https://doi.org/10.24199/j.mmv.1985.46.01 30 July 1985

TREMADOC TRILOBITES FROM THE FLORENTINE VALLEY FORMATION, TIM SHEA AREA, TASMANIA

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Abstract

Trilobites from several horizons in the Florentine Valley Formation of the Tim Shea area west of Maydena, southwestern Tasmania are described and assigned late Tremadoc to possibly early Arenig ages. Their ages approximate the Lancefieldian La1.5 zone of *Psigraptus*, La2 and possibly La3. Taxa described are *Hystricurus penchiensis* Lu, *H. lewisi* (Kobayashi), *H.* sp. cf. *H. robustus* Ross, *Tanybregma tasmaniensis* gen. et sp. nov., *Chosenia adamsensis* sp. nov., *Asaphellus* sp. cf. *A. trinodosus* Chang, *Megistaspis (Ekeraspis) euclides* (Walcott), *Dikelokephalina asiatica* Kobayashi, *Asaphopsoides florentinensis* (Etheridge), *Scotoharpes lauriei* sp. nov., Pilekiidae gen. et sp. nov., *Pilekia* sp. nov., *Protopliomerops hamaxitus* sp. nov. and *P.* sp. cf. *P. punctatus* Kobayashi.

Introduction

Trilobites of the Florentine Valley Formation in southwestern Tasmania received scant attention until recently. Etheridge (1905) described *Dikelocephalus florentinensis* and *Niobe*? sp. ind. from the Florentine River Valley near The Gap (*fide* Corbett & Banks, 1974). Kobayashi (1936) reassigned the species *florentinensis* of Etheridge to *Asaphopsis* Mansuy, 1920. Kobayashi (1940) described four species from a railway cutting at Junee east of the present town of Maydena near the siding of Fitzgerald (*fide* Lewis, 1940, p. 35); his two species of *Asaphopsis* are considered synonyms of Etheridge's *A. florentinensis*, his two species of *Tasmanaspis* are considered synonymous and *Tasmanaspis* is considered a junior subjective synonym of *Hystricurus* Raymond, 1913. He assigned the fauna to the Lower Ordovician and it may now be correlated with the OT5 to OT7 time interval as discussed below.

Corbett and Banks (1974) illustrated a number of trilobites of the Florentine Valley Formation from The Gap on the Florentine Valley Road and from 5 Road to the southwest. Although they applied numerous specific names and left many other specimens in open nomenclature we consider that they were deceived, by the subtleties of the deformation and failure to employ latex casting on the trilobites, into oversplitting the collection; in our opinion all their hystricurid specimens are referable to *H. lewisi* (Kobayashi, 1940), all the asaphopsid specimens to *Asaphopsoides florentinensis*, the "*Asaphellus*" *lewisi* to *Asaphellus* sp. cf. *A. trinodosus* Chang, and the *Cybelopsis* sp. to *Protopliomerops hamaxitus* sp. nov.

Stait and Laurie (1980) provided identifications for new trilobite faunas found in sequence along the Gordon River Road on the western side of The Needles. Our paper along with that of Laurie (1980) provides the detailed palaeontology for the discoveries of Stait and Laurie (1980) and leads to several important revisions of ranges and nomenclature. Findings herein are consistent with the assertions mady by Stait and Laurie (1980) about correlations and divisions of the faunas but limitations are placed on the ability to subdivide the faunas referred to by Stait and Laurie (1980) as Assemblages 5, 6, and 7, until more sections are available to confirm previous proposals.

Illustrated material is housed in the Department of Geology, University of Tasmania (prefix UTGD), the Tasmanian Museum (prefix Z), and accessory collections are housed in those institutions and the palaeontological collections of the Museum of Victoria.

We are grateful to Penny Green University of Tasmania, and Annette Jell for curatorial assistance, to Penny Clark for printing the photographs from negatives made by the senior author and to Heather Martin for typing the manuscript.

Localities and trilobite faunas (Fig. 1)

The localities from which trilobites are described are numbered on the fossil locality register of the Museum of Victoria (prefix NMVPL).

NMVPL1600, 1601, 1602 occur in the yellow siltstone (2nd lithology from base), dark grey calcareous siltstone, and yellow siltstones (near top) respectively, of the Pontoon Hill Siltstone Member (Stait & Laurie, 1980) of the Florentine Valley Formation on the Gordon River Road (19 km west of Maydena), where the member extends on the State Grid Reference—Wedge 8112 from 535, 694 to 529, 685.

NMVPL1600 *Hystricurus penchiensis* Lu, 1976
Tanybregma tasmaniensis gen. et sp. nov.
Dikelokephalina asiatica Kobayashi, 1934
Pilekia sp. nov.

NMVPL1601 *Hystricurus lewisi* (Kobayashi, 1940)
Asaphopsoides florentinensis (Etheridge, 1905)
Protopliomerops hamaxitus sp. nov.
Megistaspis (Ekeraspis) euclides (Walcott, 1925)
Pilekiidae gen. et sp. nov.

NMVPL1602 *Hystricurus lewisi*
Asaphopsoides florentinensis
Protopliomerops hamaxitus
Hystricurus sp. cf. *H. robustus* Ross, 1951
Chosenia adamsensis sp. nov.
Asaphellus sp. cf. *A. trinodosus* Chang, 1949
Scotoharpes lauriei sp. nov.
Protopliomerops sp. cf. *P. punctatus* Kobayashi, 1934

NMVPL182 and 183. Lower and upper beds respectively at The Gap on Australian Newsprint Mills road into the Florentine Valley from Maydena (see Corbett & Banks, 1974, fig. 4; Stait & Laurie, 1980, fig. 1). Trilobite faunas are identical at the two localities.

Hystricurus lewisi
Asaphopsoides florentinensis
Protopliomerops hamaxitus

5 Road. this locality was detailed by Corbett and Banks (1974, fig. 4, locality 3) as coordinates 440, 400 E. 742, 500 N. on 5 Road in the Florentine Valley.

Hystricurus lewisi
Asaphopsoides florentinensis
Protopliomerops hamaxitus

Adams Falls. Clear Hill Road 400 m east of Adams Falls near junction with Adamsfield Track. State Grid Reference—Wedge 8112: 423, 699.

Hystricurus sp. cf. *H. robustus*
Chosenia adamsensis
Protopliomerops hamaxitus
Asaphellus sp. cf. *A. trinodosus*
Asaphopsoides florentinensis

Age

Correlation of shelly Tremadoc faunas is relatively tentative and considerable disagreement still exists with relationships to a standard scale still a long way off; for example Chugaeva and Apollonov (1982, p. 82) place the shelly fauna zones D, E, and F (of Ross (1951) and Hintze (1953)) in the Arenig whereas Miller *et al.* (1982, p. 177) in the same publication place the same zones in the Tremadoc, and evidence for either does not seem strong.

The fauna from NMVPL1600 (Assemblage 3 of Stait and Laurie (1980) and OT3 of Banks and Burrett (1980)) contains *Psigraptus* which has been used to correlate with the La 1.5 zone of *Psigraptus* of Cooper and Stewart (1979). The trilobites do not provide a distinctive correlation and although *Dikelokephalina* suggests correlation with the *Dikelokephalina* Beds of Kazakhstan (Chugaeva & Apollonov, 1982), the Carranya Beds of the Canning Basin, Western Australia (Legg, 1978), and the *Clarkella* zone of Korea (Kobayashi, 1934) such generic level correlation should be avoided if possible and used only when a number of genera are involved. The medial Tremadoc age suggested by the graptolite is feasible but the implied contemporaneity of the Digger Island Formation (Webby *et al.*, 1981) is doubtful in light of comparison of the trilobite faunas (see discussion in Jell, 1985).

Succeeding faunas of the Florentine Valley formation (Assemblages 4 to 7 of Stait and Laurie (1980) or OT4 to OT7 of Banks and Burrett (1980)) contain and are distinguished by *Hystricurus lewisi*, *Asaphopsoides florentinensis*, and *Protopliomerops hamaxitus*; various other species occur with them at different horizons. The fauna of OT5 may be distinguished from that of OT4 by the appearance of *Chosenia*, *Asaphellus*, and *Scotoharpes* but following more detailed examination of the faunas OT5 to OT7 may not be subdivided on the basis of contained trilobites. Moreover, the utility of a zonal

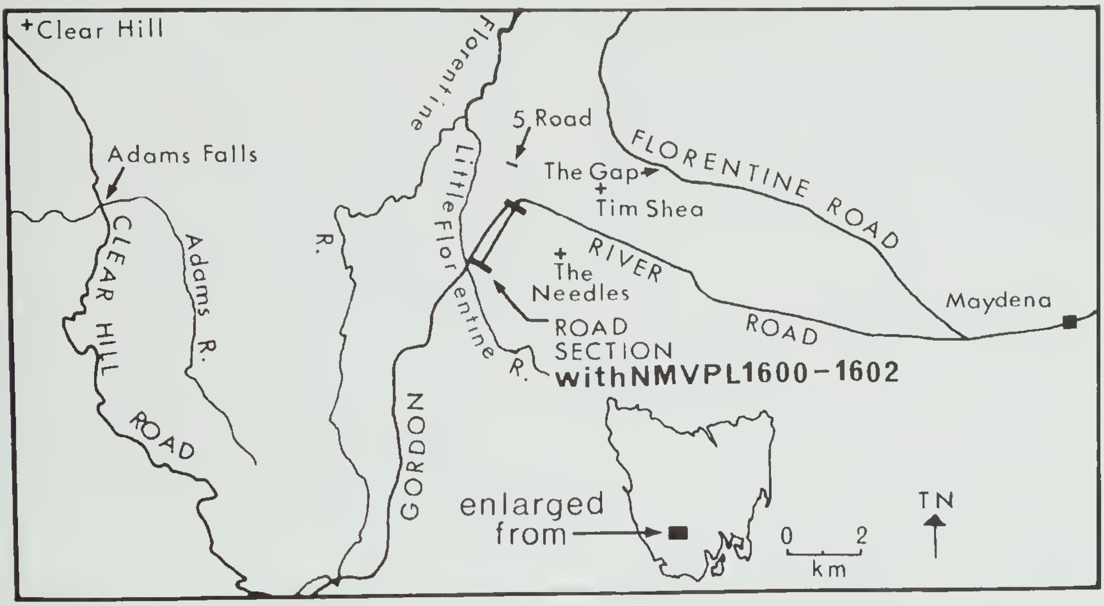

Figure 1. Sketch map of Maydena-Tim Shea area southwestern Tasmania showing fossil localities.

