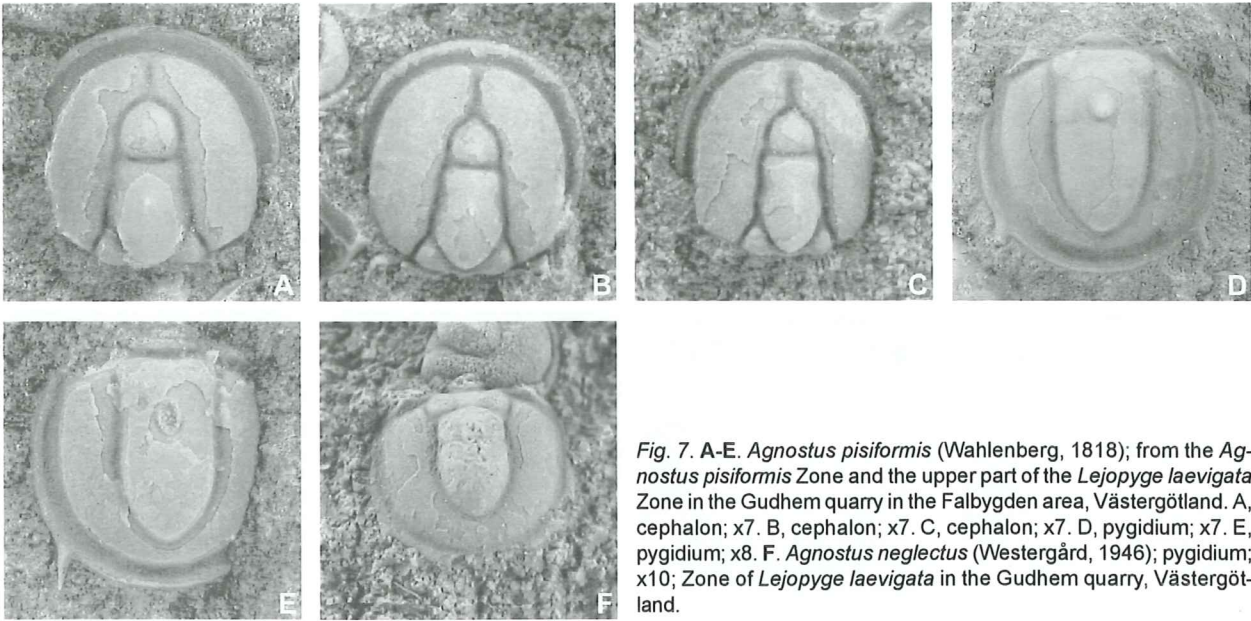


Fig. 7. A-E. *Agnostus pisiformis* (Wahlenberg, 1818); from the *Agnostus pisiformis* Zone and the upper part of the *Lejopyge laevigata* Zone in the Gudhem quarry in the Falbygden area, Västergötland. A, cephalon; x7. B, cephalon; x7. C, cephalon; x7. D, pygidium; x7. E, pygidium; x8. F. *Agnostus neglectus* (Westergård, 1946); pygidium; x10; Zone of *Lejopyge laevigata* in the Gudhem quarry, Västergötland.

Remarks. - The concept and distribution of *L. laevigata* have been reviewed comprehensively by Robison (1984, pp. 42-44). Robison (1984, p. 44) also discussed the differences in morphology between *L. laevigata laevigata* and *Lejopyge laevigata armata*. The subspecies are very similar, but *L. laevigata laevigata* lacks spines on both cephalon and pygidium, while *L. laevigata armata* has spines. Therefore Robison (see also, Shergold 1990; Öpik 1979) treats *L. laevigata armata* as a separate species, *Lejopyge armata*, and not as a subspecies (cf. Westergård 1946; Daily & Jago 1975). There is no great variation between the specimens of *L. laevigata* from Gudhem. Variations can however, be seen in the degree of effacement of the glabella and the furrows on the pygidium.

Occurrence. - *Lejopyge laevigata* Zone in the Gudhem quarry, Västergötland. *L. laevigata* occurs only in level two in section A. In section B it occurs in level two and four (very rare). In section C it occurs in all three levels. Thus, *L. laevigata* appears to range throughout the *L. laevigata* Zone.

According to Robison (1984) *L. laevigata* has been described from the *L. laevigata* Zone in Sweden, Norway, Denmark, China (Zhejiang and Guizhou), Australia (Queensland and Tasmania), USA (Utah, Nevada), North Greenland, Kazakhstan and Uzbekistan, Siberian Platform, ?Canada (Newfoundland). *L. laevigata* (very rare) has also been recognized in the Middle Cambrian-2 fauna from the Hillard Park and the Yukon River areas in east-central Alaska (Palmer 1968).

Lejopyge armata (Linnarsson, 1869)

Fig. 6I-P

Material. - 41 cephalons and 50 pygidia, which are more or less complete (the spines are broken). The size of the specimens varies.

Remarks. - The concept and morphology of *L. armata* have been reviewed by Robison (1984, pp. 39-40). *L. armata* is the only species of *Lejopyge* to possess border spines on both the cephalon and the pygidium. Daily & Jago (1975, pp. 529-532) discussed and concluded that *Lejopyge cos* Öpik 1967 is a synonym of *L. laevigata armata* (= *L. armata*). The morphological variations in *L. armata* are the same as in *L. laevigata* (see above), except that *L. armata* also exhibits a clear variation in the length of the posterolateral spines, both on the cephalon and the pygidium.

