The Ordovician trilobite faunas of the Builth–Llandrindod Inlier, central Wales. Part III

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Contents

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Synopsis

This paper, third in a series describing the Ordovician trilobite faunas of the Builth–Llandrindod inlier, describes representatives of the families Cyclopygidae, Asaphidae, Nileidae, Odontopleuridae and Proetidae. *Emmrichops* ? *extensus*, *Pricyclopyge wattisoni*, *Nobiliasaphus powysensis*, *Barrandia expansa* *Barrandia ultima* and *Homalopteon murchisoni* are described as new. A lectotype for *Ogygiocarella angustissima* (Salter) is selected.

Terminology

The terminology used is that of Harrington, Moore & Stubblefield (*in* Moore 1959) with, in addition, a few terms introduced since that date and two proposed here. The new terms introduced by Marek (1961) for the description of cyclopygids have not been adopted as the standard terms in use are believed adequate. Richter & Richter's (1940) 'greek letter' terminology for the path of the facial suture is used in the definition of some of the measurements taken on asaphids and nileids.

The following new terms are proposed:

PARATHORACIC SEGMENT — applied to the region of the transitory pygidium having the form of a thoracic segment but still fused into the pygidial exoskeleton (see *Barrandia* and *Homalopteon*).

YOUNG HOLASPIS — applied to individuals having the full number of thoracic segments but not possessing all other holaspid characters. It is preferred to 'meraspis degree 8' (as applied to asaphids) of Whittard (1964 : 260) since the term meraspis excludes forms possessing the adult number of thoracic segments.

The following terms not listed in Moore (1959) are also used:

PARADOUBLURAL LINE — applied to the line on the dorsal surface of the exoskeleton directly above the inner margin of the doublure (Henningsmoen 1960 : 210).

POSTERIOR INDENTATION — applied to the small indentation in the posterior margin of the transitory pygidium in asaphids (Henningsmoen 1960 : 230). As this structure is present in holaspides of certain asaphids (Henningsmoen 1960 : 220; pl. 1, figs 1, 2) this term is preferred to 'larval notch' (Osmolska 1962 : 57).

Definition of measurements

As in earlier parts of this study (Hughes 1969, 1971), the single orientation method of measurements proposed by Shaw (1957) has been followed. In those measurements involving distances between, or to, furrows, the measurements have been taken from the deepest (dorsoventrally) point in the furrow. All measurements are taken from internal moulds except where specifically stated to the contrary. Measurements shown as estimated indicate that measurement was not possible using both defined end points. In width measurements estimates were obtained by the doubling of measurements taken to the sagittal line from one defined end point; in length measurements an estimation was made of the position of one end point by projecting exsagittal features onto the sagittal line. Measurements given to two decimal places are rounded to the nearest 0·05 mm.

Definitions of measurements (see Fig. 1):

A maximum cephalic length – measured in sagittal line.

B glabellar length – measured in sagittal line between anterior of glabella and posterior margin of occipital ring (asaphids only herein).

C prepalpebral length – distance between anterior of cephalon and γ of facial suture, as projected onto sagittal line (asaphids only herein).

C_1 palpebral length – distance between γ and ε of facial suture, as projected onto sagittal line (asaphids only herein).

C_2 postpalpebral length – distance between ε of facial suture and posterior cephalic margin, as projected onto sagittal line.

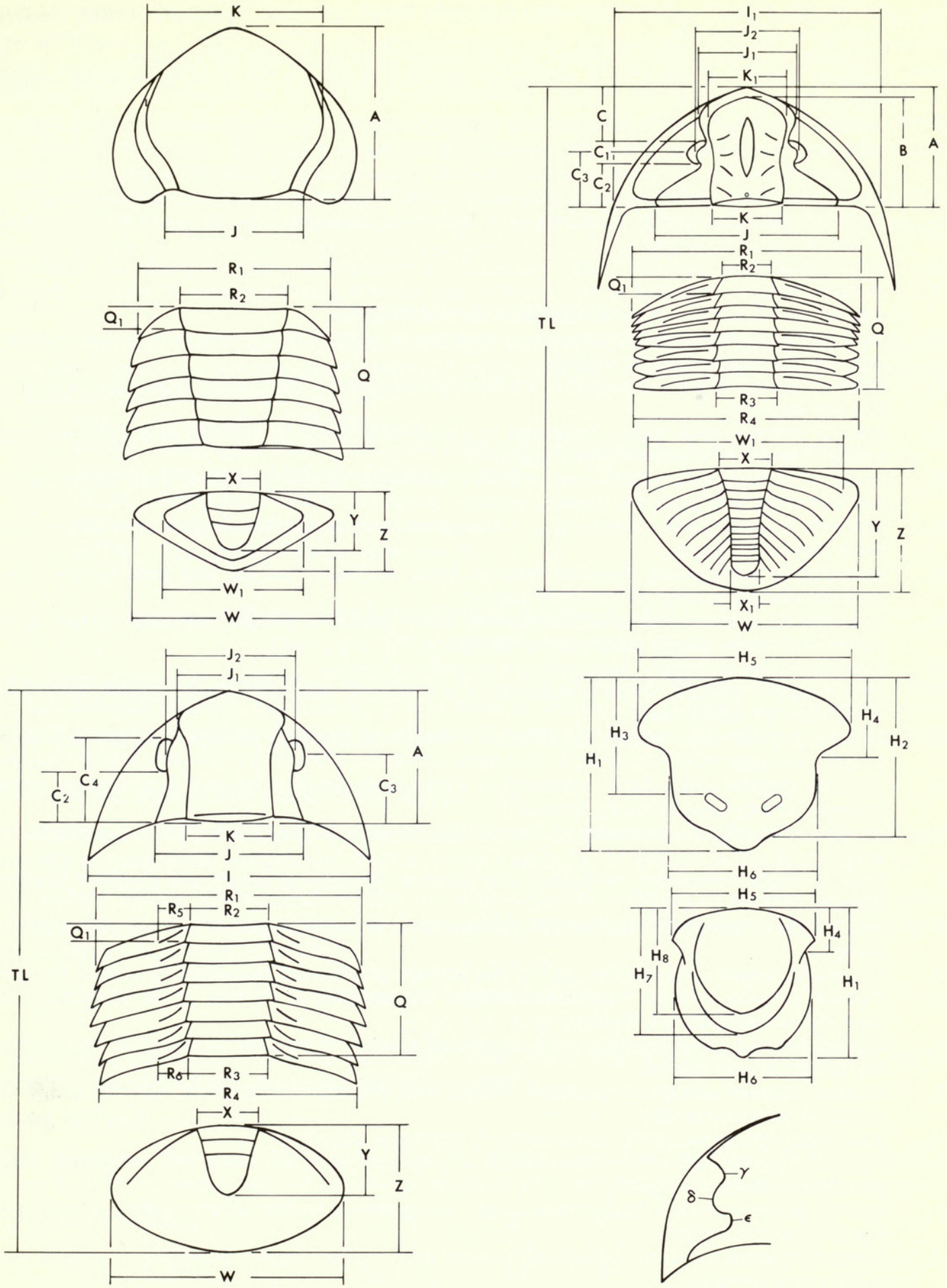

Fig. 1. Diagram showing measurements taken on cyclopygids, ogygids and nileids; also hypostomata and sutural terminology.

C_3 midpalpebral length – distance between δ of facial suture and posterior cephalic margin, as projected onto sagittal line.
I maximum cephalic width – measured in a transverse direction (nileids only herein).
I_1 cephalic width – measured in a transverse direction along line of posterior cephalic margin (asaphids only herein).
J posterior cranidial width – measured in a transverse direction along posterior cephalic margin.
J_1 maximum anterior cranidial width – measured in a transverse direction.
J_2 midcranidial width – measured in a transverse direction between δ of facial suture.
K maximum glabellar width – measured in a transverse direction between axial furrows.
K_1 posterior glabellar width – measured in a transverse direction between axial furrows, along posterior cephalic margin.
K_2 maximum anterior glabellar width – measured in a transverse direction (asaphids only herein).
Q thoracic length – measured in an exsagittal line between anterior margin of anterior thoracic segment and posterior margin of posterior thoracic segment.
Q_1 axial length of anterior thoracic segment – measured in sagittal line between anterior and posterior margins of anterior thoracic segment.
R_1 anterior thoracic width – measured in a transverse direction between lateral extremities of anterior thoracic segment.
R_2 anterior thoracic axial width – measured in a transverse direction between axial furrows, along anterior margin of anterior thoracic segment.
R_3 posterior thoracic axial width – measured in a transverse direction, between axial furrows along posterior margin of posterior thoracic segment.
R_4 posterior thoracic width – measured in a transverse direction between lateral extremities of posterior thoracic segment.
R_5 measured in a transverse direction between inner doublural margin and axial furrow along anterior thoracic margin (nileids only herein).
R_6 measured in a transverse direction between inner doublural margin and axial furrow along posterior thoracic margin (nileids only herein).
W maximum pygidial width – measured in a transverse direction.
W_1 intra-marginal pygidial width – measured in a transverse direction between distal extremities of anterior border furrows.
X anterior pygidial axial width – measured in a transverse direction between axial furrows, along anterior margin.
X_1 posterior pygidial axial width – measured in a transverse direction between axial furrows across posterior of axis (asaphids only herein).
Y pygidial axial length – measured in sagittal line between articulating furrow and posterior of axis.
Z pygidial length – measured in sagittal line between articulating furrow and posterior pygidial margin.
T.L. total length – measured in sagittal line between anterior cephalic margin and posterior pygidial margin.
H_1 hypostomal length – measured in sagittal line between anterior and posterior hypostomal margins.
H_2 distance between anterior hypostomal margin and anterior of median lip as projected onto sagittal line (asaphids only herein).
H_3 distance between anterior hypostomal margin and anterior of maculae, as projected onto sagittal line (asaphids only herein).
H_4 distance between anterior hypostomal margin and posterior extremity of anterior wings, as projected onto sagittal line.
H_5 maximum hypostomal width – measured in a transverse direction.
H_6 posterior hypostomal width – measured in a transverse direction across the maximum width posterior of anterior wings.
H_7 distance between anterior hypostomal margin and posterior border furrow, measured in sagittal line (nileids only herein).
H_8 distance between anterior hypostomal margin and middle furrow, measured in sagittal line (nileids only herein).

Stratigraphy

In earlier parts of this study (Hughes 1969, 1971), the term Llandeilo Series was taken as essentially equivalent to the single assemblage zone of *Glyptograptus teretiusculus*, and beds of low *Nema-*

graptus gracilis Zone age were referred to basal Caradoc Series. Since then, however, Addison (*in* Williams *et al.* 1972 : 35–36) has demonstrated that assemblages indicative of *N. gracilis* Zone age are present in the middle and upper Llandeilo. In this work, therefore, the *G. teretiusculus* Zone is considered to be of lower Llandeilo age and the succeeding beds of basal *N. gracilis* Zone to be of middle and upper Llandeilo age, possibly with the upper horizons being of basal Caradoc age. Thus some beds are assigned an age herein which is different from the usage in my previous papers.

The lithostratigraphical terminology of the region is badly in need of revision; the only available names (e.g. *Glyptograptus teretiusculus* Shales), formalized in Williams *et al.* (1972), though unsatisfactory, are used herein, being the best terms available at present.

Systematic descriptions

Unless otherwise stated, all specimens are in the Department of Palaeontology of the British Museum (Natural History) (registered numbers without prefix, or with prefix I or It). Specimens in other collections are cited as follows:

BU	University of Birmingham
GSM	Geological Survey Museum (Institute of Geological Sciences, London)
NMW	National Museum of Wales, Cardiff
OUM	Museum, Oxford University
SM	Sedgwick Museum, Cambridge
UCW	University College, Aberystwyth

Family **CYCLOPYGIDAE** Raymond, 1925

Genus ***EMMRICHOPS*** Marek, 1961

DIAGNOSIS. Cephalon about twice as wide as long. Eye relatively flat with much of the visual surface directed ventrally. Glabella with three pairs of transversely elongate muscle impressions. Rostral suture not arched downwards. Doublure relatively narrow. Thoracic axis wider than pleural regions; number of thoracic segments unknown. Pygidium unknown.

TYPE SPECIES. *Emmrichops planicephalus* Marek, 1961.

DISTRIBUTION. Dobrotivá Beds (lower Llandeilo) of Czechoslovakia (Marek 1961 : 52) and possibly *Glyptograptus teretiusculus* Shales (lower Llandeilo) of central Wales (herein).

DISCUSSION. Marek (1961) considered the very wide cephalon sufficient to warrant the separation of this genus from *Microparia* Hawle & Corda, 1847, to which he believed it was allied owing to the similarity in cephalic musculature.

Emmrichops ? extensus sp. nov.

(Figs 3, 4, 6, 9)

DIAGNOSIS. Cyclopygid with cranidium much wider than long. Pygidium with concave lateral margins and transversely elongate anterolateral angles.

NAME. 'Dilated'.

TYPE MATERIAL. Holotype, GSM 6142 (Fig. 4), internal mould of pygidium. Paratype, It.2838 (Figs 3, 6, 9), external mould of pygidium and associated internal mould of damaged cranidium.

DIMENSIONS (in mm).	W	X	Y	Z
Holotype	24·7	7·5	6·5	8·4
It.2838	*c.* 14·0	4·0	3·7	5·8

For explanation of symbols see Fig. 1.

TYPE LOCALITY AND HORIZON. The exact locality from which the holotype was collected is uncertain. The specimen is labelled 'Pen Cerrig, Builth' and it is possible that it is from the quarry at the south-western end of Pen-cerig Lake, although collecting at this locality has not yielded

further specimens. The paratype is from exposures in the left bank of the stream section east of Bach-y-graig, 40 yd (37 m) upstream of the point where the footpath enters the wood at the western end of the section. If the holotype is from Pen-cerig, then it is from slightly younger beds than those from which the paratype was recovered, though both lie within the *Glyptograptus teretiusculus* Shales of lower Llandeilo age.

DESCRIPTION. The single known cephalon is compressed, cracked and incomplete, but is clearly very much wider than long. It shows no obvious signs of glabellar furrows or nodes, though faint traces of possible muscle scars are present posteriorly. The preserved eye (right) is well developed; possibly not fused anteriorly with left. Lenses hexagonal except for inner median portion where they are modified to be approximately rectangular (Fig. 9).

Thorax unknown.

Pygidium nearly three times as wide as long, subtriangular with anterior margin gently convex forwards and lateral margins markedly concave (Figs 4, 6). Axis occupying nearly one-third of anterior width tapers gently to the posterior, occupies about four-fifths of pygidial length and terminates obtusely before reaching border furrow. Posterior of axis more clearly defined in holotype than in paratype pygidium where it merges into postaxial field. Anteriorly a single well-defined axial ring is developed with, in the holotype, faint traces of three further rings. Pleural field smooth and inflated. Wide, shallow border furrow present laterally and anteriorly, becoming less well defined posteriorly. Doublure narrow, underlies posterolateral border and bears several subparallel terrace lines.

DISCUSSION. The species is here tentatively assigned to *Emmrichops* mainly on the basis of the very wide cephalon. Whilst it is recognized that the unusual outline of the holotype may be due to *post-mortem* deformation, the symmetry of the specimen together with the relatively small amount of cracking or buckling of the specimen argues against tectonic deformation. The lateral margins of the paratype pygidium are not well preserved but appear to be of the same general form as those of the holotype, though possibly with a slightly smaller anterolateral projection. Although the pygidium of *Emmrichops* has not been described, it is likely to be relatively wide and the pygidium described here is not obviously anomalous when compared to the cephalon of the type species. Of other cyclopygid genera in which the pygidium is known, *Pricyclopyge* possibly exhibits the most similarity. However, the rather unusual outline of *E.* ? *extensus* distinguishes it from all known *Pricyclopyge* species.

Genus ***PRICYCLOPYGE*** R. & E. Richter, 1954

DIAGNOSIS. Cephalon larger than pygidium and somewhat wider than long. Glabella with four pairs of muscle scars. Librigena very small. Eye large, highly convex. Rostral suture, if developed, moderately vaulted upwards. Thorax of six segments. Pygidium subtriangular with distinct axis and border.

TYPE SPECIES. *Aeglina prisca* Barrande, 1872.

DISTRIBUTION. The genus is present throughout Europe in the lower Ordovician (Tremadoc – Llandeilo) and also the Arenig Series of Turkey (Dean 1973). The type species, originally described from the lower Llanvirn of Sarka, Bohemia, has since been recorded from the upper Llanvirn of Bulgaria (Spassow 1958 : 18) and from the Arenig and lower Llanvirn Series of Britain (Whittard 1961 : 177).

DISCUSSION. *Aeglina prisca* Barrande, 1872, designated type species by R. & E. Richter (1954), was considered by Marek (1961) to be conspecific with *Pricyclopyge binodosa* (Murchison, 1859). However, it is here preferred to follow Whittard's later argument (1966 : 287) in favour of considering them as two separate species.

The thoracic and pygidial morphology of *Aspidaeglina* Holub, 1911 is similar to that of *Pricyclopyge* with the exception of the spinose thoracic pleural terminations in *Aspidaeglina*. The cephalon is at present very imperfectly known and further specimens may indicate it to be congeneric with *Pricyclopyge*. *Cyclopyge* Hawle & Corda, 1847 is distinguished from *Pricyclopyge*

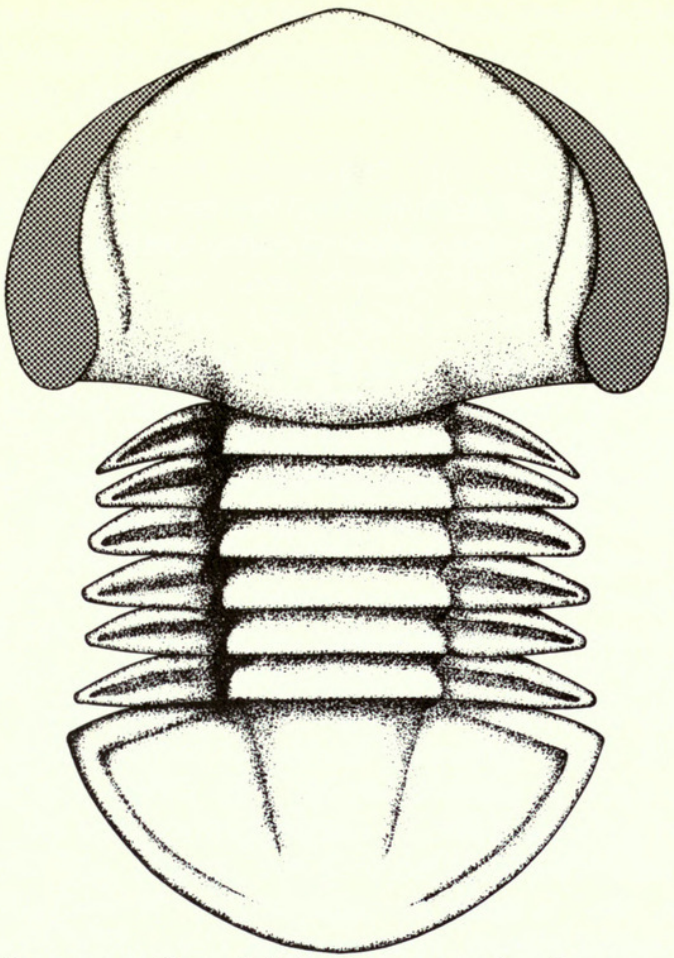

Fig. 2. Reconstruction of *Pricyclopyge wattisoni* sp. nov., *c.* x 3.

by its semicircular pygidium, lack of a large pleural spine on the sixth pleural thoracic segment and by a different configuration of cephalic muscle scars.

Pricyclopyge wattisoni sp. nov.
(Figs 7, 8)

DIAGNOSIS. *Pricyclopyge* with no median glabellar node and somewhat rounded outline to the triangular pygidium; glabellar margins ill-defined posteriorly.

NAME. After the late Mr J. T. Wattison.

TYPE MATERIAL. Holotype, BU 1913 (*ex* Wattison Collection) (Fig. 7), external mould of cranidium and anterior thoracic segment. Paratype, BU 1914 (*ex* Wattison Collection) (Fig. 8), external mould of pygidium.

DIMENSIONS (in mm).	A	J	K		Q_1	R_1	R_2
Holotype	9·5	12·0	10·8		1·6	12·0	6·0
		W	W_1	X	Z		
Paratype		13·0	11·0	4·0	7·4		

For explanation of symbols see Fig. 1.

TYPE LOCALITY AND HORIZON. Both the type specimens are from the *Glyptograptus teretiusculus* Shales in the small quarry at the south-western end of Pen-cerig Lake. This is the only locality from which the species is known.

DESCRIPTION. Cranidium elliptical, consisting almost entirely of large, gently convex, unfurrowed glabella. Cranidium slightly wider than long; posterior margin convex posteriorly. Axial furrow, marked by change of curvature between the flat fixigena and gently convex glabella, gently convex outwards medially; posteriorly indiscernible. Fixigena, present along three-quarters of glabella, very small, forming a narrow palpebral lobe lateral to glabella and expanding slightly

into a small triangular area posterolaterally. Facial suture directed anteromedially at posterior margin, becoming parallel to axial furrow. Occipital furrow very shallow, delimiting a narrow (*sag.*) occipital ring. Posterior border furrow very shallow laterally, merging axially with occipital furrow. Librigena and eye unknown.

Pygidium roundedly subtriangular with continuous border which is less pronounced posteriorly. Axis tapers posteriorly; delimited by axial furrow for only about half pygidial length. Articulating half ring and two axial rings visible, anterior one being the more prominent; pleural field smooth.

DISCUSSION. Both the cranidium and the pygidium probably belong to the same species, if not the same individual, because of their close association on the same slab, compatible size, and the fact that they both appear to be best assigned to *Pricyclopyge*.

The species is distinct from all named species of *Pricyclopyge*, although the pygidium described as 'cyclopygid E' by Whittard (1966: 289; pl. 49, figs 14, 15) may belong to this species. However, the Shelve specimen is more rounded in outline and the axis is better defined. The presence of the median doublural spine in the Shelve specimen is of uncertain significance; the doublure is not known in the Builth specimen. *P. binodosa* (Murchison, 1859) differs in that it possesses a prominent median glabellar node and the cephalic and pygidial furrows are better developed. *P. latifrons* (Tjernvik, 1956), from the Ceratopyge Limestone of Sweden, is perhaps most similar to this new species, but the latter differs in having no well-developed median glabellar node nor any transverse terrace lines. *P. obscura* Marek, 1961 differs from *P. wattisoni* in having an elongate (*sag.*) narrow (*tr.*) glabella, while *P. synophthalma* (Klouček, 1916) is distinguished by its much greater median transverse expansion of the glabella and better-defined axial furrow. *P.* (?) *campestris* Koroleva, 1967 is easily distinguished by the well-developed pygidial axis and the clearly-defined cephalic axial furrow. *P. superciliata* Dean, 1973 from the Sobova Formation of Turkey is distinguished by its relatively long glabella, well-incised axial furrow and relatively wide fixigena.

An internal mould of a thorax, It.2837, is provisionally referred to *P. wattisoni* (Fig. 5) as it occurs with the type specimens of this species at Pen-cerig Lake.

Cyclopygid gen. et sp. indet.
(Fig. 13)

FIGURED SPECIMEN. It.2839, internal mould of pygidium. Dimensions (in mm): W, 4·7. X, 1·4. Y (measurement taken to the posterior extremity of the axial furrow), 1·7. Z, 2·8. For explanation of symbols see Fig. 1.

LOCALITY AND HORIZON. Stream section 15 yd (14 m) SW of the old quarry 350 yd (320 m) west of Maesgwynne, in *Glyptograptus teretiusculus* Shales.

DESCRIPTION. Pygidium small, subsemicircular in outline. Axis occupies just under one-third of the width anteriorly and tapers to the rear. Axial furrow well developed anteriorly, but becomes progressively weaker posteriorly, finally dying out altogether at about three-fifths of the distance to posterior margin. Axis merges without interruption into postaxial field; no postaxial furrow present. One well-developed axial ring present. Pleural field gently convex and has one prominent furrowed rib, the furrow becoming more prominent distally. Anterior border narrow (*sag.*) separated by anterior border furrow. Doublure moderately wide, seemingly about half the length of the postaxial field in width, and bears a series of terrace lines parallel to the margin.

DISCUSSION. This isolated pygidium of lower Llandeilo age is very like *Microparia nudus* Whittard, 1961 and *Microparia* (*Degamella*) *gigantea* (Barrande, 1872) in outline, but differs from both in the nature of the furrowing of the axial and pleural regions.

Family **ASAPHIDAE** Burmeister, 1843
Subfamily **ASAPHINAE** Burmeister, 1843

Genus ***NOBILIASAPHUS*** Přibyl & Vaněk, 1965
[= *Pamirotchechites* Balashova, 1966]

DIAGNOSIS (emended from Přibyl & Vaněk 1965 : 277–278). Like *Opsimasaphus* but differs in that glabella is well defined frontally, and laterally with preglabellar field up to two-fifths of cephalic length. Path of anterior branches of facial suture semicircular, intramarginal, subtending an angle of between 90° and 130° frontally. Glabella clearly furrowed with median tongue-like lobe divided by two transverse furrows, posteriorly deflected adaxially. Three small lateral glabellar lobes and two very faint circular muscle areas present lateral to median lobe. Thoracic segments terminate in short blunt spines. Pygidial outline parabolic with up to 17 axial rings. Axial ring furrows and surface sculpture, posteriorly deflected medially, giving central keel to axis, which may be pointed posteriorly. Pleural field with 14 to 16 ribs. Doublure narrow posteriorly, more concave than in *Opsimasaphus*.

TYPE SPECIES. *Asaphus nobilis* Barrande, 1846.

DISTRIBUTION.The genus ranges from the Llanvirn to Ashgill Series. It is present in the Llanvirn – Caradoc (Soudleyan) of Czechoslovakia (Havlíček & Vaněk 1966 : 41, 55; Kříž & Pek 1972 : 165; Přibyl & Vaněk 1965 : 278; Přibyl & Vaněk 1968 : 192); Llanvirn and ? Llandeilo of Spain (Gil Cid 1972, 1972*a*); middle and upper Llandeilo of Wales (herein); Llandeilo of the Pamir, U.S.S.R. (Balashova 1966, 1968); lower Ordovician of France ? (Racheboeuf 1970); Caradoc of Portugal (Thadeau 1947 : 220) and of Sardinia (Laufeld 1973); ? upper Ordovician of Afghanistan (Pillet & Lapparent 1969 : 326).

DISCUSSION. On erecting *Opsimasaphus*, Kielan (1960 : 75–77) discussed '*Asaphus*' *nobilis*, which had been placed previously in *Pseudobasilicus* by some (Reed 1930 : 308; Jaanusson 1953 : 445), and concluded that its generic attribution remained in doubt. Přibyl & Vaněk (1965) erected *Nobiliasaphus*, type species *Asaphus nobilis*, as a subgenus of *Opsimasaphus*. Subsequently, Balashova (1966) erected *Pamirotchechites*, also with *A. nobilis* as type species. Balashova (1968) later assigned *nobilis* to *Pseudobasilicus* and Gil Cid (1972, 1972*a*) followed this. In 1971, however, Balashova accepted *Nobiliasaphus* and gave it full generic status; this was supported by Kříž & Pek (1972).

A full revision of this group of asaphids is beyond the scope of this paper, but the characteristic rearward kink in the pygidial axial ring furrows, so clearly portrayed by Barrande (1852 : pls 31, 32), in particular would seem to necessitate the rejection of close affinity between *Pseudobasilicus* and '*Asaphus*' *nobilis*. Further, this feature, and the better definition of the glabella, long preglabellar field and greater number of pygidial ribs, appear to be consistent differences between *Nobiliasaphus* and *Opsimasaphus*. It is clear, however, that *Nobiliasaphus* is closely related to *Opsimasaphus*, and it seems inappropriate to continue to place *Nobiliasaphus* in the Pseudoasaphidae of Balashova, 1969; both genera are thus included here in the Asaphidae. The relations of these genera to other asaphids are less clear and although they are placed here in the Asaphinae, both show some similarities to the ogygiocaridinid – niobinid group.

The generic placing of specimens described as *O. radiatus* (Salter, 1866*a*) by Whittington (1966 : 71–78) and Ingham (1970 : 18–19) is not entirely certain due to indifferent preservation.

Nobiliasaphus powysensis sp. nov.
(Figs 10, 14–16, 20)

DIAGNOSIS. Glabella occupies about three-fifths cephalic length. Anterior branches of facial suture widely divergent, becoming very nearly marginal; mid-point of eye about one-fifth of cephalic length from posterior margin. Pygidium subparabolic, axis slender, tapering posteriorly with at least 17 axial rings; anterior width about one-eighth of anterior pygidial width. Pleural field with 14–16 ribs. Border region smooth and moderately wide.

NAME. From Powys, Wales.

TYPE MATERIAL. Holotype: It.13553 (*ex* University College, Aberystwyth, UCW 19451/2) (Figs 15, 16), internal and external moulds of entire specimen. Paratypes: It.2924 (Fig. 20), internal and external moulds of disarticulated specimen consisting of cranidium, pygidium and some thoracic segments. I.2857a, internal mould of large pygidium. It.13554, internal mould of pygidium. It.13555 (Fig. 10), internal and external moulds of pygidium. SM A44731 (Fig. 14), external mould of pygidium and part of thorax.

TYPE LOCALITY AND HORIZON. The holotype is almost certainly from the *Nemagraptus gracilis* Shales, in the middle quarry, Llanfawr, Llandrindod (locality recorded in University of Wales, Aberystwyth, catalogue as ' "quarry near Hospital", Llandrindod Wells'). Paratypes It.13554–5 are from the middle quarry, Llanfawr; It.2924 is, and I.2857a and SM A44731 are most probably, from Gwern-yfed-fâch quarry.

DIMENSIONS (in mm).		A	B	C_1	C_2	J	J_1	J_2	K	
Paratype	It.2924	*c.* 22·5	13·5	*c.* 3·9	2·2	*c.* 30·0	*c.* 22·0	*c.* 16·5	8·0	
		R_1	R_2	Q_1	W	W_1	X	X_1	Y	Z
Holotype	It.13553	*c.* 22·2	5·1	1·2	21·5	16·2	3·0	1·5	10·0	12·7
Paratypes	It.2924	–	–	–	*c.* 42·0	–	5·5	2·3	*c.* 23·0	27·5
	I.2857a	–	–	–	*c.* 108·0	–	16·3	*c.* 7·5	*c.* 69·0	78·0
	It.13554	–	–	–	–	14·2	3·0	1·5	9·9	11·8
	It.13555	–	–	–	26·7	21·8	4·1	1·8	13·2	17·1*
	SM A44731	–	–	–	*c.* 26·4	*c.* 21·4	4·0	1·9	13·9	17·4*

For explanation of symbols see Fig. 1. * – measured on external mould.

DISTRIBUTION. Known only from the two localities yielding the type specimens.

DESCRIPTION. Glabella relatively short, occupying about three-fifths of cephalic length and defined laterally by weak axial furrow, particularly anteriorly; frontally glabella merges into preglabellar

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Figs 3–4, 6, 9. *Emmrichops* ? *extensus* sp. nov., p. 113. Figs 3, 6, 9, Lower Llandeilo, left bank of stream section east of Bach-y-graig, 40 yd (37 m) upstream of the point where the footpath enters the wood at the western end of the section, SO 071610. Figs 3, 9, Paratype. Internal mould of cephalon, It.2838. Fig. 3, ×4; Fig. 9, ×7. Fig. 6, Paratype. Latex impression from external mould of pygidium, It.2838, ×3·5. Fig. 4, Lower Llandeilo, ? small quarry at SW end of Pen-cerig Lake (see p. 113); SO 043541. **Holotype.** Internal mould of pygidium showing well-developed doublure, GSM 6142, ×3.

Fig. 5. ? *Pricyclopyge wattisoni* sp. nov., p. 116. Lower Llandeilo, locality as Figs 7–8. Internal mould of thorax, It.2837, ×4.

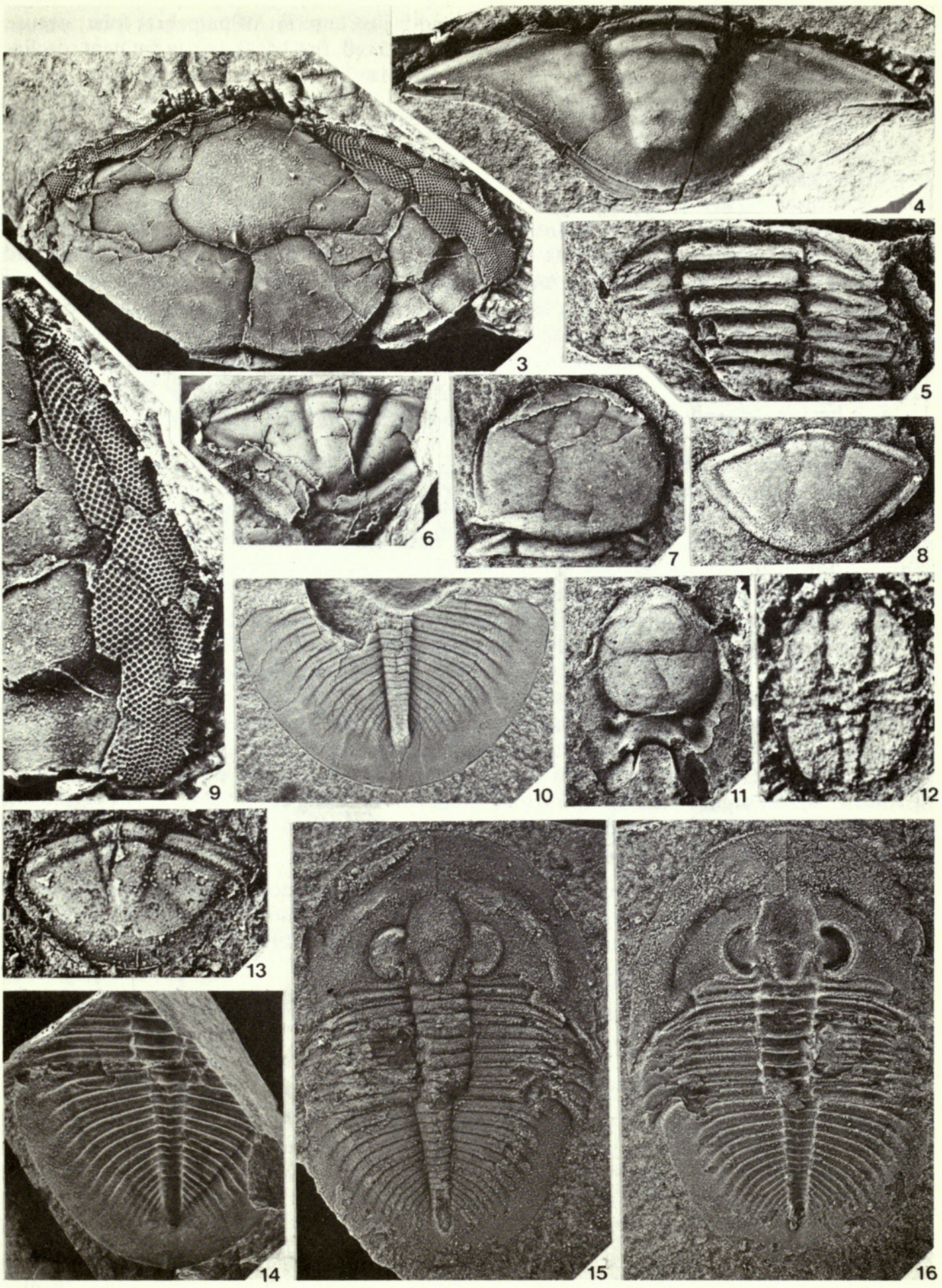
Figs 7–8. *Pricyclopyge wattisoni* sp. nov., p. 115. Lower Llandeilo, small quarry at SW end of Pen-cerig Lake, SO 043541. Fig. 7, **Holotype.** Latex impression from external mould of cranidium, BU 1913 (*ex* Wattison Coll.), ×3. Fig. 8, Paratype. Latex impression from external mould of pygidium, BU 1914 (*ex* Wattison Coll.), ×2·5.

Figs 10, 14–16. *Nobiliasaphus powysensis* sp. nov., p. 117. Fig. 10, Middle-upper Llandeilo, middle quarry, Llanfawr, Llandrindod, SO 066617. Paratype. Internal mould of pygidium, It.13555, ×1·75. Figs 15–16, Middle-upper Llandeilo, ? middle quarry, Llanfawr, Llandrindod (see above), SO 066617. **Holotype.** Internal and external moulds of entire individual, It.13553 (*ex* University College of Wales, Aberystwyth, Collection, UCW 19451, 19452), ×2. Fig. 14, Middle-upper Llandeilo, near Builth Road, Radnorshire (Powys), probably from Gwern-yfed-fâch quarry, ½ ml (805 m) SE of Builth Road station, SO 030526. Paratype. External mould of pygidium showing slight irregularity of rib development, SM A44731, ×2.

Fig. 11. ? *Opsimasaphus* sp. indet. B, p. 121. Lower Llandeilo, small quarry at SW end of Pen-cerig Lake, SO 043541. Mould of dorsal surface of hypostoma, It.2840, ×4.

Fig. 12. Ogygiocaridinid gen. et sp. indet., p. 153. Lower Llandeilo, left bank of stream section east of Bach-y-graig, 40 yd (37 m) upstream of the point where the footpath enters the wood at the western end of the section, SO 071610. Internal mould of meraspid of degree 0, It.2927, ×20.