scheme based on faunas of the Florentine Valley Formation will depend on its applicability to other sections which are not yet known. Indeed difficulties of correlating the Digger Island Formation fauna (Jell, 1985) with this section suggest that use of the trilobite faunas to establish a biostratigraphy may be premature and detailed taxonomy of all known sections is necessary before a workable scheme can be established.

The trilobites of these assemblages are not inconsistent with the late Tremadoc to early Arenig age previously suggested (Laurie, 1980; Stait & Laurie, 1980; Banks & Burrett, 1980).

Preservation

The fossils are preserved as moulds in fine-grained decalcified shale to fine sandstone of a variety of colours. There has been considerable distortion of the fossils at all localities but more so at some (e.g., NMVPL1600 and Adams Falls) than at others (e.g., NMVPL182 and 5 Road). The fossils all appear to have lain in the bedding planes and distortion is generally in two dimensions with development of slatey cleavage. Those fossils in decalcified nodules at NMVPL1601 and 1602 are much less deformed than others at the same localities in the shaly beds. The distortion at NMVPL1600 induced the tubercles on some hystricurid heads to become much more prominent and asymmetrical (Pl. 1, fig. 3) whereas in others it seems to have completely subdued the tuberculation (Pl. 1, fig. 1).

Although it may appear nonsense to place two pygidia (Pl. 5, figs 7 and 8) in the same species, the marked dimensional differences may best be explained as compression from different directions.

It is interesting to note that at NMVPL1600 distortion is marked but there has been no fracture of the exoskeletons (even of the large flat *Dikelokephalina asiatica*) as there is at most other localities particularly in the large flat *Asaphopsoides florentinensis*. The state of preservation of the fossils removes any confidence in the use of any biometrics so no measurements or reconstructions are included in the descriptions; sizes of individuals are indicated in plate explanations and most distinguishing features are not measurements.

Systematic palaeontology

Terminology follows Harrington, Moore & Stubblefield (1959) as far as possible; occipital ring is included in the glabella; all dimensions in the sagittal or exsagittal directions are discussed in terms of length and all dimensions in the transverse direction are discussed in terms of width (for example the anterior cranidial border whose sagittal dimension is often important in specific description is described in terms of long or short in our terminology).

Class Trilobita

Family HYSTRICURIDAE Hupe, 1953

Hystricurus Raymond, 1913

Type species (by original designation): *Bathyurus conicus* Billings, 1859.

Hystricurus penchiensis Lu, 1976

Plate 1, figures 1-15

Material: Holotype Nanking Institute of Geology and Paleontology No. 23885 (Lu, 1976, pl. 7, fig. 10), paratypes NIGP23886 to 23888 all from the *Callograptus* ? *taitzehoensis* zone of the Yehli Formation in Liaoning Province of northeastern China. Some fifty disassociated cranidia, pygidia, librigenae and thoracic segments as well as two articulated specimens are available from NMVPL1600 including the figured specimens UTGD122500 to 122518.

Diagnosis: Member of *Hystricurus* with subquadrate glabella; relatively long preglabellar field (0.3 of cranidial length); palpebral lobe long (0.4 of cranidial length), situated posteriorly, becoming wider posteriorly, defined by distinct palpebral furrow parallel to margin of the narrow lobe; librigena with marginal terrace lines, with strong genal spine bearing extension of border furrow down its midline. Pygidium with axis of four rings and short, medially divided terminus reaching border furrow; pleural and interpleural furrows extending to border; border narrow in dorsal view, with high marginal band bearing strong parallel terrace lines; doublure narrow.

Description: Cranidium with coarse tubercular ornament on glabella and cheeks. Glabella without furrows, with straight parallel sides posteriorly, tapering gently over anterior half, with truncated anterior rounded on corners; occipital furrow and ring of about equal length, with weak apodemal depressions in furrow laterally, with ring tapering laterally behind apodemal pits and passing across axial furrow as very low ridge into posteroproximal corner of fixed cheek, without median node or posterior spines on ring; axial furrow with elongate fossulae at anterolateral corners of glabella, shallowing over axis in front of glabella; preglabellar field weakly convex; anterior border furrow shallow, long, with gently sloping walls front and back, almost transverse, without ornament; anterior border short, weakly convex, without ornament, tapering laterally from near exsagittal line through sides of glabella as facial suture cuts across it; interocular cheek wide, rising up from axial furrow but flat distally; palpebral furrow, running around both anterior and posterior of palpebral lobe to cross facial suture and continue on librigena beneath eye socle; palpebral lobe arcuate, almost semicircular, relatively long at 0.4 of cranidial length, sloping up abaxially, becoming wider posterior to the midlength, without ornament; facial suture diverging forward from palpebral lobe in curve to widest point just behind border furrow, then curving strongly across border to anterior margin, running transversely from posterior of palpebral lobe to well beyond lateral extremity of palpebral lobe before turning sharply back for very short distance to posterior margin; posterior cephalic limb short and wide, without ornament, occupied mostly by well impressed transverse posterior border furrow of uniform length, with short convex posterior border behind. Librigena longer than wide, gently convex; with genal spine of more than half cranidial length, visual surface almost three times as long as wide (or rather high), standing almost vertically, only weakly convex transversely, apparently holochroal although lenses not clearly distinct; eye socle low, distinct, rim-like beneath visual surface, defined below by broad shallow furrow continuous from palpebral furrow; genal field weakly convex, gently downsloping abaxially from sharp change of slope at furrow beneath eye, with coarse tubercular ornament over adaxial half (tubercles of two sizes) and extremely fine low radial caecal network extending from eye socle to border; border furrow well impressed, rising steeply up onto border but smoothy up cheek, continuing down genal spine as merging lateral and posterior parts, not running around genal angle; posterior border furrow deeper and lateral border furrow deepening from just in front of genal angle back; border convex throughout becoming much narrower and more convex behind a point just in front of the genal angle, with continuous terrace lines parallel to the margin on anterior part but fading out at the same point the convexity of the border changes; genal spine not continuing curve of cheek margin but running very slightly abaxially, with high convex rims on both sides of deep furrow running down its centre; doublure as wide as border, convex ventrally to enclose cylindrical space in border. Hypostome unknown.

Thorax of at least nine segments (no complete thorax is known); axial rings of uniform length, each with median node; pleural furrows well impressed, beginning at the anterior margin in the axial furrow, occupying most of the length of the segment, fading out down free pleura against back of wide short inclined facet; anterior and posterior pleural bands each with single row of tubercles; pleural tips with posterolateral points.

Pygidium transverse, with convex axis standing above less convex pleural areas; axis tapering slightly posteriorly; axial rings with prominent high tubercle on anterior one and low less-prominent node on second, progressively shorter posteriorly, of uniform length with short wide pseudoarticulating halfrings on first and second; terminus triangular, reaching down to posterior border furrow, divided sagittally into left and right lobes by distinct furrow deepest anteriorly; pleural areas with well impressed pleural and interpleural furrows; with anterior and posterior bands of each rib bearing a transverse row of small tubercles, with all furrows becoming directed more posteriorly towards the posterior where they are almost exsagittal; border extremely narrow in dorsal view, rim-like, of uniform width, defined by shallow posteriorly tapering border furrow, with high marginal band bearing continuous parallel terrace lines, with broad often barely perceptible posteromedian indentation; doublure narrow, extending in and then up to approach the dorsal exoskeleton beneath the border furrow and enclose cylindrical space within the border.

Remarks: The Tasmanian material is assigned to this Chinese species on the comparison with Lu's (1976, pl. 7, fig. 11) flattened specimen where the glabellar shape is identical with that of the Tasmanian specimens all of which are flattened. Preglabellar, palpebral and occipital structures are identical and there can be little doubt about the specific identity. Although the genal spine looks shorter on Lu's (1976, pl. 7, fig. 12) specimen it seems likely that the ventral mould of the spine is incomplete and may go into the matrix on the counterpart. The internal mould of the pygidium figured by Lu does not allow adequate comparison but observable features are identical, when compared with Tasmanian pygidia of comparable size (e.g., Pl. 1, fig. 15). Lu (1976) compared the Asian species *H. megalops* Kobayashi, 1934 and *H. granosus* Endo, 1935 both of which are distinguished by their narrower more rounded glabellar shape and shorter preglabellar field. *H. flectimembrus* Ross, 1951 has precisely the genal spine structure of the Tasmanian specimens. *Hystricurus wilsoni* Gobbett, 1960 is similar to *H. penchiensis* in ornament as well as in general arrangement of the cranidium and pygidium. However, the Spitsbergen species and *H. flectimembrus* from Utah may be distingushed from *H. penchiensis* by the spines on the rear of the cranidium and on the thoracic segments.