Occurrence. - *Lejopyge laevigata* Zone in the Gudhem quarry, Västergötland. *L. armata* occurs in section A in levels two and three (very rare). In section B *L. armata* is present in level two and four, and in section C it is present in all three levels. According to Westergård (1946, p. 89), *L. armata* ranges throughout most of the *Lejopyge laevigata* Zone, and it is very rare in the *Solenopleura brachymetopa* Zone in Sweden. In North America and Greenland, it has been observed only in association with faunas from the upper *L. laevigata* Subzone (Robison 1984, p. 40). In Australia *L. armata* extends from *Lejopyge laevigata* (II) Zone into the *Acmarrhachis quasivespa* Zone. The boundary between the Middle and the Upper Cambrian is drawn at a level between faunas containing *L. armata* and *Blackwelderia sabulosa*. In the Siberian Platform, the Middle-Upper Cambrian boundary appears to be drawn between the *L. armata*-*Lomsucaspis alta* Zone, and the *A. pisiformis*-

"*Homagnostus fecundus*" Zone (Daily & Jago 1975).
L. armata also occurs in China (Robison 1984).

Lejopyge sp.

Material. - Hundreds of specimens.

Remarks. - The pygidial border and the posterior border on the cephalon are incomplete or not visible. It is therefore difficult to see if posterolateral spines are present or not, and to separate between *Lejopyge laevigata* and *Lejopyge armata*.

Occurrence. - *Lejopyge* sp. is present in section A in level two and three, and in section B in level two, three and four. Several specimens in section B, particularly in level four are deformed due to compression. *Lejopyge* sp. was also found in section C in all three levels, and in the Quarternary deposits above level one in section four.

Family Agnostidae M' Coy, 1849

Genus *Aagnostus* Brongniart, 1822

Aagnostus pisiformis (Wahlenberg, 1818)
Fig. 7A-E

Material. - Hundreds of more or less complete specimens in varying sizes.

Remarks. - *A. pisiformis* must be one of the most described and discussed agnostids. Material from Västergötland has been comprehensively described and discussed by Müller & Walossek (1987).

Occurrence. - In the quarry at Gudhem, it occurs in the upper part of the *Lejopyge laevigata* Zone (rare) and in the *Aagnostus pisiformis* Zone (abundant). *A. pisiformis* occurs in level one and two in sections A and B. In section C it is found in level one and three (very rare).

A. pisiformis has been described from Sweden, Norway, Denmark, Great Britain (Outwoods Formation), and eastern Canada; *Lejopyge laevigata*-*Aagnostus pisiformis* Zones; Siberia, *Aagnostus pisiformis*-*Homagnostus fecundus* Zones (Rushton 1978).

Aagnostus neglectus Westergård, 1946
Fig. 7F

Material. - Four complete/nearly complete pygidia.

Remarks. - The pygidium of *A. neglectus* is similar to that of *Aagnostus pater*, and it can be difficult to separate them apart. The pygidial axis in *A. neglectus* is narrower than in *A. pater*. Furthermore, the posterior axial lobe in *A. neglectus* is more pointed than in *A. pater*. The Gudhem material of *A. neglectus* shows, however, that the posterior lobe varies in shape. Westergård (1946, p. 85, pl. 13, figs. 7-9) gave a diagnosis of the species and discussed its affinities.

Occurrence. - In the *Lejopyge laevigata* Zone in the Gudhem quarry, *A. neglectus* occurs in section B in level two, and in section C in level one and three. According to Westergård (1946, p. 85) *A. neglectus* occurs in the upper part of the *Lejopyge laevigata* Zone. It is also present, although very rare, in the *Solenopleura brachymetopa* Zone (Westergård 1946). It has been recorded from Västergötland, Scania and Närke. *A. neglectus* has not been identified outside Sweden (Westergård 1946).

Aagnostus pater Westergård, 1930
Fig. 8P

Material. - One complete pygidium.

Remarks. - *A. pater* is quite similar to *Aagnostus pisiformis*, and the only differences observed can be seen on the pygidium. The segmentation of the axis in *A. pater* is more strongly pronounced than in *A. pisiformis*. *A. pater* was briefly described by Westergård (1946, pp. 84-85, pl. 13, figs. 4-6).

Occurrence. - In the lower part of the *Lejopyge laevigata* Zone in the Gudhem quarry, *A. pater* occurs only in section C in level three. According to Westergård (1946, p. 85) *A. pater* occurs also in the Zone of *Solenopleura brachymetopa* in Scania, Öland and Närke (Sweden) and possibly at Bennet Island, north of Siberia.

Family Spinagnostidae Howell, 1935

Genus *Hypagnostus* Jaekel, 1909

Hypagnostus sulcifer (Wallerius, 1895)
Fig. 8I-N

Material. - Hundreds of more or less complete specimens in varying sizes.