Fig. 13. Cyclopygid gen. et sp. indet., p. 116. Lower Llandeilo, stream section 15 yd (14 m) SW of the old quarry 350 yd (320 m) west of Maesgwynne, SO 059566. Internal mould of pygidium, It.2839, ×8.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field with only a very shallow preglabellar furrow. A slight, though distinct, constriction of the glabella developed approximately opposite (*tr.*) posterior of palpebral lobe. Anterior to this, glabella expands slightly, attaining its maximum width just anterior of palpebral lobe; obtusely rounded frontally. Lateral glabellar furrows poorly preserved, but basal pair prominent, declined steeply posteromedially commencing just posterior to mid-point of palpebral lobe, and delimiting a posteriorly-tapering, wedge-shaped median lobe, with small median glabellar node at its posterior extremity. A further very weak pair of furrows may be developed just anterior to palpebral lobe and declined posteromedially at about 45° to sagittal line. Occipital furrow continuous; occipital ring distinct, with posterior margin slightly convex posteriorly. Anterior branches of facial suture widely divergent, subtending an angle of about 90° at the sagittal line, and intramarginal frontally. Frontal area large and nearly flat; low median ridge may extend across the frontal area (Figs 15, 16, 20), but may be an artefact of preservation. Palpebral lobe semicircular and more or less flat. Eye large, crescentic; no traces of lenses known. Immediately to the posterior, facial suture is more or less transversely directed and just in front of the posterior border furrow; laterally it is deflected to cut the posterior margin. Posterior border furrow well developed and straight. Posterior border convex and only slightly narrower (*exsag.*) than occipital ring. Librigena smooth, very gently convex, with wide concave border. Genal spine prominent, extending back to fifth thoracic segment. Cephalic doublure slightly wider than border; median suture present frontally.

Thorax approximately rectangular in outline, though it tapers slightly to the posterior. Axial furrows deep, slightly scalloped and converging slightly towards the posterior. Deep apodemal pit developed in the axial furrow at posterior of each segment. Posterior band on the axial rings, anteriorly convex. Pleural furrow commences at inner anterior corner of pleura and directed slightly obliquely to anterior margin, dying out before it reaches the bluntly-pointed, posteriorly directed pleural termination. Doublure probably underlies about one-third of pleural width.

Pygidium subparabolic with slender axis, occupying from one-sixth to one-eighth of pygidial width anteriorly and tapering uniformly to the rear where it is slightly less than half its anterior width. At least 17 axial rings, possibly as many as 20, are developed, with an apodemal pit, most clearly developed anteriorly, present in the axial furrow at posterior of each ring. Pleural field flat, bearing 14–16 well-defined ribs which bear weak furrows. Distally the ribs are deflected posteriorly, the point of deflection occurring at about two-thirds the way along the anterior ribs, moving progressively to about the mid-point on the shorter, more posteriorly placed ribs. SM A44731 shows slight irregularity in rib development on left pleural field. Border region wide with ribs only just extending onto it. Doublure bears terrace lines oblique to the inner margin; inner edge appears to be scalloped.

DISCUSSION. This new species is clearly distinguished from all known species of *Nobiliasaphus* by the much higher number of pygidial ribs. There are also differences in outline of the pygidium and minor differences in cephalic proportions (see Kříž & Pek 1972, 1974).

Genus ***OPSIMASAPHUS*** Kielan, 1960

DIAGNOSIS. See Kielan 1960 : 75.

TYPE SPECIES. *Opsimasaphus jaanussoni* Kielan, 1960.

DISTRIBUTION. The genus ranges from the ? lower Llandeilo to Ashgill Series. It is present in the lower Llandeilo of Wales (?) (herein); the Caradoc of Ireland (Brenchley *et al.* 1967, M. Romano personal communication 1973) and northern Poland (Modlinski 1967); the Ashgill of Bohemia, Poland and Sweden (Kielan 1960), Britain (Ingham 1970) and Kazakhstan (Nikitin *et al.* 1968) and possibly of Quebec (Lespérance 1968); ? the lower Ordovician of France (Racheboeuf 1970).

DISCUSSION. With the relatively recent acceptance of *Nobiliasaphus* as a separate genus many of the reported occurrences of *Opsimasaphus* must remain in some doubt until this whole group of asaphids is revised.

? *Opsimasaphus* sp. indet. A
(Figs 18–19)

FIGURED MATERIAL. It.2925 (Fig. 19), internal mould of incomplete cranidium. Dimensions (in mm): A, 25·5. B, 18·6. J, 39·0. J_1, 28·3. J_2, 22·5. K_2, 14·0. For explanation of symbols see Fig. 1. It.2926 (Fig. 18), fragment of external mould of cranidium.

LOCALITY AND HORIZON. Both figured specimens are from the *Glyptograptus teretiusculus* Shales in the old quarry 570 yd (521 m) north of Wye Cottage.

DESCRIPTION. The single internal mould of an incomplete cranidium shows some similarities to *Nobiliasaphus powysensis*. However, the glabella is relatively longer, occupying nearly three-quarters of the cephalic length, and is relatively wider and much more clearly defined anteriorly. The palpebral lobe bears a distinct furrow. The external mould reveals that at least the frontal part of the glabella bears a sculpture of fine raised ridges lying subparallel to the preglabellar furrow.

DISCUSSION. These two specimens are clearly of the *Opsimasaphus – Nobiliasaphus* type. They are here designated ? *Opsimasaphus* mainly because of the relatively long glabella which is well defined frontally, both of which are features characteristic of *O. jaanussoni*. However, more definite generic assignment must await the discovery of further specimens.

? *Opsimasaphus* sp. indet. B.
(Fig. 11)

FIGURED SPECIMEN. It.2840, mould of dorsal surface of hypostoma.

DIMENSIONS. See Fig. 17.

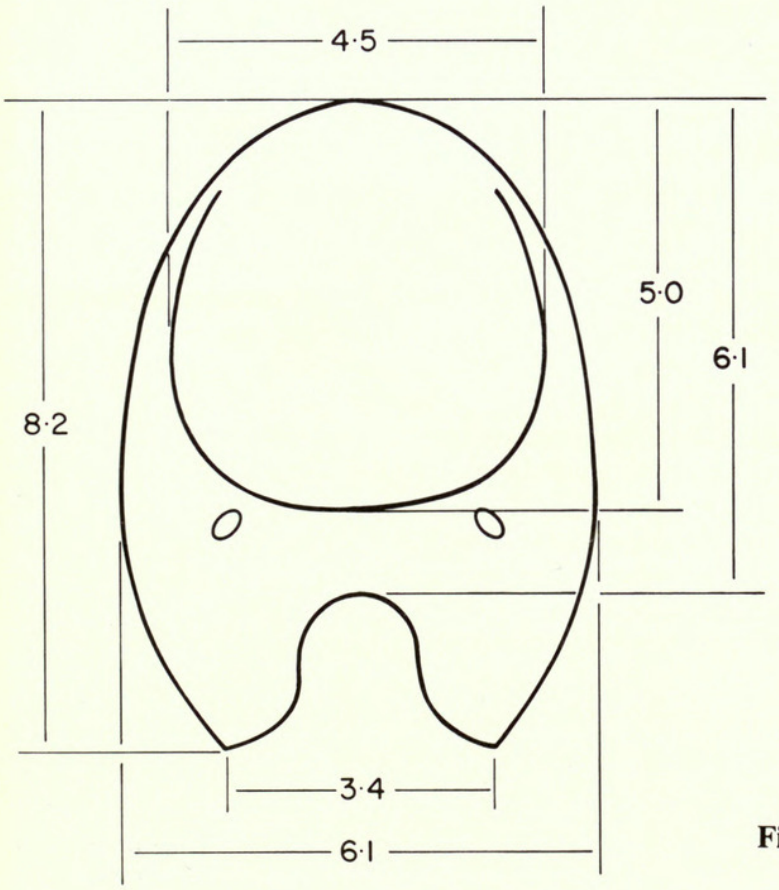

Fig. 17. Diagram showing the dimensions of ? *Opsimasaphus* sp. indet. B.

LOCALITY AND HORIZON. From the uppermost part of the *Glyptograptus teretiusculus* Shales in the quarry at the south-western end of Pen-cerig Lake.

DESCRIPTION. Middle body subcircular, gently convex and not differentiated into anterior and posterior lobes. It is separated from border regions by a clearly-developed border furrow which

is deepest posterolaterally. Lateral border widens posteriorly to reach its maximum width just behind the posterior of the middle body. Posterior border is about two-thirds as long (*exsag.*) as middle body, and deeply notched medially. Prominent circular maculae present, situated at base of the projections of the posterior border.

DISCUSSION. This specimen is clearly similar to the hypostoma of *Opsimasaphus*. The placing of isolated hypostomata is, however, difficult and it is possible that it could belong to other asaphid genera having hypostomata with deeply notched posterior borders. *Opsimasaphus* is preferred to *Nobiliasaphus* as an assignment, because other possible ? *Opsimasaphus* specimens are known from beds of similar age within the Builth region. The hypostoma of *Basilicus* Salter, 1849 shows strong similarities, but the present specimen lacks the anterior wings of that genus.

If the placing of either ? *Opsimasaphus* sp. indet. A or B is correct, the occurrence in the lower Llandeilo is of interest as being the earliest record of the genus.

Subfamily **OGYGIOCARIDINAE** Raymond, 1937

Genus ***OGYGINUS*** Raymond, 1912

DIAGNOSIS. The diagnosis of Whittard (1964 : 245–246) is followed here.

TYPE SPECIES. *Asaphus corndensis* Murchison, 1839.

DISTRIBUTION. The genus is apparently confined to Wales, Salop (Shropshire) and Brittany. Records of the genus from both North and South America (Kayser 1876 : 24; pl. 2, figs 3, 4; Kobayashi 1937 : 495; pl. 5, fig. 9; Rusconi 1950 : 84; Ross 1957 : 494; pl. 42, fig. 7) are very tentative; that of Kayser probably belongs to *Ogygitella australis* Harrington & Leanza (1957 : 142–143) and those of Ross and Kobayashi may be bathyurids and not asaphids. The specimen

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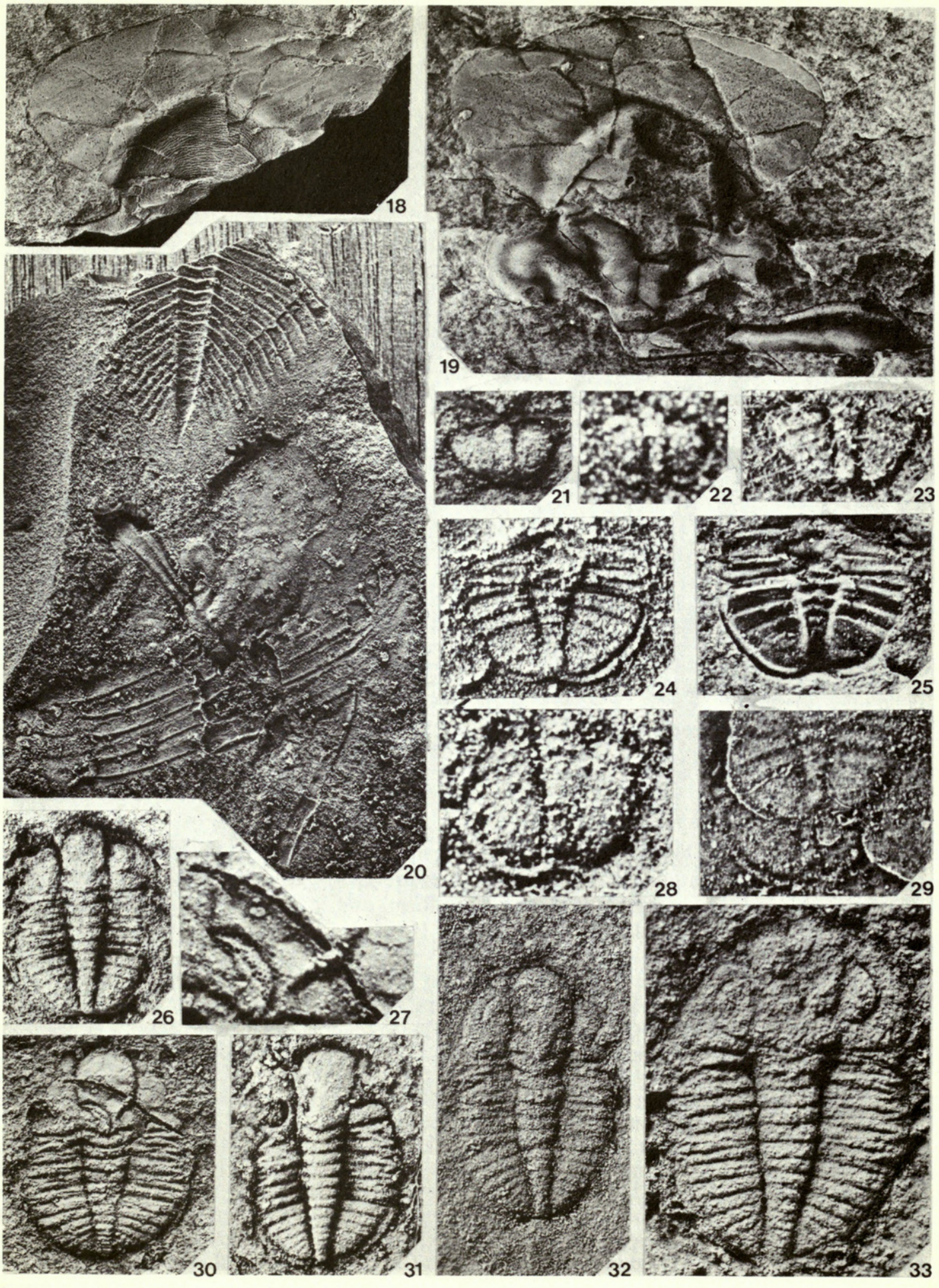
Figs 18–19. ? *Opsimasaphus* sp. indet. A, p. 121. Lower Llandeilo, old quarry 570 yd (521 m) north of Wye Cottage, SO 047538. Fig. 18, external mould of fragment of cranidium showing surface sculpture on glabella, It.2926, ×2. Fig. 19, internal mould of incomplete cranidium, It.2925, ×2.

Fig. 20. *Nobiliasaphus powysensis* sp. nov., p. 117. Middle-upper Llandeilo, quarry at Gwern-yfed-fâch, ½ ml (805 m) SE of Builth Road station, SO 030526. Paratype. Internal mould of cranidium with associated external moulds of thoracic segments and pygidium, It.2924, ×1·5.

Figs 21–33. *Ogyginus corndensis* (Murchison), p. 126. Figs 21, 23, 26, 32–33, Lower Llanvirn, small quarries 600 yd (549 m) east of Upper Gilwern, SO 092582. Fig. 21, internal mould of small meraspid transitory pygidium of unknown degree, It.2849, ×20. Fig. 23, internal mould of transitory pygidium of unknown degree with two pleural ribs and probably two axial rings, It.2875, ×20. Fig. 26, internal mould of entire meraspid of degree 4, showing the single pair of well-developed lateral glabellar furrows and continuous occipital furrow, It.2873, ×10. Fig. 32, internal mould of meraspid of degree 5, showing single pair of lateral glabellar furrows and form of occipital furrow, It.2876, ×10. Fig. 33, internal mould of meraspid probably of degree 6, It.2866, ×10. Figs 22, 31, Lower Llanvirn, eastern end of cliff section on left bank of Camnant Brook, midway between The Court and Pen-dre, SO 088567. Fig. 22, latex impression from external mould of meraspid transitory pygidium of unknown degree, showing trace of one furrow on the left pleural field and a posterior indentation, It.2845, ×20. Fig. 31, internal mould of meraspid of degree 5, with continuous occipital furrow, It.2846, ×10. Figs 24, 28–29, Lower Llandeilo, stream section 15 yd (14 m) SW of the old quarry, 350 yd (320 m) west of Maesgwynne, SO 059566. Fig. 24, latex impression from external mould of meraspid transitory pygidium, showing three pairs of ribs and axial rings and also a prominent posterior indentation, It.2880, ×20. Fig. 28, latex impression from external mould of meraspid transitory pygidium, with two pairs of pleural ribs, It.2863, ×20. Fig. 29, latex impression from external mould of transitory pygidium of unknown degree, It.2864, ×20. Fig. 25, Lower Llandeilo, left bank of stream section east of Bach-y-graig, 65 yd (59 m) upstream of the point where the footpath enters the wood at the western end of the section, SO 072610. External mould of meraspid transitory pygidium of unknown degree, showing two ribs on the left pleural field and three on the right; note also the clear axial furrowing and posterior indentation, It.2881, ×20. Figs 27, 30, Lower Llandeilo, left bank of stream section east of Bach-y-graig, 40 yd (37 m) upstream of the point where the footpath enters the wood at the western end of the section, SO 071610. Internal mould of meraspid of degree 4, showing details of the eye, It.2877. Fig. 27, ×25; Fig. 30, ×10.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referred to *Ogyginus* sp. aff. *corndensis* from the lower Ordovician of South Korea (Kobayashi 1934 : 553; pl. 4, fig. 17) has since been placed in *Birmanites* (Kobayashi 1950 : 527). The genus is known to range with certainty from the lower Llanvirn to the upper part of the lower Llandeilo Series, the occurrence in north-west France being of ? Arenig age (Henry 1971 : 66). The genus may also be represented in the Arenig (? *D. hirundo* Zone) of Whitesands Bay, Dyfed (Pembrokeshire) (see Whittard 1964 : 246).

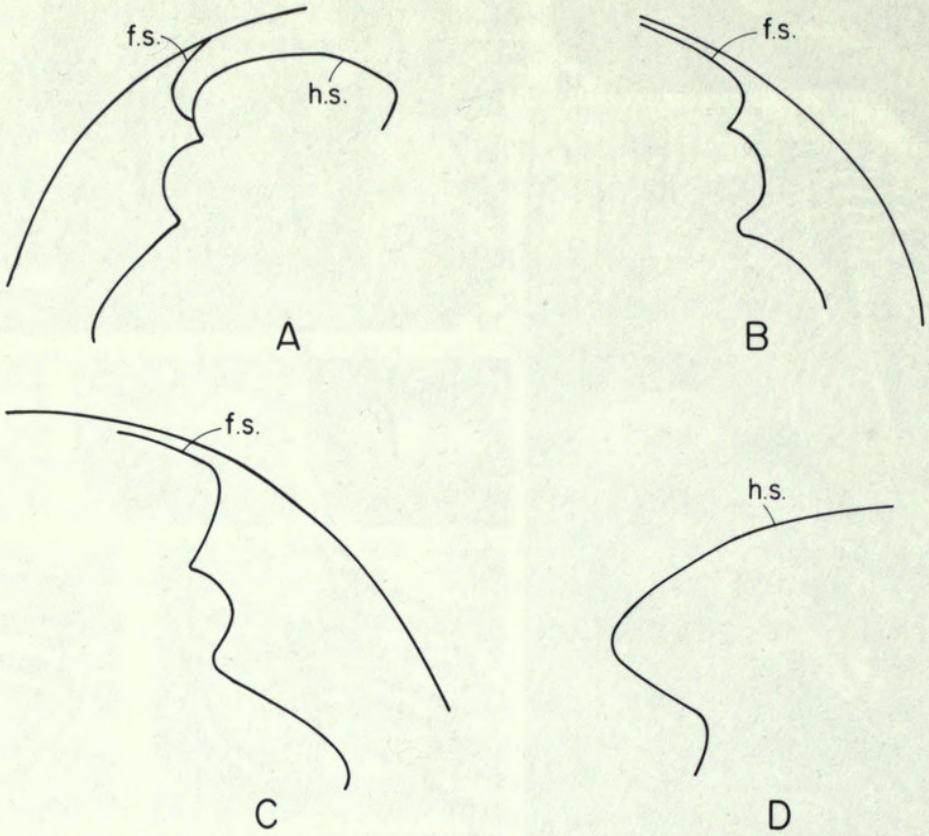

Fig. 34. Diagram showing the position of the anterior branch of the facial suture in *Ogyginus corndensis* (Murchison). A, It.2844 (Fig. 48); B, 59188; C, 59186 (Fig. 52); D, It.2865 (Fig. 58), showing anterior outline of hypostoma. f.s. – anterior branch of facial suture; h.s. – hypostomal suture.

Discussion. Whittard (1964 : 245; pl. 42, fig. 3) believed the facial suture of *Ogyginus* to be marginal and not intramarginal as had been thought previously, though as advocated elsewhere (Hughes 1971*a* : 179) his usage of the terms 'niobiform' and 'isoteliform' to describe the path of the suture anteriorly should be discontinued. However, I suggested (Hughes 1972) that

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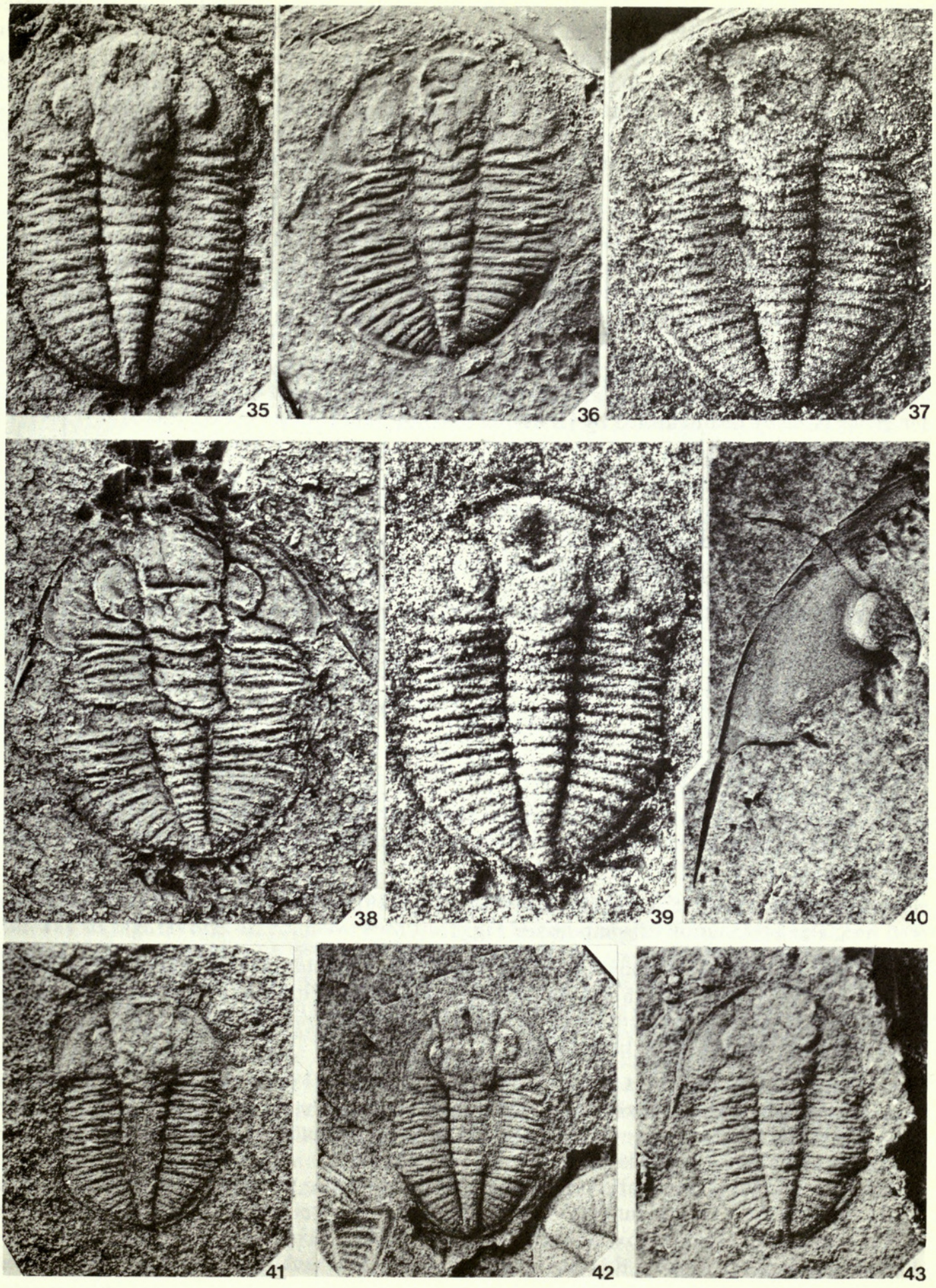
Figs 35–43. *Ogyginus corndensis* (Murchison), p. 126. Figs 35, 37, 39–43, Lower Llanvirn, small quarries 600 yd (549 m) east of Upper Gilwern, SO 092582. Fig. 35, internal mould of meraspid of degree 6, showing slight frontal expansion of glabella and discontinuous occipital furrow, It.2869, ×10. Fig. 37, latex impression from external mould of meraspid of degree 7, showing differentiation of occipital ring into an anterior and posterior region, It.2871, ×10. Fig. 39, internal mould of meraspid of degree 7, with continuous, though medially shallowing, occipital furrow, It.2855, ×10. Fig. 40, internal mould of librigena with eye, It.2870, ×3. Fig. 41, internal mould of smallest known certain holaspis, It.2847, ×5. Fig. 42, internal mould of slightly larger holaspis, It.2854, ×5. Fig. 43, internal mould of still larger holaspis, It.2867, ×5. Fig. 36, Lower Llandeilo, stream section at Wellfield Lodge immediately above where the stream is piped under the road, SO 044528. Internal mould of meraspid of degree 7, with continuous occipital furrow and genal spine extending back to fourth thoracic segment, It.2862, ×10. Fig. 38, Lower Llandeilo, left bank of stream section east of Bach-y-graig, 40 yd (37 m) upstream of the point where the footpath enters the wood at the western end of the section, SO 071610. Internal mould of slightly disarticulated possible holaspis which has retained a continuous occipital furrow; note relatively large eye lenses, It.2878, ×10.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Whittard was mistaken and that the suture was intramarginal as Salter (1866 : 130) originally described. Proof of this is difficult since the anterior portion of the cephalon is rarely well preserved, presumably because the cuticle was thin. However, It.2844 (Fig. 48) shows the anterior branch of the facial suture on the right side to be intramarginal, at least for the greater part of its course. It is believed that Whittard's interpretation (1964 : 250–251) of specimens 59188 and 59186 (see Figs 34, 52) is incorrect and that the position of the suture in these specimens is as Salter originally described. Against this it must be pointed out that specimens GSM 102135–6 (Whittard 1964 : pl. 42, figs 3, 4) indicate that the suture must be very nearly marginal in some individuals.

Even allowing for the reinterpretation of the course of the facial suture, this genus and *Ogygiocarella* Harrington & Leanza, 1957 are clearly closely related. Differences which support the continued separation of the genera include the general lack of anterior glabellar expansion and the more pronounced furrowing in *Ogygiocarella*, together with the lack of spindle-shaped pleural furrows and the zetoidal axial furrow, and the greater number of pygidial ribs and axial rings.

Hoekaspis Kobayashi, 1937, *Megalaspidella* Kobayashi, 1937 and *Ogygiocaris* Angelin, 1854 resemble *Ogyginus* in many ways, as does *Ogygitella* Harrington & Leanza, 1957, though this latter genus is easily distinguished by its deeply notched hypostoma.

Ogyginus corndensis (Murchison, 1839)
(Figs 21–61, 66)

1839 *Asaphus corndensis* Murchison : 663.
1940 *Ogyginus corndensis* (Murchison) mut. *intermedius* Elles (*pars*) : 406, 428–429, 432; pl. 31, fig. 11 only.
1964 *Ogyginus corndensis* (Murchison); Whittard : 250–254; pl. 42, figs 2–8; pl. 43, fig. 1 (includes full synonymy).
1964 *Ogyginus intermedius* Elles; Whittard (*pars*) : pl. 41, fig. 2 only.
1964 *Ogyginus corndensis* (Murchison) var. *septenarius* Whittard : 254; pl. 43, figs 2–4.
1964 *Ogyginus corndensis* (Murchison) var. *novenarius* Whittard : 254; pl. 43, figs 5–11.
1966 *Ogyginus corndensis* (Murchison); Whittard : 302.
1966 *Ogyginus corndensis* (Murchison) var. *septenarius* Whittard; Whittard : 302.
1972 *Ogyginus corndensis* (Murchison); Hughes : 13–15; fig. 6.

DIAGNOSIS. *Ogyginus* with eye situated at or slightly behind the mid-length. Thoracic axial furrows zetoidal except in meraspis. Pygidium with between seven and nine smooth ribs, approximately ten axial rings.

HOLOTYPE. GSM, Geol. Soc. Coll. GSb 4094 (Fig. 49). Dimensions: T.L. *c.* 66.0 mm; I *c.* 50·0 mm. For explanation of symbols see Fig. 1.

DISTRIBUTION. The species is known from the upper Llanvirn and lower Llandeilo of the Shelve area (see Discussion, p. 135). In the Builth region the species first occurs in the upper part of the lower Llanvirn, and is present until the upper part of the lower Llandeilo. The species is at present unknown outside these two regions.

DESCRIPTION. As this species was fully described by Whittard (1964 : 250–255) a full redescription is unnecessary, except for the hypostoma, of which complete examples are here described for the first time. Comment is made only on features where study of the Builth material adds to, or differs from, Whittard's description.

Complete individuals are ovate, having a length : width ratio of about 3 : 2. Although data are only available for a limited number of complete individuals (see Fig. 44) of a sample from east of Upper Gilwern, these show no evidence of distinct wide and narrow forms. Further, the length–width data for 96 pygidia from the same locality fail to show such forms, although as expected some variation is present (see Fig. 56).

Some cephala are slightly more angular anteriorly than others (Figs 48, 52). Three pairs of short, weak lateral glabellar furrows are developed. The anterior pair, rarely preserved, is situated

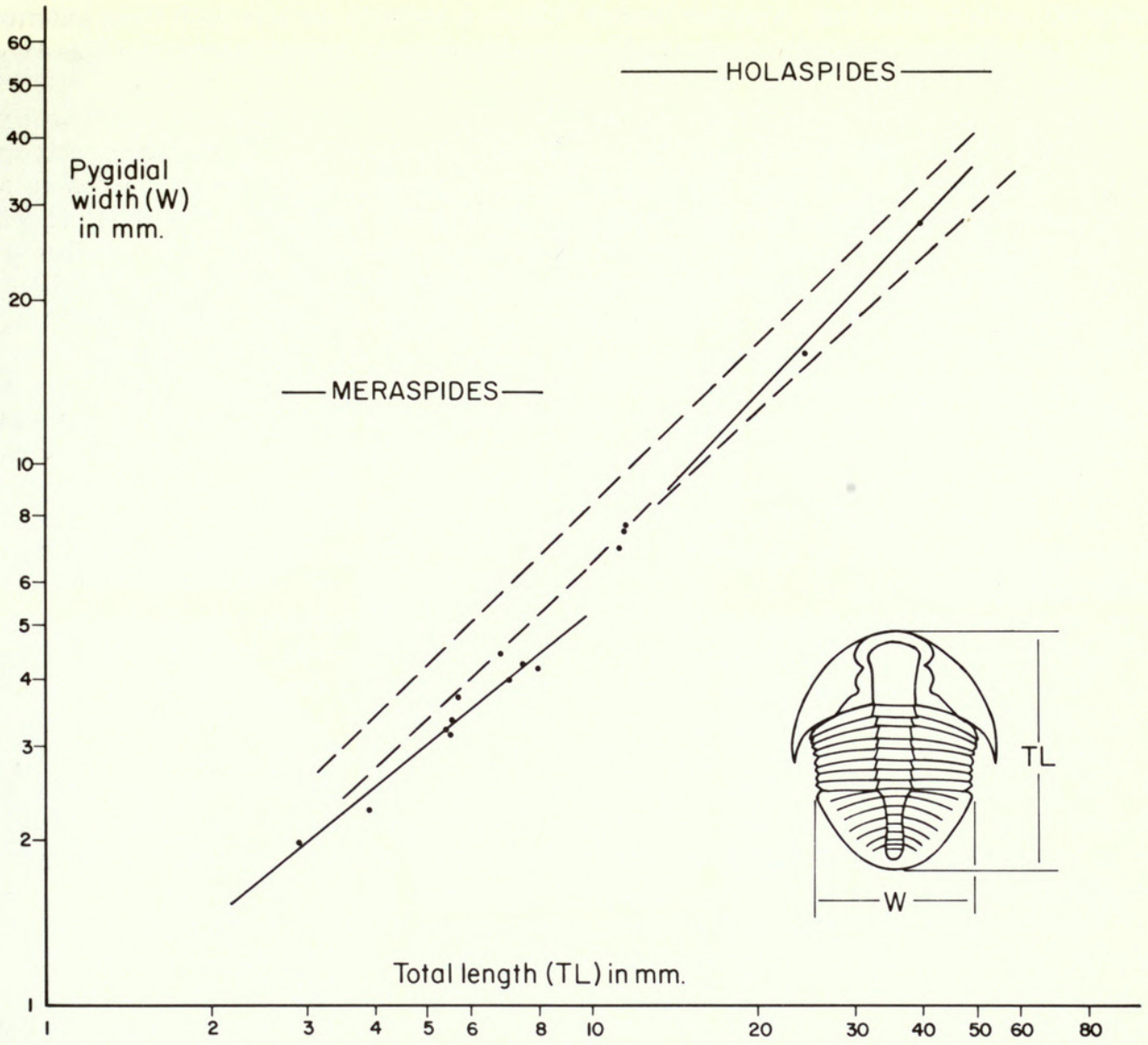

Fig. 44. Graph showing differing regression lines for meraspides and holaspides of *Ogyginus corndensis* (Murchison). The two dashed lines represent total length : width ratios of 6 : 5 and 6 : 4, and illustrate that larger specimens are relatively wider but that distinct 'wide' and 'narrow' forms are not present.

opposite anterior of palpebral lobe and directed slightly anteromedially, and extends about half-way to sagittal line. In common with the other lateral glabellar furrows, abaxial end barely reaches axial furrow (Figs 54, 55). Median pair consists of shorter, transversely-directed furrows situated approximately opposite mid-point of palpebral lobe, extending about half-way to sagittal line and failing to reach axial furrow. Like anterior pair they are rarely preserved. Basal pair most strongly developed and situated opposite posterior of palpebral lobe, being directed posteromedially at between 30° and 40°. They extend slightly further towards sagittal line than do the other two pairs (Figs 54, 55). Lateral occipital lobe virtually isolated by medial convergence of lateral occipital furrow and posterior band furrow (Fig. 55). Immediately anterior to posterior band is a small median glabellar node. On well-preserved internal moulds a low median ridge extends anterior to glabellar node terminating on frontal lobe opposite point where glabella is widest (Figs 55, 61). Posterior border uniform in width and relatively wide, being deflected only very slightly at the fulcrum.

Eye length in young holaspides about one-third of cephalic length; in large specimens eye relatively smaller, the ratio being reduced to about one-fifth. Visual surface approximately crescentic but widens anteriorly (Fig. 40). Eye with up to two thousand hexagonal lenses, situated close to axial furrow, with mid-point between two-fifths and half of cephalic length from posterior margin. Posterior branch of facial suture, immediately posterior to palpebral lobe, makes angle

of about 60° with sagittal line. Anterior branch follows a strongly arcuate path from anterior of palpebral lobe, being convex outwards, but is probably entirely dorsal anteriorly (Fig. 48) (see Discussion, p. 124).

Hypostoma, excluding large anterior wings, slightly longer than wide. Arcuate middle furrow separates oval middle body into distinct anterior and posterior lobes. In all but the largest specimen (Fig. 58), anterior lobe oval, long axis directed sagittally, and separated from anterior wing by distinct though shallow anterior border furrow (Fig. 59). In It.2865, total length 15·5 mm, no border furrow is developed and anterior lobe merges anterolaterally with anterior wing. Posterior lobe crescentic and much shorter (*sag.*), occupying only about one-fifth total length. Prominent maculae developed at anterolateral corner of posterior lobe and characterized by their smooth surface. Posterior margin projects backwards sagittally to form median lip; posterior border furrow wide and shallow. Lateral border well developed, but shoulder not prominent. Lateral notch occurs at just over two-fifths the length from anterior. Both dorsal and ventral surfaces of hypostoma, with exception of maculae, bear widely-spaced terrace lines approximately concentric about mid-point of anterior border, but which become progressively more bowed sagittally posteriorly (Fig. 58). The median ridge on posterior half of the anterior lobe in It.2860 (Fig. 60) is not thought to be an original feature as other moulds of the ventral surface fail to show any such ridge.

Anterior margin of hypostoma abuts directly onto cephalic doublure, which widens to form a process flanking anterolateral margin of the anterior wing (Fig. 59). Median suture connects anterior branches of facial suture to hypostomal suture, all being functional. Posterior margin of hypostoma extends for only a short distance behind posterior of eye (Figs 59, 60); fixigena and hypostoma have been displaced slightly to the rear in the holotype (Fig. 49).

Thorax rectangular; about twice as wide as long. Axis occupies about one-quarter of total width and tapers slightly to the rear in small specimens, but becomes nearly parallel-sided in larger individuals (Fig. 46). In very large specimens tapering is again apparent but restricted to posterior half of axis.