Hystricurus lewisi (Kobayashi, 1940)

Plate 2, fignres 1-15; plate 3, figures 9, 10, 13

1940 *Tasmanaspis lewisi* Kobayashi, p. 65, pl. 11, figs 3, 4.
1940 *Tasmanaspis longus* Kobayashi, p. 66, pl. 11, fig. 5.
1974 *Hystricurus paragenalatus* Ross; Corbett & Banks, pl. 1, figs 16, 20, pl. 2, fig. 11.
1974 *Hystricurus* sp. Corbett & Banks, pl. 1, figs 21, 25-27, pl. 2, fig. 12.
1974 hystricurid librigenae Corbett & Banks, pl. 1, fig. 19.
1980 *Hystricurus lewisi* (Kobayashi); Stait & Laurie, fig. 3, Appendix 1.

Holotype: Z151 from 'railway cutting 3.2 km west of Junee Railway Station' (i.e. just east of present day town of Maydena) in the Florentine Valley Formation.

Other material: Some 80 to 100 disarticulated cranidia, libragenae, and pygidia from NMVPL182, NMVPL1601, NMVPL1602 and 5 Road including Z150 (holotype of *Tasmanaspis longus*), Z995, material figured by Corbett and Banks (1974), and material figured herein are present in the collections of the Tasmanian Museum, Department of Geology, University of Tasmania and the Museum of Victoria.

Diagnosis: Glabella tapering forward, anteriorly rounded, extremely faint 1p furrow; preglabellar field short, becoming longer with growth; palpebral lobes short, wide, highly arcuate; anterior sections of facial suture diverging to just behind border furrow then cutting across border diagonally over a short transverse distance; librigena with convex border bearing continuous marginal terrace lines running down proximal part of genal spine. Pygidium transverse; axis of four rings and short medially divided terminus without distinct posterior boundary; axial furrow extending almost to posterior border furrow; pleural areas with sharp geniculation forming ridge parallel to margin some distance abaxial to border furrow; border and doublure quite narrow. Pygidium smooth but cephalon with fine tuberculate ornament becoming less obvious with growth.

Description: Small and convex for the genus with variable subdued ornament of pustules on all parts of exoskeleton except in furrows and on the border; cranidium with broadly convex glabella standing above cheeks; glabella with extremely vague suggestions of wide gently-oblique 1p furrows (e.g., pl. 2, fig. 15, centre); axial furrow well impressed, sharper and deeper in front of glabella (probably indicating fossulae) and shallowing adjacent to glabellar lobe 1p; occipital ring short, flat in lateral profile, tapering laterally; occipital furrow sharp and deep, with apodemal pits laterally but then shallowing to almost nothing adjacent to axial furrow; preglabellar field always short, or variable length depending on stage of growth but mostly on post-depositional distortion, downsloping forward into well impressed transverse border furrow; anterior border of uniform length, short, (may appear to be variable in length due to preservation—steeply upsloping forward was probably original attitude, appearing shorter than on flattened ones), with fine marginal terrace lines; eye lines barely evident on some specimens; palpebral lobe relatively short, arcuate, bulging laterally, flat to slightly downsloping abaxially, situated adjacent to midlength of glabella; palpebral furrow poorly impressed medially but distinct at ends of palpebral lobe, not parallel to lobe margin but rather cutting across base of lobe, continuous around ends of lobe onto free cheek beneath eye surface; posterior cephalic limb wide (glabella only 0.35 of basal cranidial width), subtriangular in shape, with well impressed posterior border furrow becoming longer laterally; posterior border becoming elongate abaxially, short and convex adaxially; facial suture running in fairly straight diagonal line from posterior of palpebral lobe to posterior border, then turning sharply back to margin.

Librigena downsloping abaxially, visual surface vertical, nearly four times as long as high, gently convex in both anterior and dorsal profiles; eye socle low, merely a rim beneath visual surface; furrow beneath eye socle very shallow but distinct without ornament, continuous with palpebral furrow of fixed cheek; genal field with ornament on adaxial part decreasing towards border furrow, gently convex; border furrow well impressed but shallowing distinctly for short section just in front of genal angle, continuing down genal spine where posterior and lateral border furrows merge into one furrow for short distance; doublure as wide as border extending quite a distance forward beyond genal field, terminating forward on an oblique rostral suture.

Pygidium transverse, convex, apparently without ornament; axis of four rings and short widely divided terminus, convex, standing above pleural areas; articulating half ring short standing up high medially; axial rings each of uniform length, becoming shorter towards posterior until fourth ring is extremely short rim; terminus represented by two lobes separated by wide medial depression, not clearly distinguished posteriorly; axial furrow not impressed but expressed as change of slope from axis onto flat proximal part of pleural area, continuing posteriorly down steep slope of pygidium to finish near posterior border furrow (extension down posterior slope may be fourth interpleural furrow simply continuing line of axial furrow but this cannot be determined without knowing termination of axis which in *H. penchiensis* becomes much lower as it extends posteriorly towards the posterior border furrow); pleural area clearly divided by sharp geniculation forming prominent ridge parallel to margin a considerable distance inside the border furrow; adaxial part of pleural area flat, crossed by four long gently sided pleural furrows and three (or four, depending on interpretation of posterior) short sharp interpleural furrows; pleural furrows cutting diagonally back across segment from axial furrow, finishing against ridge of geniculation; interpleural furrows continuing through gaps in geniculation ridge, running down steep outer slope almost to border furrow; outer part of pleural area sloping steeply down to border, smooth except for interpleural furrows; border extremely narrow, tapering forward, merely a flange at base of steeply sloping pleural area, defined by poorly impressed border furrow at change of slope, with fine parallel continuous terrace lines along margin; doublure narrow, convex, leaving cylindrical space in border; articulating facet small sloping steeply abaxially; pygidium without ornament.

Remarks: Kobayashi (1940) nominated this species as the type for his genus *Tasmanaspis* and the holotype is an internal mould, refigured herein (Pl. 2, fig. 2), of a medium sized cranidium. The features quoted by Kobayashi as distinguishing *Tasmanaspis* are not of generic significance in the modern understanding of *Hystricurus* and the "concavo-convex curvature of the frontal limb and rim" is considered to appear distinctive only by virtue of the preservation at the type locality. *Tasmanaspis* is undoubtedly a junior synonym of *Hystricurus*.

Angle of the facial suture and elongate cranidium, quoted by Kobayashi (1940) as distinguishing *Tasmanaspis longus* from *T. lewisi* are the result of lateral compression as opposed to sagittal compression in the type of *H. lewisi*. The eye ridge and length of occipital ring are not distinctive and the relative length of preglabellar area and position of palpebral lobe are not quoted accurately because Kobayashi's illustration of the type of *H. lewisi* is retouched in the left posterior region; the posterior cephalic limb is not preserved and the posterior margin of the occipital ring is not evident either. Kobayashi's specimens from Junee have been flattened during diagenesis as well as distorted and this flattening has produced the apparent elongation of the preglabellar area. However the distance from the depth of the border furrow to the tip of the border is approximately the same in most of the larger specimens from the other localities listed above. Perhaps most important of all is structure of the palpebral lobe which in mature specimens (e.g. Pl. 2, fig. 13) has the palpebral furrow well away from the margin at the midlength of the highly arcuate lobe just as it is in the holotype. In juvenile specimens this lobe is much narrower. As this and all other non-dimensional features match, the identity of these recent collections as *H. lewisi* is almost certain.

The wide flat palpebral lobes approach *Parahystricurus* Ross, 1951 and although the forward position of the lobes is distinctive of that genus the closest species to *H. lewisi* may well be *P. pustulosus* Ross, 1951 and related forms.

The pygidium resembles closely that figured by Ross (1951, pl. 19, figs 6, 11, 15) from his zone E with the marked ridge on the pleural area particularly distinctive. Ross's suggestion that it probably belongs to *Parahystricurus carinatus* Ross, 1951 further suggests alliance of *H. lewisi* with *Parahystricurus* although it is suggested below that Ross's pygidium may belong to *Hystricurus robustus* which occurs at the same locality.

Hystricurus megalops Kobayashi, 1934 from Korea and *H. granosa* Endo, 1935 from Liaoning, China resemble each other as well as *H. lewisi* in glabellar shape, ornaent and most proportions of the cranidium so that the three may prove ultimately to be synonymous but we prefer to retain the Tasmanian name until a fuller understanding including knowledge of pygidia is available for each of the Asian species.

Hystricurus sp. cf. **H. robustus** Ross, 1951

Plate 3, figures 8, 11, 12; plate 4, figures 1-7

Material: Some 20 to 30 cranidia librigenae, and pygidia from NMVPL1602 and from the Adam's Falls locality.

Description: Ross (1951, p. 51, 52) gave a detailed description of this species so only those features that add to or are at variance with his description are mentioned here. Ross's specimens are smaller than these Tasmanian individuals so some of the features that do not match exactly are probably due to comparison of different growth stages of the species. In the Tasmanian material the palpebral lobe is even wider and just a little shorter; the facial suture runs directly forward from the anterior of the palpebral lobe (Pl. 4, figs 1, 3) (distortion of individuals in Pl. 4, figs 4, 6 erroneously suggests divergence) and runs diagonally back to the margin from the rear of the palpebral lobe; on the librigena the genal spine is deflected a little more noticeably laterally and does not exhibit the same adaxial curve in its posterior part.