Remarks. - *H. sulcifer* has been described by West-

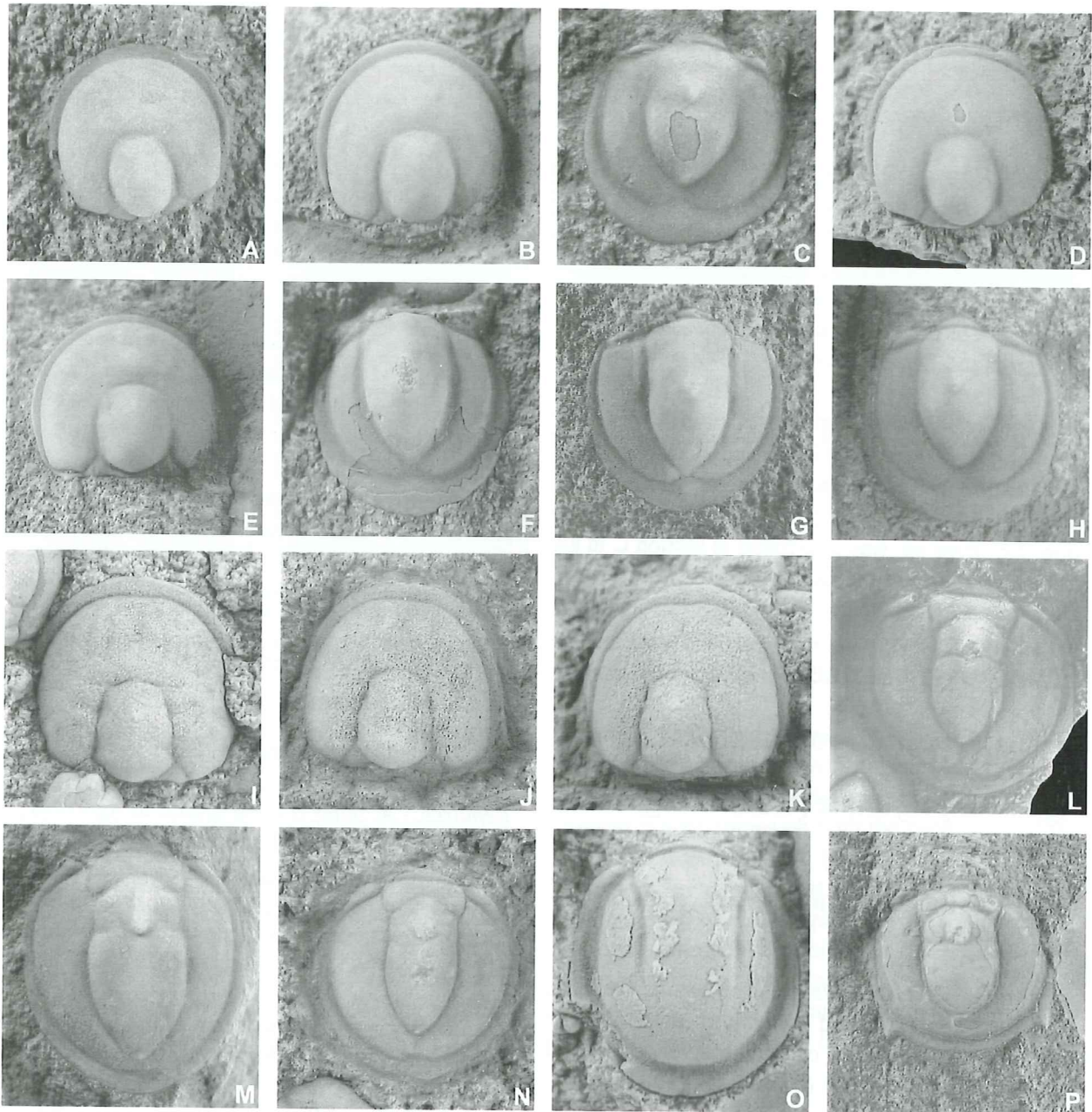


Fig. 8. A-C. *Hypagnostus parvifrons* (Linnarsson, 1869); Zone of *Hypagnostus parvifrons* in the Gudhem quarry in the Falbygden area, Västergötland. A, cephalon; x7. B, cephalon; x9. C, pygidium; x10. D-H. *Hypagnostus mammillatus* (Brögger, 1878); Zone of *Hypagnostus parvifrons* in the Gudhem quarry, Västergötland. D, cephalon; x9. E, cephalon; x7. F, pygidium; x7. G, pygidium; x8. H, pygidium; x12. I-N. *Hypagnostus sulcifer* (Wallerius, 1895); Zone of *Lejopyge laevigata* in the Gudhem quarry, Västergötland. I, cephalon; x9. J, cephalon; x7. K, cephalon; x7. L, pygidium; x7. M, pygidium; x8. N, pygidium; x8. O. *Peratagnostus cicer* (Tullberg, 1880); pygidium; x11; Zone of *Lejopyge laevigata* in the Gudhem quarry, Västergötland. P. *Agnostus pater* (Westergård, 1930); pygidium; x13; Zone of *Lejopyge laevigata* in the Gudhem quarry, Västergötland.

ergård (1946, p.52, pl. 6, figs. 7-17). The specimens from Gudhem are fairly variable. The cephalons range from scrobiculate to smooth. The subspecies *Hypagnostus sulcifer integer* (Wallerius, 1895) differs from the nominal subspecies in having a smoother pygidium. The pygidia of the two subspecies are very similar.

Occurrence. - The species has been found in the *Lejopyge laevigata* Zone (especially in the upper part) in the quarry at Gudhem. *H. sulcifer* occurs in level two in section A (very rare) and B (very abundant),

and in all three levels in section C. *H. sulcifer* has also been found in Östergötland, where it is very rare (Westergård 1946). It has not been identified outside Sweden (Westergård 1946).

Hypagnostus parvifrons (Linnarsson, 1869)

Fig. 8A-C

Material. - One cephalon and three pygidia, which are more or less complete.