Pygidium becomes relatively slightly longer with increase in length. Only anterior five or six axial rings well marked. Articulating half-ring furrows generally well defined, becoming shallower medially. Axis occupies up to nine-tenths of pygidial length in small specimens (Fig. 47), but in large specimens only about three-quarters (Fig. 52). Pleural field gently convex (*tr.*) with eight or nine smooth, unfurrowed, gently convex ribs. Due to *post-mortem* deformation faint furrows may be developed, particularly on anterior ribs. Irregular or asymmetrical development of ribs is very rare, being known on only four specimens (e.g. Figs 50, 51, 53).

Anterior border deflected slightly to posterior laterally with large articulating facets bearing

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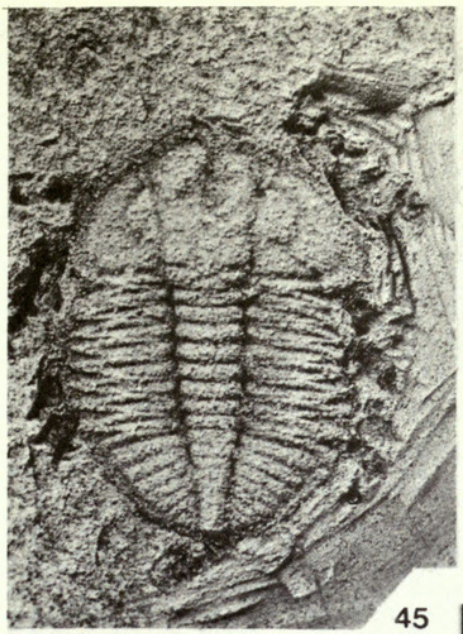
Figs 45–55. *Ogyginus corndensis* (Murchison), p. 126. Figs 45–47, 50–54, Lower Llanvirn, small quarries 600 yd (549 m) east of Upper Gilwern, SO 092582. Fig. 45, internal mould of small holaspis showing general adult form, It.2859, ×5. Fig. 46, internal mould of thorax and pygidium with nine pleural ribs, It.2848, ×1. Fig. 47, internal mould of small pygidium with only seven pleural ribs; note relatively long axis, It.2858, ×6. Fig. 50, external mould of pygidial fragment, showing irregular rib development, It.2857, ×2. Fig. 51, external mould of pygidium, showing incomplete separation of the fifth and sixth pleural ribs on the left pleural field (right side of specimen), It.2872, ×2. Fig. 52, internal mould of nearly complete individual with intramarginal facial suture (see p. 124) and relatively short pygidial axis, 59186, ×⅔. Fig. 53, internal mould of pygidium showing incomplete development of furrow separating sixth and seventh pleural ribs, It.2861, ×2. Fig. 54, latex impression from external mould showing glabellar furrows, It.2850, ×2. Fig. 48, Lower Llandeilo, left bank of stream section east of Bach-y-graig, 80 yd (73 m) upstream of the point where the footpath enters the wood at the western end of the section, SO 072610. Specimen with exoskeleton preserved showing intramarginal facial suture, It.2844, ×2. Fig. 49, Weston Beds, near Middleton, Salop (Shropshire). Holotype. Internal mould of damaged specimen; note weak development of eighth pleural rib. GSM Geol. Soc. Coll. GSb.4094, ×1. Fig. 55, Lower Llanvirn, left bank of stream SW of Gilwern, about 100 yd (91 m) from its source, SO 080581. Internal mould of cranidium showing details of occipital ring and node and median glabellar ridge, It.2842, ×4.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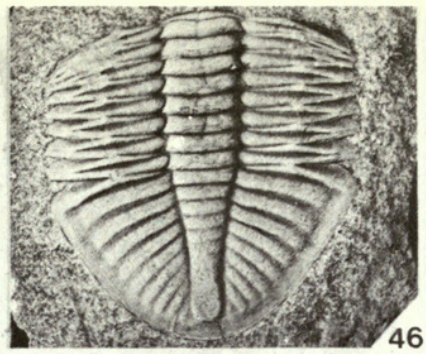
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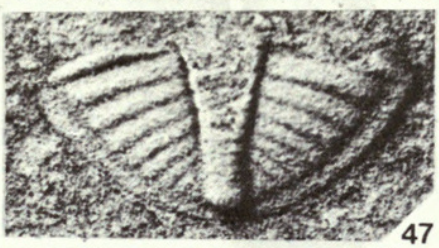
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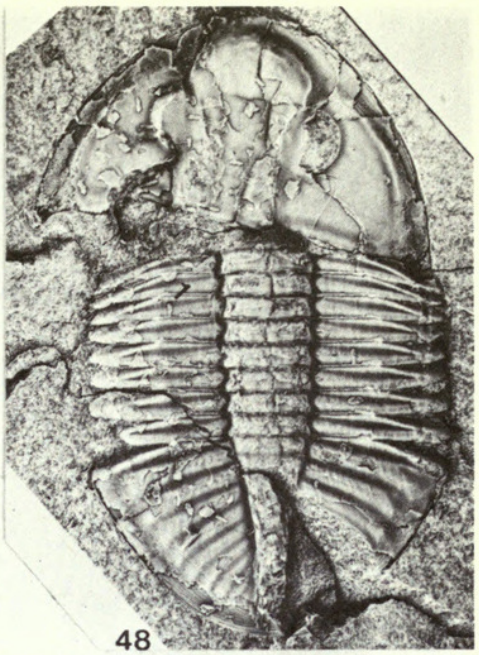
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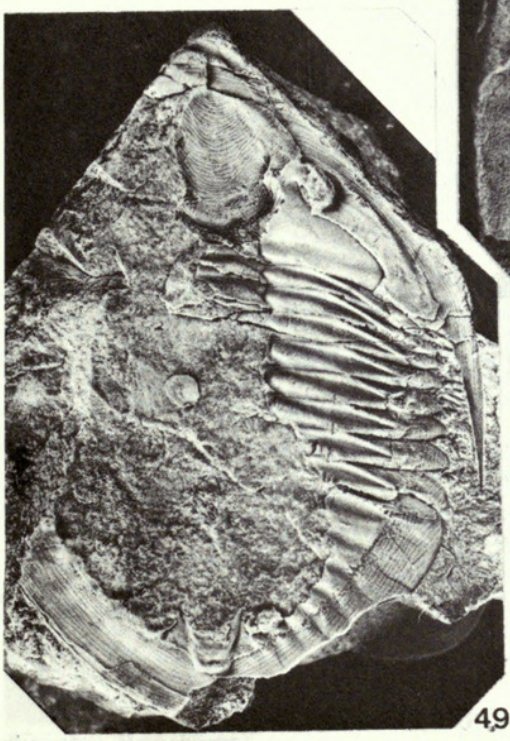
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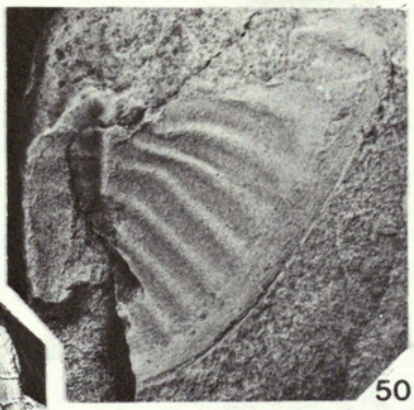
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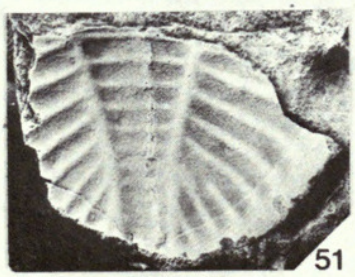
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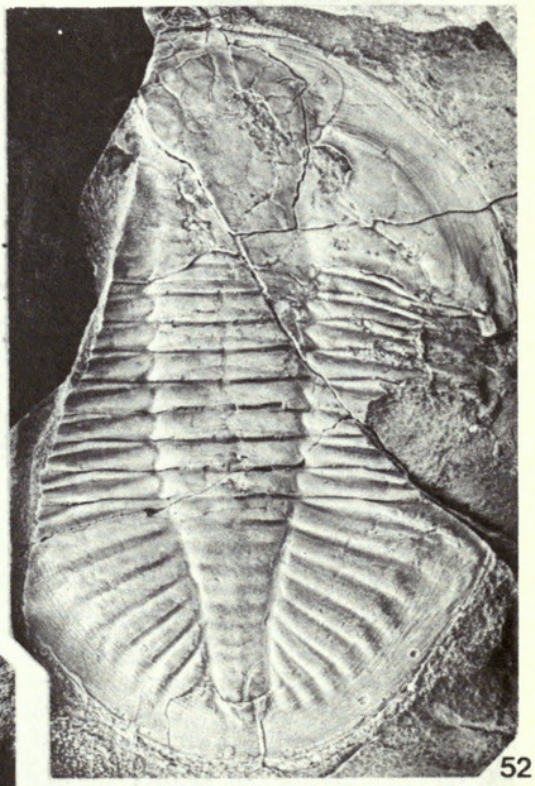
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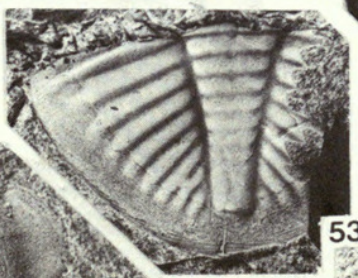
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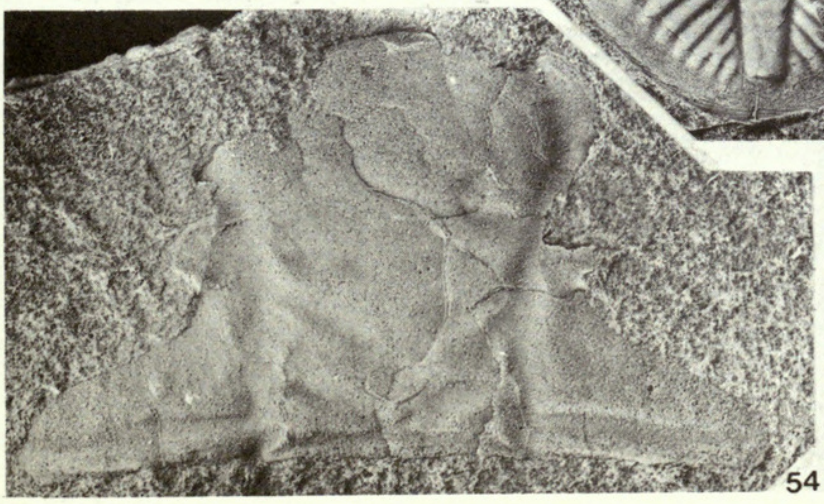
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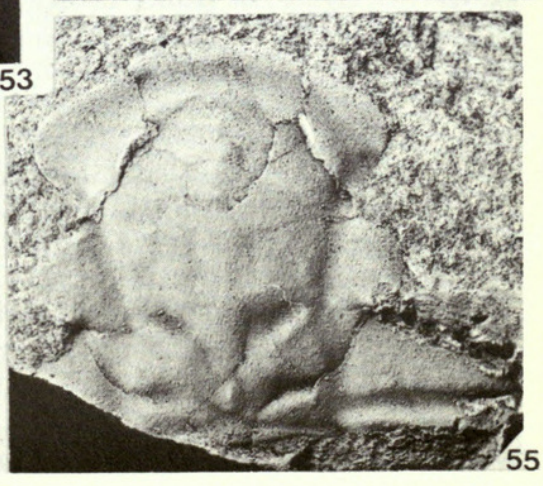
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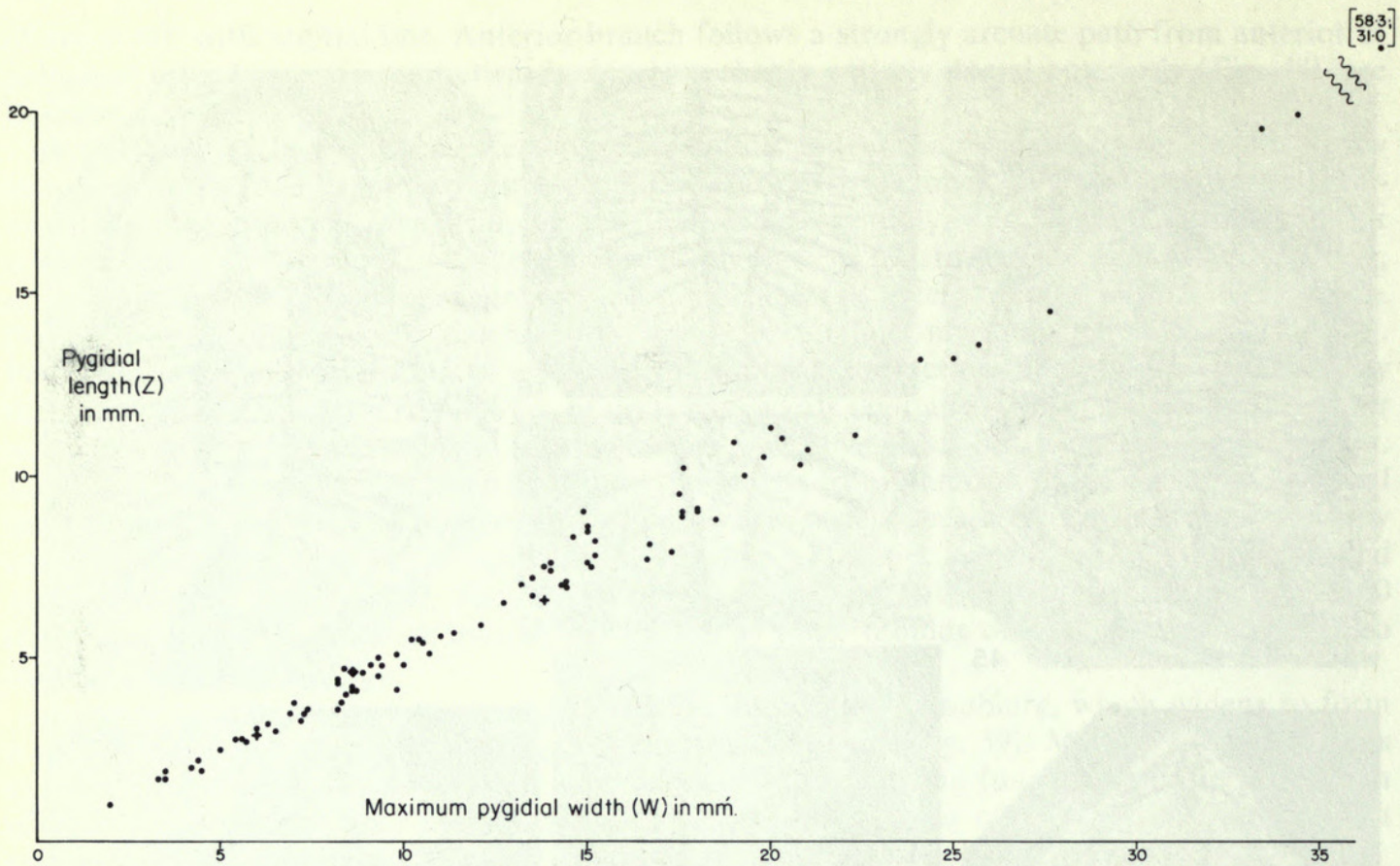


Fig. 56. Plot of length and width of 96 pygidia of *Ogyginus corndensis* (Murchison) from the small quarries 600 yd (549 m) east of Upper Gilwern. + – two specimens.

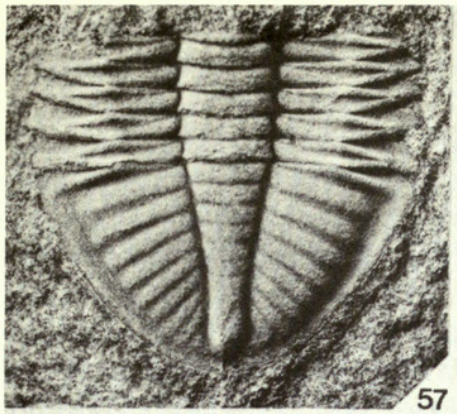
terrace lines; lateral and posterior borders well developed. Doublure relatively wide, being somewhat wider than borders. In small specimens it is generally poorly preserved, but is thought to be relatively narrower than in large specimens where it may be up to one-quarter of pygidial length (Fig. 52). Posteriorly 12–16 relatively widely spaced terrace lines are developed. These lie parallel to the margin on inner half, but are slightly oblique on outer parts. The obliqueness tends to increase towards anterolateral corners and extra lines may be intercalated (Fig. 52). Posteriorly, terrace lines on inner portion of doublure appear to reflect the posterior indentation found in the early meraspid stage.

ONTOGENY. An almost complete suite of meraspid stages is known, principally from the small quarries east of Upper Gilwern.

Figs 57–61, 66. *Ogyginus corndensis* (Murchison), p. 126. Figs 57–61, Lower Llanvirn, small quarries 600 yd (549 m) east of Upper Gilwern, SO 092582. Fig. 57, internal mould of typical pygidium and part of thorax, It.2874, ×3. Fig. 58, mould of dorsal surface of hypostoma, It.2865, ×3·5. Fig. 59, external mould of librigena with mould of dorsal surface of hypostoma and part of cephalic doublure, It.2853, ×3. Fig. 60, mould of ventral surface of hypostoma, with internal mould of librigenae showing median suture, It.2860, ×2. Fig. 61, internal mould of cranidium, showing median pair of lateral glabellar furrows, It.2851, ×4. Fig. 66, Lower Llanvirn, left bank of stream SW of Gilwern, about 100 yd (91 m) from its source, SO 080581. Enrolled specimen, It.2843, ×4.

Figs 62–64. *Ogyginus intermedius* Elles, p. 136. Figs 62, 64, Lower Llanvirn, left bank of upper reaches of Camnant Brook 210 yd (192 m) S 13° W of the fence crossing near the stream source, SO 088575. Fig. 62, internal mould of librigenae with mould of ventral surface of hypostoma, It.2883, ×1. Fig. 64, internal mould of pygidium with ribs furrowed along entire length, It.2882, ×1. Fig. 63, Lower Llanvirn, left bank of upper reaches of Camnant Brook 240 yd (219 m) S 13° W of the fence crossing near the stream source, SO 088575. Internal mould of pygidium with nine ribs furrowed at distal end, It.2885, ×3.

Fig. 65. ? *Ogyginus intermedius* Elles, p. 137. Lower Llanvirn, left bank of Howey Brook, 30 yd (27 m) below the cliff section ½ ml (805 m) ESE of Carregwiber, SO 089582. Internal mould of meraspid transitory pygidium, It.2889, ×10.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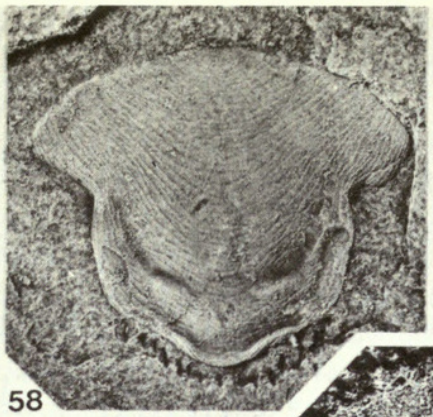
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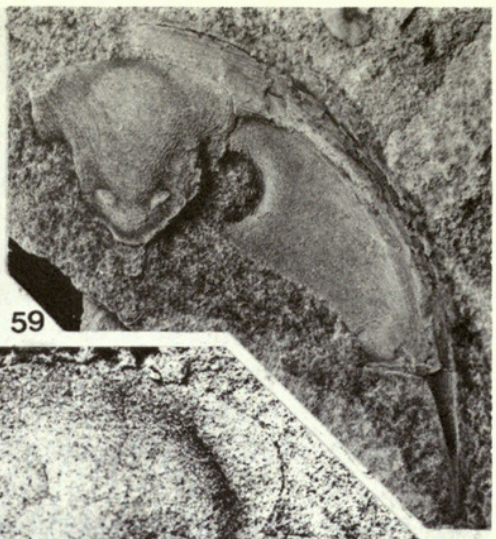
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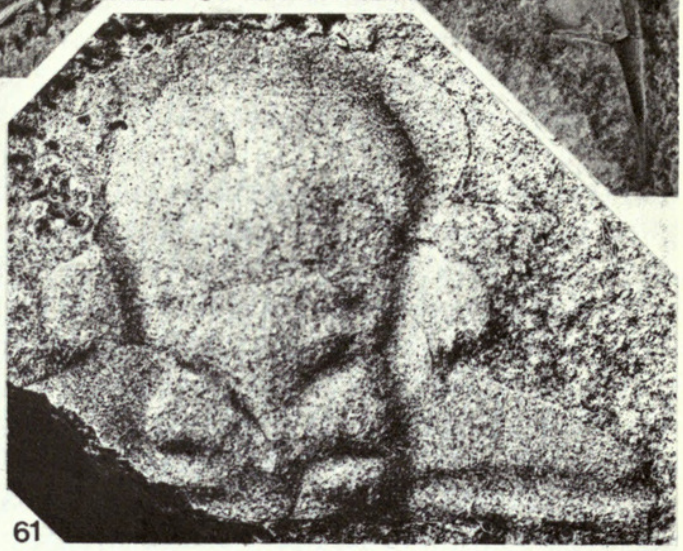
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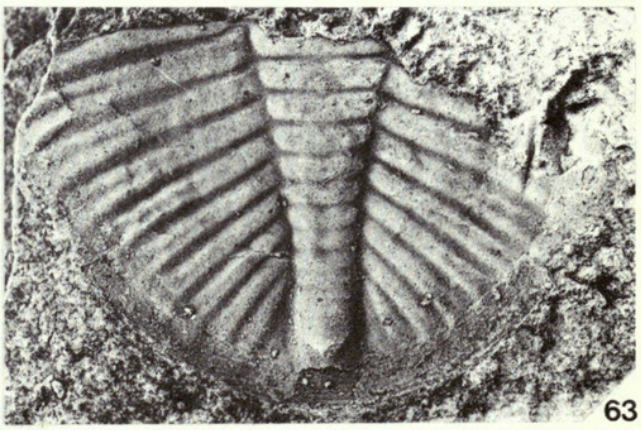
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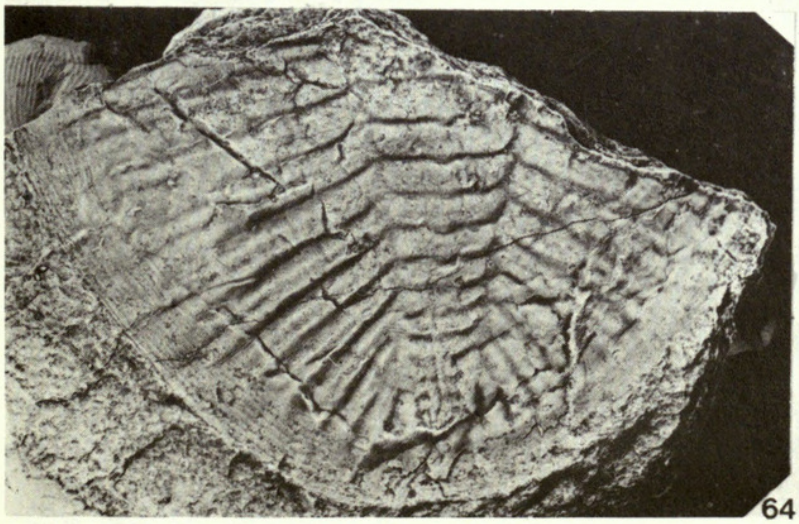
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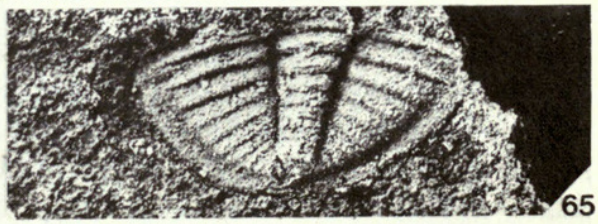
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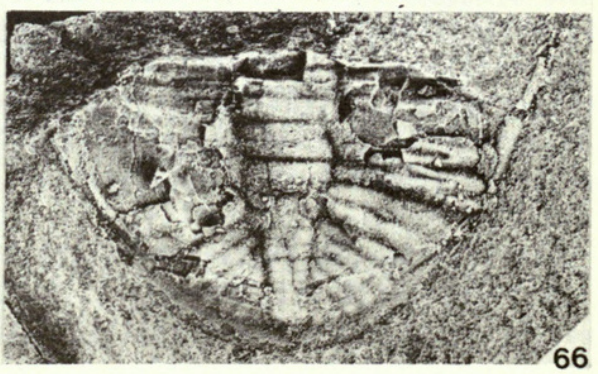

66

Degree uncertain. A single isolated globose transitory pygidium, 0·85 mm wide and 0·45 mm long, is roughly semicircular in outline with well-developed posterior indentation (Fig. 22). Axis well defined and tapers posteriorly. Only one pleural rib and at least one axial ring are developed, in contrast to the two ribs developed on transitory pygidium of the degree 0 ogygiocaridinid meraspis described below (p. 153). A further specimen (It.2849) of similar dimensions (Fig. 21) has no ribs or axial rings preserved. The degree to which these specimens belong cannot be determined, though their size suggests that they may be degree 2 or 1, or possibly even degree 0.

Several further isolated transitory pygidia are known which are slightly larger than these two specimens but still smaller than the smallest known transitory pygidium of degree 4 meraspis. These further specimens, whose width ranges from 1·2 to 1·5 mm, are very similar to the smaller ones except that two or three pleural ribs are developed (Figs 23, 24), with up to three axial rings. In all these specimens the ribs occupy, approximately, anterior half of pleural field and become less well developed posteriorly. These transitory pygidia are thought to belong to either degree 2 or 3.

Degree 4. Two complete specimens have lengths of 2·9 mm and 3·2 mm, the cephalon accounting for 1·2 mm and 1·5 mm respectively. Cephalon moderately convex (*tr.*), subsemicircular in outline, being very slightly less than twice as wide as long. Glabella well differentiated, but shows very little, if any, widening of anterior lobe. Single pair of short, clearly incised, lateral glabellar furrows reaches half-way to sagittal line at one-quarter the way along glabella, as measured from the occipital furrow. Occipital ring swollen and bowed backwards sagittally and clearly differentiated by the occipital furrow. Eye well developed, occupies about one-third of cephalic length and has relatively few large lenses (Figs 27, 30). Anterior branch of facial suture not seen, but posterior branch appears to follow a similar course to that of holaspid form. Genal region moderately convex with a pronounced, straight posterior border furrow; posterior border narrow medially, becoming slightly wider distally.

The four thoracic segments, although preservation is not good, appear to be essentially similar to those of holaspides. Axis strongly convex (*tr.*), bounded laterally by well-developed axial furrows. Pleural region appears to possess the typical spindle-shaped pleural furrows, with the fulcrum occurring at about three-quarters of the length out from the axial furrow.

Transitory pygidia approximately semicircular, 2 mm wide and strongly convex (*tr.*) with well-defined convex axial region. Anterior portion of the axis tapers gently to the rear, whilst posterior portion is parallel-sided. Up to nine axial rings developed with at least four ribs on strongly convex pleural field. Outer region of pleural field steeply declined, reaching maximum posteriorly where it is nearly vertical. Border relatively wide laterally and flat, being about one-tenth of pygidial length in width, becoming narrower posteriorly where a shallow terminal incurvation is developed medially.

Degree 5. Two complete specimens, It.2846 and It.2876 (Figs 31, 32), are 3·3 and 3·9 mm long with cephala 1·5 and 1·7 mm respectively. Cephalon roughly semicircular, only a little over one and a half times as wide as long. Glabella moderately convex (*tr.*) with no frontal expansion. The single pair of lateral glabellar furrows differs from that of degree 4 in being directed posteromedially rather than transversely. Occipital ring swollen, clearly differentiated by deep occipital furrow which is transversely directed for a short distance laterally before bending to lie parallel to posterior margin of occipital ring (Fig. 32). This curved central portion of the furrow is considerably shallower than lateral parts, thus anticipating the condition found in degree 6 which lacks central portion of the furrow. Eye well developed, occupies about one-third of cephalic length. Anterior branch of facial suture not known; course of posterior branch similar to that of adult.

The five thoracic segments are typically those of *Ogyginus*, except that axial furrow is more or less straight and shows little sign of the zetoidal shape it so characteristically assumes in the adult form.

Transitory pygidia semicircular, 1·0 mm and 1·2 mm long and 2·1 mm and 2·3 mm wide respectively. Axis shows typical adult outline and has up to seven axial rings. Pleural field moderately convex with six or possibly seven ribs. Border region flat with maximum width equal

to one-ninth of pygidial length, becoming narrower and less well defined posteriorly. Preservation is such that it is impossible to determine any posterior indentation.

Degree 6. Only two specimens (It.2869, Fig. 35 and SM A51177) certainly of degree 6 are known; they are about 5·4 mm and 4·2 mm in length, with cephala 2·2 mm and 1·7 mm long respectively. One further specimen (It.2866, Fig. 33) may be of degree 6, but transitory pygidium has overridden the thorax slightly so that no definite count can be made of thoracic segments. Length of this specimen is also about 5·4 mm. Cephalon roughly semicircular in outline, though only just over one and a half times as wide as long. Although the anterior is poorly preserved, the well-defined glabella clearly expands frontally. Single pair of lateral glabellar furrows directed posteromedially as in degree 5. As in earlier degrees, occipital ring swollen and bowed backwards sagittally but occipital furrow no longer continuous, being represented by two short, transversely-directed laterally-placed furrows. Eye well developed and occupies about one-third of cephalic length. Course of anterior branch of facial suture not discernible; that of posterior branch as in adult. Posterior border furrow clearly developed and straight; posterior border narrow medially, widening laterally.

Thoracic segments have the same general form as the adult. Fulcrum, however, situated three-fifths way along pleura as measured from axial furrow, and axial furrow has not attained typical zetoidal shape.

Transitory pygidium only very slightly less than twice as wide as long. Axis clearly differentiated and same shape as in adults, with at least seven and possibly ten axial rings. Pleural region convex, being steeply declined posteriorly. Seven or eight ribs appear to be present. Border region varies in width between one-eighth and one-ninth of pygidial length and is nearly horizontal laterally, becoming narrower and less well defined posteriorly.

Degree 7. Three complete specimens known (It.2855, Fig. 39; It.2871, Fig. 37; It.2862, Fig. 36). Preservation of It.2855 is superior to that of the other two and the following is based mainly on this specimen. Total length 5·5 mm (5·7 mm in It.2871; 4·7 mm in It.2862) with cephalon 2·2 mm in both It.2855 and It.2871 (1·9 mm in It.2862). Cephalon semicircular with glabella expanding frontally (see It.2871). Single pair of lateral glabellar furrows directed transversely. Eye occupies approximately one-third of cephalic length. Occipital furrow in It.2855 entire and shows very little, if any, shallowing medially. It.2871, however, exhibits differentiation of occipital ring into anterolateral lobes and a posterior band as is found in the adult form. In It.2862 occipital furrow still appears continuous medially as in It.2855. Course of both anterior and posterior branches of facial suture appears to be similar to that in holaspides. In It.2862 a short genal spine is present, reaching back as far as fourth thoracic segment. Hypostoma, although not well preserved, appears to be similar to that of adult (It.2855, Fig. 39).

Thorax is essentially like that of adult form except that axial furrow has not attained the typical zetoidal shape.

Transitory pygidium showing seven, possibly eight, pleural ribs in It.2855, but only five or six in It.2871. Axial furrowing not well preserved, but there appear to be at least six axial rings. Border region horizontal laterally, in marked contrast to the steep outer portion of the pleural region, and about one-eighth of pygidial length in breadth. Posteriorly border region becomes narrower and less well defined.

Young holaspides. The smallest specimen, total length 6·8 mm, is not well preserved (Fig. 41), but its length is about 1·2 times greater than that known for any meraspis. Occipital ring still somewhat swollen although posterior band clearly present. A possible young holaspis (It.2878, Fig. 38) still retains a deep, continuous furrow. Eye slightly larger relative to the length of the cephalon than in meraspides, and set well to the posterior. Eye lenses are few and relatively large (Fig. 38). Short genal spine present.

Thorax closely resembles that of larger individuals, except that axial furrow does not show the typical zetoidal shape.

Pygidium relatively wide, just over two and a half times as wide as long. Posteriorly axial rings and pleural ribs poorly preserved, but only seven ribs appear to be developed. Pygidium less strongly convex and with less narrowing of the border region posteriorly than in meraspides. No posterior indentation developed.

A slightly larger specimen (It.2854, Fig. 42), length 7·1 mm, shows eight ribs present on the pleural field.

DISCUSSION OF DEVELOPMENT. Table 1 shows that specimen size, as measured by its total length, is not by itself indicative of a particular meraspid degree; this may in part at least be a reflection of varying amounts of tectonic deformation. If, however, specimens from the single locality east of Upper Gilwern are considered alone, then there is a progressive increase in total length, although at times very small, with increase in meraspid degree. There is no constant growth factor between each degree (see Table 2); this may be due to the paucity of data or to there being more than one instar in some or all degrees.

Table 1. Measurements and rib counts on meraspid and young holaspid specimens of *Ogyginus corndensis* (Murchison). For explanation of symbols see Fig. 1. * – specimen from the small quarries 600 yd (549 m) east of Upper Gilwern. All measurements in mm.

Specimen Number	T.L.	A	C	C_1	C_2	W	Z	Pleural ribs		Axial rings	Degree
								Left	Right		
It.2845	–	–	–	–	–	0·85	0·45	1	?	1+?	?
It.2849*	–	–	–	–	–	0·85	0·50	?	?	?	?
It.2875*	–	–	–	–	–	1·2	0·70	2	2	2+ ?	?
It.2880	–	–	–	–	–	1·3	0·85	3	3	3+ ?	?
It.2863	–	–	–	–	–	*c.* 1·5	*c.* 0·95	2	2	3+ ?	?
It.2881	–	–	–	–	–	*c.* 1·5	0·80	2	3	3	?
It.2873*	2·9	1·2	–	–	–	2·0	1·0	4+ ?	4+ ?	6, ? 7	4
It.2877	3·2	1·5	–	0·55	–	2·3	1·0	4+ ?	5+ ?	9	4
It.2846	3·3	1·5	–	–	–	2·1	1·0	4+	6, ? 7	7+ ?	5
It.2876*	3·9	1·7	0·8	0·6	0·3	2·3	1·2	5, ? 6	5, ? 6	5, ? 6	5
SM A51177	4·2	*c.* 1·7	0·6	0·7	–	3·1	1·3	7	7	? 9	6
It.2866*	*c.* 5·4	*c.* 2·3	–	0·8	–	3·2	1·4	?	6+	8	? 6
It.2869*	*c.* 5·4	*c.* 2·2	0·95	0·75	0·5	3·2	1·7	7	8	7, ? 10	6
It.2862	4·7	1·9	–	–	–	3·1	1·4	7, ? 8	7, ? 8	4+	7
It.2855*	5·5	2·2	1·05	0·75	0·4	3·4	1·6	7, ? 8	7, ? 8	6+ ?	7
It.2871*	5·7	2·2	–	–	–	3·7	1·7	5, ? 6	5, ? 6	?	7
It.2878	*c.* 5·1	*c.* 2·0	–	0·8	–	3·3	1·4	?	? 8	8+	? holaspis
It.2847*	6·8	*c.* 2·9	*c.* 1·4	*c.* 1·0	*c.* 0·5	4·5	1·9	? 7	? 7	?	holaspis
It.2854*	7·1	2·8	–	–	–	4·0	1·8	8	8	6+	holaspis

Table 2. Mean lengths (T.L.) and growth factors between meraspid degrees of *Ogyginus corndensis* (Murchison) from the small quarries 600 yd (549 m) east of Upper Gilwern. 8* taken as the smallest two holaspides known which are assumed to belong to the same instar. All measurements in mm. n – number of specimens.

Degree	Mean T.L.	n	Growth factor
4	2·9	1	
			1·33
5	3·9	1	
			c. 1·38
6	*c.* 5·4	2	
			c. 1·04
7	5·6	2	
			1·24
8*	6·95	2	

The most interesting morphological feature in the ontogeny of the species is that of the development of the occipital ring and associated features. In general their development shows a progressive change towards the condition found in the adult form, with the deep continuous occipital furrow of degree 4 being reduced to short, transversely-directed furrows by degree 6, with the posterior band appearing in degree 7. However, there are some apparent exceptions, e.g.

It.2855 of degree 7 (Fig. 39) clearly shows a deep continuous occipital furrow with little shallowing medially; a similar condition is found in a ? young holaspis (Fig. 38). The earliest stage in which the differentiation of the occipital ring into anterolateral lobes and a posterior band occurs is degree 7. A latex impression from an external mould (Fig. 37) clearly shows this, although an internal mould of the same degree shows no such differentiation. In earlier degrees there are no such differences apparent between internal and external moulds.

Whilst it is considered that specimens It.2845–6 from the lower Llanvirn belong to *O. corndensis*, the possibility remains that they may represent meraspides of *Ogyginus intermedius* Elles (see p. 136) which may be present at the same locality. The specimens are here assigned to *O. corndensis* on account of their similarity to other mersapides of this species, a holaspis of which is known from the locality. The lack of a distal furrow on the anterior rib may not preclude it from *O. intermedius*, as the ontogeny of the latter species is virtually unknown at present. It may be that early, if not all, meraspides of these two species are indistinguishable.

BIOMETRICAL DATA. Abundant well-preserved material has yielded considerable data which are summarized in Tables 3 & 4.