The pygidium figured by Ross (1951, pl. 19, figs 6, 11, 15) from the same locality as the cranidia named *H. robustus* are identical with the Tasmanian pygidia and may belong to this species rather than *Parahystricurus carinatus* as suggested by Ross in the explanation of his plate 19. Moreover the thorax assigned to *H. robustus* (Ross, 1951, pl. 14, fig. 27) is identical with the Tasmanian specimen (Pl. 3, fig. 12) in all observable features.

Remarks: This species is difficult to distinguish from *H. lewisi* with which it stands out from the rest of the genus by virtue of its palpebral structure. However the two may be separated by *H. robustus* having coarser tuberculate ornament overall, much shorter preglabellar field, exsagittal to converging course of facial sutures forward of palpebral lobes, and occasional tubercles on the pygidial pleural ribs. The resemblance of the pygidia of the two species is remarkable as the only distinguishing feature is the fine pustules on internal moulds and rare course pustules on the external surface of *H. robustus*.

Tanybregma gen. nov.

Etymology: From the Greek *tany* meaning long and *bregma* meaning front of the head; the reference is to the considerable preglabellar length.

Type species: *Tanybregma tasmaniensis* sp. nov.

Diagnosis: Cranidium subquadrate, of low convexity, with tuberculate ornament of two different sizes on glabella and interocular cheeks; glabella tapering forward, truncated anteriorly, with long 1p furrow at high angle to transverse line; preglabeller length more than 0.35 total cranidial length, with well developed caecal network, gently downsloping forward; anterior border short, upturned; palpebral lobe long, situated posteriorly, arcuate but narrow, limited by well impressed palpebral furrow; facial suture diverging forward from palpebral lobe to widest point near anterior of border furrow, transverse behind palpebral lobe. Librigena with extremely wide doublure reaching well forward of genal field and terminating there in a rounded rostral suture.

Remarks: This genus is based on cranidia and librigenae only but it is possible that the pygidium is so similar to that of the co-occurring *H. penchiensis* that it is not possible to separate them in the deformed state in which they are found. Cranidial features are reminiscent of *Hystricurus* but the longer preglabellar field, 1p furrow, row of denticles on the adaxial side of the genal spine and in particular the wide doublure and curved rostral suture distinguished *Tanybregma*. It has some similarity to a number of genera but none has the combination of *Tanybregma*; *Nyaya* Rozova, 1968 is shorter in front of the glabella, has longer less arcuate palpebral lobes and is smooth but it does have a pygidium that could easily be confused with that of *H. penchiensis*. Some species of *Hystricurus*, namely *H.* spp. A and E of Ross (1951, pl. 9, figs 31, 34, 37 and pl. 15, figs 10, 11, 13, 14) show a tendency towards preglabellar elongation so it is not unreasonable to suggest that *Tanybregma* may have arisen out of a form like *H. penchiensis* with the features cited above sufficient to warrant generic separation. *Hyperbolochilus* Ross, 1951 (type species *H. marginauctum* Ross, 1951) is superficially similar but its short palpebral lobes, glabellar shape and course of its rostral suture are distinctive at the generic level. *Hystricurus* (*Guizhouhystricurus*) Yin in Yin & Li, 1978 (type species *H.* (*G.*) *yinjiangensis* Yin & Li, 1978) has the long preglabellar field of *Tanybregma* but is clearly distinguished by its short convex anterior border and palpebral structure indicating placement in a separate hystricurid lineage.

Tanybregma tasmaniensis sp. nov.

Plate 3, figures 1-7; plate 8, figure 7

Etymology: This species name refers to its discovery in Tasmania.

Material: Holotype UTGD95983, paratypes UTGD96674, 96676, 122528 to 122531 and 122554 plus some 10 to 15 cranidia and librigenae in the collection of the Museum of Victoria, all from NMVPL1600.

Diagnosis: As for genus.

Description: Cephalon semicircular, of low convexity; cranidium a little longer than wide but generally subquadrate; glabella with gently curved sides converging forward, truncated anteriorly by transverse preglabellar furrow and rounded anterolateral corners, with well impressed 1p furrow extending from close to axial furrow at level of midlength of palpebral lobe in a straight line at high angle to transverse to finish close to occipital furrow near sagittal line; occipital furrow deep, steep sided, with flat bottom, with wide deeper apodemal pits laterally separated from axial furrow by narrow very shallow part of furrow; occipital ring of uniform length, without median node, convex in lateral profile; axial furrow well impressed but shallowing anteromedially and posteriorly; preglabellar field long, gently downsloping, with typical caecal network, approximately equal in length to the border plus border furrow; border furrow long, shallow; anterior border concave, flattening out near border, upturned, of uniform length throughout; eye ridge narrow and relatively long, consisting of two parallel trunks, separated from palpebral lobe by sharp extension of palpebral furrow; palpebral lobe with short very narrow exsagittal anterior section, remainder arcuate, almost semicircular, of uniform width, narrow, defined by well impressed palpebral furrow, more than half as long as glabella, situated posteriorly; palpebral furrow cutting off eye ridge from beneath eye socle on librigena; facial suture diverging forward from anterior of palpebral lobe to be widest at border furrow, cutting fairly directly across anterior border but then running along close to anterior margin for some distance before reaching margin, almost transverse behind palpebral lobe, extending well beyond abaxial extremity of palpebral lobe then curving posteriorly to reach margin at high angle; posterior cephalic limb short, wide, with well impressed posterior border furrow near anterior, with highly convex abaxially-elongating posterior border occupying most of its length.

Librigena smooth, with long genal spine; visual surface at high angle to genal field, of uniform width, with well rounded ends, apparently holochroal; eye socle low, simply a rim appearing like a piece of wire lain beneath the visual surface; genal field sloping gently out to border furrow, longer than wide; border furrow wide and shallow as on anterior of cranidium, continuing posteriorly down length of genal spine after merging of posterior and lateral border furrows just behind genal angle; border narrow, convex, sharply upturned, with subdued terrace lines laterally; genal spine quite long, with posterior border bearing set of 9 or 10 or more distinct denticles as it runs down adaxial side of genal spine; doublure wide, with well developed parallel continuous anastomosing terrace lines, developing into angular ridge running down centre of genal spine beneath border furrow, extending some distance forward of the genal field where it terminates against an adaxially convex rostral suture.

Family LEIOSTEGIIDAE Bradley, 1925

Chosenia Kobayashi, 1934

Type species (by original designation): *Chosenia laticephala* Kobayashi, 1934 from the

Early Ordovician *Clarkella* Zone at Saisho-ri, South Korea.

Diagnosis: Leiostegiid with weakly impressed glabellar furrows; glabella truncated anteriorly; anterior border shorter and more convex in front of glabella, longer and flatter laterally; strong caecal trunk issuing from anterolateral corner of glabella, crossing axial furrow but not continuing; eye ridges beginning much further back in axial furrow, oblique (c. 45°) to exsagittal line; palpebral lobes short, situated posteriorly. Pygidium transverse; anterior border furrow curving back strongly behind articulating facet and running to margin in front of marginal spine; with relatively wide border; pair of long marginal spines issuing from first, second or third pygidial segment; pleural furrows well impressed; interpleural furrows evident.

Other species: Apart from the type and *C. adamsensis* described here, only *C. divergens* Lu, 1975 from the *Acanthograptus-Tungtzuella* Zone (late Tremadoc) of the Fenhsiang Formation at Yanshuiping, Changyang, western Hupeh Province, China is assigned to this genus.

Remarks: The type species was poorly illustrated and does not provide sufficient morphology upon which to interpret a separate genus. The fragmentary holotype cranidium (Kobayashi, 1934, pl. 8, fig. 8) is particularly unsatisfactory. However, one paratype pygidium (Kobayashi, 1934, pl. 8, fig. 11) shows sufficient morphology to be confident that it is congeneric, if not conspecific, with *Chosenia divergens*. Pygidial characters of the genus may be discerned from Lu's (1975, pl. 2, figs 28-31; pl. 3, figs 1, 2) well illustrated pygidia. However, the only cranidium figured by him is also fragmentary and reveals only a few more features than the type species.

Assignment of *Chosenia adamsensis* sp. nov. is discussed under that species below but its inclusion allows a somewhat more complete understanding of the morphology and systematic position of *Chosenia*. The cranidium is almost identical with that found in some species of *Leiostegium* Raymond, 1913 (e.g. *L. ulrichi* Berg & Ross, 1959, pl. 21, figs 1, 6). There is undoubtedly a close relationship between the two genera but features of the pygidium other than the marginal spines (see discussion of species below) are critical in this group of trilobites. Taking the pygidia into consideration the well impressed pleural furrows are probably most distinctive; also important is the course of the border furrow anterolaterally. These features along with the larger anterior fixigenal area on the cranidium, laterally longer anterior cranidial border and glabellar shape distinguish *Chosenia* from *Evansaspis* Kobayashi, 1955 whose type species is *E. glabrum* Kobayashi, 1955 from the Lower Ordovician McKay Group in British Columbia. *Evansaspis* resembles *Chosenia adamsensis* specifically only in the position of its pygidial marginal spines as discussed below. A case for considering *Chosenia* a subgenenus of *Leiostegium* could be made on the basis of the similarities between *C. adamsensis* and *Evansaspis* but we consider that the pygidial structure of *Chosenia* indicates a separate lineage worthy of generic separation but included in the same family. How each of these groups is related to *Leiostegium* and its origins is not yet apparent but if its origin is from the Kaolishaniidae as seems most likely then one of these lineages may have produced *Leiostegium* by loss, possibly into the thorax, of the macropleural segment. The possibility should be investigated that the *Chosenia* line may have emerged from the Mansuyiinae with its ornamented pygidial spines, well impressed pleural furrows, subtle pygidial border, posterior eyes and large faint glabellar furrows and that *Evansaspis* may have emerged from the Kaolishaniidae with more prominent pygidial borders, less distinct pleural furrows, and better impressed lateral glabellar furrows. If this proves to be so then the Leiostegiidae would be polyphyletic.