Remarks. - The species was discussed by Westergård (1946, p. 45, pl. 4, figs 27-31) and Westrop et al. (1996, pp. 823-824). *H. parvifrons* is very similar to *Hypagnostus mammillatus*, but *H. mammillatus* has a more convex pygidial axis, wider pygidial border and the axial node is more centrally situated. *H. parvifrons* from Gudhem has a fairly wide pygidial border, and in this respect it closely resembles *H. mammillatus*. The two species occurs together, but *H. parvifrons* is not as abundant as *H. mammillatus* in the Gudhem quarry. *H. mammillatus* was previously treated as a subspecies (*H. parvifrons mammillatus*) of *H. parvifrons* (e.g. Westergård 1946).

Occurrence. - It appears in the *Ptychagnostus atavus*/*Tomagnostus fissus* (lower part) Zone and ranges upwards into the *Hypagnostus parvifrons* Zone (Westergård 1946). It is common in the *Hypagnostus parvifrons* Zone. *H. parvifrons* is present in section D in level one in the quarry at Gudhem. Outside Sweden, *H. parvifrons* has been found in Bornholm, Norway, Great Britain and western Newfoundland (Westergård 1946; Westrop et al. 1996).

Hypagnostus mammillatus (Brögger, 1878)

Fig. 8D-H

Material. - Several complete or nearly complete cephalons and pygidia, and numerous fragmentary specimens. The size of the specimens varies.

Remarks. - *Hypagnostus mammillatus* is discussed by Westergård (1946, pp. 45-46, pl. 5, figs. 2-4) and Westrop et al. (1996, p. 824). The differences between *H. mammillatus* and *H. parvifrons* are discussed above under *Hypagnostus parvifrons*.

Occurrence. - *H. mammillatus* is very common in level one in section D in the quarry at Gudhem. The species appears in the zone of *Ptychagnostus atavus*/*Tomagnostus fissus*, and is usually common in the upper part of the *Hypagnostus parvifrons* Zone (Westergård 1946). It ranges upwards into the *Ptychagnostus punctuosus* Zone where it is rare. It has also been identified in Norway, Bornholm and western Newfoundland (Westergård 1946; Westrop et al. 1996).

Hypagnostus sp.

Material. - 10 incomplete pygidia.

Remarks. - The posterior border of the pygidium and

the posteroraxis are generally incompletely preserved, and it is not possible to identify the species.

Occurrence. - The pygidia were found in section D in level one.

Genus *Peratagnostus* Öpik, 1967

Peratagnostus cicer (Tullberg, 1880)

Fig. 8O

Material. - One almost complete pygidium and an internal mould of one pygidium.

Remarks. - Westergård (1946) regarded the species as belonging to the genus *Ciceragnostus*. Recently, it was, however, assigned to *Peratagnostus* because of character transformations during both ontogeny and inferred phylogeny (Robison 1994). The assignment to *Peratagnostus* is based on both juvenile and adult characters, especially those of the pygidium. *P. cicer* is an agnostid species showing greater than usual ontogenetic variability in some features of the pygidium (Robison 1994). The specimens collected from Gudhem are very similar to Robison's (1994) specimens. The Gudhem specimens at hand appear, however, to have slightly more curved pygidial axial furrows and a fainter axial node.

Occurrence. - *Lejopyge laevigata* Zone in the Gudhem quarry, Västergötland. *P. cicer* was only found in level two in section B. According to Robison (1994, p. 68) *P. cicer* is known from Denmark, Sweden, the United States (Skeels Corners Formation, Vermont), China (Hunan and Guizhou), Russia (Siberia) and Greenland (Kap Stanton Formation, Peary Land). The stratigraphic range of *P. cicer* is from the *Ptychagnostus atavus* Zone to the *Lejopyge laevigata* Zone (Robison 1994).

Family Peronopsidae Westergård, 1936

Genus *Peronopsis* Hawle & Corda, 1847

Peronopsis insignis (Wallerius, 1895)

Fig. 9F-H

Material. - 10 more or less complete cephalons and two complete pygidia.

Remarks. - The species was discussed by Westergård (1946, p. 43, pl. 3, figs. 10-15). The pygidium of *P.*