Table 3. Bivariate statistics for holaspid specimens of *Ogyginus corndensis* (Murchison) from the small quarries 600 yd (549 m) east of Upper Gilwern. All measurements in mm. For explanation of symbols see Fig. 1.

x : y	$\bar{x}$	var. x	$\bar{y}$	var. y	r	r_e	α	var. α	a	var. a	n
A : C_1	12·99	21·15	2·66	0·28	0·93	0·93	0·57	0·0085	–	–	7
A : C_3	12·99	21·15	5·60	4·10	1·00	1·00	1·02	0·0013	0·44	0·0002	7
B : J	19·80	159·78	11·80	56·78	1·00	1·00	1·00	0·0006	0·60	0·0002	12
B : J_1	10·28	42·52	9·91	53·41	1·00	1·00	1·13	0·0005	–	–	18
B : K_2	9·86	35·40	7·09	21·99	1·00	1·00	1·08	0·0003	–	–	30
J : J_1	20·79	177·87	12·01	84·81	0·99	1·00	1·16	0·0009	–	–	9
K_2 : K_1	7·03	21·37	5·84	14·90	1·00	1·00	1·01	0·0003	0·84	0·0002	28
R_1 : Q	16·50	73·73	8·04	15·47	1·00	1·00	0·95	0·0007	0·46	0·0002	8
R_1 : R_2	16·50	73·73	4·29	4·14	1·00	1·00	0·92	0·0006	–	–	8
R_1 : R_4	17·14	82·16	17·63	85·42	1·00	1·00	0·99	0·0008	1·02	0·0008	7
R_2 : R_3	4·35	4·77	4·10	5·05	1·00	1·00	1·08	0·0005	–	–	17
R_4 : R_3	19·70	206·39	4·83	14·58	1·00	1·00	1·07	0·0002	–	–	13
W : Z	13·66	61·90	7·09	19·03	0·99	1·00	1·06	0·0001	–	–	88
W : X	13·60	62·53	3·03	3·18	0·99	0·99	1·01	0·0001	0·23	0·00001	94
W_1 : Y	11·09	39·61	6·07	13·32	0·99	0·99	1·05	0·0001	–	–	107
Z : Y	7·48	23·85	6·63	17·49	1·00	1·00	0·97	0·00002	–	–	123
Y : X	6·38	14·11	3·07	3·16	0·99	0·99	0·98	0·0001	0·47	0·00003	131

Table 4. Measurements of hypostomata of *Ogyginus corndensis* (Murchison) from the small quarries 660 yd (549 m) east of Upper Gilwern. First three specimens are moulds of the dorsal surface, the last two, moulds of the ventral surface. All measurements in mm. For explanation of symbols see Fig. 1.

	H_1	H_2	H_3	H_4	H_5	H_6
NMW 68.376.G208	5·3	4·6	3·7	2·4	–	4·2
It.2853	9·0	8·1	6·5	4·0	*c.* 10·2	6·0
It.2865	15·5	13·0	11·3	7·0	18·5	13·0
It.2860	10·2	8·9	7·0	5·0	10·7	6·0
NMW 68.376.G209	10·6	9·5	7·5	4·5	–	–

DISCUSSION. Although the holotype is from the Weston Beds, near Middleton, Salop (Shropshire), Salter (1866) based his description and figures mainly on specimens from Builth where the species is very abundant.

Although the forms occurring in the Builth and Shelve regions clearly belong to a single species, there is an interesting difference in the stratigraphical distribution of the various forms based on the number of pygidial ribs present. Whittard (1964 : 254) proposed the two varieties *O. corndensis* var. *septenarius* and *O. corndensis* var. *novenarius* to accommodate forms with seven and nine ribs. In the Builth region, unlike Salop (Shropshire), all three forms are found together in the Llanvirn, although the vast majority of specimens have eight ribs. In the lower Llandeilo, however, eight- and nine-rib forms occur in about equal numbers, with seven-rib forms occurring only rarely. In the Shelve region, however, eight-rib forms are restricted to the Llanvirn. Seven-rib forms, which as in the Builth region are rare, occur with eight-rib forms in the Llanvirn excluding the topmost beds (Betton Beds). The nine-rib form occurs with eight-rib forms in the Betton Beds, but is the only form occurring in the Llandeilo. Although the proportion of the various forms within an assemblage has a similar stratigraphical significance in both regions, it is felt that there is little justification for formal recognition of three subspecies. It seems likely the species was evolving under a selection pressure favouring an increased number of ribs, which differed in the two areas.

Whittard (1964 : 253) indicated the distinctions between *O. corndensis* and *O. grandis* Whittard, 1964, *O. porcatus* Whittard, 1964 and *O. intermedius* Elles, 1940. To these may be added *O. armoricanus* (Tromelin & Lebesconte, 1876), redescribed by Henry (1971 : 66–68), which is distinguished by its short genal spine, lack of well-developed occipital ring and lack of occipital node.

Two possible examples of enrolled specimens are known but both are flattened and may be the result of the disarticulated parts of an exuvia being preserved on top of one another.

Ogyginus intermedius Elles, 1940
(Figs 62–64, 68, 71–73, 75)

1940 *Ogyginus corndensis* (Murchison) mut. *intermedius* Elles (*pars*) : 395, 397–398, 428–429; pl. 31, fig. 10, *non* fig. 11.
1964 *Ogyginus intermedius* Elles; Whittard (*pars*) : 246–248; pl. 41, figs 1, 3, 4, *non* fig. 2.
1966 *Ogyginus intermedius* Elles; Whittard : 302, 305.

DIAGNOSIS. *Ogyginus* with relatively small eye situated well to the anterior; glabella expanding onto anterior border. Nine or ten ribs on pleural field with short pleural furrow on distal portion of anterior ribs.

HOLOTYPE. SM A10087 (Fig. 73), internal mould of complete specimen. Dimensions (in mm): T.L., 61·7. A, 20·3. C, *c.* 11·2. C_1, *c.* 3·0. C_2, 6·7. C_3, *c.* 8·2. I_1, *c.* 41·1. K_2, 13·5. Q, 18·9. Q_1, 2·5. R_1, 38·2. R_3, 8·0. R_4, 38·4. W, 38·0. X, 7·8. Y, 18·7. Z, 22·5. For explanation of symbols see Fig. 1.

TYPE LOCALITY AND HORIZON. *Didymograptus bifidus* Shales south-east of Elusendy, Golden Grove, near Llandeilo.

DISTRIBUTION. Elles (1940 : 429) originally recorded the species from the lower Llanvirn of the Llandeilo and Builth regions together with rare occurrences in the upper Llanvirn and Llandeilo of Builth. Whittard (1964 : 248) found the species to be restricted to the lower Llanvirn in the Shelve region, and noted that it was also present in the *bifidus* fauna from west of Llan Mill, Dyfed (Pembrokeshire). Specimens identified as *O. intermedius* from the upper Llanvirn and lower Llandeilo of the Builth region by Elles are here placed in *O. corndensis*, so that the species is now restricted to the lower Llanvirn throughout the Anglo-Welsh region.

In the Builth district the species is most common in the beds exposed in the upper reaches of the Camnant Brook, where it is more abundant than *O. corndensis*. The only other localities within the area where it is certainly present are the 'cliff' section, Howey Brook, Hendy Bank and Frank's Bridge. Elles (1940 : 398) also records it from east of Bwlchyfedwen, but no specimens have been traced to confirm this.

DESCRIPTION. Comment is made only on features in which the Builth material differs from, or adds to, Whittard's redescription (1964 : 246–248). Cephalon known in the Builth region from

very few rather poor fragmentary specimens. Three pairs of lateral glabellar furrows appear to be present together with a discontinuous occipital furrow (Fig. 68), although it is uncertain which depressions are true lateral glabellar furrows and which are due to compression. Anterior and median pairs situated approximately opposite small palpebral lobe, with anterior pair directed slightly anteromedially and median pair more or less transverse. Posterior pair situated about half-way between median pair and occipital furrow and directed posteromedially. Lateral glabellar furrows extend no more than about three-quarters of the way to sagittal line (Fig. 68).

Thorax known only from a few poorly-preserved specimens. However, some larger specimens have an axial furrow of moderately well-developed zetoidal form, whilst others show the supposedly more characteristic scalloping (Fig. 68).

Pygidium with axis tapering over its anterior half and well defined by deep axial furrow. Eleven or twelve axial rings may be developed, together with a short terminal piece. Ring furrows continuous though considerably shallower medially. Nine or ten ribs may be developed (Figs 63, 71), with short, shallow furrows present on the distal portions of up to the first six ribs (Fig. 63). The furrows along the entire length of the ribs in It.2882 (Fig. 64) are thought to be the result of compression. It.2886 shows a rib which apparently bifurcates on the right pleural field (Fig. 75). Doublure relatively narrow, in width only about one-eighth of pygidial length and bearing terrace lines.

A single slightly distorted isolate pygidium is known which may represent an immature example of this species (Fig. 65). It shows at least eight axial rings. Although they are poorly defined posteriorly it appears that only eight ribs are present, the anterior one having a short furrow present distally.

The presence of the furrow on the anterior rib suggests that this may belong to *O. intermedius* rather than *O. corndensis*. The development of only eight ribs suggests that the specimen may be of a late stage meraspis rather than a young holaspis. In size it is clearly comparable to meraspides of *O. corndensis* of degree 7.

Discussion. About 30 specimens are known from Builth and they show more variation in the number of pygidial axial rings and pleural ribs than those (not more than 15) known from the Shelve area (Whittard 1964 : 246–248; 1966 : 302). In the light of the variation in the number of pygidial ribs in *O. corndensis* it is not surprising to find a similar variation in *O. intermedius*. The moderately well-developed zetoidal aspect of the axial furrow on the thorax of some large specimens may reflect inherent variation, as in *O. corndensis*.

Whittard (1964 : 246, 248) considered *Ogygiocaris henningsmoeni* conspecific with *O. intermedius*. Struve's (1962) description and illustrations were of rather incomplete material and a detailed comparison is not possible; however, the glabellar furrowing and apparently larger, more posteriorly placed eye in *O. henningsmoeni* suggest that the two forms are distinct.

The species is distinguished from all other *Ogyginus* species by the small eye situated well forward, and a glabella encroaching onto the anterior border. Isolate pygidia with nine ribs are very difficult to distinguish from nine-rib forms of *O. corndensis*, though the short furrow on the distal portion of the anterior ribs in *O. intermedius* may be utilized if compression is not too great. For a fuller comparison with related species see the discussion of *O. corndensis* (p. 135) and Whittard (1964 : 253).

Ogyginus cf. ***intermedius*** Elles, 1940
(Fig. 177)

Figured specimen. It.2890, internal mould of pygidium.

Locality and horizon. *Didymograptus bifidus* Shales, left bank of the stream section in the upper reaches of the Camnant Brook, 270 yd (247 m) below the fence crossing the stream above the ravine.

Description. This pygidium is very similar to pygidia here attributed to *O. intermedius*, except that the doublure is considerably wider, the width being slightly over one-quarter of the total pygidial length.

DISCUSSION. It has been shown that in the closely-related species *O. corndensis* the relative width of the doublure is dependent on the size of the individual and increases with increase in size. Since this specimen is no larger than specimens of *O. intermedius* from the same locality, the wider doublure would seem to indicate a significant difference between this specimen and *O. intermedius*.

Ogyginus? laticostatus (Salter, 1866)
(Fig. 109)

1851 *Isotelus* (*Basilicus*) ? *laticostatus* (Green sp.); Sedgwick & M'Coy (*pars*) : 170; pl. 1E, fig. 18a only (*non laticostatus* of Green, 1832).
1852 *Isotelus laticostatus* (Green sp.); Sedgwick & M'Coy : 366.
1866 *Asaphus* (*Basilicus*) *laticostatus* Sedgwick & M'Coy; Salter : 158–159; pl. 18, fig. 6.
1931 *Ogyginus* ? *laticostatus* (McCoy); Reed : 462.
1953 '*Asaphus*' *laticostatus* M'Coy; Jaanusson : 445.

HOLOTYPE. SM A16693, internal mould of large pygidium. Holotype by monotypy.

LOCALITY AND HORIZON. This specimen was originally cited as having been collected from Maen Goran, Llangollen (Sedgwick & M'Coy 1851 : 170). Subsequently (Salter 1866 : 159; 1866*a* : 311–312) stated that it was from Maen Goran, Builth. No Maen Goran has been traced in either district, but there is a house named Maen Cowyn at Llanelwedd just north of Builth. This may be a modern spelling of Maen Goran (see note by G. L. Elles in the Sedgwick Museum Catalogue under the entry for the holotype); it might be noted, however, that Maen Cowyn was in use as early as 1894 (Woods 1894 : 572). Thus it is thought possible that the specimen came from near Maen Cowyn, possibly from the small track-side quarry, about 270 yd (247 m) west of Maen Cowyn, in ashy beds possibly of upper Llanvirn age.

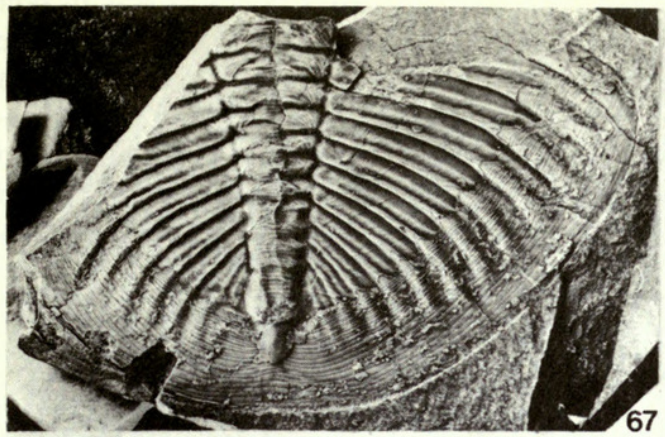
DESCRIPTION. Cephalon and thorax unknown.

Pygidium, though damaged, is roughly semicircular in outline. Axis slightly under one-quarter of pygidial width anteriorly, tapering posteriorly and defined by deep axial furrow. Exact number of axial rings uncertain but at least ten developed. Ring furrows continuous though very much shallower medially than laterally. At least nine, and possibly ten, flat-topped pleural ribs present. Doublure relatively narrow, being about one-seventh of the pygidial length in width. It appears to have a simple arcuate inner margin and bears terrace lines.

DISCUSSION. If the location and age of this specimen are correct it represents the only occurrence of a trilobite from the upper Llanvirn in the southernmost part of the Inlier.

Figs 67, 69–70, 74. *Ogygiocarella debuchii* (Brongniart), p. 142. Fig. 67, Lower Llandeilo, old quarry 350 yd (320 m) west of Maesgwynne, SO 059566. Internal mould of pygidium, showing doublure and form of axial rings, It.2900, ×1·5. Figs 69–70, Lower Llandeilo, old quarry 570 yd (521 m) north of Wye Cottage, SO 047538. Fig. 69, internal mould of pygidium showing furrowing of axis, It.2904, ×2. Fig. 70, external mould of librigena with mould of dorsal surface of doublure and part of hypostoma, It.2911, ×1·5. Fig. 74, Lower Llandeilo, stream section 15 yd (14 m) SW of the old quarry 350 yd (320 m) west of Maesgwynne, SO 059566. Internal mould of damaged cranidium showing sculpture of fine ridges on glabella and occipital ring, It.2899, ×2·5.

Figs 68, 71–73, 75. *Ogyginus intermedius* Elles, p. 136. Figs 68, 75, Lower Llanvirn, right bank of upper reaches of Camnant Brook 175 yd (160 m) S 13° W of the fence crossing near the stream source, SO 088575. Fig. 68, internal mould of cranidium and part of thorax, showing glabellar furrows and scalloped nature of thoracic axial furrow, It.2887, ×1. Fig. 75, internal mould of pygidium showing irregular rib development, It.2886, ×1. Fig. 71, Lower Llanvirn, right bank of upper reaches of Camnant Brook 220 yd (201 m) S 13° W of the fence crossing near the stream source, SO 088575. Internal mould of small pygidium with an incipient tenth pleural rib developed, It.2884, ×7·5. Fig. 72, ? Lower Llanvirn, Frank's Bridge, Builth. Internal mould of complete large individual, SM A45484, ×0·5. Fig. 73, Lower Llanvirn, SE of Elusendy, Golden Grove, Llandeilo. Holotype. Internal mould of complete specimen, SM A10087, ×1.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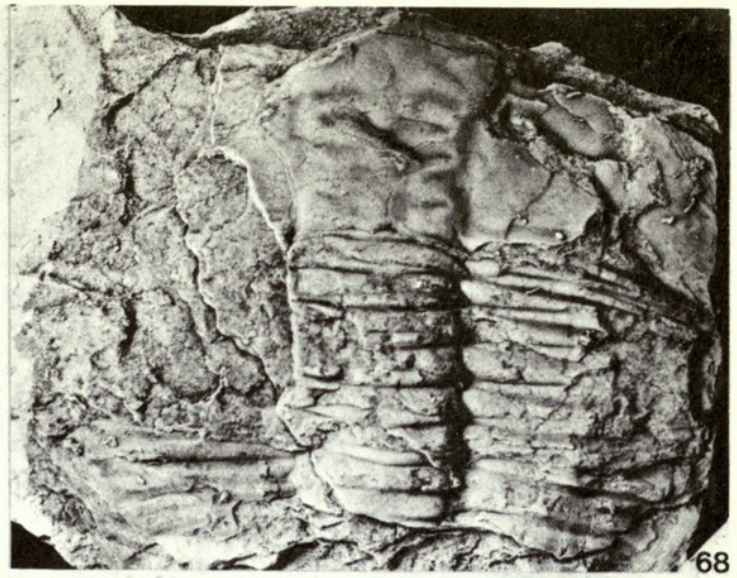
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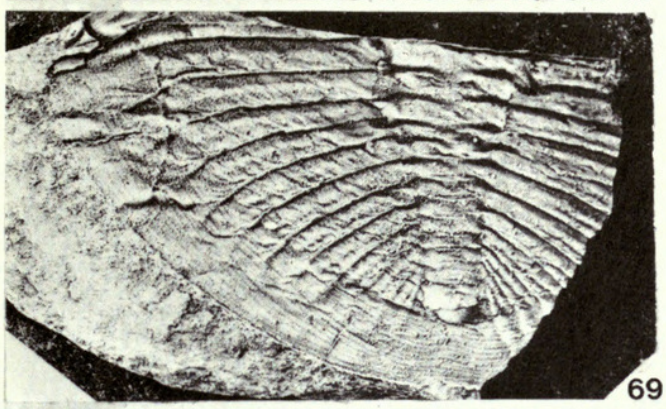
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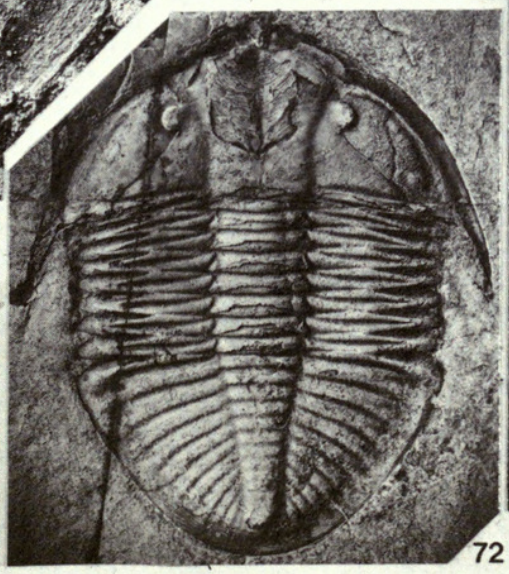
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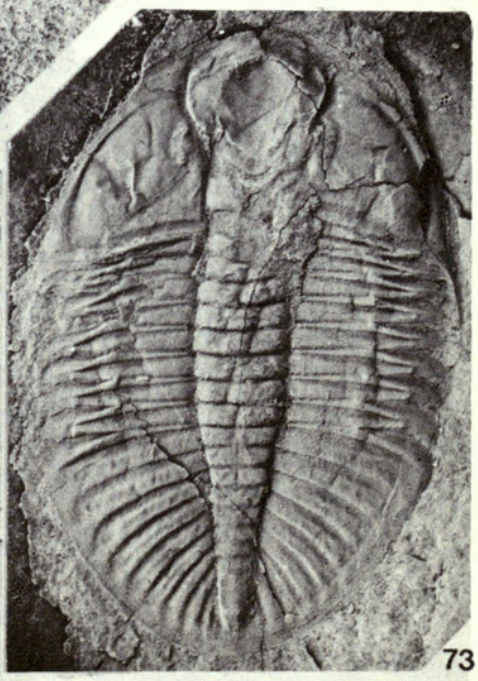
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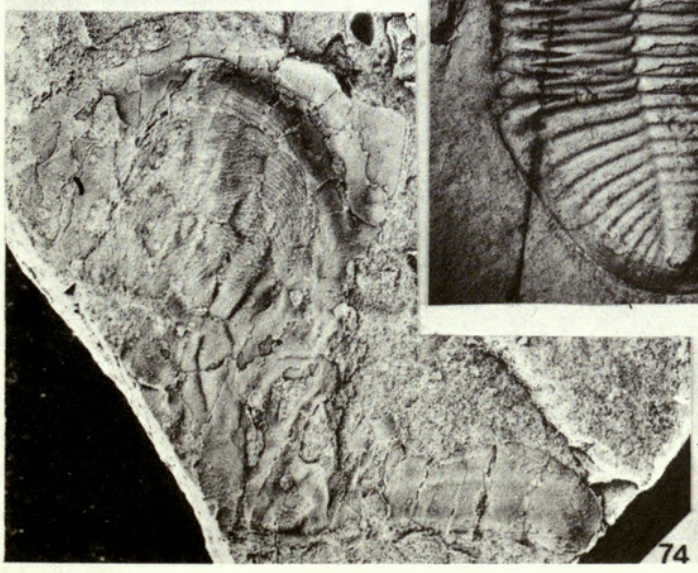
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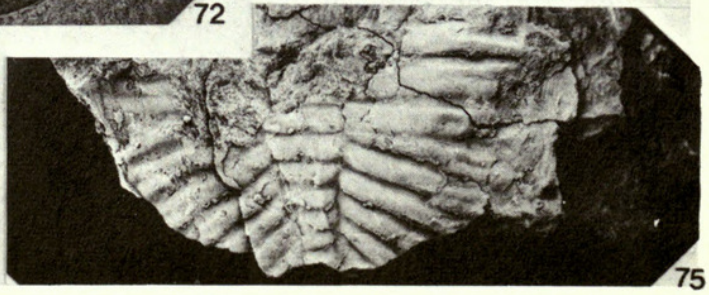
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Salter (1866 : 158–159; 1866*a* : 311–312) commented on M'Coy's inexplicable reference of this specimen to *Isotelus* (*Basilicus ?*) *laticostatus* Green, 1832, which Salter believed was in fact a phacopid, and indicated that the specimen clearly represented a distinct form with genuine asaphid affinities. Reed (1931 : 462) considered that the annulation of the axis, the relative width of the doublure and the nature of the pleural ribs indicated close affinity to *Ogyginus*, a suggestion also given some support by Jaanusson (1953 : 445–446). The specimen is very similar to large pygidia of *O. intermedius* and a tentative generic assignment to *Ogyginus* would seem the most plausible proposition. In view of the relatively poor preservation and the uncertainties regarding the age and locality of this specimen it is proposed that the species name should be retained but restricted to the holotype.

Genus *OGYGIOCARELLA* Harrington & Leanza, 1957

DIAGNOSIS. Outline oval, isopygous; cephalon and pygidium subsemicircular. Glabella parallel-sided posteriorly, expanding slightly frontally; four pairs of lateral glabellar furrows; eye situated in posterior half of cephalon; anterior branch of facial suture marginal frontally. Hypostoma with entire posterior margin. Thorax with scalloped axial furrow. Pygidium generally with 11 or more ribs and about 14 axial rings; inner edge of doublure sinuous.

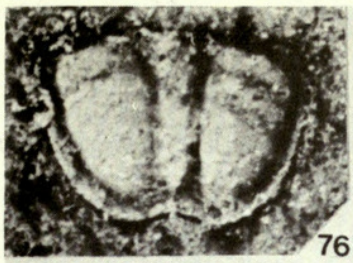
TYPE SPECIES. *Asaphus debuchii* (Brongniart, 1822). By original designation of Harrington & Leanza (1957 : 160–161), where it is misquoted as '*Asaphus debuchianus* (Brongniart, 1822)' (see Jaanusson *in* Moore 1959 : O352; Jaanusson 1956; Whittard 1964 : 255–256; Hughes 1972)[1].

DISTRIBUTION. Genus characteristic of the Anglo-Welsh region, particularly south Wales and Salop (Shropshire); only a single specimen is known from north Wales (MacGregor 1963 : 792–793). Also present in the Lower Llanvirn of Peru (Newell & Tafur 1944: pl. 92, figs 2–4; Hughes, Rickards & Williams in press).

DISCUSSION. Despite the reinterpretation of the course of the facial suture in *Ogyginus* (p. 124) the differences between *Ogygiocarella* and *Ogyginus* are few. However, the difference in facial suture pattern together with the greater expansion of the frontal glabellar lobe, the zetoidal axial furrow, the non-sinuate inner margin of the pygidial doublure and the generally lower number of pleural ribs in *Ogyginus* are considered to be sufficient to retain them as separate genera. *Ogygiocarella* also shows similarities to *Ogygiocaris* Angelin, 1854, but it may be distinguished by its marginal facial suture anteriorly, narrower cephalic doublure and lack of any posterior indentation in holaspides.

[1] For suppression of *Asaphus debuchianus* Brongniart *in* Desmarest, 1817, *non* 1822, see *Opin. Decl. int. Commn zool. Nom.*, London, **18** (4) : 241–256 (1958).

Figs 76–85. *Ogygiocarella debuchii* (Brongniart), p. 142. Figs 76–77, 82, Lower Llandeilo, stream section 15 yd (14 m) SW of the old quarry 350 yd (320 m) west of Maesgwynne, SO 059566. Fig. 76, latex impression from external mould of the smallest known transitory pygidium, It.2897, ×20. Fig. 77, internal mould of transitory pygidium showing at least three ribs, It.2896, ×20. Fig. 82, latex impression from external mould of meraspid of degree 4, It.2898, ×15. Fig. 78, Lower Llandeilo, 160 yd (146 m) SE of Tre Coed, on left bank of stream, SO 054552. Internal mould of transitory pygidium with eight ribs, It.2892, ×10. Figs 79, 81, 83–84, Lower Llandeilo, left bank of stream section east of Bach-y-graig, 45 yd (41 m) upstream of the point where the footpath enters the wood at the western end of the section, SO 071610. Figs 79, 83, internal mould of longitudinally compressed meraspid of degree 7, It.2913. Fig. 79, ×15; Fig. 83, ×10. Fig. 81, details of eye, It.2894, ×15. Fig. 84, internal mould of transversely compressed meraspid of degree 7, It.2893, ×10. Fig. 80, Lower Llandeilo, old quarry 570 yd (521 m) north of Wye Cottage, SO 047538. Internal mould of librigena and mould of ventral surface of doublure, It.2902, ×1·5. Fig. 85, Lower Llandeilo, stream section at Wellfield Lodge immediately above where the stream is piped under the road, SO 044528. Internal mould of young holaspis, It.2891, ×5.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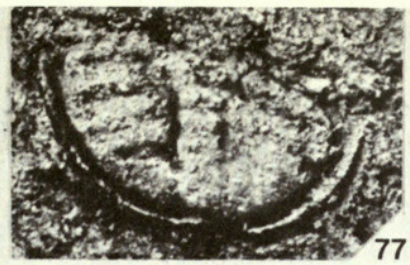
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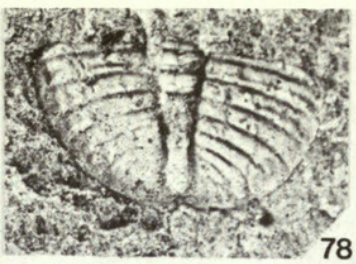
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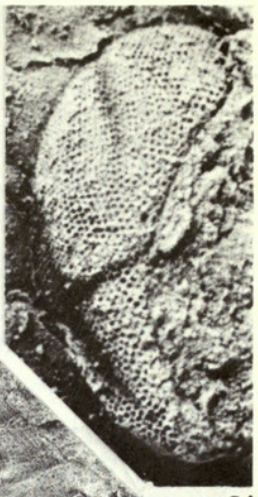
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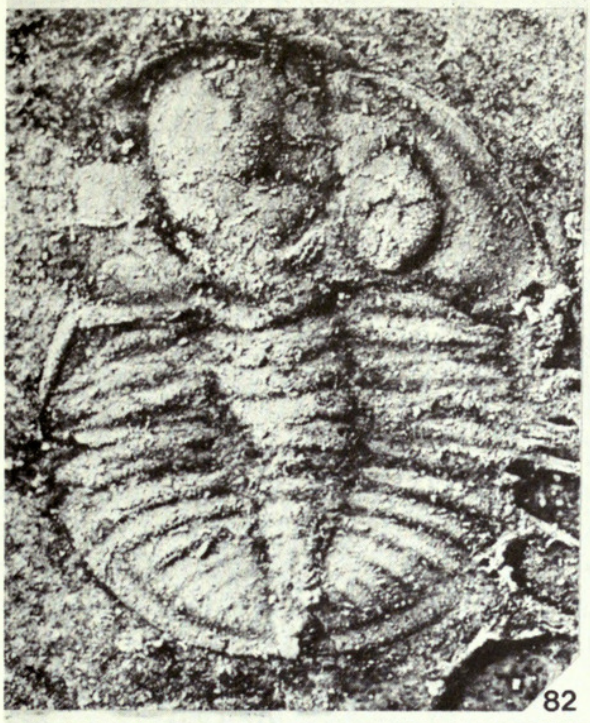
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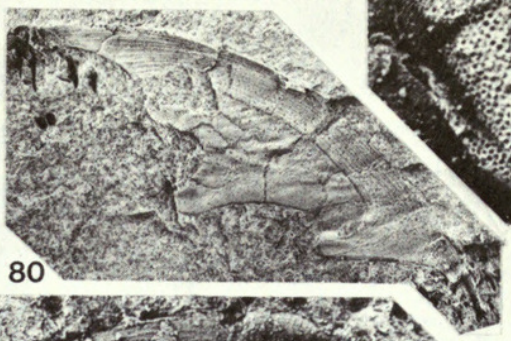
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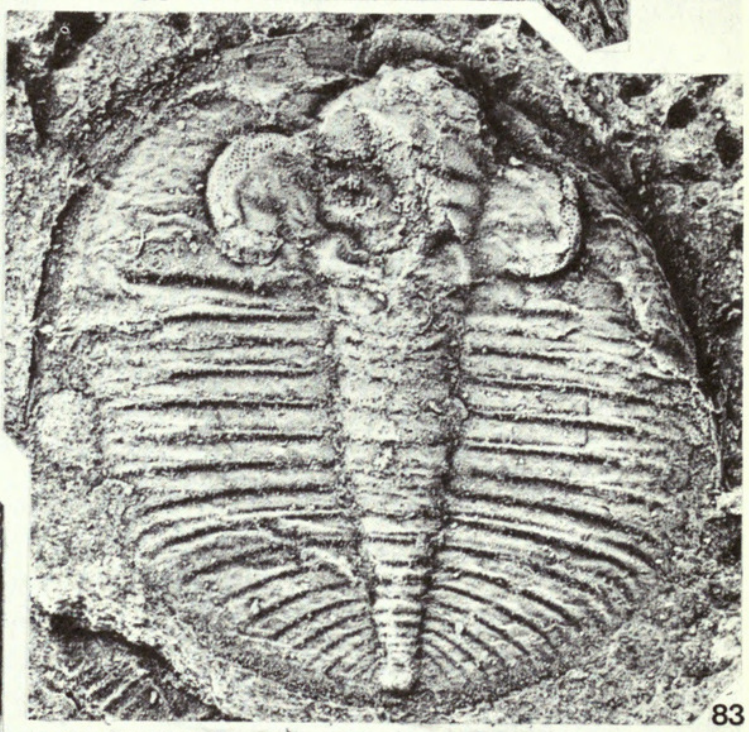
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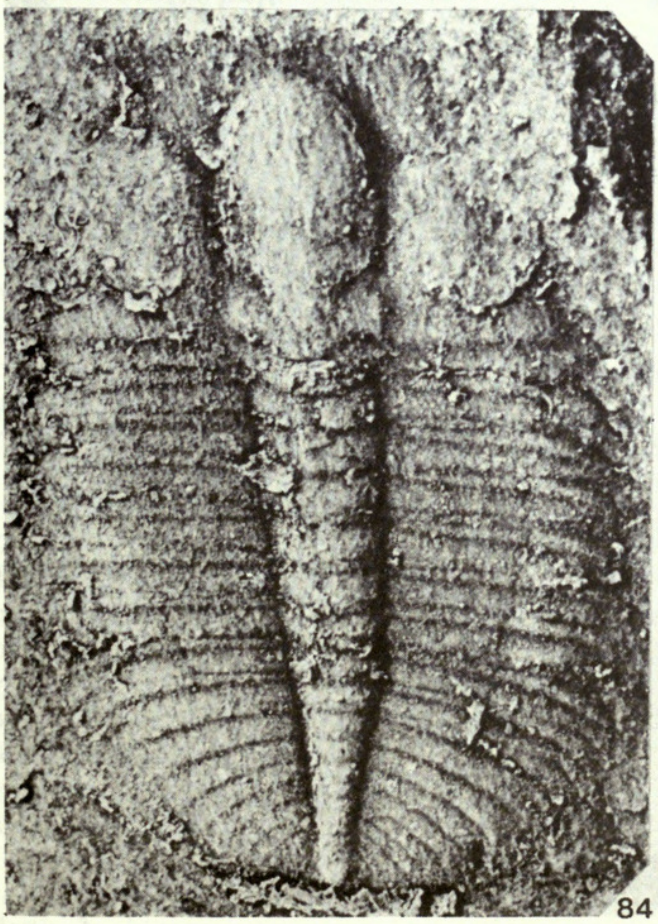
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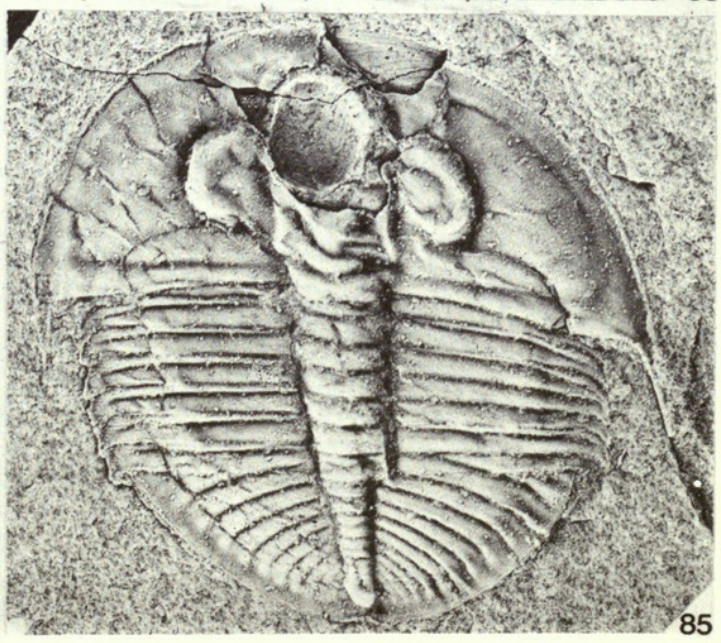
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Ogygiocarella debuchii (Brongniart, 1822)
(Figs 67, 69–70, 74, 76–86, 88–89, 91–92, 97)

1843 *Ogygia Buchii* (Brongniart); Goldfuss : 555.
1846 *Asaphus Buchii* Brongniart; De la Beche : 31.
1940 *Ogygiocaris buchi* (Brongniart) Elles (*pars*) : 406–412.
1964 *Ogygiocarella debuchii* (Brongniart); Whittard : 255–261; pl. 44, figs 1–11; pl. 45, figs 1–8 (includes fuller synonymy).
1966 *Ogygiocarella debuchii* (Brongniart); Whittard : 302.
1970 *Ogygiocarella debuchii* (Brongniart); Toghill : 122.
1972 *Ogygiocarella debuchii* (Brongniart); Hughes : 7–17.

DIAGNOSIS. *Ogygiocarella* generally having eleven pygidial ribs, rarely ten or twelve.

LECTOTYPE. Whittard (1964 : 261) selected as lectotype the specimen on which Brongniart (1822) based his plate 2, fig. 2A. This was unsatisfactory since the whereabouts of this specimen was, and is still, unknown. Nevertheless, it is proposed to accept Whittard's designation in order to preserve current usage of the name *O. debuchii* (see also Whittard 1964 : 256; Hughes 1972).