Leiostegium (*Leiostegium*) *floodi* Shergold, 1975 from the early Tremadoc *Oneotodus bicuspatus* with *Drepanodus simplex* zone of the lower Ninmaroo Formation at Black Mountain, western Queensland may well be a species of *Chosenia* also but it is not possible to distinguish the genera on cranidia alone.

Chosenia adamsensis sp. nov.

Plate 4, figures 8-11; plate 5, figures 1-10

Etymology: Named for Adam's Falls near the type locality of this species.

Material: Holotype UTGD122535, and paratypes UTGD95175, 95927, 95942, 95945, 96023, 96025, 96027, 96029, 96602, 96611, 96637, 96642, 96646.

Diagnosis: Member of *Chosenia* with well impressed palpebral furrows, tuberculate ornament, pair of long curving pygidial marginal spines from second or third segment of pygidium.

Description: Moderately large convex species (cephala up to 2.5 cm long); surface ornament of fine sparsely scattered tubercles over whole exoskeleton. Cranidium subquadrate, with glabella lower than cheeks; glabella with straight sides, tapering slightly forward, with anterior truncated to broadly curved, highly convex in anterior profile; lateral glabellar furrows in 4 pairs not evident on all specimens, shallow, indistinct; 1p furrow directed obliquely back from the axial furrow but then curving to be transverse and shallower but continuous sagittally in smaller specimens, discontinuous in larger specimens; 1p and 2p furrows joining in axial furrow in smaller individuals, appearing as a Y-shaped furrow in larger individuals; 2p, 3p and 4p approximately parallel to 1p but not curved adaxially and not continuous over axis, becoming progressively shallower and shorter forward, 4p in front of eye ridge, and not reaching axial furrow, 3p meeting axial furrow just behind eye ridge; tuberculate ornament on lateral glabellar lobes but not furrows; occipital furrow well impressed, long, with steeper wall in front than behind, transverse medially but with narrow posteriorly sloping lateral sections accommodating apodemes; occipital ring of uniform length, flattened on top in lateral profile, with only extremely vague anteromedian node; axial furrow deep and wide, of uniform width, with a pair of strong fossulae at anterior border furrow and another pair of prominent pits just behind the strong ridge (caecum) extending out of the anterolateral corner of the glabella across the axial furrow and fading into the cheek; crossed by low ridge from anteriorly-curving occipital ring into posterolateral corners of cheeks; preglabellar field absent; anterior border furrow deep and long in front of glabella, shallower and shorter in front of cheeks, with almost vertical wall up onto border and steep but gentler slope posteriorly; anterior border highly convex, flattened and sloping forward in lateral profile, longer laterally (before tapering along facial suture), excavated posteromedially by the border furrow thrust forward in front of the elongate glabella, with continuous terrace lines near and parallel to the margin; eye ridge prominent, composed of two parallel caeca, at approximately 45° to transverse, meeting but not crossing axial furrow well back from (nearly 0.3 of glabellar length) glabellar anterior; palpebral lobe strongly arcuate, short, situated opposite posterior third of glabella, strongly elevated and then flattened on top medially; palpebral furrow well impressed shallowing over midlength, parallel to lobe, running across eye ridge at junction with palpebral lobe, turning down around posterior of the lobe; facial sutures diverging slightly forward from anterior of palpebral lobes to border furrow, cutting diagonally at low angle to transverse across anterior border, highly arcuate around palpebral lobe then dropping down almost vertically and slightly posteriorly to the posterior margin in the same exsagittal line as the outermost point on the palpebral lobe; posterior border furrow well impressed, of uniform length throughout, transverse; posterior border short, convex, of uniform length throughout, strongly downturned as part of cephalic posterolateral limb beyond articulating point directly behind posterior of palpebral lobe.

Librigena with broad, gently convex genal field; eye socle high, vertical, marked off by a wide poorly-impressed furrow; border composed of two distinct parts separated by a shallow furrow, rather flat; outer part narrow, with continuous comarginal terrace lines continuing across facial suture onto cranidium, terrace lines running over margin at end of outer part of border near midlength of eye, tapering to nothing before level of posterior border furrow; inner part of border broader than outer part, beginning anteriorly with a smooth area just behind the facial suture and continuing posteriorly into a long strong genal spine, with less-regular sometimes anastamosing longitudinal terrace lines that continue down the genal spine; border wide in area of overlap of two parts but rather narrow anteriorly and with strong reduction in width posteriorly at the spine base; posterior border short and highly convex; border furrow short and deep posteriorly, with small re-entrant in base of genal spine (elongate into a furrow down the spine in one specimen) where posterior border furrow comes to genal spine, shallow laterally, continuing in curve onto cranidium; rostral suture running adaxially towards posterior.

Thorax of 10 segments, of uniform width; axis with deep axial furrow having narrow posteriorly-sloping parts and apodemes as in occipital furrow; articulating half-ring short, smooth, almost as high as ring; ring of uniform length running back from axial furrow for short distance then transverse medially; axial furrow weakly impressed; pleurae flat to articulating line then gently down turned beyond; well impressed pleural furrows occupying most of length of pleura as far as articulating line, then tapering to nothing against the posterior of the facet in a short distance; anterior and posterior pleural ribs of equal length; pleural extremities with free spines (as shown by extent of doublure on internal mould), with large facets over full width and occupying full length for distal half, half as wide as fixed pleurae; prominent processes at lateral articulating points.

Pygidium subtriangular to semicircular, of moderate convexity; axis of seven (or eight in larger specimens) rings and short terminus, tapering to rounded posterior, reaching close but not quite to the inner edge of the doublure, transaxial furrows transverse, progressively shallower posteriorly; pleural areas convex, with well impressed pleural furrows becoming less distinct and narrower posteriorly and not extending onto the border region; anterior border furrow (i.e. first pleural furrow) very well impressed especially laterally behind the long narrow sloping and indistinct facet, curving strongly back in this area and running to the margin in front of spine; interpleural furrows evident on first three pleural ribs; border furrow shallow, indistinct, beginning behind marginal spines; border relatively narrow, of uniform width, with some terrace lines near the margin, convex near the border furrow then flatter and down sloping distally; pair of marginal spines issuing from second or in some specimens third segment of pygidium, long, curving adaxially, with fine longitudinal discontinuous and rarely anastamosing terrace lines; doublure convex ventrally, with well developed continuous and anastamosing terrace lines, widest anteriorly, narrowest sagittally, swinging around anterolateral corner to finish at lateral articulating process.

Remarks: This species is assigned to *Chosenia* on the basis of the cranidial similarities with Lu's (1975, pl. 2, fig. 27) *C. divergens* and on pygidial features behind the segment carrying the macropleural marginal spine. We suggest that the more posterior position of the spine in *C. adamsensis* is due to the fact that one or two thoracic segments remained ankylosed in the pygidum (i.e. not released into the thorax) whereas in *C. divergens* these segments have been released forward so the marginal spines appear on the first pygidial segment. This is reinforced by the pleural furrows in front of the spine running to the margin in *C. adamsensis*. The variation between second and third pygidial segment being macropleural in this species indicates that it is not an important feature and that the first segment being macropleural in *C. divergens* is a relatively minor distinction phylogenetically. We consider it a specific taxobase and further the pleural furrows and posteriorly turned anterior border furrow are considered generic taxobases. For this reason we consider *Perischodory* Raymond, 1937 and *Evansaspis* Kobayashi, 1955 belong to a separate lineage within which they may be congeneric, despite Berg & Ross (1959, p. 114), by analogy with *C. divergens* and *C. adamsensis* in their lineage. With the origin of pygidial marginal spines as incorporated macropleural segments in mind, better understanding of species relationships in these groups may be achieved.

The considerable variation among available specimens of *C. adamsensis* is partly due to intraspecific variation and partly due to distortion after burial. The latter is easily recognised in the transverse or elongate pygidial shape but the former is more difficult to discern. Position of the pygidial marginal spines is variable between the second and third pygidial segments and the structure of the 1p and 2p glabellar furrows is also variable from being two discrete furrows to being a single Y-shaped furrow but this latter feature may change during growth. The identity of 1p and 2p combined into one rather than a single Y-shaped 1p is clear.

Family ASAPHIDAE Burmeister, 1843

Asaphellus Callaway, 1877

Type species (by original designation): *Asaphus homfrayi* Salter, 1866.

Asaphellus sp. cf. **A. trinodosus** Chang, 1949

Plate 4, figure 12; plate 6, figures 1-12

Material: UTGD95877, 95895, 95917, 96002, 96005, 96032, 98111, 98117, 98137 and 122536 to 122539 all from NMVPL1602.