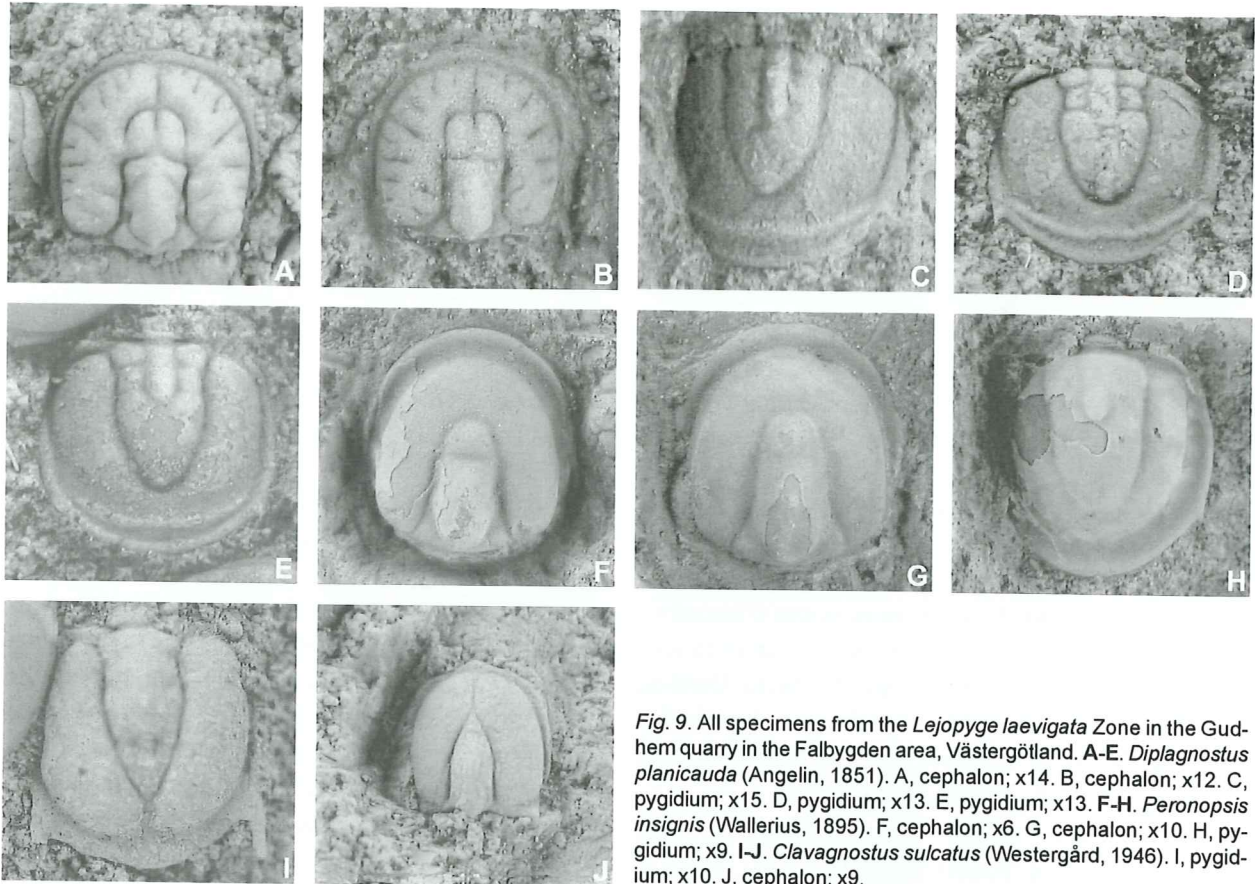


Fig. 9. All specimens from the *Lejopyge laevigata* Zone in the Gudhem quarry in the Falbygden area, Västergötland. A-E. *Diplagnostus planicauda* (Angelin, 1851). A, cephalon; x14. B, cephalon; x12. C, pygidium; x15. D, pygidium; x13. E, pygidium; x13. F-H. *Peronopsis insignis* (Wallerius, 1895). F, cephalon; x6. G, cephalon; x10. H, pygidium; x9. I-J. *Clavagnostus sulcatus* (Westergård, 1946). I, pygidium; x10. J, cephalon; x9.

insignis is similar to that of *Agnostus pisiformis*, but the latter has more distinct axial furrows and longer posterolateral spines.

Occurrence. - Zone of *Lejopyge laevigata* (upper part) in the Gudhem quarry, Västergötland. *P. insignis* occurs in level two in section A and in level one and two in section C. *P. insignis* is known only from Västergötland and has not been identified outside Sweden (Westergård 1946).

Family Diplagnostidae Whitehouse, 1936

Genus *Diplagnostus* Jaekel, 1909

Diplagnostus planicauda (Angelin, 1851) Fig. 9A-E

Material. - 51 cephalons and 31 pygidia. The specimens are complete or nearly complete and vary in size.

Remarks. - *D. planicauda* was discussed by Westergård (1946, pp. 61-63, pl. 8, figs. 13-29). According to Robison (1988, p. 35), *D. planicauda* is a variable species and there is no reason to subdivide the

species into subspecies. Robison (1988, p. 35) noted that "It has been common practice to identify subspecies based on combinations of the variant characters". The Gudhem material of *D. planicauda* has a strongly scrobiculate cephalon and a relatively short pygidial axis, and resembles material previously assigned to the subspecies *Diplagnostus planicauda vestgothicus* (Wallerius, 1895) (see Westergård 1946, pp. 62-63, pl. 8, figs. 25-29). The specimens from Gudhem are similar in morphology and no apparent variation can be observed.

Occurrence. - *Lejopyge laevigata* Zone in the Gudhem quarry, Västergötland. The species has been found in level two in sections A and B. In section C *D. planicauda* is present in all three levels. *D. planicauda* is widely distributed and known from Scandinavia, Australia, China, Greenland, USA (Nevada and Utah), the former Soviet Union and Argentina? (Robison 1988). It ranges from near the base of the *Ptychagnostus punctuosus* Zone to near the top of the *Lejopyge laevigata* Zone (Robison 1988, p. 35).