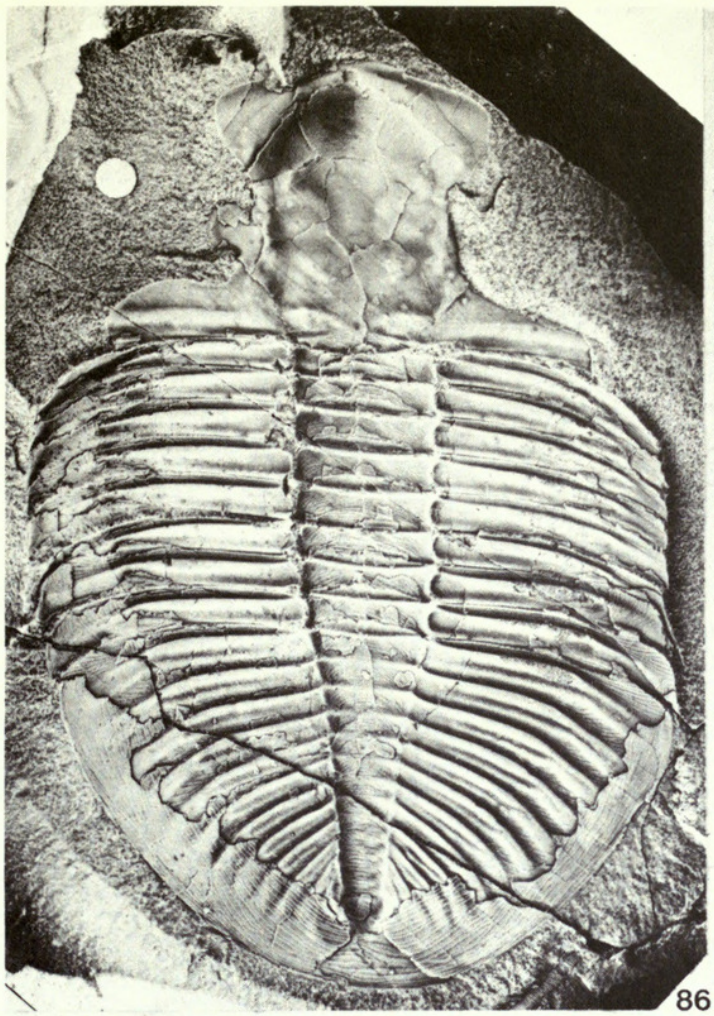
DISTRIBUTION. The species is common throughout much of south and central Wales and Salop (Shropshire), although some differences in stratigraphical range occur in different areas. The species first occurs near the top of the upper Llanvirn of the Builth district. De la Beche (1846 : 31) reported the species from the Grey Feldspar Sands at Tan-y-graig at a horizon somewhat lower than this, but no specimens have been located in substantiation. It persists until just below the top of the lower Llandeilo. In Salop it does not appear until the upper part of the lower Llandeilo (upper part of the Meadowtown Beds) and continues into the upper Llandeilo (Rorrington Beds), while in the Llandeilo region the species appears to be restricted to the Llandeilo. Numerous occurrences of the species have also been recorded from south Wales, but until the trilobites of this region are revised there is some doubt as to whether they can all be referred to *O. debuchii*, though it is certainly present in the Hendre Shales at Mydrim (Toghill 1970 : 122).

DESCRIPTION. The following descriptive notes supplement Whittard's (1964 : 257–261) description. Complete individuals are oval in outline being about one and a half times longer than wide. Some variation occurs in length/width ratio, but there is no evidence of the existence of distinct wide and narrow forms (Fig. 101) as claimed by Whittard (1964 : 257).

Cephalon approximately two and a half times as wide as long. In uncompressed specimens, unfurrowed frontal portion of the glabella moderately convex (*tr.*) with steep convex frontal face (cf. 59207, Fig. 86; SM A49721). Total length of glabella and occipital ring about one and three-quarters that of maximum glabellar width. Palpebral lobe situated entirely in posterior half of cephalon, mid-point being only about one-third of cephalic length from posterior margin. Eye moderately large, with all lenses approximately equal in size and hexagonal in outline. A relatively small specimen (eye length 3·0 mm) has visual surface with approximately 1000

Figs 86, 88–89, 91–92. *Ogygiocarella debuchii* (Brongniart), above. Fig. 86, unknown loc. in the Builth district. External mould of specimen lacking librigenae, 59207, ×1. Fig. 88, ? Llandeilo, loc. unknown but probably from the Llandeilo district. Internal mould of complete specimen showing well-developed nodes on the thoracic and pygidial axis, GSM 12880, ×1. Figs 89, 92, Lower Llandeilo, old quarry 570 yd (521 m) north of Wye Cottage, SO 047538. Fig. 89, internal mould of pygidium with twelve ribs, It.2908, ×1·5. Fig. 92, details of eye lenses, It.2910, ×10. Fig. 91, Lower Llandeilo, left bank of stream section east of Bach-y-graig, 20 yd (18 m) upstream of the point where the footpath enters the wood at the western end of the section, SO 072610. Internal mould of cephalon and part of thorax prepared to reveal mould of ventral surface of hypostoma, It.2895, ×2.

Figs 87, 90. *Ogygiocarella angustissima* (Salter), p. 150. Fig. 87, Middle-upper Llandeilo, quarry at Gwern-yfed-fâch, ½ ml (805 m) SE of Builth Road station, SO 030526. Internal mould of small pygidium with a slight posterior indentation, It.2923, ×7. Fig. 90, Middle-upper Llandeilo, middle quarry, Llanfawr, Llandrindod, SO 066617. Mould of dorsal surface of hypostoma, It.2917, ×3.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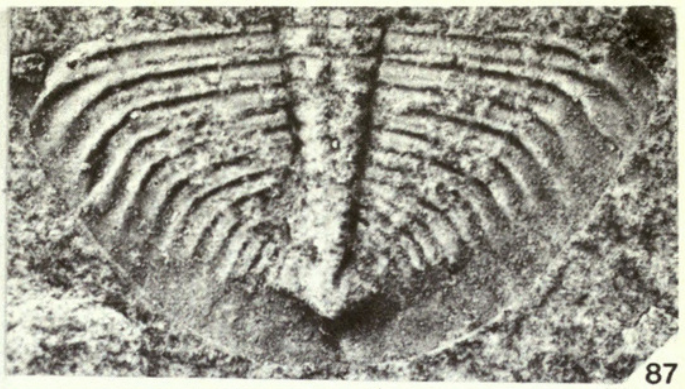
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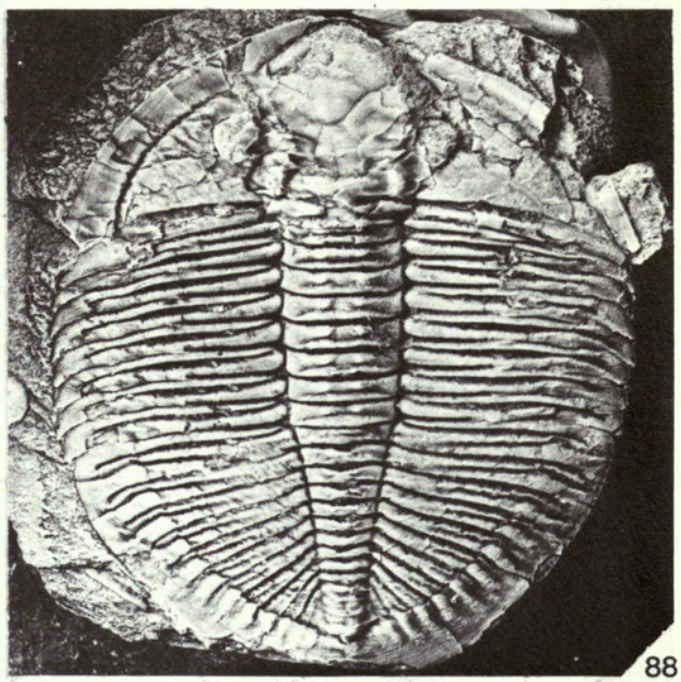
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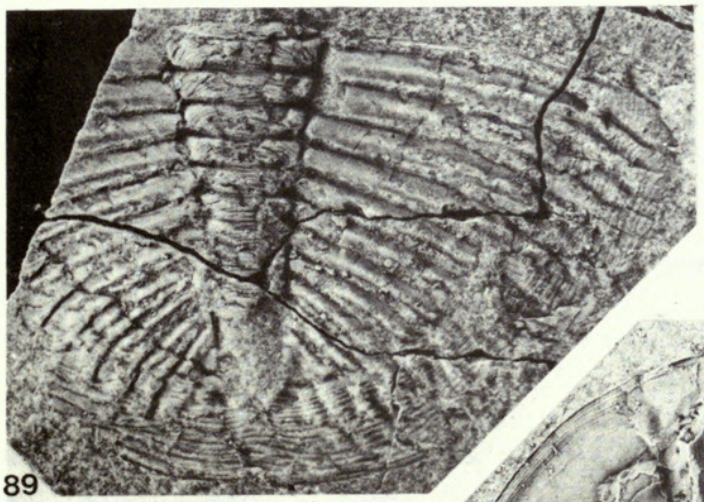
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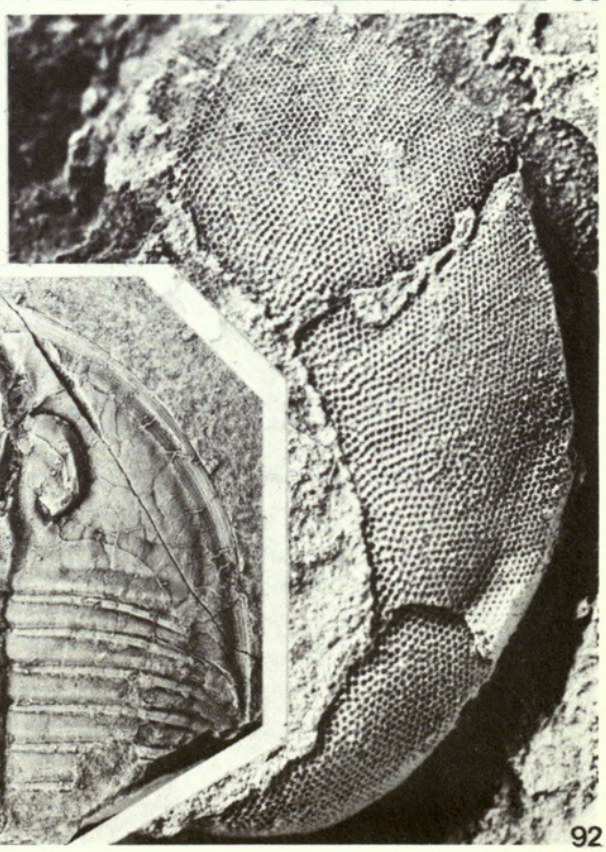
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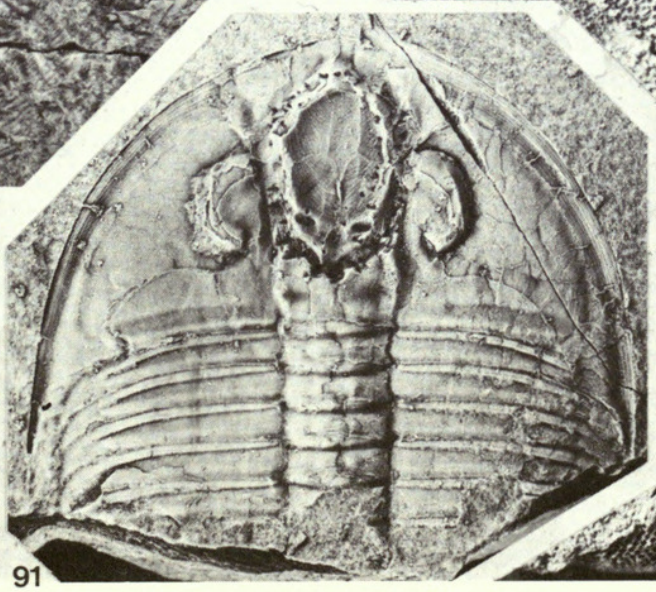
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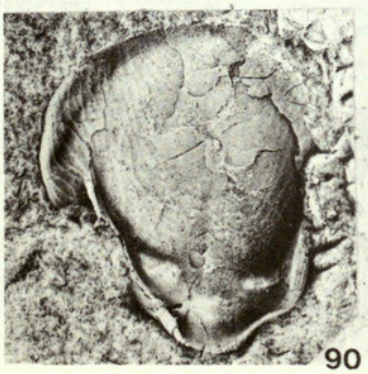
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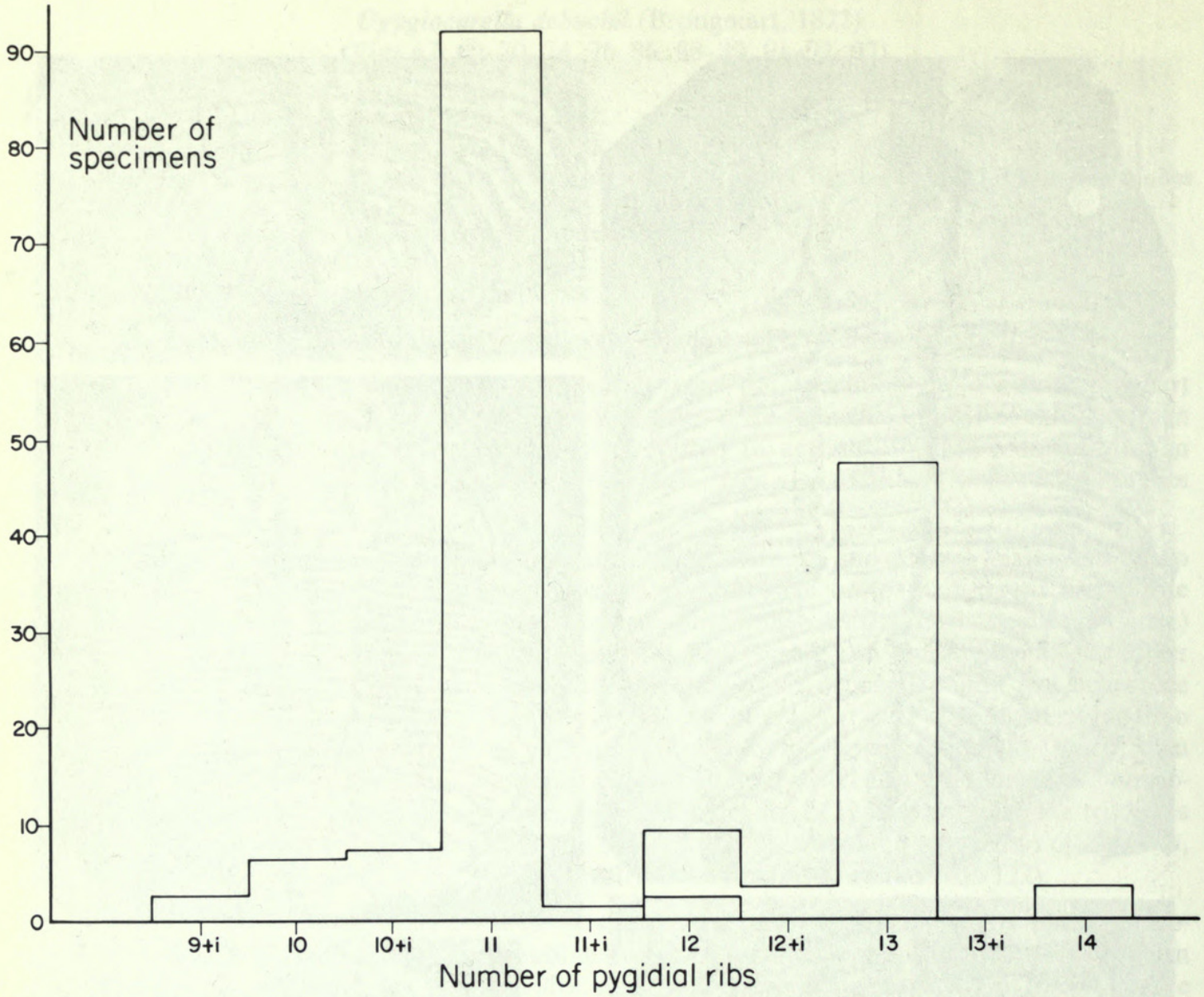

Fig. 93. Histogram of the number of pygidial ribs developed in *Ogygiocarella debuchii* (Brongniart) (left peak) and *Ogygiocarella angustissima* (Salter) (right peak).

lenses of about 0·033 mm diameter (Fig. 81). A larger specimen (eye length 8·5 mm) has approximately 4000 lenses of 0·055 mm diameter (Fig. 92). Visual surface approximately crescentic in outline, appearing to be widest anteriorly in dorsal view owing to the steeper inclination of the visual surface posteriorly.

External surface of frontal glabellar lobe bears a Bertillon pattern of fine, closely-spaced ridges (Figs 74, 86). Similar ridges are also present medially on posterior of glabella and occipital

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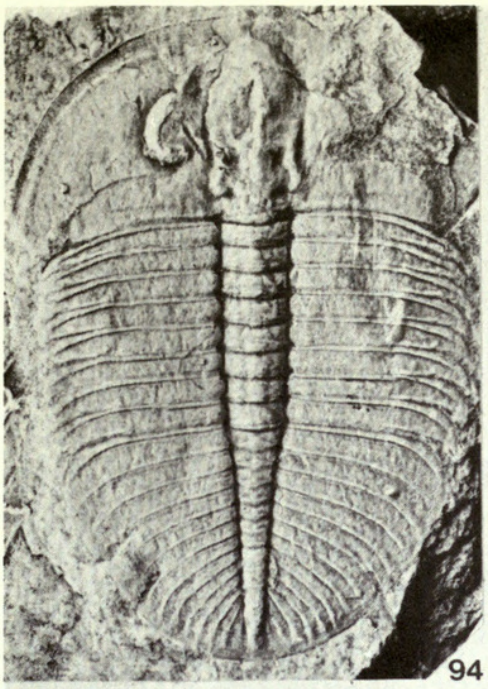
Figs 94–96, 98–100. *Ogygiocarella angustissima* (Salter), p. 150. Figs 94–95, Middle-upper Llandeilo, loc. uncertain (see p. 151). Fig. 94, **Lectotype.** Internal mould, 59198, ×2. Fig. 95, Paralectotype. Internal mould showing glabellar furrowing, 59199a, ×1·5. Figs 96, 100, Middle-upper Llandeilo, middle quarry, Llanfawr, Llandrindod, SO 066617. Fig. 96, part of cephalic doublure, showing possible panderian node near posterior margin, It.2919, ×3. Fig. 100, external mould of pygidial fragment showing surface sculpture, It.2914, ×3. Fig. 98, ? Middle-upper Llandeilo, loc. unknown but in the Builth district. Internal mould of virtually complete specimen having fourteen pygidial ribs, OUM B.123, ×1 (figured as *Asaphus debuchii* by Brongniart 1822: pl. 2, fig. 2c). Fig. 99, Middle-upper Llandeilo, ? quarry at Gwern-yfed-fâch, ½ ml (805 m) SE of Builth Road station, SO 030526. Internal mould of large pygidium and posterior part of thorax, showing sinuate inner edge of pygidial doublure, I.2857b, ×⅔.

Fig. 97. *Ogygiocarella debuchii* (Brongniart), p. 142. Lower Llandeilo, old quarry 570 yd (521 m) north of Wye Cottage, SO 047538. Internal mould of relatively narrow pygidium, It.2906, ×1.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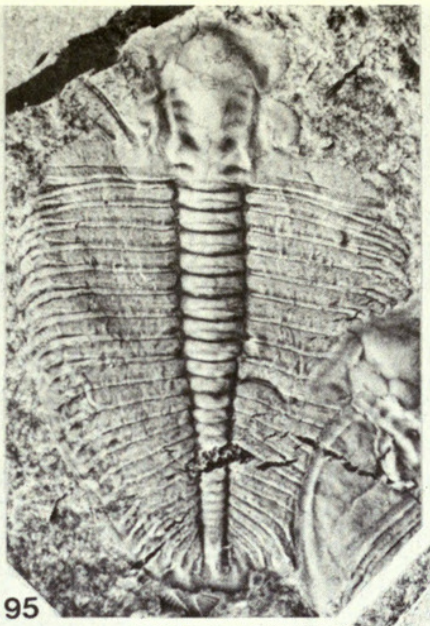
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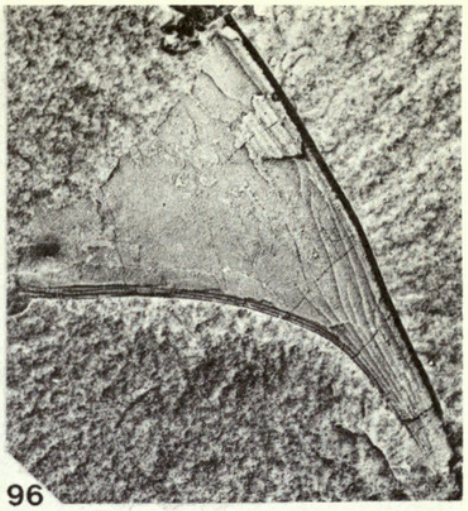
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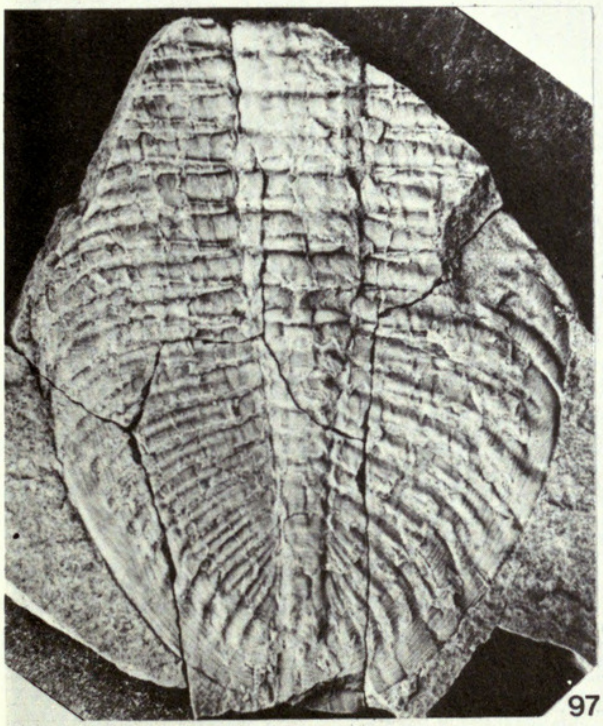
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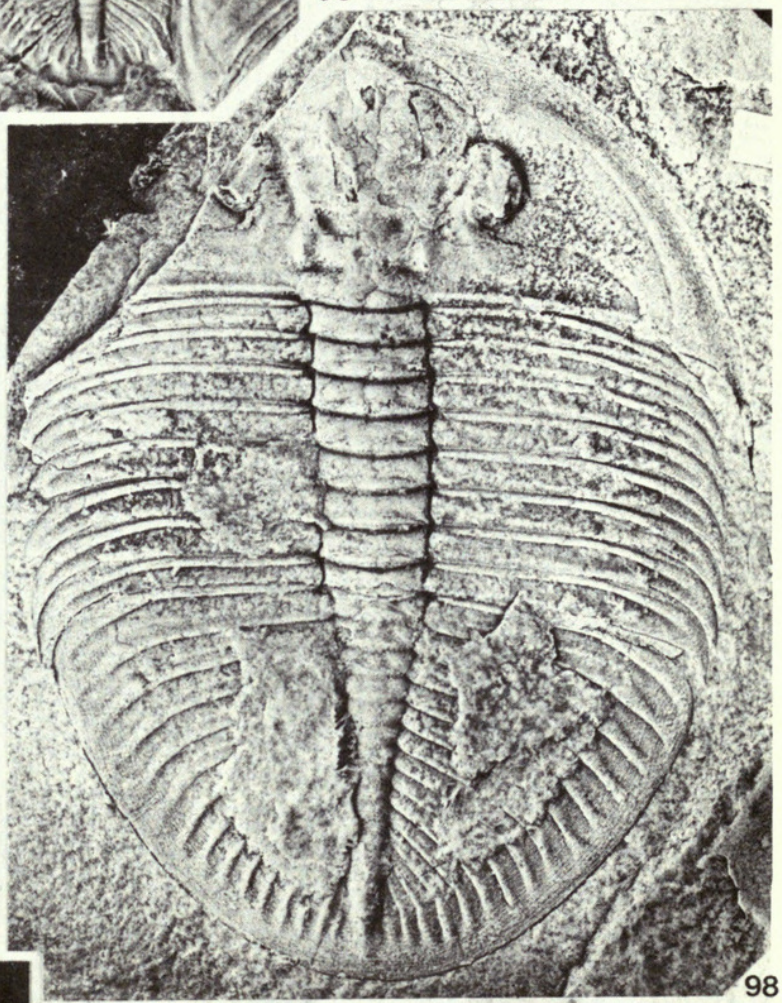
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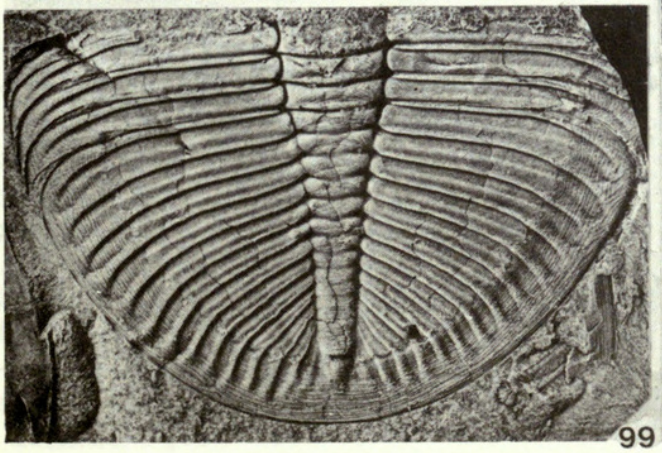
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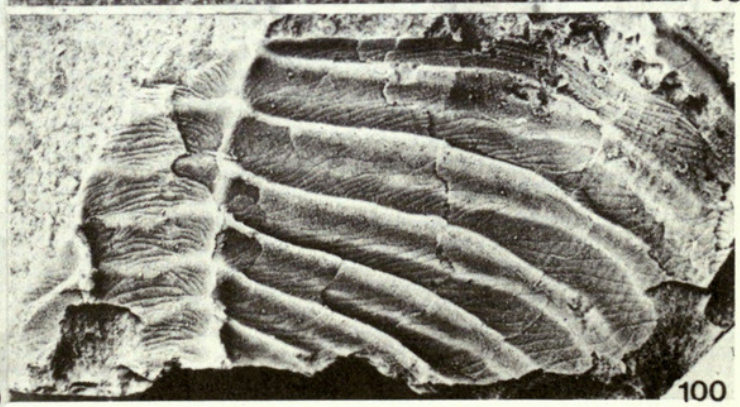
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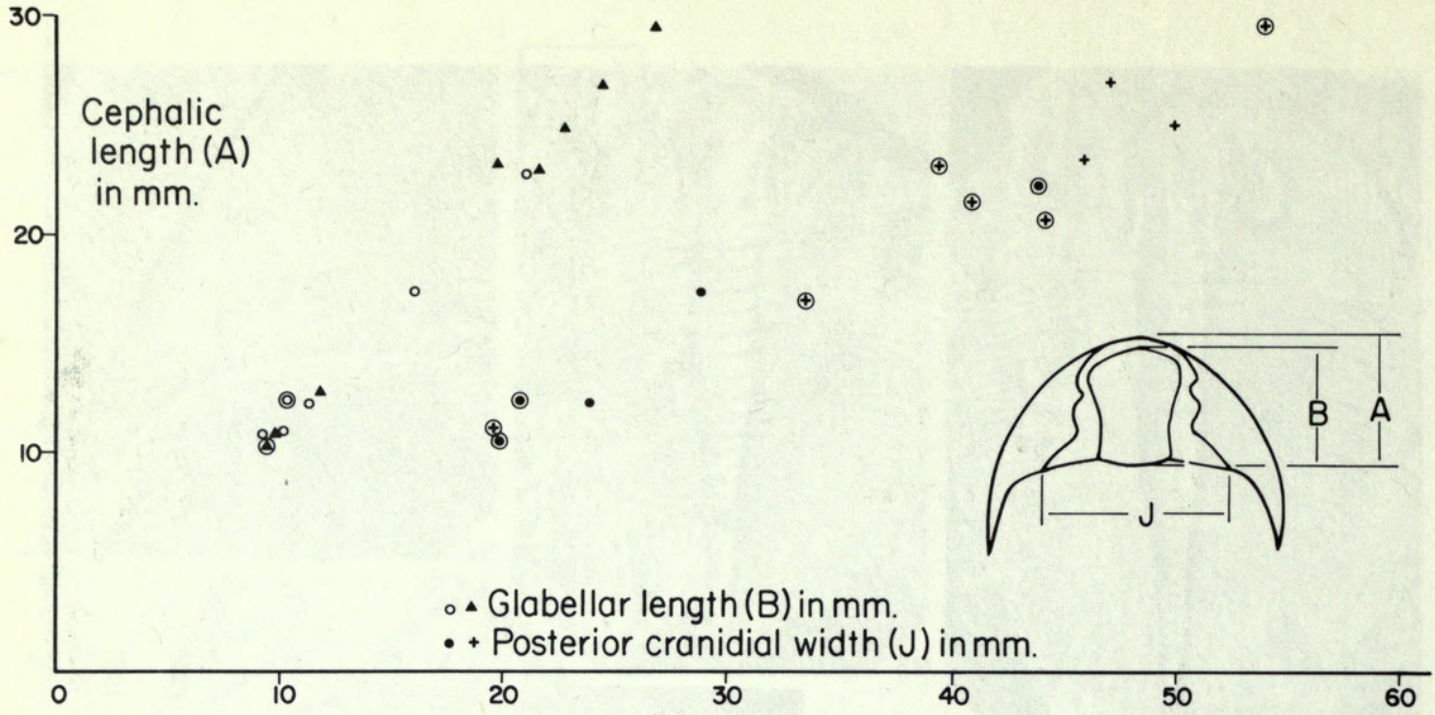

Fig. 101. Plots showing similarities between the cephalic dimensions of *Ogygiocarella debuchii* (Brongniart) (● ○) and *Ogygiocarella angustissima* (Salter) (+ ▲). Points enclosed by a circle are approximate.

ring (Fig. 74); here, however, they are not so markedly convex forwards. Remaining portions of dorsal cephalic exoskeleton smooth. Doublure moderately wide, though narrower anteriorly owing to location of hypostoma, and bearing fine terrace lines.

Thorax tapering slightly posteriorly. Axial furrows also converge slightly posteriorly. Nodes on axial rings occasionally developed in the Builth material; the only specimen known with these fully developed is GSM 12880, probably from Llandeilo (Fig. 88). No panderian openings or protuberances developed.

Pygidial axis infundibular, occupying slightly over one-sixth of pygidial width anteriorly and with up to 13 axial rings (rather than the 14 mentioned by Whittard), plus terminal piece. Generally, however, only between seven and nine axial rings are clearly differentiated, with little trace of furrowing on posterior of axis. Posteriorly apodemal pits in axial furrow become progressively less pronounced, disappearing at about the eighth or ninth axial ring. Typically eleven well-developed ribs present (see Table 11, p. 150). Posterior band of ribs is more convex (*exsag.*) than anterior one and distal to paradoublural line; ribs are deflected slightly more to the rear, this becoming progressively less posteriorly. Externally posterior bands bear raised lines lying oblique to interpleural furrows; distally these lines become subparallel to the margin

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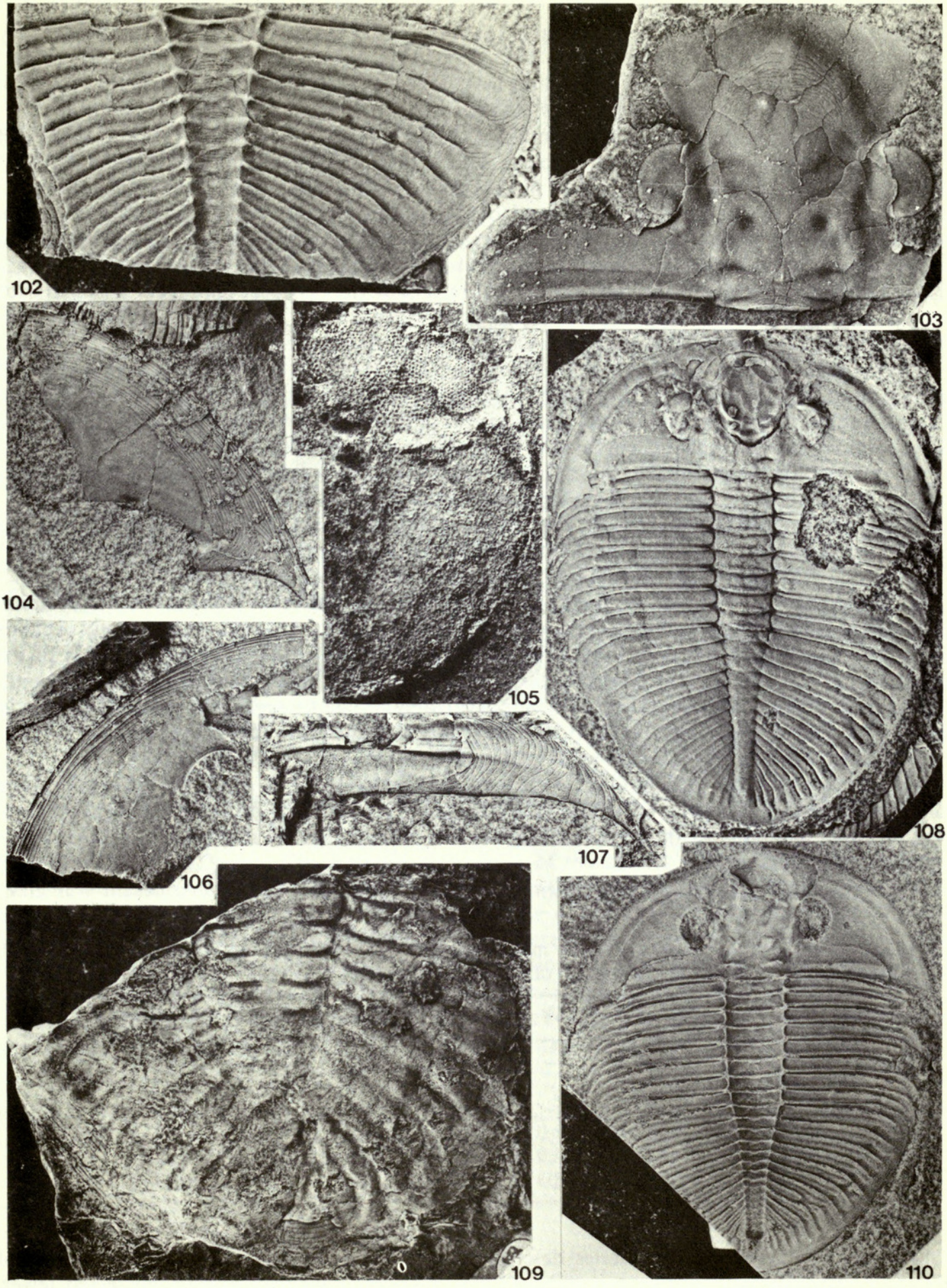
Figs 102–108, 110. *Ogygiocarella angustissima* (Salter), p. 150. Figs 102–103, 105–107, Middle-upper Llandeilo, middle quarry, Llanfawr, Llandrindod, SO 066617. Fig. 102, external mould of pygidium showing apodemal pits, It.2921, ×2. Fig. 103, latex impression from external mould showing sculpture, form of occipital ring, fixigenae and palpebral lobes, It.2918, ×2. Fig. 105, internal mould of eye showing traces of eye lenses, It.2920, ×10. Fig. 106, internal mould of damaged librigena showing sculpture and median suture, It.2915, ×3. Fig. 107, internal mould of part of thoracic segment, showing form and sculpture of the thoracic doublure, It.2916, ×2. Figs 104, 110, Middle-upper Llandeilo, quarry at Gwern-yfed-fâch, ½ ml (805 m) SE of Builth Road station, SO 030526. Fig. 104, internal mould of librigena showing sculpture of cephalic doublure, It.2922, ×7. Fig. 110, external mould showing slight irregularity in the eighth rib on the left pleural field, 59206, ×0·5. Fig. 108, Middle-upper Llandeilo, ? Harper's quarry, NE of Wellfield, SO 038532. Internal mould of nearly complete specimen showing general form and position of the hypostoma, GSM 12918, ×1.

Fig. 109. *Ogyginus* ? *laticostatus* (Salter), p. 138. ? Upper Llanvirn, 'Maen Goran, Builth'; ? small quarry about 270 yd (247 m) west of Maen Cowyn, SO 054525 (see p. 138). Internal mould of pygidium, SM A16693, ×1.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and extend onto the distal extremities of anterior bands (Fig. 86). Strong terrace lines developed on doublure subparallel to margins, becoming bunched together in post-axial region (Fig. 86).

ONTOGENY. Although only a few meraspid specimens are known from the Builth region, they show some interesting differences from the ontogenetic series described by Whittard (1964: 259–260) from the Shelve region. The Builth material consists of one entire specimen of degree 4 and two of degree 7, together with a few isolated transitory pygidia of uncertain degree.

Isolated transitory pygidia. Smallest known specimen, It.2897 (Fig. 76) is 1·3 mm wide and 0·8 mm long, roughly semicircular, globose, with a prominent posterior indentation. At least two ribs are present on anterior part of pleural field. Axial region approximately parallel-sided and weakly furrowed. Posterior and lateral borders well developed and flat. It.2896 (Fig. 77), width and length 1·6 mm and 0·8 mm respectively, is very similar but has at least three ribs developed. It.2892 (Fig. 78), 3·0 mm wide and 1·7 mm long, has eight ribs, the anterior ones having well-developed furrows along their entire length (*tr.*). The development of eight ribs would suggest, by comparison with Whittard's ontogenetic series, degree 3 or 4, but the well-developed pleural furrows are more characteristic of his degree 7 specimens.

Degree 4. Single known specimen, It.2898 (Fig. 82) is about 4·0 mm long. Cephalon not well preserved axially, but occipital ring appears simple, bowed posteriorly with continuous occipital furrow and no lateral occipital lobes. Basal pair of lateral glabellar furrows well developed. Eye large, almost half the cephalic length, with relatively few (up to 100) large lenses.