Description: Cranidium of extremely low convexity, without obvious furrows; glabella barely outlined by an extremely subtle change of slope onto the cheeks, broad at base (approx. 0.5 cranidial width) tapering forward, about 0.83 of cranidial length, with low inconspicuous median node 0.16 of crandial length from posterior margin; occipital furrow barely evident, very near posterior margin; cheeks narrow, with narrowest point at anterior of palpebral lobes; palpebral lobes flat, situated with anterior of lobe at midlength of cranidium, comparatively long, broadly arcuate; preglabellar area flat; posterior limb downsloping abaxially, with long extremely shallow posterior border furrow parallel to and close to the posterior margin, with blunt lateral margin at facial suture; facial suture isotelliform, hardly diverging forward of the palpebral lobes, with widest point forward of palpebral lobes well behind glabellar anterior, curving smoothly forward to the ogive in the midline, running straight back from rear of palpebral lobe for short distance then curving smoothly abaxially but never transverse (always oblique back) then curving smoothly into an exsagittal line to meet posterior margin at right angle; posterior margin transverse. Librigena long and relatively narrow, of low convexity like the cranidium; eye socle vertical, low, defined below by the change of slope onto the flat genal field but also with a wide shallow furrow around its base; border furrow broad and very shallow, fading out anteriorly, swinging adaxially into the posterior border furrow well before base of genal spine; border narrow, weakly convex, of uniform width, with some weak longitudinal terrace lines near posterior; genal spine short, tapering strongly, with fine longitudinal terrace lines extending along it, continuing the line of the lateral margin of the cheek to its tip. Hypostome incompletely known from only one specimen (Pl. 6, fig. 10). Median body broadest at posterior of the anterior wings, subcircular, of low convexity, with fine ornament of concentric terrace lines about an anteromedian point; posterior lobe only 0.2 of length of median body; median furrow as two oblique lateral clefts, connected to lateral border furrow by very much shallower more exsagittal furrow; anterior border flat, with gently arched anterior margin; posterior border short, convex, isolated by longer well impressed border furrow, with median elongation.

Pygidium of low convexity, with poorly impressed furrows, semicircular or just slightly more transverse in dorsal view; axis broadly convex in anterior profile, flat in lateral profile, of nine rings plus posteriorly rounded terminus, rings becoming shorter and less well defined posteriorly, tapering strongly along anterior three or four rings then tapering only slightly if at all, apparently widening again at terminus in some specimens; transaxial furrows transverse, with slightly deeper apodemal pits laterally, extending to inner edge of doublure; pleural areas with extremely shallow pleural and interpleural furrows visible on a few specimens; axial furrow not impressed, marked by small change of slope from axis to pleural area; anterior border furrow well impressed behind lateral articulating process, fading out about halfway along width of articulating facet, straight, sloping a little to posterior abaxially; facet steep, wide, flat, longest near middle of doublure; border furrow very wide and shallow, parallel to border, finishing against facet; doubleure almost as wide as anterior of axis, relatively wide, with distinct, parallel, continuous terrace lines.

Remarks: This material is assigned to *Asaphellus* rather than *Megistaspis* on the basis of its long glabella, almost effaced axial furrow, larger eyes, and different hypostomes. Within *Asaphellus* it is related to a group of Tremadoc species from Argentina (*A. catamarcensis* Kobayashi, 1935 (see Harrington & Leanza, 1957, p. 147), *A. jujuanus* Harrington & Leanza, 1957, and *A. riojanus* Harrington & Leanza, 1957), from Korea (*A. tomkolensis* Kobayashi, 1934) and from China (*A. changi* Sheng, 1958. *A. inflatus* Lu, 1959, *A. trinodosus* Chang, 1949, *A. praetrinodosus* Lu, 1976 among others). Of this array of virtually indistinguishable species the Tasmanian material seems most closely comparable with *A. trinodosus* in so far as subtle swellings are barely apparent just behind the palpebral lobes in a similar position to the more obvious ones of the Chinese species. The course of the facial suture just behind the palpebral lobe seems distinctive of the Tasmanian material but this hardly seems sufficient to erect a species especially within such a difficult taxonomic complex of essentially contemporary species.

Megistaspis (Ekeraspis) Tjernvik, 1956

Type species (by original designation): *Plesiomegalaspis (Ekeraspis) armata* Tjernvik, 1956.

Megistaspis (Ekeraspis) euclides (Walcott, 1925)

Plate 7, figures 1-15

1925 *Xenostegium euclides* Walcott, p. 126, pl. 24, figs 13, 14.
1925 *Xenostegium albertensis* Walcott, p. 125, pl. 24, figs 10, 11.
1955 *Kayseraspis* (?) *euclides* Walcott; Kobayashi, p. 442, pl. 4, figs 4-12; pl. 5, figs 8-10.

Syntypes: USNM70364 and 70365 (figured by Walcott, 1925, pl. 24, figs 13, 14) from Mons Formation, Sawback Range, British Columbia.

Material available: Some 40 or 50 fragmentary and distorted specimens are available from NMVPL1601 including UTGD95994, 98095, 98102 and 122540 to 122551.

Diagnosis: Ekeraspid with very low convexity, axial furrow extremely poorly impressed; glabella with rounded anterior, waisted at level of palpebral lobes; palpebral lobes small, wide, semicircular, situated behind midlength of cranidium; facial suture diverging forward of palpebral lobes, concave forward of palpebral lobe to widest point, sigmoidal behind palpebral lobe, meeting posterior margin at large angle, as it runs posteroaxially. Free cheek with long genal spine. Hypostome highly convex, with complete rounded posterior margin, with widest point near midlength. Pygidium subtriangular, with long terminal spine decreasing in length with growth; pleural and interpleural furrows weakly impressed on anterior segments.

Description: This description only refers to additions or modifications to that of Kobayashi (1955, p. 442). Occipital furrow evident only on internal moulds, extremely shallow, relatively very close to posterior margin. Palpebral lobe comparatively short, close to glabella, wide, semicircular, flat but slightly elevated, situated near midlength of glabella and behind midlength of cranidium. Facial suture diverging slightly forward from palpebral lobes, with widest point forward of glabellar anterior, then anteriorly concave to anteromedian point, curving laterally a short distance behind the palpebral lobes, then almost transverse but always slightly oblique, then curving posteriorly to be exsagittal and curving back towards the axis near posterior margin to give rounded margin to extremity of posterior cephalic limb.

Librigena with broad flat genal field, without border furrow; eye socle low, vertical, prominent; genal spine long, almost circular in section but with strong ridge running down ventral side, with distal part in exsagittal line; doublure, wide, elongate anteriorly, in transverse section slightly upturned adaxially to remain flush against dorsal exoskeleton, with strong parallel terrace lines from base of genal spine to median suture of isotelliform suture pattern, with terrace lines diverging and increasing in number by intercalation anteriorly. Hypostome convex, subquadrate, covered with terrace lines more or less concentric about an anteromedian point on the high part of the median body; median body longer than wide, rounded anteriorly, with well-impressed median furrow dividing it into large anterior lobe and very short low posterior lobe; median furrow at high angle to transverse line laterally, not continuous across axis; anterior wings short almost vertical, well ornamented; shoulder wide, fairly flat, tapering strongly both forward and back; border furrow well impressed laterally, not connected directly to anterior border furrow, running most distinctly into median furrow but also connected by shallow furrow with posterior border furrow; posterior margin complete, short medially, covered with terrace lines; anterior border furrow cutting across anterior wing to margin in front of lateral notch. Thorax of six or more segments (complete specimen not available); pleural furrow beginning at anterior in axial furrow, in midlength for most of its course, fading out about the midwidth of the free pleura, deepest crossing articulating line; thorax typically asaphid.

Pygidium triangular, with long posterior spine becoming relatively shorter with growth; axis long, slightly tapering, almost parallel sided, with seven barely discernible rings and a long axis consisting presumably of several more rings that are not defined; pleural fields with poorly impressed pleural furrows anteriorly, with even fainter interpleural furrows on the ribs, with well impressed anterior border furrow identical with the thoracic pleural furrows; articulating facet wide, steeply inclined; border furrow not impressed; doublure of moderate width, with well developed parallel and anastamosing terrace lines, close beneath dorsal exoskeleton; posterior spine circular in section, connected to posterior of axis by low ridge across border area in some specimens.

Remarks: This species was erected by Walcott for pygidia and a hypostome and the interpretation of the cephalon depends upon Kobayashi's (1955, pl. 4, figs 5, 10; pl. 5, fig. 8) assignment of cranidia. The Tasmanian material, where only one asaphid species occurs at the horizon in question, confirms his association and all that remains is for this type of cephalon to be discovered at the type locality. However, morphology of the species is now well established. Kobayashi (1955) recognised the alliance of the species with *Megistaspis* but assigned it to *Kayseraspis* Harrington, 1938 without commenting on the reasons. The parallel-sided glabella, shorter glabella, more posterior eyes, triangular pygidium and longer stouter posterior spine distinguish this species from *Kayseraspis*.