Family Clavagnostidae Howell, 1937

Genus *Clavagnostus* Howell, 1937

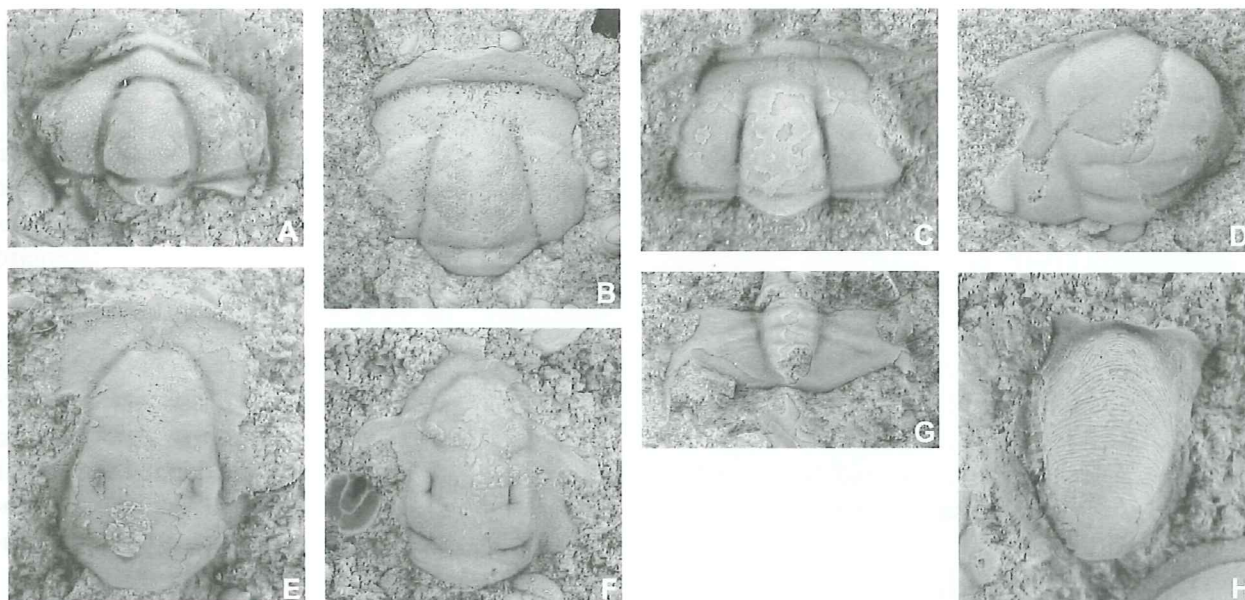


Fig. 10. A. *Acrocephalites stenometopus* (Angelin, 1851); cephalon; x4; Zone of *Lejopyge laevigata* in the Gudhem quarry, Västergötland. B. *Nerica* cf. *septemdentata* (Westergård, 1948); cephalon; x1.1; Zone of *Lejopyge laevigata* in the Gudhem quarry, Västergötland. C. *Andrarina costata* (Angelin, 1854); cephalon; x6; Zone of *Lejopyge laevigata* in the Gudhem quarry, Västergötland. D. *Paradoxides paradoxissimus* (Wahlenberg, 1818); cephalon; x5; Zone of *Hypagnostus parvifrons* in the Gudhem quarry, Västergötland. E-G. *Proceratopyge conifrons* (Wallerius, 1895); Zone of *Lejopyge laevigata* in the Gudhem quarry, Västergötland. E, cephalon; x5. F, cephalon; x5. G, pygidium; x5. H. *Dorypyge* cf. *aenigma* (Linnarsson, 1869); hypostome; x10; Zone of *Lejopyge laevigata* in the Gudhem quarry, Västergötland.

Clavagnostus sulcatus Westergård, 1946
Fig. 9I-J

Material. - Three cephalons and one pygidium. They are almost complete, but the spines are incompletely preserved.

Remarks. - *C. sulcatus* has long posterolateral spines on both the pygidium and the cephalon. It differs from other species of *Clavagnostus* in that the anterior cephalic margin is pointed (Jago & Daily 1974). *C. sulcatus* has been discussed by Westergård (1946, p. 57, pl. 4, figs. 23-26) and Jago & Daily (1974, pp. 95-102)

Occurrence. - *Lejopyge laevigata* Zone (upper part) in the Gudhem quarry, Västergötland. *C. sulcatus* was found in level two in sections A and B. It is very rare in Västergötland (Westergård 1946). *C. sulcatus* is probably present also in northwest Siberia (Jago & Daily 1974).

Order and family uncertain

Genus *Toxotis* Wallerius, 1895

Toxotis pusilla Wallerius, 1895

Material. - Fragments from two cephalons and internal moulds of four pygidia.

Remarks. - *T. pusilla* is the smallest non-agnostidean trilobite found in the Gudhem quarry. The length of the cephalon and the pygidium is only about 1.0 mm, and the width is 1.5-2.0 mm. Distinctive feature is the presence of three bosses in the anterior part of the cephalon. The pygidial axis consists of five rings. *T. pusilla* is further discussed by Westergård (1948, p. 23, pl. 3, figs. 17-21) and Wallerius (1895, pp. 59-61).

Occurrence. - *Lejopyge laevigata* Zone (upper part) in the Gudhem quarry, Västergötland. *T. pusilla* occurs in level two in section B and in level one in section C. *T. pusilla* has not been identified outside Västergötland (Westergård 1948).

Order Ptychopariida Swinnerton,
1915
Family Solenopleuridae Angelin,
1854

Genus *Acrocephalites* Wallerius, 1895

Acrocephalites stenometopus (Angelin,
1851)

Fig. 10A

Material. - One incomplete cephalon and some fragmentary cephalons.

Dimensions (mm). - Maximum length of cephalon = 5.3 (almost complete); maximum width of cephalon = 7.5 (incomplete); maximum and minimum width of glabella = 3.0 respectively 2.1 (complete); maximum length of glabella = 3.9 (complete).