Thorax slightly disarticulated, but appears to consist of only four segments, similar to those of holaspides but with relatively deeper pleural furrows.

Transitory pygidium semielliptical, nearly three times as wide as long. Seven unfurrowed ribs developed. Axis with at least six axial rings and extending close to indented posterior margin.

Degree 7. Two entire specimens are 6·5 mm and 8·2 mm long (see Table 5).

Although basically similar to holaspides, the cephalon differs in various ways. Occipital ring simple with continuous furrow and no lateral occipital lobes. Glabella progressively expands slightly anteriorly and has only three pairs of lateral glabellar furrows, the anterior pair of the adult being absent. Eye still relatively large, being only just under half the cephalic length. Posterior border furrow dies out distally approximately in line (*exsag.*) with the fulcrum. As in holaspides, genal spine relatively short, reaching only to fourth thoracic segment.

The seven thoracic segments are as in holaspides.

Transitory pygidium semielliptical, with 9–11 ribs which may be shallowly furrowed along their entire length (*tr.*) (Fig. 83). Ribs deflected slightly posteriorly on reaching paradoublural line. Axis infundibular with ten axial rings and a terminal piece. No posterior indentation developed.

Apart from being slightly larger, specimen It.2893 (Fig. 84) is similar.

Table 5. Measurements and rib counts on meraspid specimens of *Ogygiocarella debuchii* (Brongniart). All measurements in mm. For explanation of symbols see Fig. 1.

Specimen	T.L.	A	W	Z	Ribs	Degree
It.2897	–	–	1·3	0·8	2+?	?
It.2896	–	–	1·6	0·8	3	?
It.2892	–	–	3·0	1·7	8	?
It.2898	*c.* 4·0	*c.* 2·0	3·0	*c.* 1·1	7	4
It.2913	6·5	2·9	5·2	1·9	9	7
It.2893	8·2	3·3	4·7	2·2	7+	7

DISCUSSION OF ONTOGENY. The series described by Whittard shows that transitory pygidia of degree 1 probably had six ribs and suggests that degree 0 transitory pygidia possessed fewer. The present study, however, has revealed meraspid transitory pygidia with only two or three ribs developed. Whether these are of degree 0 or not cannot be ascertained. Their size and the

number of ribs developed would suggest that they are earlier than degree 4, but more likely to be of degree 2 or 3 than 0 or 1. The present study also shows that variations in the number of ribs developed at a particular degree do occur.

A striking difference between the Builth and Shelve meraspides is that of size, the Builth specimens being generally much smaller. Table 6 gives the comparative data for specimens from the two areas. As in the holaspid form, variations in the overall length/width ratios are known in the meraspides (Figs 83, 84; Whittard 1964 : pl. 45, figs 6, 7), although much of this variation results from *post-mortem* deformation.

Table 6. Comparative data for meraspid specimens of *Ogygiocarella debuchii* (Brongniart) from the Builth and Shelve regions. Column headed 'Locality' gives an indication of which specimens are from the same locality as others. All measurements in mm. * indicates a further incipient rib developed. For explanation of symbols see Fig. 1.

Specimen	Degree	T.L.	A	Z	Ribs	Locality
Builth						
It.2897	?	–	–	0·8	2+ ?	A
It.2896	?	–	–	0·8	3	A
It.2898	4	*c.* 4·0	*c.* 2·0	*c.* 1·1	7	A
It.2892	?	–	–	1·7	8	B
It.2913	7	6·5	2·9	1·9	9	C
It.2893	7	8·2	3·3	2·2	7+	C
Shelve						
GSM 102160	1	–	–	1·3	6	1
GSM 102163	2	3·3	–	1·5	7*	2
GSM 102164	3	*c.* 4·0	–	1·6	7+	2
GSM 102165	4	6·4	3·0	2·2	9	3
GSM 102166	5	5·7	2·6	1·8	10	4
GSM 102167	7	14·5	–	2·8	10	3

BIOMETRICAL DATA. Despite the common occurrence of the species in the Builth district, relatively few measurements are possible owing to the damaged state of much of the available material. Pygidia have provided most of the available data; insufficient cephalic and thoracic data are available to allow any formal analysis. Measurements are given in certain cases to give some quantitative idea of the dimensions and variation of some features. For ease of comparison, various dimensions of *O. debuchii* and *O. angustissima* (p. 146) are plotted on Fig. 101. In the cases where bivariate analyses have been possible, they have been computed using the total measurable sample from the Builth inlier rather than the sample from any specific locality.

Table 7. Ratios of the maximum cephalic length (A), thoracic length (Q), maximum pygidial width (W) and pygidial length (Z) to the total length (T.L.) for *Ogygiocarella debuchii* (Brongniart).

Specimen	T.L.	A/T.L.	Q/T.L.	W/T.L.	Z/T.L.
NMW 68.376.G210	26·4	0·33	0·31	0·67	0·36
NMW 68.376.G211	33·5	0·33	0·32	0·67	0·35
NMW 68.376.G212	*c.* 35·5	*c.* 0·30	*c.* 0·31	*c.* 0·71	*c.* 0·39
NMW 68.376.G213	*c.* 36·0	*c.* 0·32	*c.* 0·32	*c.* 0·67	*c.* 0·36
NMW 68.376.G214	38·4	0·33	0·29	*c.* 0·71	0·38

Table 8. Cephalic measurements for *Ogygiocarella debuchii* (Brongniart). All measurements in mm. For explanation of symbols see Fig. 1.

Specimen	A	B	C_3	J	J_1	K
NMW 68.376.G215	10·7	9·5	–	*c.* 20·0	–	–
NMW 68.376.G211	11·0	10·0	–	–	–	5·6
NMW 68.376.G214	12·5	11·4	–	24·0	–	*c.* 6·0
NMW 68.376.G216	12·6	*c.* 10·5	4·4	*c.* 21·0	–	5·5
NMW 68.376.G217	17·5	16·2	–	29·0	16·8	9·4
NMW 68.376.G218	*c.* 22·3	–	–	44·0	–	–
NMW 68.376.G219	23·0	21·3	–	–	–	12·4
NMW 68.376.G220	–	*c.* 11.0	–	–	–	*c.* 6·0

Table 9. Bivariate statistics for the thorax and pygidium of *Ogygiocarella debuchii* (Brongniart). All measurements in mm. For explanation of symbols see Fig. 1.

x : y	$\bar{x}$	var. x	$\bar{y}$	var. y	r	r_e	α	var. α	a	var. a	n
Q : R_2	15·08	41·29	7·21	10·68	0·95	0·95	1·06	0·0156	0·51	0·0036	9
R_2 : R_3	7·87	12·79	6·72	8·94	1·00	1·00	0·98	0·0005	0·84	0·0004	6
W : Z	30·08	299·07	18·28	131·04	0·97	0·98	1·08	0·0025	0·66	0·0008	29
W : X	25·92	253·52	4·61	9·33	0·99	0·99	1·07	0·0007	–	–	24
Z : Y	14·52	83·82	12·07	54·16	1·00	1·00	0·97	0·0001	–	–	38
Z : X	14·55	96·65	4·35	8·47	0·97	0·97	0·99	0·0015	0·30	0·0001	39

Table 10. Thoracic measurements for *Ogygiocarella debuchii* (Brongniart). All measurements in mm. For explanation of symbols see Fig. 1.

Specimen	R_1	Q	Specimen	R_1	Q
NMW 68.376.G216	*c.* 23·0	9·8	NMW 68.376.G221	*c.* 33·0	14·0
NMW 68.376.G211	*c.* 24·0	10·8	It.2903	*c.* 44·0	23·2
NMW 68.376.G215	*c.* 24·5	10·9	NMW 68.376.G217	*c.* 53·6	23·8
NMW 68.376.G213	25·4	11·4	NMW 68.376.G222	*c.* 55·0	23·2
NMW 68.376.G214	31·2	11·2	NMW 68.376.G223	*c.* 61·0	24·0

Table 11. Frequency distribution of ribs on the pleural fields of *Ogygiocarella debuchii* (Brongniart). The suffix 'i' indicates the development of a further incipient rib. See also Fig. 93, p. 144).

Number of ribs	9i	10	10i	11	11i	12
Number of specimens	0	1	7	82	1	2

DISCUSSION. Under a variety of names, this is one of the most commonly cited species in British Ordovician palaeontological literature, being first figured by Lhuyd in 1698. The validity and authorship of the species has been the subject of much debate, the two most recent contributions being by Whittard (1964) and Hughes (1972).

Ogygiocarella angustissima (Salter, 1865–6)
(Figs 87, 90, 94–96, 98–100, 102–108, 110)

1846 *Ogygia Buchii* (Brongniart); Burmeister (*pars*) : 59–61.
1865 *Ogygia angustissima* Salter : pl. 14, figs 8–9 (figures only).
1866 *Ogygia angustissima* Salter: 129 (text).
1940 *Ogygia buchi* (Brongniart); Elles (*pars*) : 408, 411, 412, 414–419, 421– 433.
1964 *Ogygiocarella debuchii* (Brongniart) var. *angustissima* (Salter) Whittard : 261–262; pl. 45, fig. 9; pl. 26, fig. 1. Includes earlier synonymy.
1966 *Ogygiocarella debuchii* (Brongniart) var. *angustissima* (Salter); Whittard : 302.

DIAGNOSIS. *Ogygiocarella* with 12–14 ribs developed on pleural field, majority of individuals having 13.

LECTOTYPE (herein selected): 59198 (Fig. 94), internal mould of nearly complete individual. Dimensions (in mm): T.L., 33·5. A, 11·2. B, 10·0. C, 5·3. C_1, 2·1. C_2, 3·8. J, *c.* 19·8. K_1, *c.* 4·3. R_1, *c.* 22·0. R_2, 3·7. R_3, 3·1. R_4, *c.* 21·0. Q, 10·8. Q_1, 1·2. W, 19·7. X, 2·9. Y, 11·5. Z, 12·0. For explanation of symbols see Fig. 1. Both pleural fields have thirteen ribs and at least nine axial rings developed.

Paralectotypes: 59199a (Fig. 95), 59199b, internal moulds of nearly complete specimens, 59199a lacking librigenae.

TYPE LOCALITY AND HORIZON. Specimen 59198, here selected as lectotype, is labelled as coming from 'Llandeilo Flags, Gilwern' and was recorded as such by Salter in his original description (1866 : 129). However, the beds exposed at and around Gilwern are of uppermost lower Llanvirn age, whereas this species is characteristic of the highest lower Llandeilo to upper Llandeilo rocks of the Builth area. The lithology of the lectotype slab is unlike any found at Gilwern, but is similar to that of the *Nemagraptus gracilis* Shales of middle–upper Llandeilo age, and it seems likely that the specimen is either from the middle quarry, Llanfawr, Llandrindod, or possibly from Gwern-yfed-fâch quarry, near Builth Road. While it is accepted that the designation of a lectotype from uncertain locality leaves much to be desired, a similar problem over locality exists for the other syntypes (59199a, b); they are listed as from Gwern-fydd, but their lithology strongly suggests that they are from Harper's quarry, a quarter mile (402 m) north-west of Wellfield. Specimen 59198 has, therefore, been selected as lectotype as it is the most perfect of the three syntypes.

DISTRIBUTION. The species appears to be restricted to the high lower Llandeilo and middle to upper Llandeilo. Until the faunas of south Wales have been restudied little can be said about its occurrence south of Builth except that it has recently been recorded from the topmost Llandeilo Flags at Pant-yr-hendre and Llan quarries near Mydrim, Dyfed (Carmarthenshire) (Toghill 1970 : 122).

DESCRIPTION. Complete individuals oval in outline, about one and a half times as long as wide, but with some variation (see Table 12).

The cephalon is identical to that of *O. debuchii* except that the palpebral lobe may be slightly more anteriorly placed in larger specimens of *O. angustissima*, but insufficient data are available at present to confirm this quantitatively. Eye appears to be similar to that of *O. debuchii*; one specimen (eye length 6·0 mm) has *c.* 2500 lenses (Fig. 105).

Hypostoma apparently like that of *O. debuchii*.

Pygidium, although basically similar to that of *O. debuchii*, differs in some features. Outline tends to be parabolic, slightly longer relative to its width than in *O. debuchii*, except in small specimens (width less than 27 mm). Infundibular axis occupies about one-seventh of pygidial width anteriorly. Between 12 and 14 ribs may be developed on the pleural field, with over three-quarters of the specimens having 13 ribs (see Table 15 and Fig. 93). At least 14 axial rings may be developed, but generally only the anterior seven or eight are clearly discernible (as in *O. debuchii*). A comparison of the respective bivariate statistics for pygidial length and anterior axial width reveals that the pygidial axis of *O. angustissima* is narrower, with respect to pygidial length, than in *O. debuchii*. As in other asaphids, irregularities in the rib development are rare, only a single example being known in *O. angustissima* (Fig. 110). In all other features the pygidium appears to be identical to that of *O. debuchii*, with the exception that some small holaspid specimens show a slight posterior indentation (Fig. 87).

BIOMETRICAL DATA. Slightly more data are available for *O. angustissima* than for *O. debuchii*, and they are presented in a similar manner, some slight modifications being made to suit the extra data available.

Table 12. Ratios of the maximum cephalic length (A), thoracic length (Q), maximum pygidial width (W) and pygidial length (Z) to the total length (T.L.) for *Ogygiocarella angustissima* (Salter).

Specimen	T.L.	A/T.L.	Q/T.L.	W/T.L.	Z/T.L.
NMW 68.376.G224	*c.* 29·0	*c.* 0·34	–	*c.* 0·62	*c.* 0·34
BM 59198	33·5	0·33	0·32	0·58	0·36
SM A44685	38·6	0·32	0·31	–	0·39
BM I.8076	48·1	0·30	0·31	0·69	0·39
SM A44686	50·5	0·30	0·31	0·70	0·39
NMW 68.376.G225	54·0	0·30	0·32	0·61	0·38
BM I.59215	60·4	0·29	0·31	0·67	0·40
BM I.4381	65·0	0·32	–	0·78	0·39
BM I.1330	70·5	0·33	0·30	*c.* 0·63	0·37
GSM 12918	71·5	0·29	0·31	0·68	0·41
SM A44696	71·8	*c.* 0·28	0·32	–	0·39
BM 59211	83·4	0·30	0·31	0·69	0·39
BM 59202	88·0	0·31	0·30	0·65	0·40
OUM B123	96·8	0·29	0·29	0·65	0·40
SM A44714	101·9	0·30	0·29	0·64	0·40

Table 13. Cephalic measurements for *Ogygiocarella angustissima* (Salter). All measurements in mm. For explanation of symbols see Fig. 1.

Specimen	A	B	C_3	J	J_1	K_2
NMW 68.376.G226	10·4	*c.* 9·5	*c.* 4·1	–	–	–
BM 59198	11·2	10·0	3·8	*c.* 19·8	–	–
SM A44685	12·4	–	4·6	–	–	–
NMW 68.376.G227	13·0	11·9	*c.* 5·4	–	–	–
SM A44730	13·6	–	–	27·0	12·3	–
SM A44686	15·0	–	–	–	14·2	–
NMW 68.376.G228	17·3	–	–	*c.* 33·6	–	–
BM 59215	17·4	–	–	37·1	–	–
NMW 68.376.G229	20·7	–	–	*c.* 44·2	21·5	–
BM I.4381	20·7	–	7·9	44·2	–	–
NMW 68.376.G230	21·6	–	8·9	*c.* 41·0	18·4	–
BM I.1330	23·3	21·7	–	*c.* 39·5	–	–
NMW 68.376.G231	23·5	20·0	*c.* 6·5	46·0	–	–
BM 59211	25·2	23·0	*c.* 10·8	50·0	–	15·7
BM 59202	27·0	24·6	12·4	47·0	–	*c.* 14·0
BM 59203	29·0	26·5	–	61·3	–	–
OUM B123	29·6	27·0	–	*c.* 54·4	–	–
BM 59211	30·0	27·0	–	–	–	–
SM A44714	30·3	26·8	12·4	*c.* 58·5	*c.* 28·5	16·8
SM A44723	34·0	30·5	14·1	68·6	29·0	19·2

Discussion. Apart from the number of pygidial ribs, the differences between *O. angustissima* and *O. debuchii* are slight. If samples of each form in the Builth region are considered, there is a clear distinction based on the pygidial rib counts, although both species include morphologically intermediate specimens. There is also a clear stratigraphical separation between the two species in the Builth region. In the Shelve Inlier the situation is not quite so straightforward, as the two forms have an overlapping stratigraphical range with both occurring in the uppermost lower Llandeilo. This suggests that the fossil record has preserved details of a stock undergoing speciation, with concomitant blurring of sharp distinctions between the two species.

Table 14. Bivariate statistics for *Ogygiocarella angustissima* (Salter). All measurements in mm. For explanation of symbols see Fig. 1.

x : y	$\bar{x}$	var. x	$\bar{y}$	var. y	r	r_e	α	var. α	a	var. a	n
A : B	25·10	51·48	22·64	41·89	1·00	1·00	1·00	0·0007	0·90	0·0006	11
R_1 : Q	49·34	435·01	21·29	74·70	0·98	0·98	0·96	0·0055	0·41	0·0011	8
Q : R_2	20·23	48·74	8·53	11·55	0·97	0·97	1·14	0·0044	0·49	0·0008	19
R_2 : R_3	8·48	10·96	7·32	7·87	0·99	0·99	0·98	0·0009	0·85	0·0007	20
R_4 : Q	54·80	175·52	23·71	27·80	0·96	0·96	0·92	0·0065	0·40	0·0012	11
W : Z	46·31	349·97	27·51	115·22	0·93	0·94	0·97	0·0039	0·57	0·0015	32
W : X	47·18	351·83	7·88	10·26	0·89	0·90	1·02	0·0056	0·17	0·0002	34
Z : Y	26·89	111·61	22·36	70·82	1·00	1·00	0·96	0·0002	0·80	0·0001	42
Z : X	26·54	112·58	7·25	9·61	0·95	0·96	1·06	0·0018	0·29	0·0001	54

Table 15. Frequency distribution of ribs on the pleural fields of *Ogygiocarella angustissima* (Salter). The suffix 'i' indicates the development of a further incipient rib. See also Fig. 93.

Number of ribs	12	12i	13	13i	14
Number of specimens	9	3	77	2	5

Ogygiocaridinid gen. et sp. indet.
(Fig. 12)

FIGURED SPECIMEN. It.2927, internal and external moulds of complete meraspid of degree 0.

LOCALITY AND HORIZON. Left bank of stream section east of Bach-y-graig, 40 yd (37 m) upstream of the point where the footpath enters the wood at the western end of the section; in *Glyptograptus teretiusculus* Shales.

DESCRIPTION. Exoskeleton apparently complete, oval in outline, being 1·4 mm long and 1·05 mm wide. Cephalon semicircular with no genal spines. Glabella parallel-sided; axial furrow deep. Glabellar furrows consist of two notch-like indentations on either side of glabella situated at one-third and two-thirds the way along the glabella. Occipital ring bowed backwards sagittally, occipital furrow continuous but deepest laterally. Posterior border and border furrow well defined. Genal region convex, with no eye. Facial suture may, however, be submarginal with the librigena, and with it the eye, missing.

Transitory pygidium semicircular and slightly smaller than cephalon, being 0·55 mm long. Axis well defined, occupying one-fifth of pygidial width anteriorly and tapering posteriorly to become parallel-sided over the posterior half. Two ribs occupy anterior half of the gently convex pleural fields. Number of axial rings developed cannot be determined.

DISCUSSION. The taxonomic placing of isolated occurrences of very early growth stages is difficult. Among the genera known in association with this specimen is *Barrandia*, but although the early ontogenetic stages of this genus are not known, the general characters of both the cephalon and transitory pygidium of this specimen are more akin to the ogygiocaridinids, and it would seem most likely to belong to either *Ogyginus corndensis* (Murchison) or *Ogygiocarella debuchii* (Brongniart), both species being known from the same locality.

The apparent lack of eyes is noteworthy, as relatively large, prominent eyes are present in degree 4 meraspides of both *O. debuchii* and *O. corndensis*. However, Evitt (1961) found that no visual surface is discernible in the protaspides of some asaphids, although its future position is indicated by the course of the facial suture.

Asaphid gen. et sp. indet.
(Fig. 112)

FIGURED SPECIMEN. It.2928, internal mould of glabella and part of left fixigena. Dimensions (in mm): B, 11·6. C_1, *c.* 3·8. C_2, 3·5. K_2, 8·0. For explanation of symbols see Fig. 1.

LOCALITY AND HORIZON. Gwern-yfed-fâch quarry, ½ml (805 m) south-east of Builth Road Station; *Nemagraptus gracilis* Shales.

DESCRIPTION. Glabella well defined, constricted at about one-fifth of its length, expanding slightly to just anterior of the palpebral lobe, obtusely rounded anteriorly. Three pairs of lateral glabellar furrows present. Posterior pair situated opposite the narrowest part of glabella and develops pits adaxially. Median pair moderately deep, curved posteromedially, situated at about half-way along glabella, and distally fail to reach axial furrow. Anterior pair situated opposite anterior of palpebral lobe, short, shallow and directed slightly anteromedially. Occipital furrow continuous, though central portion shallower and bowed posteriorly. Very little of fixigena preserved, but apparently posterior portion extends for some way laterally posterior to eye. Both posterior border and border furrow moderately well developed.

DISCUSSION. The affinities of this specimen are unknown, although it bears some similarity to *Nobiliasaphus powysensis* sp. nov. (see p. 117). However, the glabella furrowing, occipital ring and position of the eye serve to distinguish it from that species. Specimen I.1331, labelled as '*Ogygia* . . . from Gwernyfod', is probably closely related to this form.

Family **NILEIDAE** Angelin, 1854

Genus ***BARRANDIA*** M'Coy, 1849

DIAGNOSIS. Exoskeleton oval, depressed and subisopygous. Glabella smooth, expanded frontally; axial furrow shallow; fixigena narrow (*tr.*) posteriorly. Eye well developed; genal spine short. Thorax of eight segments; doublure extending beneath more than half pleural width. Pygidium subsemicircular to subelliptical with prominent, weakly furrowed, axis and generally smooth pleural field.

TYPE SPECIES. *Barrandia cordai* M'Coy, 1849.

DISTRIBUTION. The genus first occurs in the Lower Llanvirn of south Wales, Salop (Shropshire) and Pont Seiont, north Wales. In the Builth area it is restricted to the lower Llandeilo, a horizon at which it is unknown elsewhere. The record of *B. homfrayi* Hicks from the Lower Llanvirn at Builth (Elles 1940 : 395) is considered to be based on a misidentification. The genus has been recorded also from the mid-Ordovician of North America (Hintze 1953; Webb 1956). However, it is thought likely that the specimen referred to by Hintze belongs to *Aponileus* (see Hu 1963) and that those mentioned by Webb also belong to that or a related genus.

DISCUSSION. The assignment of *Barrandia* to the Nileidae rather than the Asaphidae has been subject to some debate (Reed 1931; Prantl & Přibyl 1949; Jaanusson *in* Moore 1959). New

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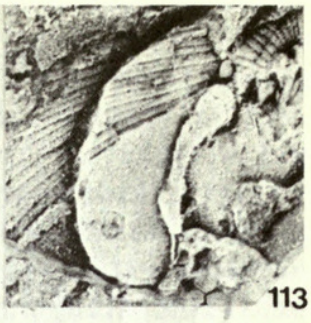
Figs 111, 114–119. *Barrandia cordai* M'Coy, p. 156. Fig. 111, Llandeilo, Builth, exact loc. unknown (see p. 156). Holotype. Internal mould of damaged specimen, SM A15626, ×2·5. Figs 114–119, Lower Llandeilo, left bank of Dulas Brook, 150 yd (137 m) SW of the old quarry 350 yd (320 m) west of Maesgwynne, SO 058564. Figs 114, 117, internal and external moulds of pygidium showing furrow separating parathoracic segment, It.2933, ×5. Fig. 115, internal mould of pygidium, It.2929, ×6. Fig. 116, internal mould of cranidium, It.2930, ×6. Fig. 118, internal mould of cranidium showing axial furrows fading out anteriorly, It.2931, ×6. Fig. 119, internal mould of pygidium with parathoracic segment, It.2932, ×6.

Fig. 112. Asaphid gen. et sp. indet., p. 153. Middle-upper Llandeilo, quarry at Gwern-yfed-fâch, ½ ml (805 m) SE of Builth Road station, SO 030538. Internal mould of glabella and part of left fixigena, It.2928, ×3.

Figs 113, 120–124. *Barrandia* cf. *cordai* M'Coy, p. 158. Figs 113, 120–122, 124, Lower Llandeilo, stream section 15 yd (14 m) SW of the old quarry 350 yd (320 m) west of Maesgwynne, SO 059566. Figs 113, 124, internal mould of entire specimen, It.2934. Fig. 113, enlargement of eye, ×10; Fig. 124, ×4. Fig. 120, external mould of transitory pygidium, showing weakly-developed ribs on the pleural fields, It.2939, ×8. Figs 121, 122, internal and external moulds of transitory pygidium, showing traces of two ribs, It.2938, ×6. Fig. 123, Lower Llandeilo, old quarry 350 yd (320 m) west of Maesgwynne, SO 059566. Internal mould showing cephalic doublure, It.2936, ×3.


111


112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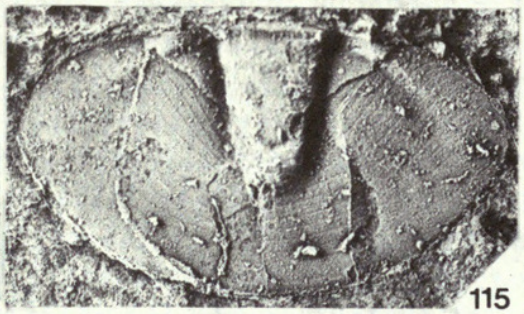
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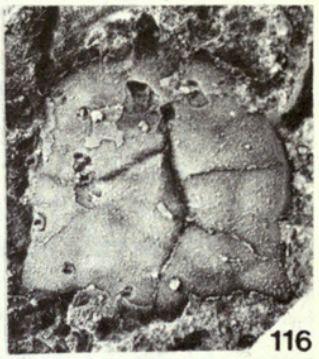
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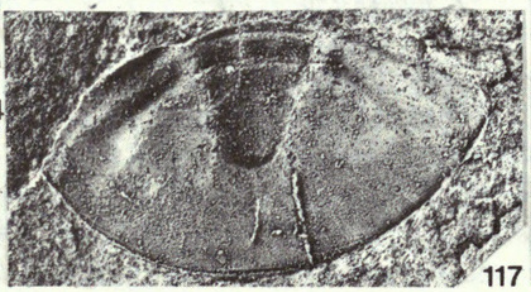
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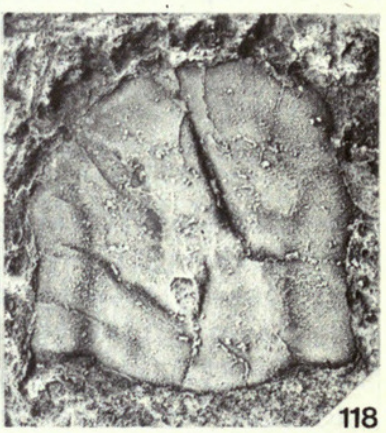
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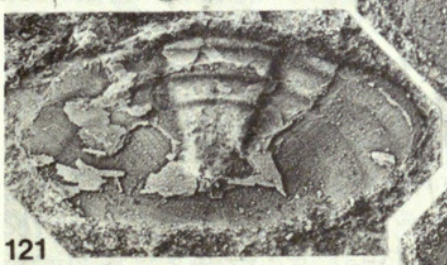
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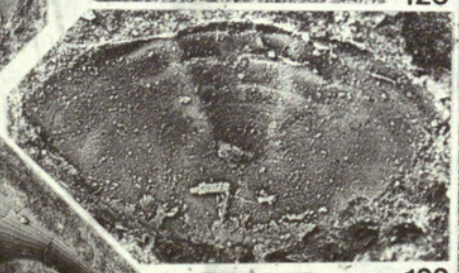
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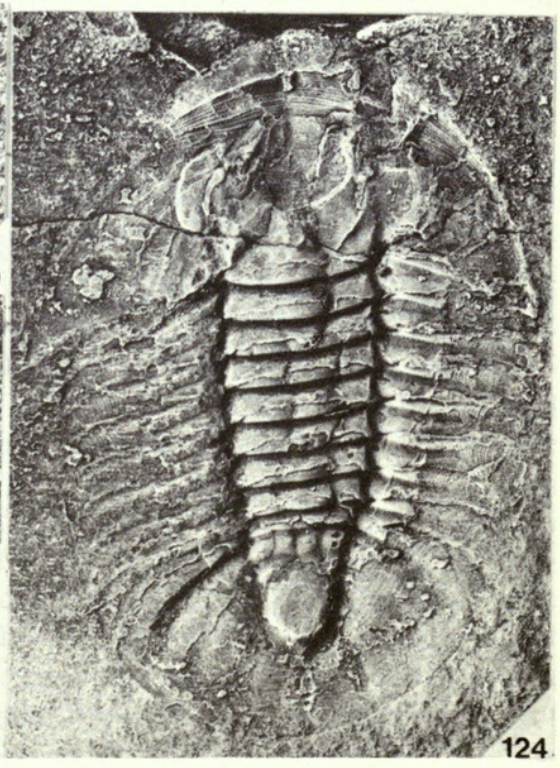
123


124

information regarding the nileids has recently become available (Fortey 1975) and it is believed that the general form of the exoskeleton, in particular that of the hypostoma (despite the presence of a furrow passing across the median body), cephalic doublure and eye, suggests that the assignment to the Nileidae is correct.

The eye-like 'nodular areas' described by Whittard (1961*a* : 221) are clearly seen in *Barrandia* and *Homalopteon* from the Builth area (Figs 113, 149), and have the concavo-convex outline characteristic of many trilobite compound eyes. Eye lenses in nileids are minute and commonly can only be seen with difficulty in well-preserved material (Fortey 1975). Despite the lack of visible lens structures in *Barrandia* and *Homalopteon* it is difficult to imagine these 'nodular areas' as anything but eyes.

The distinction between this genus and *Homalopteon* Salter is considered under the latter genus (p. 164). Owing to the common crushing and distortion of specimens, and also damage to, or complete loss of, the dorsal surface over the doublure, specific determinations are generally difficult. This applies particularly to *Barrandia* with its very wide doublure, although owing to the thin nature of the exoskeleton details of axial rings and pleural ribs are commonly distinguishable on both internal and external moulds; data from both have been included in the following specific descriptions. Systematic difficulties, especially assessments of variation, are further increased by the rareness of most species. Out of a total of fewer than 30 specimens from the Stapeley Shales, Whittard recognized five species based essentially on differences in the furrowing of the pygidial axis and pleural region. Some specific separations have been made in the present study on similar criteria, but it is possible that in both cases the differences may prove to be of an intraspecific nature.

Barrandia cordai M'Coy, 1849
(Figs 111, 114–119, 134)

1849 *Barrandia cordai* M'Coy; 409–410, text–fig.
1931 *Barrandia cordai* M'Coy; Reed : 443, 467 (gives earlier synonymy).
1940 *Barrandia cordai* M'Coy; Elles (*pars*) : 412.
1949 *Barrandia cordai* M'Coy; Prantl & Přibyl : 2, 4, 5, 14.
1961*a* *Barrandia cordai* M'Coy; Whittard : 221–223, 226–227; pl. 33, fig. 8.

DIAGNOSIS. *Barrandia* with subelliptical pygidium, having narrow conical axis with first two axial rings distinct; third and fourth indistinct; pleural field smooth apart from well-developed border furrow.

HOLOTYPE. SM A15626 (Fig. 111), internal mould of damaged entire individual. Dimensions (in mm): T.L., *c.* 25·0. A, *c.* 8·8. I, *c.* 17·0. J_2, *c.* 9·0. Q, *c.* 8·5. Q_1, 1·4. R_1, 15·5. R_2, 5·1. R_4, 13·2. R_5, 2·3. R_6, 2·0. W, 12·6. X, 3·2. Z, 7·7. Dimensions of hypostoma It.2948 (in mm): H_1, 8·2. H_4, 2·9. H_5, 7·7. H_6, *c.* 8·3. H_7, 7·0. H_8, 5·8. For explanation of symbols see Fig. 1.

TYPE LOCALITY AND HORIZON. The locality for the holotype was given by M'Coy (1849 : 410) as 'Black Wenlock shale of Builth'. Salter (1866 : 143) quotes it as from 'Penkerrig, near Builth, Radnorshire'. Elles (1940 : 412, 421) recorded the species from various localities which she believed to be of Llandeilo and basal Caradoc age; Whittard (1961*a* : 227), however, considered the species to be most likely of basal Caradoc age (basal *N. gracilis* Zone). Addison (*in* Williams *et al.* 1972 : 35–36) has shown that the basal portion of the *N. gracilis* Zone is of middle and upper Llandeilo age. The holotype is preserved in a dark greyish-blue shale which compares with both lower and middle to upper Llandeilo rocks of the Builth sequence. The present study indicates that *Homalopteon radians* (M'Coy) is the only nileid occurring at Pen-cerrig and that forms attributable to *B. cordai* are known only from the exposures in the left bank of the Dulas Brook, 150 yd (137 m) south-west of the old quarry 350 yd (320 m) west of Maesgwynne, and from the old quarry in the right bank of the stream 570 yd (521 m) north of Wye Cottage. Both these exposures are in *Glyptograptus teretiusculus* Shales of lower Llandeilo age.

DESCRIPTION. The holotype is the only complete specimen known. Its length is about one and a half times its maximum width.

Cephalon roughly semicircular, about one-third of the total length of the specimen. Glabella

characteristically devoid of furrows, the two longitudinal furrows on the holotype being due to distortion, which, owing to the thin exoskeleton, is relatively common and may show a degree of symmetry in some specimens. Posteriorly the glabella occupies slightly over three-fifths of the cranidial width, anteriorly expanding in width to form the whole of the anterior part of the cranidium. Axial furrows shallow and subparallel posteriorly, becoming divergent and shallower anteriorly and fading out altogether before reaching lateral margins (Fig. 118). Fixigena a narrow flat band alongside the posterior two-thirds of the glabella, merging anteriorly with the expanded frontal region of the glabella. No discrete palpebral lobe developed and relatively little posterior expansion of the fixigena. Facial suture gently sigmoidal, being curved outwards in its anterior and posterior portion, becoming marginal anteriorly. Librigena subtriangular with a short genal spine. No median suture developed, and the librigenae form a single unit with the ventral doublure. The eye is not certainly known. The so-called eye previously described is thought to be an artefact resulting from imperfect preservation. Cephalic doublure poorly known, but anteriorly appears to have projections on the inner margin presumably surrounding the anterior wings of the hypostoma. Doublure bears a series of parallel terrace lines, at least 12 being present anteromedially in the holotype.

Hypostoma subrectangular with small anterior wing extending for about one-third of the hypostomal length. Lateral margins subparallel though slightly convex outwards. Posterior wing small, short (*sag.*); posterior margin protruded into a broad mesial tongue-like extension. Anterior lobe subcircular, much larger than posterior lobe, and bounded by a well-developed middle and lateral furrow; posterior lobe crescentic. Posterior border furrow well developed mesially, though shallower than middle furrow with which it merges anterolaterally. Maculae absent. Surface bears fine raised lines generally conforming in shape to that of the middle furrow; on the posterior border, however, they become modified to be subparallel to the posterior margin.

Eight thoracic segments are present as in other *Barrandia* spp., not seven as shown in Moore (1959 : O357, fig. 267.9). Axial rings simple, bowed gently posteriorly and with a well-developed articulating furrow. Anteriorly the axis occupies about two-fifths of thoracic width and tapers slightly to the rear. Axial furrow well incised and slightly zetoidal. Pleurae falcate, each having a strong diagonal furrow commencing at the inner anterior corner and fading out about halfway across the pleural region. Wide doublure underlies nearly two-thirds of pleural region and bears numerous outwardly concave terrace lines.

Pygidium subelliptical with anterior margin convex forwards. Axis relatively narrow and cone-shaped, occupying slightly under one-quarter of the anterior width and extending for about two-thirds of the pygidial length. In the holotype the axis is poorly preserved, but nevertheless shows a faint indication of one axial ring. It.2932 (Fig. 119) shows two distinct, and possibly up to four faintly-defined, axial rings and a terminal piece. This specimen, however, is small, and the furrowing may become lost in the larger individuals. Anterior border well developed, becoming shallower distally and failing to reach the lateral margins. Remainder of pleural field thought to be smooth, although owing to the common loss of the dorsal exoskeleton in this region it is difficult to be certain. Wide doublure underlies almost entire pleural region and

Table 16. Measurements for *Barrandia cordai* M'Coy. All measurements in mm. For explanation of symbols see Fig. 1.

Specimen	A	J	K_1	W	X	Y	Z
It.2929	–	–	–	8·0	1·9	2·5	4·3
It.2930	4·3	*c.* 4·7	2·8	–	–	–	–
It.2931	5·6	5·7	3·6	–	–	–	–
It.2932	–	–	–	7·7	2·0	2·1	3·7
It.2933	–	–	–	7·9	2·2	2·1	*c.* 4·2
NMW 68.376.G232	*c.* 5·7	–	3·5	–	–	–	–
NMW 68.376.G233	6·5	*c.* 7·0	4·3	–	–	–	–

bears fine terrace lines subparallel to the margins. Posteromesially about 15 terrace lines are present.