Family DIKELOKEPHALINIDAE Kobayashi, 1936

This family was placed with the asaphids by Harrington *et al.* (1959) probably by association with the Taihungshaniidae which were correctly placed in the Asaphoidea. The Dikelokephalinidae have a glabella usually about 0.6-0.7 of cranidial length while asaphids have a much longer glabella. In the pygidium the critical taxobase is the attitude of pleural furrows—relatively transverse in asaphids but strongly curved backwards in the dikelokephalinids. The Taihungshaniidae and Dikelokephalinidae both possess a pair of pygidial marginal spines but these are homeomorphous structures shared with a great many other trilobites as well. It appears far more likely that the Dikelokephalinidae evolved from the Dikelocephalidae as suggested by Kobayashi (1936, 1960). The brief remark by Fortey and Peel (1983, p. 54) that the Dikelokephalinidae are probably related to the Ceratopygacea would need some amplification if it is to be taken seriously especially in light of the prominent occipital node (Pl. 8, fig. 7); position of the node, forward of the occipital furrow rather than on the occipital ring, was used to relate *Macropyge* to the Ceratopygacea (Owens *et al.*, 1982) so some discussion of the importance of this feature would seem appropriate. The Hungaiidae Raymond, 1924 may have a similar origin and these two derived families could be synonymous.

Dikelokephalina Brøgger, 1896

Type species (designated Vogdes, 1925): *Cen-*

tropleura ? *dicraeura* Angelin, 1854 from the Tremadocian *Ceratopyge* Limestone of Gamlebyen, Oslo, Norway.

Diagnosis: Large isopygous trilobites of low convexity. Glabella convex, anteriorly rounded, with three pairs of lateral glabellar furrows; posterior pair being forked adaxially, none reaching the axial furrow. Frontal area 0.3 to 0.5 length of cranidium, together with anterior parts of fixed cheeks forming an extensive flat anterior area. Palpebral lobes of medium to large size, at or behind midlength of glabella. Fixed cheeks approximately half glabellar width at level of midlength of palpebral lobe. Posterior cephalic limb very wide and short. Pygidium with long, narrow axis of at least seven or eight rings. Pleural furrow curved posteriorly, becoming almost exsagittal posteriorly. Border with relatively narrow semielliptical excavation so that the margin on either side of it is extended into a strong spine.

Remarks: Affinities of the group of genera to which this genus belong were discussed by Kobayashi (1936, 1960) and by Henningsmoen (1959). As mentioned above the several groups of genera having spinose pygidia, with which affinities for the Dikelokephalinidae have been inferred, are homeomorphous forms and the true affinities of *Dikelokephalina* will only be arrived at by careful plotting of phylogenies at the species level. The rarity of *Dikelokephalina* in all its known occurrences suggests that plotting of such phylogenies will not be possible for some time but the Dikelocephalidae seems the family most likely to contain the ancestral stock.

The posterior pygidial spines are the most distinctive feature of the genus and their absence from any described species or the inability to observe the morphology of that part of the exoskeleton (e.g. for *D. parva* Kobayashi, 1960 and *D. conica* Kobayashi, 1960) must throw doubt on assignment to the genus. Another genus with similar posterior pygidial border morphology is *Asaphelina* Bergeron 1889, the type species of which was originally included in *Dikelokephalina* by Brøgger (1896). However, that genus is referred to the *Taihungshaniidae* (Courtessole *et al.*, 1981), which family is distinguished by the asaphoid glabella and pygidial pleural furrows being transverse or almost so; in *Taihungshania* itself, the pleural furrows are transverse in juvenile individuals so indicating its asaphoid affinities—their posterior sweep in adults is a secondary development. The posterior spines may reasonably be considered homeomorphous.

Within the family the position of the posterior spines distinguishes *Dikelokephalina* from all other genera.

Age and Distribution: Late Tremadoc; Norway, Sweden, Wales, South Korea, Tasmania.

Dikelokephalina asiatica Kobayashi, 1934

Plate 8, figures 1-8

1934 *Dikelokephalina asiatica* Kobayashi, p. 563, pl. 6, figs 1-3.
1934 *Dikelokephalina kanaegata* Kobayashi, p. 564, pl. 6, figs 4, 5.
1980 *Dikelokephalina* sp. nov.; Stait & Laurie, p. 205, fig. 3, appendix 1.

Holotype (by original designation): Cranidium figured by Kobayashi (1934, pl. 6, fig. 2) from the *Clarkella* Zone (Late Tremadoc) at Saishori, South Korea.

Material: Apart from the figured material of Kobayashi the specimens assigned to this species are all from Faunal Assemblage No. 3 of Stait and Laurie on the Gordon Road Section and are numbered UTGD95978-95982, 96689, 122552, 122553.

Description of Tasmanian material: Cranidium of low convexity except for broadly convex glabella; glabella tapering gently forward to rounded anterior, with three pairs of lateral glabellar furrows adjacent to but separated from the axial furrow, furrow 1p bifurcate adaxially, elongate transversely, running very slightly to the posterior adaxially, not very deep, and with very gentle sides, its anterior branch shorter and less elongate and running forward adaxially; furrows 2p and 3p rounded pits very close to the axial furrow; 3p being just behind junction of eye ridge and axial furrow; occipital furrow well impressed, with deeper short wide apodemal pits reaching the axial furrow, medially shallowing and curving slightly forward; occipital ring of approximately uniform length, with prominent median tubercle near midlength, with transverse posterior margin; extremely weak development of alae on one specimen (Pl. 8, fig. 7); preglabellar length 0.3 of cephalic length; anterior border furrow very vaguely apparent just forward of the midlength of the preglabellar length; all area in front of glabella flat; fixed cheeks narrow and flat; palpebral lobes prominent, with semicircular outer margin, with anterior end much closer to glabella than posterior end, sloping up abaxially; palpebral furrow not well impressed but nevertheless distinct, parallel to outer margin of lobe medially but swinging around both ends of lobe to facial suture; facial suture running forward from palpebral lobe in a broad curve but the palpebral lobe extends laterally beyond widest extent of anterior part of facial suture; posteriorly, facial suture running transversely out for 0.75 of basal glabellar width before curving sharply posteriorly to the margin; posterior cephalic limb wide and short, with uniform posterior border furrow running across its anterior part to the facial suture before the suture curves back; posterior border of uniform length, convex in lateral profile and downturned abaxially, with prominent gently curved terrace lines running mainly in the exsagittal direction; posterior margin transverse adaxially but curving slightly back abaxially.

Pygidium of low convexity, with axis standing only slightly above pleurae in anterior profile; length to width ratio unknown, articulating half-ring very short; axis of five well defined rings and a long poorly divided terminus that includes at least four more rings and the terminal piece which is at the inner edge of the doublure, quite wide anteriorly, tapering markedly in anterior half; rings of uniform length; wide, sharp, poorly defined, apodemal pits laterally in transaxial furrows visible only on internal moulds; axial furrow evident only as a change of slope and change of direction of furrows; pleural areas crossed by five pairs of well impressed pleural furrows becoming more exsagittal in direction, closer together and shallower towards the posterior; pleural furrows extend almost to the margin, shallowing markedly to nothing abaxial to the inner margin of the doublure; border not clearly defined but a fairly wide flat marginal area that tapers forward is weakly defined by change of slope from pleural areas and ends of pleural furrows; posteriorly is a long but narrow excavation in the border with, as a consequence, a pair of sharp marginal spines beside it; border raised up to the margin of this excavation; on the border and possibly over the whole pleural area are very faint, irregular transverse terrace lines most numerous at the margin decreasing in number adaxially; doublure wide, very close beneath dorsal exoskeleton throughout being upturned near its mid-width to the pleural areas and being upturned with the dorsal exoskeleton around the posterior excavation, with strong terrace lines parallel to the margin over the entire width; inner edge of doublure with marked excavation posteromedial around the rear of the axis.

Remarks: The material illustrated by Kobayashi (1934) is relatively incomplete making comparison with new collections difficult. However, introduction of a new specific name when all observable features between the Korean and Tasmanian specimens are so clearly identical would be irresponsible. Although the margin of the two figured Korean cranidia (Kobayashi 1934, pl. 6, figs 2, 3) are very incomplete his dashed suggestions for their positions seem quite reasonable. However, his dashed outline for the holotype pygidium of *D. kanaegata* (Kobayashi, 1934, pl. 6, fig. 5) appears to have a right angle bend at the left anterolateral corner that is unlikely to be correct. The pygidium assigned to *D. asiatica* by (Kobayashi, 1934, pl. 6, figs 2, 3) are very incomplete his dashed suggestions for their posi-have narrow raised pleural ribs separated by wide interspaces. If the external surface is correctly described then this specimen should be separated at least at the generic level from the associated cranidia. It is far more likely to be an internal mould of a juvenile specimen and its external morphology is likely to be more in line with the two pygidia assigned to *D. kanaegata*. As the two species occur together at Makkol, South Korea and after considering the states of preservation but without actually seeing the material we consider the two species of Kobayashi (1934) to be synonymous. Only the structure and position of the palpebral lobe may appear to distinguish the Tasmanian species but the posterior course of the facial suture was interpreted by Kobayashi and may be in error. The holotype and one Tasmanian specimen show incipient alar development on one side only. One feature which does appear distinctive is the border region sloping down to the margin of the posterior excavation in Kobayashi's material (1934, pl. 6, fig. 4) whereas it is upturned in the Tasmanian specimens. This is considered to be intraspecific variation if it is real but the exoskeleton of this species is quite flexible and the difference may be due to preservational history. Further collection and study of material from the type locality is urgently needed to clarify this species. *Dikelokephalina asiatica* may be distinguished from the type species by its broader subtriangular rather than subquadrate pygidium, the closer position of the posterior spines, straight pleural furrows, very weak alae, anteriorly placed posterior border furrow on cranidium and less divergent more rounded facial suture in front of the palpebral lobe.

Asaphopsoides Hupe, 1955

Type species (by original designation): *Dicellocephalus* ? *villebruni* Bergeron, 1895 from the earliest Arenig of Montagne Noire, southern France.