Remarks. - The species was described and discussed by Westergård (1948, pp. 19-20, pl. 2, figs 9-13).

Occurrence. - *A. stenometopus* occurs in the *Lejopyge laevigata* Zone in the Gudhem quarry, Västergötland. It is identified in level two in section B, and in level one and three in section C. *A. stenometopus* has been described from Scania, Öland and Närke, but not outside Sweden (Westergård 1948).

Family Andrarinidae Raymond, 1937

Genus *Andrarina* Raymond, 1937

Andrarina costata (Angelin, 1854)

Fig. 10C

Material. - One incomplete cephalon.

Remarks. - The species was discussed by Westergård (1948, pp. 14-15, pl. 4, figs. 1-4).

Occurrence. - In a loose boulder in the Quarternary layer above section D (*Hypagnostus parvifrons* Zone) in the Gudhem quarry, Västergötland. According to Westergård (1948), *A. costata* is restricted to the *Lejopyge laevigata* Zone. *A. costata* has also been identified in the same zone in Norway (Westergård 1948).

Family Marjumiidae Kobayashi, 1935

Genus *Nericia* Westergård, 1948

Nericia cf. *septemdentata* (Westergård, 1948)

Fig. 10B

Material. - An internal mould of an incomplete cranidium.

Dimensions (mm). - Maximum length of cranidium = 23.0 (almost complete); width of cranidium = 22.0 (incomplete); maximum width of the anterior border = 4.0 (almost complete); maximum length of preglabellar field = 3.5 (complete); maximum and minimum width of glabella = 12.2 respectively 8.0 (complete); maximum length of glabella = 13.5 (complete).

Remarks. - *N. cf. septemdentata* from the Gudhem quarry seems to have a slightly wider glabella than Westergård's cranidium from Gudhem (which is incomplete). For further discussion, see Westergård (1948, p. 17, pl. 4, figs. 10-12 (13?)).

Occurrence. - Zone of *Lejopyge laevigata* in the Gudhem quarry, Västergötland. *N. cf. septemdentata* occurs only in level two in section B. According to Westergård (1948) it is only found in the upper part of the *Lejopyge laevigata* Zone at Gudhem. *N. septemdentata* is extremely rare and it has not been identified outside Sweden (Westergård 1948).

Order Asaphida Salter, 1864

Family Ceratopygidae Linnarsson, 1869

Genus *Proceratopyge* Wallerius, 1895

Proceratopyge conifrons Wallerius, 1895 Fig. 10E-G

Material. - Three incomplete cephalon (only the glabella, the preglabellar field and the anterior border), two almost complete pygidia, and some very fragmentary specimens.

Remarks. - The species was further discussed by Westergård (1948, pp. 5-6, pl. 1, figs. 7-16) and Jago (1987, pp. 221-222).

Occurrence. - In the upper part of the *Lejopyge laevigata* Zone in the Gudhem quarry, Västergötland. *P. conifrons* occurs in level two in section B, and in level one in section C. It has only been found in Västergötland, Sweden (Westergård, 1948) and in south-west Tasmania (Jago 1987).

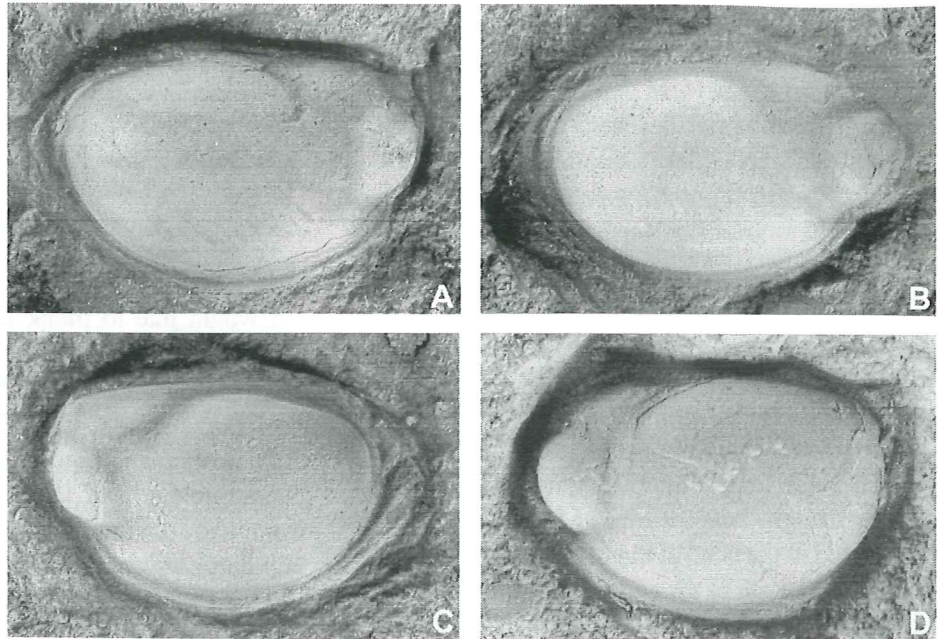
Order Corynexochida Kobayashi, 1935

Family Dorypygidae Kobayashi, 1935

Genus *Dorypyge* Dames, 1883

Dorypyge cf. *aenigma* (Linnarsson, 1869) Fig. 10H

Fig. 11. A-D. *Anabaroichilina primordialis* (Linnarsson, 1869); Zone of *Lejopyge laevigata* in the Gudhem quarry in the Falbygden area, Västergötland. A, right valve; x6.5. B, right valve; x7.5. C, left valve; x6.5. D, left valve; x6.5.