ONTOGENY. Two small pygidia similar to those of holaspides are known in which a 'thoracic' segment appears to be fused along the anterior margin (Figs 114, 117, 119). It.2933 (Fig. 117) does not show any furrow between the 'thoracic' segment and the rest of the pygidium on the external surface, but a clear furrow is impressed on the internal mould (Fig. 114), indicating a slight thickening of the exoskeleton along the line of junction. It is thought that both these specimens represent late meraspides with a parathoracic segment developed prior to release into the thorax. Fortey (1975 : 63) has shown that the release of the final segment in Nileidae may occur at a comparatively late stage in ontogeny. A meraspis of *B. ultima* sp. nov. (Fig. 130) shows two segments developed in the anterior part of a relatively large transitory pygidium. Unfortunately nothing more is known of the ontogenies of *Barrandia* species.

DISCUSSION. Previous descriptions of this species have been based on the holotype, which, although a relatively complete specimen, has certain crucial regions either missing or poorly preserved. Elles believed the species to be fairly widespread in all post-Llanvirn beds of the Builth region but did not give any redescription. The present study has shown that the species is rare in the Builth inlier.

B. cordai is distinguished from *B.* cf. *cordai* by its narrower pygidial axis and from *B. expansa* sp. nov. (p. 159) by the different outline of the pygidial axis. *B. ultima* sp. nov. (p. 160) has a better-developed cephalic axial furrow, relatively wider (*tr.*) fixigena and a greater number of axial rings on the pygidium. *B. homfrayi* Hicks, 1875 differs in having a relatively wide furrowed pygidial axis and a relatively wide cranidium. *B. tasgarensis* Whittard, 1961*a*, which is very similar to though narrower than *B. homfrayi*, is distinguished by the lack of furrows on the pygidial axis, while *B. bianularis* Whittard, 1961*a*, is readily distinguished by its relatively wide, stumpy pygidial axis with two clearly-defined axial rings. *B. parabolica* Whittard, 1961*a* is in many ways similar to *B. cordai*, but the marked parabolic outline of the cephalon and pygidium appears to distinguish Whittard's species. The hypostoma is similar to that described by Whittard (1961*a* : 223–224) in *B. homfrayi* but the anterior wing is more anteriorly placed and the posterior lobe narrower (*tr.*) in *B. cordai*.

Barrandia cf. ***cordai*** M'Coy
(Figs. 113, 120–126)

DIMENSIONS (in mm): It.2934: T.L., *c.* 23·7. A, *c.* 7·5. I, *c.* 18·0. K_1, *c.* 5·6. Q, *c.* 8·8. Q_1, 1·3. R_1, *c.* 16·0. R_2, 5·3.

	W	X	Y	Z
It.2934	13·0	3·6	4·0	7·4
It.2935	10·5	3·0	3·2	5·5
It.2937	6·2	1·8	2·0	3·2
It.2938	6·7	1·9	2·2	–
It.2939	*c.* 6·0	1·5	*c.* 2·0	3·3

For explanation of symbols see Fig. 1.

LOCALITIES AND HORIZON. It.2935–6 are from the old quarry 350 yd (320 m) west of Maesgwynne, and It.2934, 2937–9 are from the stream section 15 yd (14 m) south-west of this quarry; both are in *Glyptograptus teretiusculus* Shales of lower Llandeilo age.

DESCRIPTION. It.2934–5 are very like *B. cordai*, except that the pygidial axis is somewhat broader and has a slightly expanded anterior portion similar to that of *B. expansa* sp. nov. It.2934 also shows one eye moderately well preserved, situated at about the mid-length of the cephalon, with a clear concavo-convex outline (Figs 113, 124). No lens structures are preserved.

It.2936 is the only other specimen of *Barrandia* known from the old quarry west of Maesgwynne and is included here. It shows the mesial portion of the cephalic doublure with about

16 subparallel terrace lines anteriorly, and the projection on the inner margin that abuts against the anterior wing of the hypostoma (Fig. 123).

ONTOGENY. Three smaller *Barrandia* pygidia from the stream section appear to have two well-developed axial rings and two pleural ribs. The ontogeny of *Barrandia* species suggests that these probably represent meraspides, rather than a small species characterized by a ribbed pleural field. Although an impression of the dorsal exoskeleton is absent in the pleural regions in both internal moulds and not well preserved in the external mould, traces of the two ribs are present axially (Figs 120–122), which, together with the two anterior axial rings, may make up parathoracic segments. The lateral extent of these ribs is not known; traces on the doublure in It.2937 suggest they continue to near the lateral margin, whereas in It.2939 they appear to die out rapidly with only the deeper anterior border furrow encroaching onto the wide border region. Wide doublure underlies most of pleural region, and bears terrace lines subparallel to pygidial margins.

DISCUSSION. The slightly wider axis in this form may be an expression of intraspecific variation present in *B. cordai*, but until more material is available it is best considered as a form closely related to *B. cordai*. If the small pygidia with two ribs are correctly assigned to the meraspid period they support the other evidence suggesting that the late retention of parathoracic segments is a characteristic of all *Barrandia* species.

Barrandia expansa sp. nov.
(Figs 127–129)

DIAGNOSIS. *Barrandia* with marked expansion of anterior portion of pygidial axis; pleural field with well-developed anterior border furrow; axis with two axial rings and large terminal piece.

NAME. 'Spread out'.

TYPE MATERIAL. Holotype It.2940 (Fig. 128), internal mould of pygidium. Paratypes, It.2941 (Fig. 127), external mould of thorax; It.2942 (Fig. 129), internal mould of pygidium.

DIMENSIONS (in mm):	Q_1	R_1	R_2	R_4	W	X	Y	Z
Holotype	–	–	–	–	*c.* 14·5	4·3	*c.* 4·0	7·3
It.2941	1·2	11·0	4·1	10·5	–	–	–	–
It.2942	–	–	–	–	*c.* 14·0	*c.* 4·0	*c.* 4·6	–

For explanation of symbols see Fig. 1.

LOCALITIES AND HORIZON. The holotype and It.2941 are from the left bank of the stream section east of Bach-y-graig, 45 yd (41 m) upstream of the point where the footpath enters the wood at the western end of the section. It.2942 is from the left bank of the stream section, 120 yd (109 m) south-east of Tre Coed. Both are in *Glyptograptus teretiusculus* Shales of lower Llandeilo age. The species is known with certainty only at these two localities.

DESCRIPTION. Cephalon unknown. Thoracic axial rings simple, with terrace lines on external surface. Pleurae falcate, with pleural furrow extending obliquely from the anterolateral corner towards the posterolateral corner, dying out just over one-third of the distance across the pleura at a point thought to coincide with the inner margin of the doublure. Dorsal surface bearing a series of fine, gently sigmoidal, raised lines in an anterolateral–posteromedian direction.

Pygidial axis slightly over half pygidial length, anteriorly occupying about three-tenths of greatest pygidial width. Axis funnel-shaped, with axial furrows converging posteriorly in the anterior half, becoming parallel-sided in posterior portion. Two well-developed axial rings present in the anterior tapering portion; posterior portion without furrows. Axis bears fine, transversely-directed, raised lines. Pleural field with well-developed anterior border furrow. Wide doublure underlies most of pleural field, and has terrace lines subparallel to pygidial margins.

DISCUSSION. Only the three figured specimens are known. Of other *Barrandia*, *B. expansa* appears to be most like *B. bianularis* Whittard, 1961*a*, but it is readily distinguished from this by its infundibular axis.

Barrandia ultima sp. nov.
(Figs 130–133, 135–136, 140)

1940 *Barrandia* (*Homalopteon*) *radians* (M'Coy); Elles (*pars*) : 412.

DIAGNOSIS. *Barrandia* having relatively well developed cephalic axial furrow reaching lateral cranidial margin. Pygidial axis with probably four axial rings and terminal piece; pleural field smooth apart from anterior border furrow.

NAME. 'Last'.

TYPE MATERIAL. Holotype, It.2945 (Fig. 136), internal mould of entire, but damaged, specimen. Paratypes, It.2943 (Fig. 135), internal mould of pygidium with parathoracic segment. It.2944 (Fig. 131), internal mould of cranidium. BU 455 (*ex* Chamberlain Collection 147/14) (Fig. 140), internal mould of damaged entire specimen.

DIMENSIONS (in mm). Holotype: T.L., *c.* 15·4. A, *c.* 5·8. I, *c.* 13·4. K_1, 3·9. Q, 5·2. Q_1, 0·8. R_1, *c.* 12·0. R_2, *c.* 3·5.

	W	X	Y	Z
Holotype	*c.* 9·0	2·4	2·5	4·4
It.2943	8·3	1·7	2·0	3·4
BU 455	9·7	2·5	3·0	5·0

For explanation of symbols see Fig. 1.

LOCALITY AND HORIZON. All type specimens are from the stream section 400 yd (365 m) north-east of Gorse, north-east of Llandrindod; *Glyptograptus teretiusculus* Shales of Lower Llandeilo age. Restricted to the type locality and to beds a little higher in the succession exposed about 20 yd (18 m) downstream from it.

DESCRIPTION. Similar to *B. cordai* and a comparative description only is required.

Complete individuals tend to be slightly wider than *B. cordai* having a length : width ratio of about 12 : 9 against 12 : 8 for *B. cordai*, but how flattening may have altered the original proportions is not known.

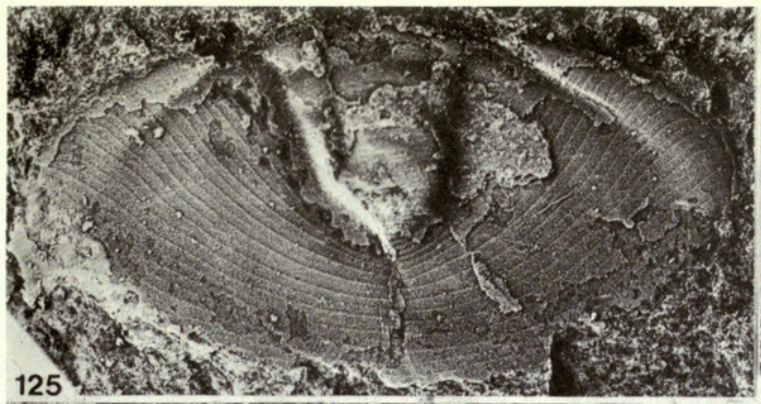
Cephalon differs from *B.* cordai in that the axial furrow is more strongly developed anteriorly and extends to the lateral cranidial margin, to cut it immediately anterior of δ, and the fixigena is slightly wider (*tr.*). Traces of the hypostoma are seen in It.2945 (Fig. 136), and it appears to conform to the general *Barrandia* pattern with large subcircular anterior lobe and a short (*sag.*) crescentic posterior lobe. Posterior margin protruded into a median lip and surface of median body bearing a series of subconcentric raised lines.

Figs 125–126. *Barrandia* cf. *cordai* M'Coy, p. 158. Lower Llandeilo, old quarry 350 yd (320 m) west of Maesgwynne, SO 059566. Internal and external moulds of pygidium showing wide, slightly forwardly expanding axis and transverse sculpture on dorsal surface, It.2935, ×6.

Figs 127–129. *Barrandia expansa* sp. nov., p. 159. Figs 127–128. Lower Llandeilo, left bank of stream section east of Bach-y-graig, 45 yd (41 m) upstream of the point where the footpath enters the wood at the western end of the section, SO 071610. Fig. 127, Paratype. External mould of thorax, It.2941, ×5. Fig. 128, **Holotype.** Internal mould of pygidium showing frontal expansion of axis, It.2940, ×4. Fig. 129, Lower Llandeilo, 120 yd (109 m) SE of Tre Coed on left bank of stream, SO 054552. Paratype. Internal mould of pygidium, It.2942, ×3·5.

Figs 130–133, 135. *Barrandia ultima* sp. nov., above. Lower Llandeilo, stream section 400 yd (365 m) NE of Gorse, SO 072617. Fig. 130, internal mould of meraspid ? of degree 6, BU 456 (*ex* Chamberlain Coll. 147/14), ×6. Fig. 131, Paratype. Internal mould of cranidium, showing axial furrows extending to lateral margins and relatively wide fixigena, It.2944, ×6. Fig. 132, internal mould of pygidium with parathoracic segment and furrowed axis, It.2947, ×6. Fig. 133, internal mould of meraspid of degree 5 or 6, It.2946, ×6. Fig. 135, Paratype. Internal mould of pygidium with parathoracic segment, It.2943, ×6.

Fig. 134. *Barrandia cordai* M'Coy, p. 156. Lower Llandeilo, stream section 15 yd (14 m) SW of the old quarry 350 yd (320 m) west of Maesgwynne, SO 059566. Internal mould of hypostoma, It.2948, ×4.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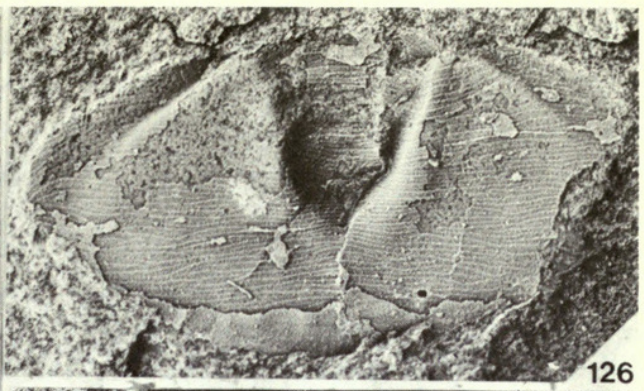
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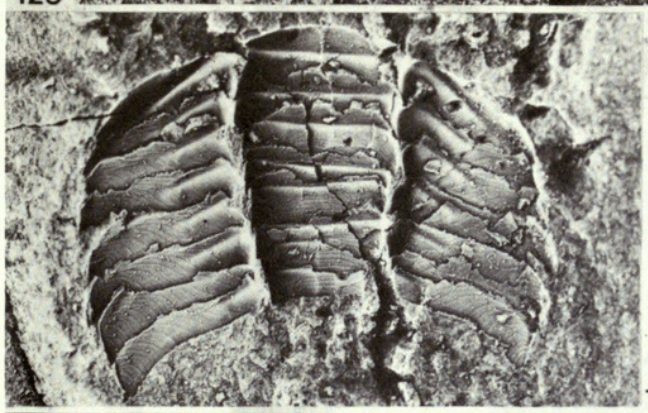
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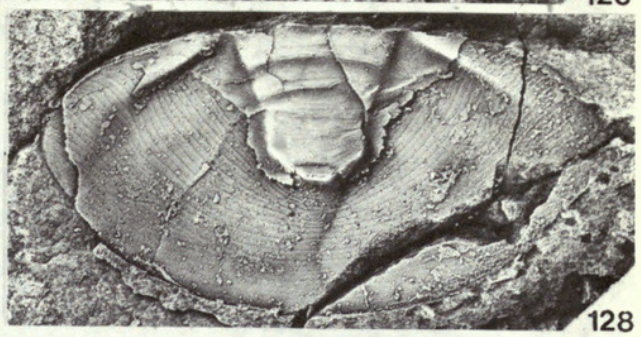
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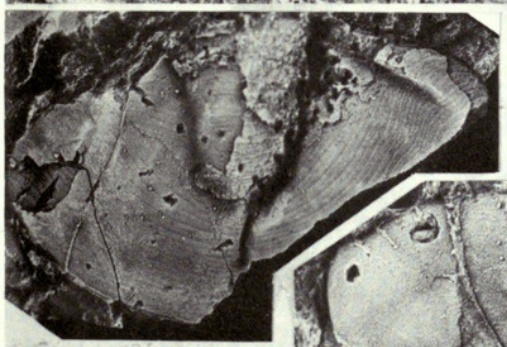
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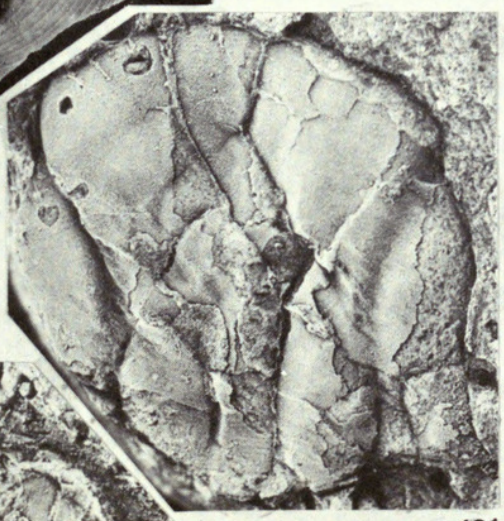
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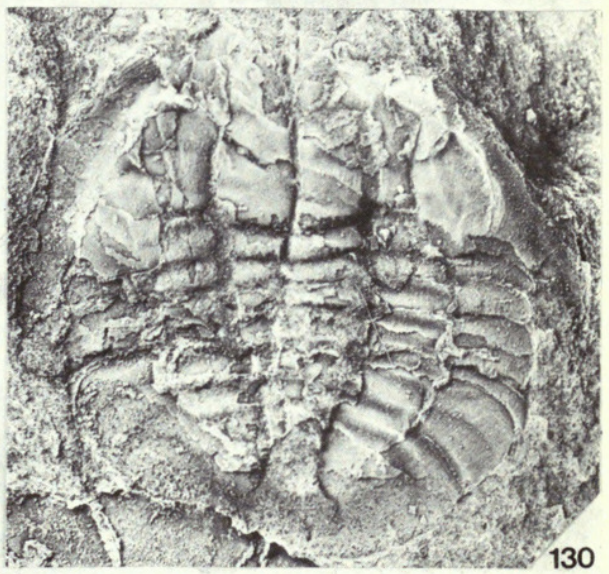
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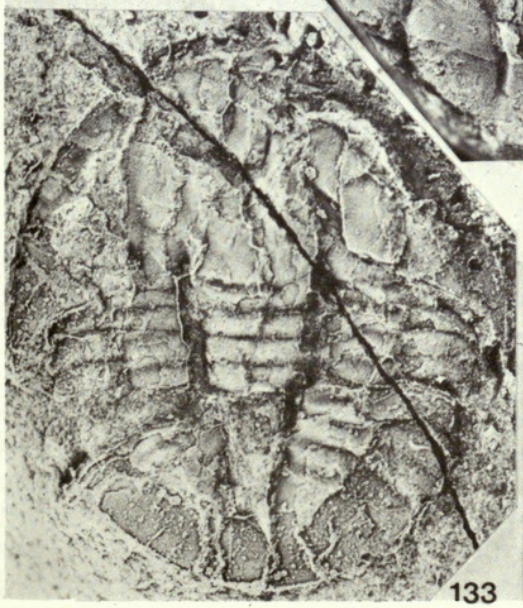
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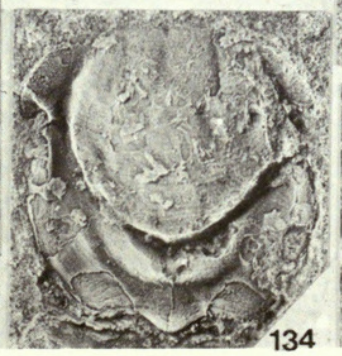
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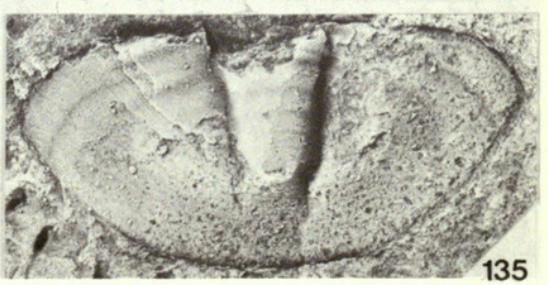
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Thorax appears to be identical to *B. cordai*.

Pygidium differs from *B. cordai* in that four axial rings and a short terminal piece are almost certainly present (Fig. 135) and the doublure is narrower. Paratype pygidium It.2943, with its parathoracic segment, is only a little smaller than other pygidia with no such segment and is another example of late retention of the eighth thoracic segment in the pygidium (p. 158).

ONTOGENY. Two late meraspides are known, but determination of their precise degree is not possible. BU 456 is most likely a degree 6 and It.2946 may be degree 5 or 6.

Cephalon, as far as can be determined, very similar to that of holaspides. BU 456 shows the eye but no trace of lens structures. Genal spine (Fig. 130) possibly relatively larger than in holaspides but this may be due to distortion. BU 456 also shows parts of six thoracic segments, which appear to be freely articulating, and two parathoracic segments. It.2946 has the anterior region very poorly preserved and it is more difficult to assess where the front of the transitory pygidium lies. It is believed that there are also two parathoracic segments present. In outline it is similar to the holaspis pygidium, but it is relatively longer with a larger axis.

DISCUSSION. This species is distinguished from other *Barrandia* species by the relatively narrow pygidial doublure. The species is the youngest known *Barrandia*, from beds near the top of the *Glyptograptus teretiusculus* Shales above the level at which *Ogyginus corndensis* dies out. Other species previously recorded from approximately this level or higher (Elles 1940) are here placed in *Homalopteon*.

Genus ***HOMALOPTEON*** Salter, 1866

DIAGNOSIS. Exoskeleton oval, depressed and subisopygous. Glabella expanded frontally; four pairs of very shallow lateral glabellar furrows; axial furrow shallow particularly anteriorly; fixigena narrow expanding posteriorly. Eye well developed; librigenae fused; genal spine short. Eight thoracic segments, doublure extending under slightly less than half pleural width. Pygidium subsemicircular; axial rings prominent; up to three ribs on gently convex pleural field.

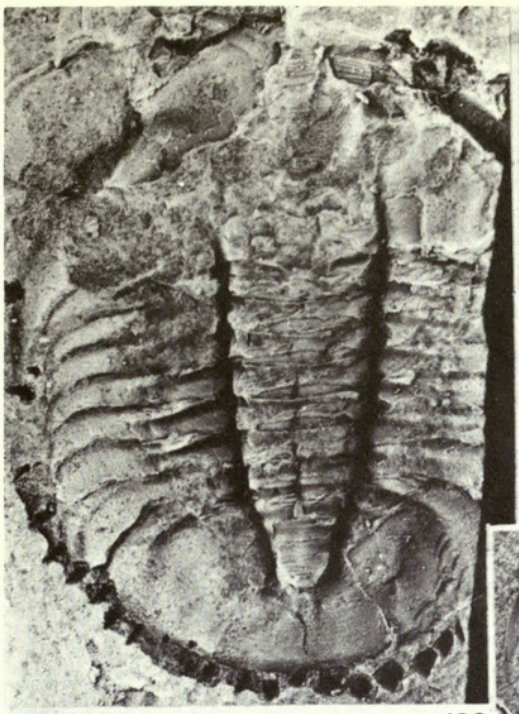
TYPE SPECIES. *Ogygia portlockii* Salter, 1849.

DISTRIBUTION. The type species is from the Raheen Shales (Caradoc) of Co. Waterford, Ireland. In central Wales the genus is present in the uppermost lower, and middle to upper Llandeilo; it was also recorded by Salter (1867 : 179) from Abereiddy Bay, probably from beds of lower Llandeilo age.

DISCUSSION. The genus was separated at subgeneric level from *Barrandia* by Salter (1866 : 137–138) on characters which are summarized below. He placed both in the Asaphidae, but Reed (1931 : 468), having given full generic status to *Homalopteon*, assigned them to the Nileidae on the basis of the absence of the median suture. In Moore (1959 : O352) Jaanusson tentatively placed *Homalopteon* back in the Asaphidae. *Homalopteon* is certainly very closely allied to *Barrandia* and is thus a nileid.

Figs 136, 140. *Barrandia ultima* sp. nov., p. 160. Lower Llandeilo, stream section 400 yd (365 m) NE of Gorse, SO 072617. Fig. 136, **Holotype.** Internal mould showing traces of hypostoma and cephalic doublure, It.2945, ×4. Fig. 140, Paratype. Internal mould of nearly complete specimen, BU 455 (*ex* Chamberlain Coll. 147/14), ×4.

Figs 137–139, 141–144. *Homalopteon radians* (M'Coy), p. 164. Figs 137–138, 141–142, Lower Llandeilo, small quarry at SW end of Pen-cerig Lake, SO 043541. Fig. 137, internal mould of cranidium showing traces of glabellar furrows, It.2960, ×5. Fig. 138, internal mould showing cephalic axial furrows, It.2950, ×5. Fig. 141, external mould of thorax and pygidium showing surface sculpture, It.2949, ×2. Fig. 142, internal mould of larger pygidium showing four axial rings and a terminal piece, It.2961, ×2. Figs 143–144, Lower Llandeilo, 'Pen-cerig, Builth'; probably from small quarry at SW end of Pen-cerig Lake, SO 043541. Fig. 143, Lectotype. Internal mould of pygidium, SM A16691, ×4. Fig. 144, Paralectotype. External mould of pygidium, SM A16692, ×4. Fig. 139, Lower Llandeilo, Builth, exact loc. unknown. Internal mould of complete specimen, NMW 98.433, ×2.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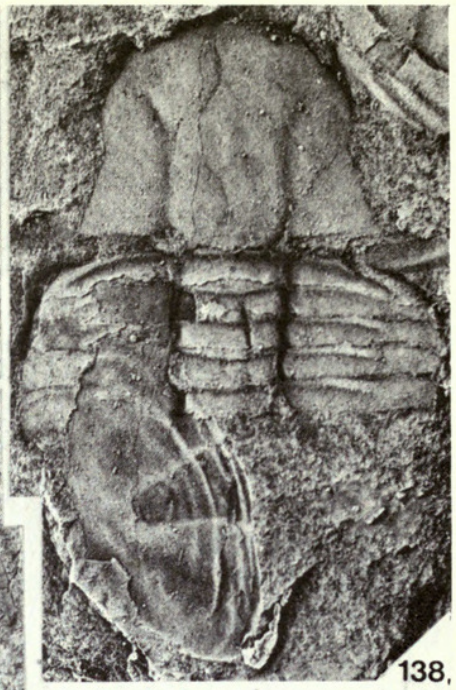
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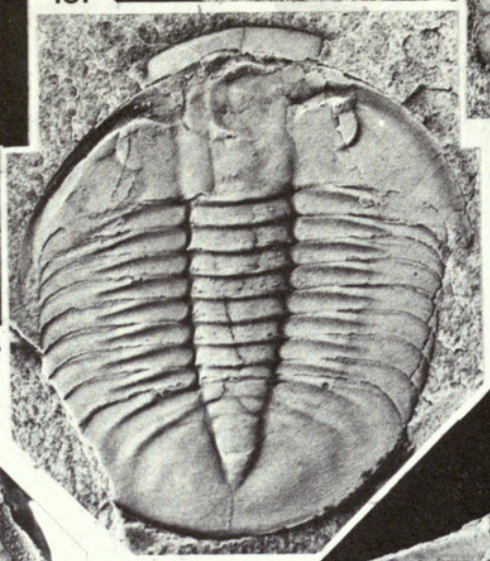
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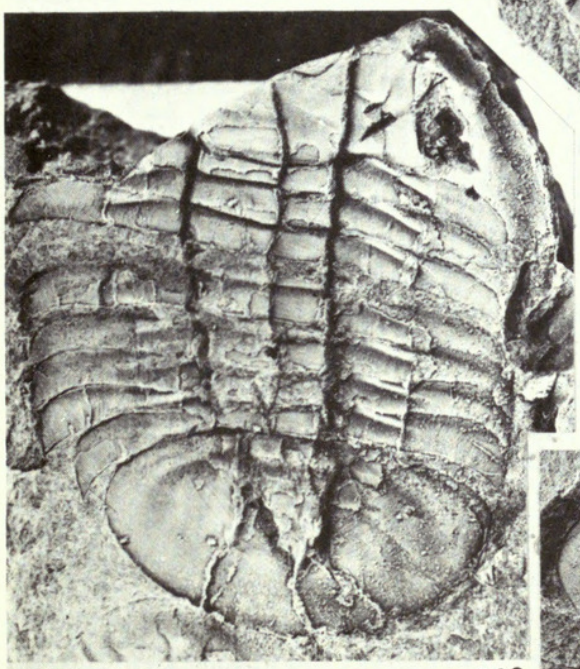
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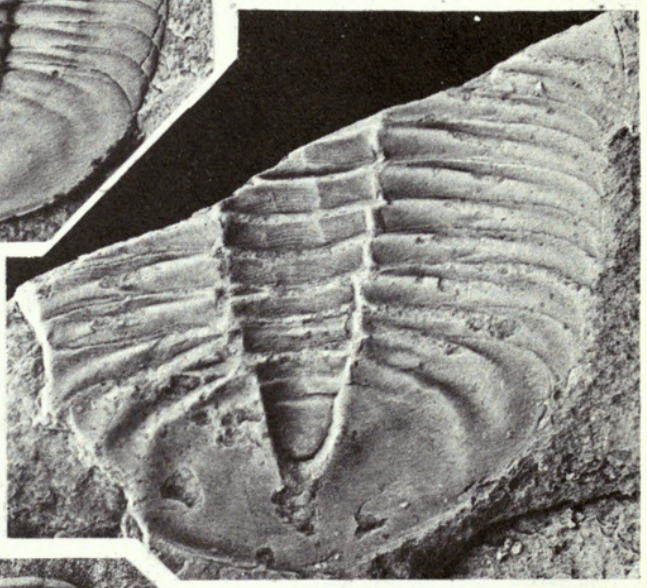
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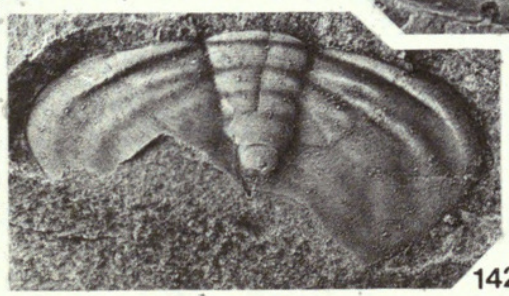
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In retaining *Homalopteon* as a separate genus, some modification to Salter's original definition is required (Table 17).

Table 17. Summary of important differences between *Barrandia* and *Homalopteon*, as envisaged by Salter (1866) and the present author.

	After Salter		Herein	
	Barrandia	*Homalopteon*	*Barrandia*	*Homalopteon*
Glabella	Unfurrowed	Furrowed	Unfurrowed	Four furrows
Axial furrow	Incomplete	Complete	—	—
Fixigena	—	—	Narrow posteriorly; no posterior border	Expanded posteriorly; narrow posterior border
Eye	Subcentral	Anterior	—	—
Pleura	Fulcrum near axis	Fulcrum remote	—	—
Doublure	—	—	$>\frac{1}{2}$ pleural width	$<\frac{1}{2}$ pleural width
Pygidial axis	Unfurrowed	Furrowed	Weakly furrowed; up to 4 axial rings	Strong furrows; up to 5 axial rings
Pleural field	Unfurrowed	Furrowed	Generally unfurrowed; occasionally with up to 2 weak furrows	Furrowed; up to 4 prominent ribs

Salter's use of the cephalic axial furrow as a diagnostic feature was unsatisfactory, as the anterior portion is very shallow in *Homalopteon* and is easily obliterated by poor preservation. Further, the position of the eye can no longer be regarded as diagnostic, for the 'eye' in the type specimen of *B. cordai* (the only specimen available to Salter) is merely a broken area of shale (p. 158); new material from Builth shows the eye to be more anteriorly positioned, as in other species of *Barrandia* from the Shelve region. Similarly the pygidial axis of *B. cordai*, and also other species of *Barrandia* (Whittard 1961*a* : 221–228), is now known to be weakly furrowed.

Homalopteon radians (M'Coy, 1849)
(Figs 137–139, 141–145, 147–148, 150–151, 153, 155–159)

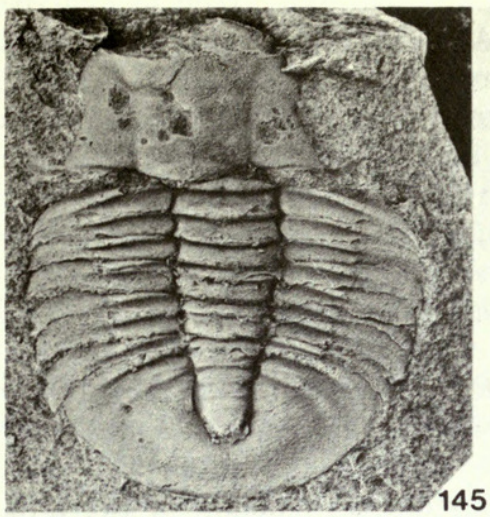
1849 *Ogygia radians* M'Coy : 408–9.
1866 *Barrandia* (*Homalopteon*) *radians* (M'Coy) Salter : 140.
1940 *Barrandia* (*Homalopteon*) *radians* (M'Coy); Elles (*pars*) : 410–412, 417, 432.
1961*a* *Barrandia radians* (M'Coy); Whittard : 227–228 (gives other earlier synonymy).

DIAGNOSIS. *Homalopteon* having generally three axial rings on pygidium with second pygidial rib only weakly developed.

TYPE MATERIAL. In his original description, M'Coy (1849 : 408) gave no figure, nor any indication of the specimens upon which his description was based. However, specimens SM A16691

Figs 145, 147–148, 150–151, 153, 155–156. *Homalopteon radians* (M'Coy), above. Lower Llandeilo, small quarry at SW end of Pen-cerig Lake, SO 043541. Fig. 145, internal mould of nearly complete specimen, showing thoracic doublure, It.2954, ×2. Fig. 147, external mould of early meraspis, It.2957, ×7·5. Fig. 148, internal mould of meraspid ? of degree 5, showing traces of parathoracic segments in the transitory pygidium, It.2956, ×5. Fig. 150, internal mould of meraspid of degree 7, showing traces of eyes and hypostoma, It.2952, ×5. Fig. 151, internal mould of hypostoma with attached librigena, It.2953, ×6. Fig. 153, external mould of young holaspid pygidium, It.2959, ×7·5. Fig. 155, internal mould of meraspid of degree 6, showing two parathoracic segments in the transitory pygidium, It.2955, ×5. Fig. 156, internal mould of meraspid ? of degree 6, It.2958, ×5.

Figs 146, 149, 152, 154. *Homalopteon murchisoni* sp. nov., p. 168. Middle-upper Llandeilo, quarry at Gwern-yfed-fâch, $\frac{1}{2}$ ml (805 m) SE of Builth Road station, SO 030526. Paratype. Internal and external moulds of left librigena showing eye region and sculpture of cephalic doublure, It.2963. Figs 146, 152, ×5; Figs 149, 154, ×12.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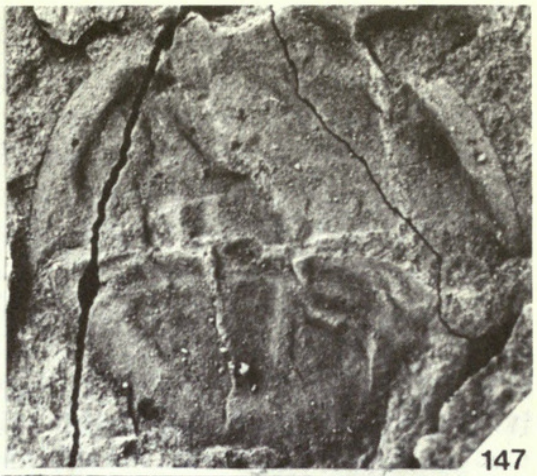
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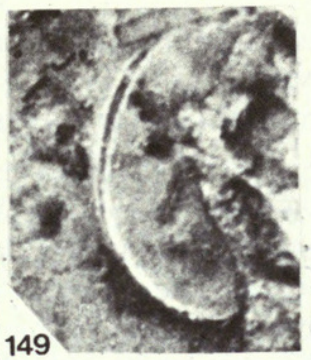
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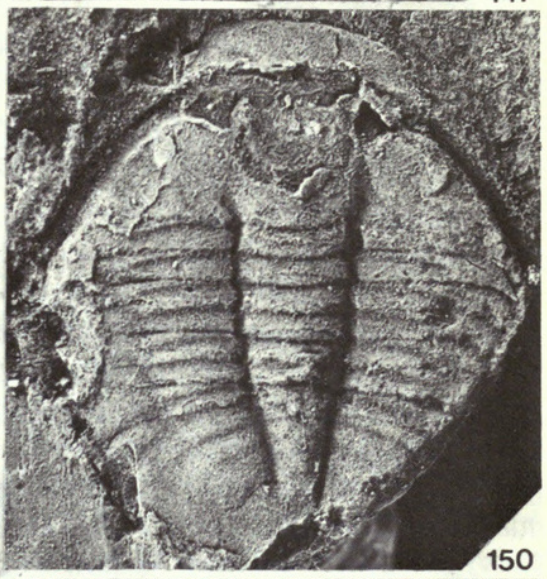
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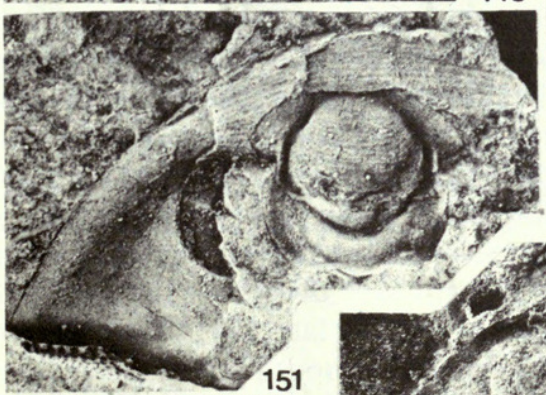
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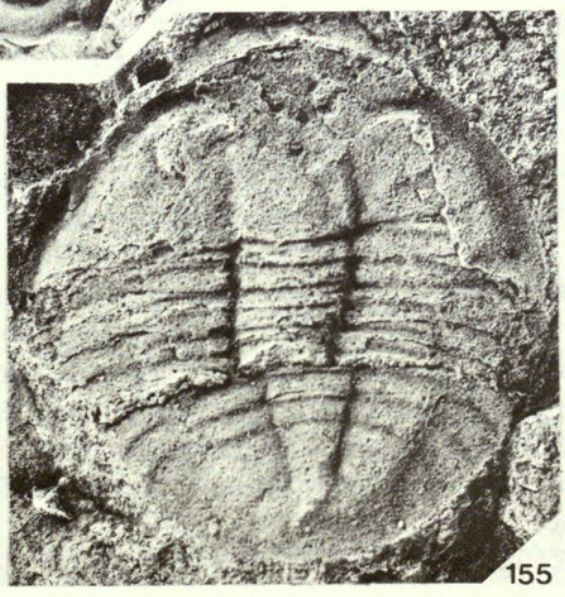
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(figured Sedgwick & M'Coy 1851 : pl. 1F, fig. 2) and SM A16692 are the only specimens known from M'Coy's original collection in the Sedgwick Museum and are here taken as syntypes. Whittard (1961*a* : 227) referred to A16691 as holotype and A16692 as paratype; this is tantamount to selecting them as lectotype and paralectotype, respectively, and they should be designated as such. The lectotype (Fig. 143) is an internal mould of a pygidium; the paralectotype (Fig. 144) an external mould of a pygidium.