Material. - One complete hypostome.

Remarks. - A detailed description of *D. aenigma* was given by Westergård (1948, pp. 7-9, pl. 2, figs. 1-8). The hypostome at hand is similar to a hypostome illustrated by Westergård (1948, pl. 2, fig. 7).

Occurrence. - The hypostome was found in level two in section B (the *Lejopyge laevigata* Zone) in the Gudhem quarry, Västergötland. According to Westergård (1948) *Dorypyge aenigma* is known only from the *Solenopleura brachymetopa* Zone of Västergötland (infrequent) and Scania (very rare).

Order Redlichiida Richter, 1932
Family Paradoxididae Hawle & Corda, 1847

Genus *Paradoxides* Brongniart, 1822

***Paradoxides paradoxissimus* Wahlenberg, 1818**

Fig. 10D

Material. - One incomplete cephalon.

Remarks. - *P. paradoxissimus* was briefly discussed by Westergård (1953, pp. 34-35, pl. 8).

Occurrence. - *Hypagnostus parvifrons* Zone in the Gudhem quarry, Västergötland. It occurs in level one in section D. According to Westergård (1953) it is present in the *Ptychagnostus (Triplagn.) gibbus*, *Tomagnostus fissus*/*Ptychagnostus atavus* and

Hypagnostus parvifrons Zones. *P. paradoxissimus* has also been recorded from Bornholm, Norway, and probably England.

Class uncertain
Order Bradoriida Raymond, 1935
(nom. correct. Ivanov 1960)
Family Svealutidae Öpik, 1968

Remarks. - To the family Svealutidae belong four genera with nine known species. These species are considered to have been pelagic (Hinz-Shallreuter 1993). According to Siveter & Williams (1997) and Williams & Siveter (1998) the family Svealutidae comprises bradoriids which are 2-10 mm long, elongate and subamplete to postplete. The dorsal margin is straight or gently curved anterodorsally and the hinge-line is well developed. The carapace has up to

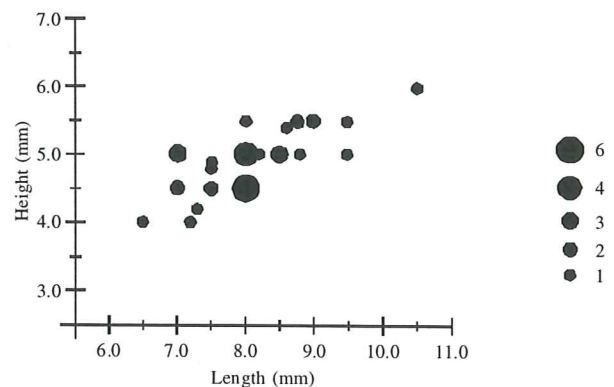


Fig. 12. Length/height diagram of the bradoriid arthropod, *Anabaroichilina primordialis*. The size of the black dots indicates the number of specimens (from 1 to 6).

three, mid-anterior to anterodorsally placed nodes (Williams & Siveter 1998).

Genus *Anabarochilina* Abushik, 1960

Anabarochilina primordialis (Linnarsson, 1869)

Fig. 11A-D

Material. - Several complete isolated valves and hundreds of fragmentary valves.

Description. - The carapace is medium to large (about 6.5-10.5 mm long; Fig. 12), equivalved and amplete with a straight hinge-line. The maximum convexity is situated in the central to postero-central region. The maximum length of the carapace is between mid-dorsal and the median. The free margin is smoothly convex, except for the angular posterior end and the straight dorsal part. The marginal furrow follows around the entire valve, also at the dorsal margin. The furrow has the same width around the carapace except from the broader postero-central part. The lobation is restricted to the anterior part of the valve and consists of two nodes, the smaller and flatter anterodorsal triangular node, which varies from very weak to clearly visible, and the larger subglobose node. The latter node is placed antero-centrally and may extend above the anterior margin. The sulcus varies from just a small depression in the anterodorsal part to a longer depression, which extends from the anterodorsal part towards the nodes and separates them more clearly. *A. primordialis* is further discussed by Hinz-Shallreuter (1993, pp.433-435), Rushton (1978, pp. 278-279) and Williams & Siveter (1998).

Occurrence. - The *Lejopyge laevigata* Zone in the Gudhem quarry, Västergötland. *A. primordialis* occurs in all levels in section A (level one is uncertain, only fragments) and C, while in section B it is only found in level two. Wallerius (1930) distinguished between two beds in the *Lejopyge laevigata* Zone, the basal *Primordialis* bed (with *A. primordialis*) and the overlying *Exsculptus* bed. The name of the *A. primordialis* bed was not satisfactory, because *A. primordialis* occurs almost throughout the entire *Lejopyge laevigata* Zone. The trilobite *Loganellus costatus* occurs in the basal part of the *Lejopyge laevigata* Zone and is very rare in the *Exsculptus* bed. This appears to be a better index fossil for the basal part of the *Lejopyge laevigata* Zone in the Falbygdén area. According to Hinz-Schallreuter (1993) and Williams & Siveter (1998), *A. primordialis* is also

found in the lower part of the Mancetter Formation (*Lejopyge laevigata* Zone) in the Nuneaton area in England and from the Middle Cambrian (*Lejopyge laevigata* Zone; erratic material) in the northern part of Germany.

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