Dimensions (in mm).	W	Y	Z
SM A16691	15·0	4·5	7·4
SM A16692	14·5	–	8·0

For explanation of symbols see Fig. 1.

Locality and horizon. Both type specimens are recorded as from Pen-cerig, near Builth, and are thought to be from the small quarry at the south-western end of Pen-cerig Lake, from near the top of the *Glyptograptus teretiusculus* Shales.

Distribution. The species is most common in the uppermost lower Llandeilo of the Builth region. It may also be present as an extreme rarity in the Shelve region in beds of lower Llanvirn age, but the exact systematic position of the specimen described by Whittard (1961*a* : 227–228) as *Barrandia* cf. *radians* is not certain.

Description. Complete individuals slightly over one and a quarter times as long as wide (Fig. 139).

Cephalon semielliptical, slightly over twice as wide as long and almost exactly one-third of total exoskeletal length. Glabella occupies about one-quarter of cephalic width posteriorly, and is more or less parallel-sided over posterior two-thirds of its length. Glabella expands quite sharply anteriorly to occupy entire cephalic width, the axial furrow being deflected to cut the lateral margin (Fig. 145); preglabellar field and anterior border absent. Glabella with four pairs of evenly-spaced, weakly-developed glabellar furrows (Fig. 137). Anterior pair situated opposite maximum glabellar width; posterior about one-third of glabellar length from posterior margin. The furrows are more or less transversely directed but adaxially deflected slightly to posterior. Anterior pair slightly the longest, though all fail to reach the axial furrow and axially leave the mesial quarter of the glabella smooth. A further very weak pair of short, transversely-directed furrows with a small median node occasionally present between their axial extremities is developed about mid-way between the posterior pair of glabellar furrows and the posterior margin. These represent the occipital furrows, and the weakly-developed, forwardly-convex furrow situated behind them, a posterior band furrow. Axial furrow extends with very little shallowing to lateral cranidial margin. In some specimens the furrow appears to die out anteriorly owing to imperfect preservation. Posterior branch of facial suture extends from slightly under half-way along the posterior margin from the axial furrow and is straight and directed slightly axially until it reaches the eye. In front of the eye the suture is gently convex laterally, becoming coincident with the axial furrow anteriorly. Fixigena virtually flat and smooth. Librigenae fused (Fig. 151), smooth and gently convex, sloping down laterally to a slightly concave border region. Short genal spine extends to second thoracic segment. As in *Barrandia*, eye lacks any preserved lens structures (Fig. 139).

Cephalic doublure convex dorsally with fine terrace lines on both ventral and dorsal surfaces (Figs 151, 159). Anteriorly, doublure widens to form a projection abutting anterior wing of hypostoma. Hypostoma subrectangular, with small anterior wing extending for about one-third of hypostomal length. Lateral margin slightly convex outwards with very small posterior wing. Posterior margin with small median lip (Figs 151, 159). Anterior lobe circular and delimited by a well-developed furrow. Posterior lobe crescentic, short (*sag.*); maculae absent. Both ventral and dorsal surfaces bear fine terrace lines.

Thorax subrectangular. Axis occupies just under one-quarter of thoracic width anteriorly, tapers slightly (Fig. 139). Axial rings simple and defined by a well-developed axial furrow which tends to be slightly zetoidal, owing to the asymmetrical location of the swollen axial end of the posterior pleural band (Fig. 139). Pleurae falcate; each has a strong pleural furrow, axially

lying nearly parallel to anterior margin, becoming deeper and deflected to be posterolaterally-directed at a point about one-third, finally dying out slightly over two-thirds, the way across the pleura (Fig. 139). Width of thoracic doublure slightly less than half pleural width (Fig. 145).

Pygidium generally a little over twice as wide as long. Anterior margin gently convex anteriorly; anterolateral corners obtusely rounded. Axis occupies just under one-quarter of pygidial width anteriorly, tapers posteriorly and extends for about three-fifths of pygidial length; terminates in an obtusely rounded terminal piece. Generally three, less commonly two or four axial rings developed (Figs 142, 157, 158). Pleural field very gently convex with no distinct border. Anterior border furrow prominent. One well-developed rib present with a shallow pleural furrow axially (Fig. 158). A second rib also present, but very weakly developed and commonly obscured by imperfections in preservation. In small holaspid specimens only the anterior rib appears to be developed, but inadequate data preclude any tests of correlation between size and presence of a second rib. Ventral doublure slightly narrower than that of *Barrandia*, and underlies approximately the outer two-thirds of the pleural field, becoming a little narrower posteromedially. Dorsal surface bears fine raised lines directed transversely, but slightly concave anteriorly (Fig. 141).

ONTOGENY. A single specimen is known (Fig. 147) of a very early meraspis, probably of no higher degree than 2. It is more or less circular with length (*sag.*) of 5·2 mm. Cephalon shows no details apart from a well-developed doublure. Pygidial axis clearly defined but no details of axial rings preserved. As in later meraspides the pygidial region has a well-developed, slightly concave, border region.

The other four known meraspides are of degree 5 or above and, except for the transitory pygidial regions, they are very like the holaspid form. The cephalon is not well preserved in any of these, although It.2958 (Fig. 156) shows the axial furrow clearly developed and diverging anteriorly. It.2956, possibly a degree 5 meraspis, shows traces of two parathoracic segments, as does It.2955 (Fig. 155), a meraspis of degree 6. In the latter it is possible that these two segments may have been freely articulating. In the degree 7 meraspis (Fig. 150) only one parathoracic segment appears to be developed. In It.2958 it is not clear how many segments are present in the thorax, and although it seems most likely that seven are developed there are also indications of two parathoracic segments.

A small isolated pygidium in which three axial rings are developed (Fig. 153) is larger than a degree 7 transitory pygidium and may represent a young holaspis.

Table 18. Bivariate statistics for *Homalopteon radians* (M'Coy) from the small quarry at the south-western end of Pen-cerig Lake. All measurements in mm. For explanation of symbols see Fig. 1.

x : y	$\bar{x}$	var. x	$\bar{y}$	var. y	r	r_e	α	var. α	a	var. a	n
A : C_3	8·15	7·43	4·24	1·61	0·99	0·99	0·90	0·0027	0·47	0·0008	8
A : K_1	7·39	5·43	4·48	2·89	0·99	0·99	1·19	0·0021	–	–	17
W : Z	11·11	16·15	5·44	4·81	0·97	0·98	1·11	0·0021	–	–	29
W : X	11·49	20·98	2·66	1·42	0·98	0·99	1·11	0·0012	–	–	30
Y : X	3·36	1·66	2·66	1·20	0·96	0·96	1·07	0·0022	0·85	0·0015	38
Z : Y	5·42	4·14	3·21	1·23	0·98	0·98	0·93	0·0008	–	–	36

Table 19. Frequency distribution and mean and variance of axial rings on pygidia of *Homalopteon radians* (M'Coy) from the small quarry at the south-western end of Pen-cerig Lake. The suffix 'i' indicates the development of a further incipient ring, and such rings have been counted as half a ring in the calculation of the mean.

Number of axial rings	2	2i	3	3i	4
Number of specimens	4	1	15	1	2

mean = 2·9; var. = 0·29; n = 23.

DISCUSSION. Although Reed (1931 : 468) considered the species to belong to *Barrandia* on the basis of the development of the cephalic axial furrow, the wide posterior part of the fixigena and the pygidial axial rings indicate its affinities with *Homalopteon*.

H. radians is similar to *H. murchisoni* sp. nov. (below) but is distinguished by its fewer pygidial axial rings and weaker furrowing of the pleural field. The type species, *H. portlockii*, may be distinguished by its greater posterior expansion of the fixigena and also its higher number of pygidial axial rings and pleural ribs.

Homalopteon murchisoni sp. nov.
(Figs 146, 149, 152, 154, 160–172)

1866 *Barrandia* (*Homalopteon*) *radians* (M'Coy); Salter (*pars*) : 140–142; pl. 19, fig. 4.
1940 *Barrandia* (*Homalopteon*) *radians* (M'Coy); Elles (*pars*) : 416–418, 421, 432.

DIAGNOSIS. *Homalopteon* with three to five, typically four, axial rings visible on dorsal surface and two well-developed ribs on the pygidium.

NAME. After R. I. Murchison.

TYPE MATERIAL. Holotype: BU 457 (*ex* Chamberlain Collection 54/4) (Figs 161–2), internal and external moulds of large pygidium. Paratypes: It.2963 (Figs 146, 149, 152, 154), internal and external moulds of left librigena; It.2964 (Figs 167–8), internal mould of right librigena; It.2965 (Fig. 171), external mould of isolated hypostoma; It.2966 (Fig. 165), external mould of cranidium; It.2967 (Fig. 160), internal mould of pygidium; It.2968 (*ex* Straw Collection, Manchester University) (Fig. 164), internal and external moulds of pygidium and part of thorax; It.2969 (Fig. 169), internal and external moulds of hypostoma and librigenae; It.2970 (Fig. 166), internal and external moulds of pygidium; It.2971 (Fig. 163), internal and external moulds of cranidium; It.2972 (Fig. 172), internal mould of complete meraspis; It.2973 (Fig. 170), internal mould of hypostoma.

DIMENSIONS (in mm).

	A	J	J_1	J_2	K	T.L.
It.2966	4·4	*c.* 5·0	–	–	2·5	–
It.2971	12·3	17·0	10·9	13·4	7·3	–
It.2972	–	–	–	–	–	8·7

	W	X	Y	Z	H_1	H_5	H_7	H_8
BU 457	*c.* 28·8	6·7	10·5	11·3	–	–	–	–
It.2967	8·3	1·7	2·9	4·1	–	–	–	–
It.2972	6·0	–	–	–	–	–	–	–
It.2968	16·5	3·8	5·2	9·1	–	–	–	–
It.2965	–	–	–	–	7·0	6·6	6·7	5·5
It.2969	–	–	–	–	*c.* 6·3	–	*c.* 5·3	*c.* 4·2

For explanation of symbols see Fig. 1.

Figs 157–159. *Homalopteon radians* (M'Coy), p. 164. Lower Llandeilo, small quarry at SW end of Pencerig Lake, SO 043541. Figs 157, 158, internal and external moulds of pygidium, showing three axial rings, It.2962, ×5. Fig. 159, external mould showing ventral cephalic exoskeleton with no median suture, It.2951, ×3.

Figs 160–166. *Homalopteon murchisoni* sp. nov., above. Figs 160–162, 165, Middle-upper Llandeilo, quarry at Gwern-yfed-fâch, ½ ml (805 m) SE of Builth Road station, SO 030526. Fig. 160, Paratype. Internal mould of small pygidium with relatively long axis and traces of three pairs of ribs, It.2967, ×6. Figs 161–162, **Holotype.** Internal and external moulds of damaged pygidium, showing five axial rings and terminal piece, BU 457 (*ex* Chamberlain Coll. 54/4), ×2. Fig. 165, Paratype. External mould of cranidium showing glabellar furrows, It.2966, ×6. Figs 163, 166, Middle-upper Llandeilo, middle quarry, Llanfawr, Llandrindod, SO 066617. Fig. 163, Paratype. Internal mould of cranidium, showing traces of posterior band on occipital ring and posterior border furrows, It.2971, ×3. Fig. 166, Paratype. Internal mould of pygidium with only three, possibly four, axial rings, It.2970, ×5. Fig. 164, Middle-upper Llandeilo, ? middle quarry, Llanfawr, Llandrindod, SO 066617. Paratype. Internal mould of thorax and pygidium, It.2968 (*ex* Straw Coll., Manchester University), ×2.


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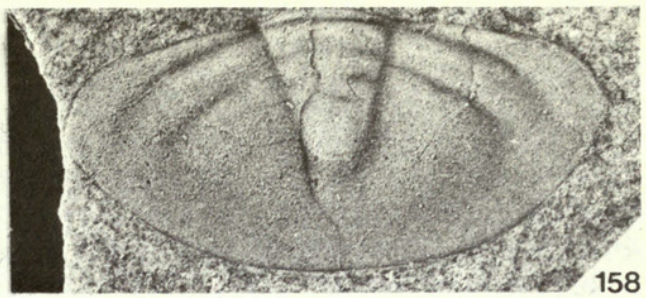
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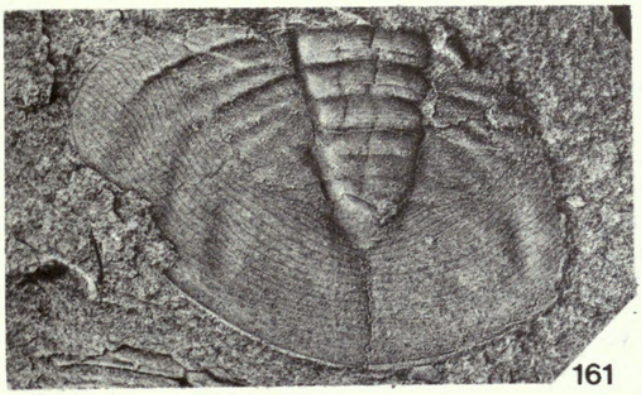
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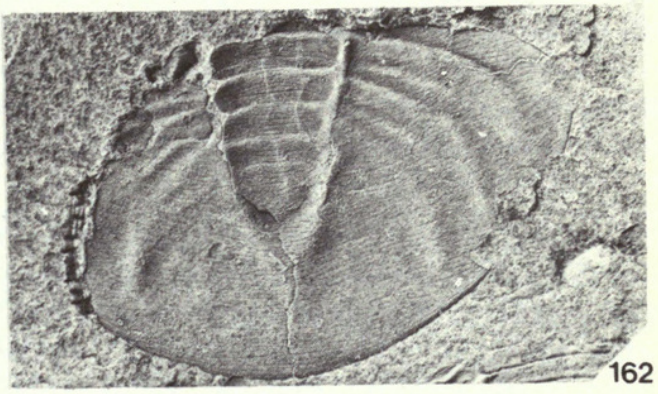
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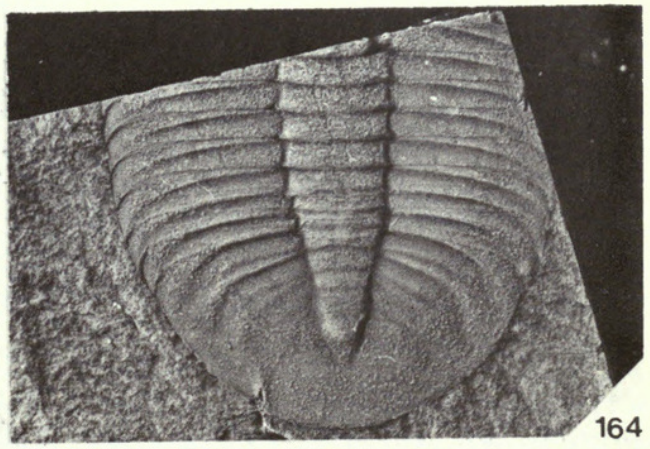
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LOCALITY AND HORIZON. The holotype and paratypes It.2963–7 are from the quarry at Gwern-yfed-fâch, half a mile (805 m) south-east of Builth Road station. The other paratypes are from the middle quarry, Llanfawr, Llandrindod. Both localities are in the *Nemagraptus gracilis* Shales. The species is known only from the two localities yielding the type material.

DESCRIPTION. The species is similar to *H. radians* and only a comparative description is given.

Cephalon similar to *H. radians* although there may be slight differences in glabellar furrowing (compare Fig. 137 with Figs 163, 165). Posterior border is developed on fixigena, separated by a narrow, though clearly-developed, border furrow (Fig. 163). Eye devoid of visible lenses (Figs 146, 149, 152, 154, 167–8).

Hypostoma (Figs 171–2) and only known thorax (Fig. 164) similar to *H. radians*.

Pygidium typically with four axial rings and two well-developed ribs; occasionally there is an indication of a third rib (Fig. 160).

ONTOGENY. One poorly-preserved specimen is thought to be a meraspis of degree 3 or 4 (Fig. 172). As far as can be determined its exoskeleton, including the hypostoma, is very like that of holaspides except for the number of thoracic segments.

BIOMETRICAL DATA. Very few data concerning the cephalon are known from the holotype locality, so details are given based on material from the middle quarry, Llanfawr (Table 20) from which much of the paratype material was recovered. Pygidial data from both type localities are given.

Table 20. Bivariate statistics of *Homalopteon murchisoni* sp. nov. Upper part of table from the middle quarry, Llanfawr; lower part from the quarry at Gwern-yfed-fâch. All measurements in mm. For explanation of symbols see Fig. 1.

x : y	$\bar{x}$	var. x	$\bar{y}$	var. y	r	r_e	α	var. α	a	var. a	n
A : C_3	9·47	4·51	5·05	1·09	0·99	0·99	0·92	0·0059	0·49	0·0017	6
A : J_1	10·06	2·99	8·98	1·69	0·98	0·98	0·84	0·0071	0·75	0·0060	5
A : J_2	10·22	3·81	11·15	3·43	0·99	0·99	0·87	0·0038	0·95	0·0045	4
A : K_1	9·47	4·51	5·47	1·80	1·00	1·00	1·09	0·0024	0·63	0·0008	6
W : Z	13·79	13·91	7·61	5·56	0·99	0·99	1·14	0·0052	0·63	0·0017	8
W : X	13·90	12·28	3·22	0·86	0·98	0·99	1·13	0·0051	0·26	0·0003	9
Y : X	5·26	2·61	3·69	1·24	0·93	0·93	0·98	0·0103	0·69	0·0053	14
Z : Y	9·31	9·06	5·41	2·68	0·95	0·95	0·94	0·0067	0·54	0·0023	14
W : Z	9·23	9·95	4·83	4·85	0·98	0·99	1·31	0·0058	–	–	9
W : X	9·64	9·69	2·21	0·74	1·00	1·00	1·19	0·0009	–	–	8
Y : X	3·13	1·22	2·30	0·62	0·99	0·99	0·97	0·0030	0·71	0·0017	10
Z : Y	6·73	16·31	4·12	6·40	0·99	0·99	1·02	0·0012	0·63	0·0005	12

Table 21. Frequency distribution and mean and variance of axial rings on pygidia of *Homalopteon murchisoni* sp. nov. Upper part of table from quarry at Gwern-yfed-fâch; lower part from the middle quarry, Llanfawr. The suffix 'i' indicates the development of a further incipient ring, and such rings have been counted as half a ring in the calculation of the means.

Number of axial rings	3	3i	4	4i	5
Number of specimens	3	0	5	1	1
mean = 3.85; var. = 0·45; n = 10					
Number of specimens	7	0	7	0	0
mean = 3·50; var. = 0·27; n = 14					

Comparison of these and the equivalent data for *H. radians* (both data sets include internal and external moulds) shows that the mean number of axial rings developed in *H. murchisoni* is significantly higher than in *H. radians*. While in *H. murchisoni* the mean is higher in the sample from Gwern-yfed-fâch, the difference between this and that of the Llanfawr sample is not

significant. Contingency tests show that the difference between the axial ring counts of the two species is not because of any correlation between pygidial size and number of rings.

DISCUSSION. The species is obviously closely related to *H. radians*, but the greater development of the pygidial furrowing together with the small cephalic differences warrant its specific separation. Morphologically the species provides a link between *H. radians* and *H. portlockii*, the pygidial furrowing being even more marked in the type species.

Family **ODONTOPLEURIDAE** Burmeister, 1843
Subfamily **ODONTOPLEURINAE** Burmeister, 1843

Genus ***DIACANTHASPIS*** Whittington, 1941

DIAGNOSIS. Whittington's emendment (1956 : 210) of his original diagnosis (1941 : 501) is extended to cover species with up to eight pairs of horizontally-directed pygidial border spines.

TYPE SPECIES. *Diacanthaspis cooperi* Whittington, 1941.

DISTRIBUTION. Accepting the tentative generic assignment of the Builth specimen, the genus ranges in Britain from uppermost lower Llanvirn (*D. bifidus* Zone) to Ashgill (Zones 1–3) (Tripp 1954, Whittington 1968, Price 1974) and possibly into the lower Llandovery (Temple 1969). It is also recorded from the Caradoc of Estonia (Bruton 1968), Norway (Bruton 1965) and eastern United States of America (Whittington 1956); the Ashgill of Ireland (Dean 1974), Bornholm (Poulsen 1966), Sweden (Bruton 1966) and Poland (Kielan 1960). In addition it is possibly present in the Arenig (Zones H-L) of the western United States of America (Hintze 1953, Ross 1967, 1970, Young 1973).

DISCUSSION. The earliest certain occurrence of the genus is in the basal Caradoc (lower Edinburgh Limestone) of North America, the first unquestioned occurrence in Britain being from the mudstones in Craighead Quarry, near Girvan, from a horizon probably a little higher in the Caradoc (Tripp 1954 : 688). The possible appearance of the genus in the lower Llanvirn at Builth is of particular interest. It is one of the few possible pre-Llandeilo records of odontopleurids. With the provisional placing by Whittington & Bohlin (1958 : 41–42) of *Ceratocephala solis* ? (Öpik) (Bohlin 1949 : 539, 560, 566, fig. 8) and '*Acidaspis*' *solis* Öpik, 1925 in the apianurine genus *Boedaspis* Whittington & Bohlin, 1958, the only records of earlier odontopleurinids are restricted to *Diacanthaspis* ? *trispineus* Young, 1973, from the Arenig of the western United States of America, and a probable cranidium of *Diacanthaspis* sp. (Hintze 1953 : pl. 19, figs 16, 16a; Ross 1970 : 10) and other specimens of *Diacanthaspis* (Ross 1967 : 30; 1970 : 46), together with possible odontopleurinid fragments, from the early Arenig of Västergötland (Tjernvik 1956 : 264). The latter have been shown by Bruton (1966) to belong to *Perialaspis*, a genus of unknown subfamilial affinities.

Diacanthaspis ? sp. A
(Fig. 176)

FIGURED SPECIMEN. It.3020, internal mould with eight thoracic segments attached to pygidium. Dimensions (in mm): anterior thoracic width – 3·7; anterior thoracic axial width – 1·1; posterior thoracic axial width – 0·8; thoracic length – 2·0; anterior pygidial width – *c.* 2·1; anterior pygidial axial width – 0·7; pygidial length – 0·6; pygidial border spine length – 0·3.

LOCALITY AND HORIZON. The single specimen is from the uppermost *Didymograptus bifidus* Shales exposed in the cliff section on the left bank of the Howey Brook, half a mile (805 m) ESE of Carregwiber.

DESCRIPTION. Cephalon unknown. Thorax apparently subrectangular; of at least eight segments with four or five major spines on posterior band. Axis convex and occupying about one-quarter of total width anteriorly, tapering slightly to the rear; articulating furrow broad and bowed forwards mesially. Axial furrow deep with apodemes at anterior of each segment. Pleural furrow shallow, more or less transversely-directed, separating anterior and posterior bands of

approximately equal width (*exsag.*). Anterior band flat with short pleural spine. Posterior band convex (*exsag.*) with four or five spines along its crest, outer two or three being more closely spaced than inner ones; distally the band is prolonged into a long pleural spine which becomes progressively longer and more backwardly-curved on successive segments.

Pygidium with more than six, possibly eight pairs of horizontally-directed pygidial border spines; upwardly-directed (?) spine opposite base of sixth border spine; smaller spines opposite second and fourth spines. Excluding the spines, it is triangular, about three times as wide as long. Axis occupies about one-third of anterior width and tapers gently to posterior. As in thorax no trace of any spines is seen on the axis. Pleural field unfurrowed, but a pleural ridge is developed opposite the first axial ring, initially transversely-directed, but turning abruptly posteriorly and ending in a large spine base (spine is not preserved but presumably was directed upwards) at the base of sixth border spine. Two further smaller spine bases occur opposite the second and fourth border spines.

DISCUSSION. The generic placing of odontopleurids is difficult when cephalic details are lacking and the affinities of the Builth specimen are not certain. It is clearly not closely related to *Periallaspis* (Bruton 1966 : 29; pl. 6, figs 4–6; text-figs 7A, B), and it is best compared to either *Primaspis* R. & E. Richter, 1917 or *Diacanthaspis* Whittington, 1941, both Ordovician odontopleurine genera. However, early examples of *Primaspis*, for example *P. multispinosa* (Bruton 1965 : pl. 2, fig. 3), *P.* cf. *whitei* (Whittard 1961*a* : pl. 27, fig. 8), *P.* cf. *simulatrix* (Whittard 1961*a* : pl. 27, fig. 10) and *P.* ? sp. (MacGregor 1963 : pl. 116, fig. 22), may all be distinguished by their broadly curved pleural ridge. Similarly, this specimen may be distinguished from all known *Diacanthaspis* by the presence of the major upwardly-directed spine opposite the second and fourth border spines. If it should subsequently be shown that eight border spines are indeed developed then this also would distinguish it from all others except *D. sladensis* (see Temple 1969). D. L. Bruton (personal communication) has pointed out that the position and granulation of the pygidial pleural ridge is very like that found in *Odontopleura*, a genus currently restricted to two or three European Silurian species. The granulation on the thoracic pleurae, however, shows a close similarity to that of many *Diacanthaspis* and on balance it is believed the present specimen shows closest affinity to that genus.

Odontopleuridid gen. et sp. indet.
(Figs 174–175)

FIGURED SPECIMEN. It.3021, internal and external moulds of librigenal fragment.

LOCALITY AND HORIZON. Stream section 400 yd (365 m) north-east of Gorse, Llandrindod, in *Glyptograptus teretiusculus* Shales.

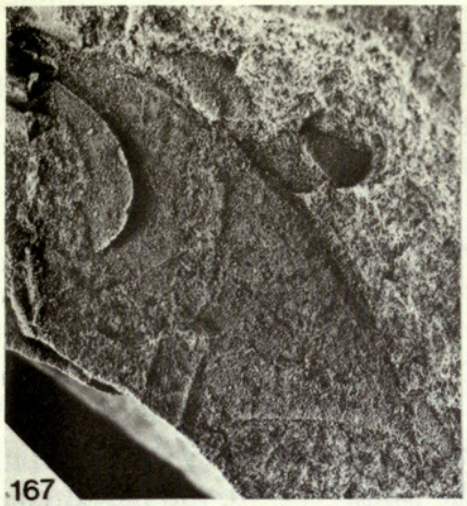
Figs 167–172. *Homalopteon murchisoni* sp. nov., p. 168. Figs 167–168, 171, Middle-upper Llandeilo, quarry at Gwern-yfed-fâch, ½ ml (805 m) SE of Builth Road station, SO 030526. Figs 167–168, Paratype. Internal mould of right librigena, It.2964. Fig. 167, ×4; Fig. 168, ×10. Fig. 171, Paratype. External mould of hypostoma, It.2965, ×4. Figs 169–170, 172, Middle-upper Llandeilo, middle quarry, Llanfawr, Llandrindod, SO 066617. Fig. 169, Paratype. External mould of hypostoma with attached librigenae, showing lack of median suture and relative position of the hypostoma, It.2969, ×4. Fig. 170, internal mould of hypostoma, It.2973, ×4. Fig. 172, internal mould of meraspid of degree 3 or 4, It.2972, ×5.

Fig. 173. *Rorringtonia* sp., p. 174. Middle-upper Llandeilo, quarry at Gwern-yfed-fâch, ½ ml (805 m) SE of Builth Road station, SO 030526. Internal mould of cranidium, It.3022, ×7·5.

Figs 174, 175. Odontopleuridid gen. et sp. indet., above. Lower Llandeilo, stream section 400 yd (365 m) NE of Gorse, SO 072617. External and internal moulds of librigenal fragment, It.3021, ×8.

Fig. 176. *Diacanthaspis* ? sp. A, p. 171. Lower Llanvirn, cliff section on left bank of Howey Brook, ½ ml (805 m) ESE of Carregwiber, SO 089582. Internal mould of pygidium and part of thorax, It.3020, ×10.

Fig. 177. *Ogyginus* cf. *intermedius* Elles, p. 137. Lower Llanvirn, left bank of upper reaches of Camnant Brook, 270 yd (247 m) S 13° W of the fence crossing near the stream source, SO 088575. Internal mould of pygidium, It.2890, ×1.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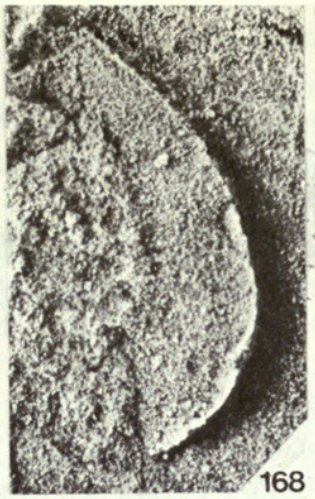
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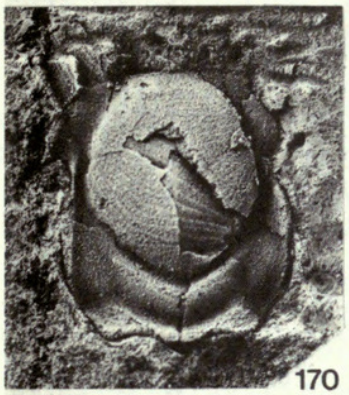
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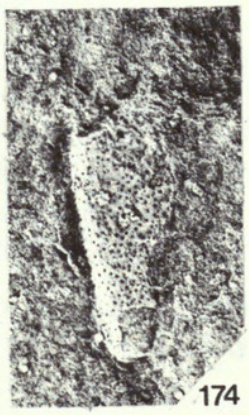
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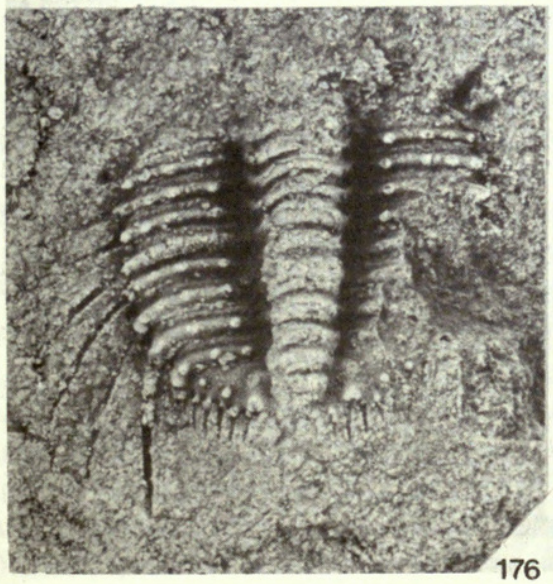
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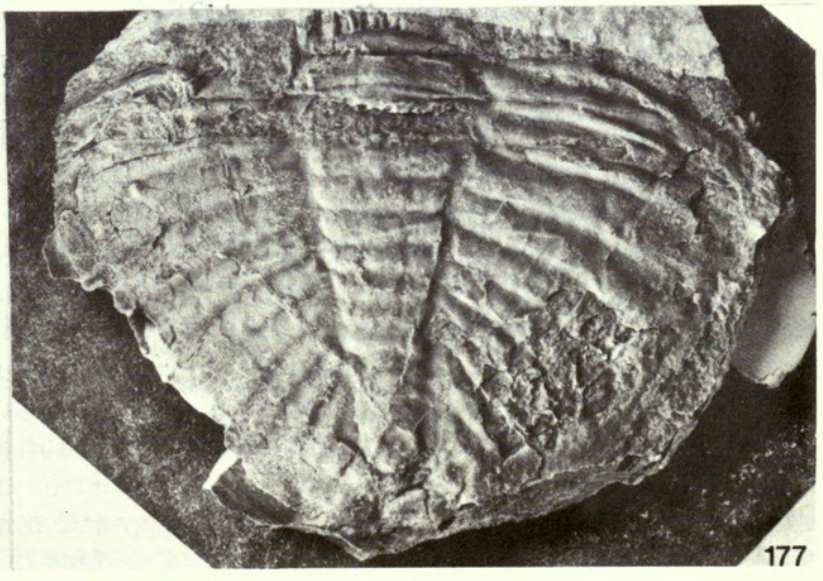
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DESCRIPTION. The single librigenal fragment shows a well-developed border region and bases of four stout lateral cephalic border spines. External surface bears irregularly-spaced granules about 0·3 mm in diameter.

DISCUSSION. This specimen is the only odontopleuridid so far recorded from the Llandeilo of the Builth region. It is similar to librigenae attributed to *Primaspis whitei* (Whittard 1961*a*: pl. 27, fig. 7) from beds of similar age at Shelve, but differs in having a sharper border ridge.

Family **PROETIDAE** Salter, 1864

Genus ***RORRINGTONIA*** Whittard, 1966

DIAGNOSIS. See Owens (1973 : 76).

TYPE SPECIES. *Rorringtonia flabelliforme* Whittard, 1966.

DISTRIBUTION. The genus is known from the Rorrington Beds (Caradoc) of the Shelve region, the *Nemagraptus gracilis* Shales (middle to upper Llandeilo) of the Builth region, the Balclatchie Group (Caradoc) near Girvan and from the Glenkiln Shales near Moffat (J. K. Ingham, personal communication 1975).

DISCUSSION. Whittard regarded the familial affinities of this genus as uncertain. The author concluded (1967, unpublished thesis) that it was most likely an early proetid, a conclusion supported by more recent work on the Proetidae by Owens (1973) and Fortey & Owens (1975). As noted by Owens, *Rorringtonia* exhibits many similarities to *Pseudoproetus* Poulsen, 1934, and may indeed be a junior synonym of Poulsen's genus.

Rorringtonia sp.
(Fig. 173)

1973 *Rorringtonia* sp. 1 Owens : 78.

FIGURED SPECIMEN. It. 3022, internal and external moulds of cranidium. Dimensions (in mm): cranidial length – 3·5; glabellar length excluding occipital ring – 2·1; glabellar length including occipital ring – 2·3; length (*sag.*) of frontal area – 1·2; length (*sag.*) of preglabellar field – 1·0; maximum cranidial width – 9·0; anterior cranidial width – *c.* 3·0; distance between posterior of palpebral lobes – 2·7; maximum glabellar width – 2·0.

LOCALITY AND HORIZON. Quarry at Gwern-yfed-fâch, half a mile (805 m) south-east of Builth Road station; *Nemagraptus gracilis* Shales.

DESCRIPTION. The single cranidium is small and gently convex. Glabella parabolic in outline, about two-thirds length of cephalon, and, excluding occipital ring, slightly longer than wide. Three pairs of lateral glabellar furrows developed; anterior pair very weak; median and posterior pairs, though possibly a little distorted, strong and directed inwards and backwards at about 45°. Posterior pair shallow mesially and deflected posteriorly, just failing to reach the occipital furrow. Median pair uniformly deep and extending about half-way to the mid-line on each side. In lateral view, convexity of glabella greatest anteriorly, sloping gently down to rear; maximum elevation between anterior lateral glabellar furrows. Glabella bounded by deep, narrow axial furrow. Preglabellar field long and only gently convex, bounded anteriorly by wide, shallow, gently curved anterior border furrow. Occipital ring poorly preserved; occipital furrow moderatelv deep and nearly straight; small occipital node may be present.

Eye probably developed, situated near axial furrow and opposite median lateral glabellar furrow. Course of facial suture uncertain, but anterior branch moderately divergent forwards; posterior branch directed transversely from posterior of palpebral lobe, curving gently to cut posterior margin. Posterior border furrow deep and more or less straight, separating a narrow (*sag.*) border which widens laterally. External surface of the cranidium appears to be smooth.

DISCUSSION. This specimen closely resembles *R. flabelliforme* Whittard, 1966 from the basal Caradoc Series of the Shelve region, but appears to differ in that the glabella, excluding the

occipital ring, is slightly longer than wide. Further, the occipital furrow in the Builth specimen is not bowed forwards and the posterior lateral glabellar furrow shows no branching at its inner end. The presence of this latter feature in the type species is, however, considered as possibly due to *post-mortem* cracking of the exoskeleton. Eye ridge is apparently absent in the Builth specimen but this region of the cephalon is poorly preserved.

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