Diagnosis: Dikelokephalinid with preglabellar length 0.3 or more of cephalic length; strong, wide, diagonally directed, linear apodemes in preglabellar furrow. Pygidial axis may contain 6 to 16 rings; pleural furrows swept backwards with posterior pleural furrows at very low angle to sagittal line; pygidial border moderately to very wide, without border furrow but with at least a pair of variably sized, prominent, flat spines placed relatively widely apart at posterolateral corners.

Species content of genus: *A. villebruni* type species. See Thoral, 1935 and Courtessole *et al.*, 1981.

Dikelocephalus florentinensis Etheridge, 1905 (Early Arenig; Tasmania) see below.
[= *Asaphopsis juneensis* Kobayashi, 1940a and *A. (?) gracicostatus* Kobayashi, 1940]
Asaphopsis nakamurai Kobayashi, 1936 (Early Ordovician; Doten, South Korea).
Asaphus elegantulus Gortani, 1934 (Early Ordovician; Chisil Pass, Karakorum).
Ogygites (?) annamensis Mansuy, 1920 (Early Arenig; Dong-san, North Vietnam).
Taihungshania welleri Sheng, 1934 and *Taihungshania welleri* var. *brevica* Sheng, 1934 (Tremadoc; Chekiang, China).
Asaphopsis granulatus Hsu, 1948, *A. planispiniger* Hsu, 1948, *A. angustigenatus* Hsu, 1948, *A. immanis* Hsu, 1948, *Temnoura grandispinifer* Hsu, 1948, and *Temnoura alata* Hsu, 1948 all from the Late Tremadoc or Early Arenig of western Hupeh, China.
Asaphopsis semicircularis Lu, 1975, *A. angulatus* Lu, 1975, *A. (?) abnormis* Lu, 1975, and *A. yaokoutzeensis* Lu, 1975, all from the Tremadoc or earliest Arenig of western Hupeh or southern Sichuan.
Asaphopsis wuchuanensis Yin in Yin & Li, 1978 (Tremadoc; Guizhou, China)
Asaphopsis yinjiangensis Yin in Yin & Li, 1978 (Tremadoc; Guizhou, China)
Asaphopsis sanchaqiensis Lu in Zhou *et al.*, 1978 (Tremadoc; southern China)
Asaphopsis latilimbatus Lu in Lu *et al.*, 1976 (Tremadoc; southern China)
Asaphopsis hanyuanensis Li, 1978 (Tremadoc; Sichuan, China)
Asaphopsis yanjinensis Li, 1978 (Tremadoc; Sichuan, China)
Asaphopsis ovoideus Xia, 1978 (Tremadoc; Hupeh, China)
Asaphopsis budabnensis Balashova, 1966 (Early Ordovician; Russian Platform)

Discussion: *Asaphopsoides* was erected to separate *Dicellocephalus ? villebruni* from *Asaphopsis* Mansuy, 1920 where it had previously been placed (Kobayashi, 1936, 1940). In doing so Hupe (1955) quoted features of the cranidium as generic taxobases. He, therefore, did not have the type species of *Asaphopsis* in mind as *A. jacobi* is known only from fragmentary pygidia and thoracic segments (Mansuy, 1920, pl. 1, fig. 7a-g). Although the concept of *Asaphopsis* has for almost 40 years rested upon Kobayashi's species *A. nakamurai* it is essential that Mansuy's (1920) type species be reappraised for a stricter generic basis. Of the pygidia figured by Mansuy only one (1920, pl. 1, fig. 7a) clearly shows the marginal spine and should be considered the lectotype. Both this and the other interpretable specimen (Mansuy, 1920, pl. 1, fig. 7b) have their pleural furrows running transversely near the anterior and at only a small angle (less than 20°) to the transverse line posteriorly. This feature alone suggests that the type is not congeneric with any other species so far referred to *Asaphopsis*. This type of pleural structure is much more reminiscent of asaphoid trilobites (e.g. *Asaphellina* of the Taihungshaniidae). The marginal spines of the Taihungshaniidae and Dikelokephalinidae probably developed homeomorphously. The distinction is most evident in glabellar features of the cranidium but even in the pygidium, the Taihungshaniidae have much more transverse pleural furrows in adult *Asaphellina* Bergeron, 1889 (see Courtessole *et al.*, 1981, pl. 7, figs 1, 3, 6) and in juvenile *Taihungshania* Sun, 1931 (see Courtessole *et al.*, 1981, pl. 5, figs 1-6, 8, 9). Taking these data into account *Asaphopsis* should be restricted to *A. jacobi* and probably *A. reedi* which may be synonymous with the type species and that genus should be removed to a tentative placement in the Taihungshaniidae pending collection of cephala of the type species.

The glabellar features of *Asaphopsoides villebruni* are illustrated by Thoral (1935, pl. 23, figs 5, 6) and Courtessole *et al.* (1981, pl. 4, fig. 5); the latter authors point out that they have been incorrectly illustrated in general textbooks. Certainly the illustration in the *Treatise* (Harrington *et al.*, 1959, fig. 268-6a) is highly inaccurate. However, the illustration of Courtessole *et al.* (1981) is not identical with the figures offered by Thoral (1935, pl. 23, figs 5, 6) and it may very well be that the bulge in the side of the glabella adjacent to the prominent pit in the glabella (presumably furrow 2^e of Courtessole *et al.* 1981, p. 21) is an artefact of compression in the sediment. There is indication from many of the illustrated specimens of this genus (e.g. Lu, 1975, pls 26, 27) that the exoskeleton was very thin and had a certain amount of flexibility so generic taxobases should not be cited as such detailed features. Variations in the shape, size and position of lateral glabellar furrows should be used at present only as species taxobases in this trilobite family. As significant features listed in the diagnosis are remarkably uniform, where observed, through the species listed above, the many species previously referred to *Asaphopsis* should now be referred to *Asaphopsoides*. The long preglabellar part of the cephalon, marked linear apodemes in preglabellar furrow, posteriorly swung pygidial pleural furrows, and fairly widely separated marginal spines appear to be the most significant generic taxobases. The single pygidium upon which is based *Dainellicauda* Kobayashi, 1960 is also referred to *Asaphopsoides* as none of the features mentioned as diagnostic by Kobayashi (1936, p. 177; 1960, p. 253) are valid. His indication that the marginal spine arises from the first pygidial segment is not substantiated and the position of the abaxial end of the fourth pleural furrow, aiming at the margin just behind the base of the spine, is identical with that in several Chinese species of *Asaphopsoides* as well as *A. florentinensis*. *Dainellicauda* is a junior subjective synonym of *Asaphopsoides*.

Distribution and age: Late Tremadoc to Arenig of China; Early Arenig of France and Tasmania; Early Ordovican of Russia, South Korea, northern Vietnam and Pakistan.

Asaphopsoides florentinensis (Etheridge, 1905)

Plate 2, figure 15; plate 9, figures 1-11; plate 10, figures 1-10

1905 *Dikelocephalus florentinensis* Etheridge, p. 24, pl. 10, fig. 4.
1914 *Dikelokephalina florentinensis* (Etheridge); Walcott, p. 350.
1936 *Taihungshania florentinensis* (Etheridge); Kobayashi, p. 179, pl. 20, fig. 16 (not fig. 15).
1936 *Asaphopsis florentinensis* (Etheridge); Kobayashi, p. 177, pl. 21, fig. 5.
1940 *Asaphopsis juneensis* Kobayashi, p. 64, pl. 11, figs 6-9.
1940 *Asaphopsis (?) gracicostatus* Kobayashi, p. 65, pl. 11, fig. 10.
1974 *"Asaphopsis" juneensis* Kobayashi; Corbett & Banks, pl. 1, figs 14, 17, 18, 22, 23, 24; pl. 2, fig. 9.
1980 *Asaphopsis juneensis* Kobayashi; Stait & Laurie, p. 207.
1980 *Asaphopsis* sp. nov. Stait & Laurie, p. 207.

Holotype (by monotypy): AMF9282 a damaged and distorted pygidium from the Florentine Valley, southwestern Tasmania at a site near 'The Gap' (*fide* Corbett & Banks, 1974, p. 219).

Other material: More than fifty dissociated exoskeletal parts from 'The Gap' and from the Gordon Road Section. *Asaphopsis* sp. nov. and *A. juneensis* of Stait and Laurie (1980, fig. 3) and *A. juneensis* of Corbett and Banks (1974) were available (including UTGD80995, 80999, 81001, 81019, 81086, 96022, 96036, 96038, 96650, 96652, 98053, 98060, 98075, 122525, 122555-122561).

Diagnosis: Member of *Asaphopsoides* with parallel-sided to anteriorly tapering glabella ternal mould with its convexity reversed during or after burial; such specimens are known in the available collection. Therefore the short pleural ribs are actually moulds of the pleural furrows and this is clear on the proximal doublure. Although one of his pygidia shows at least 9 pygidial axial rings this is a notoriously variable feature likely to be greater on internal moulds. It seems most likely that, given the ubiquitous tectonic deformation of specimens from the Florentine Valley Formation, *Asaphopsoides* is represented in that formation by a single species. Certainly material available to us does not indicate otherwise.

Of foreign species *A. villebruni* is very close to the Tasmanian species but its preglabellar length appears (based on only two specimens figured by Thoral in 1935) to be less, its palpebral lobes are proportionally longer and the pygidium has different transaxial furrows and very slightly longer marginal spines. However, these are minor differences that may ultimately prove to be of less than specific significance. *A. nakamurai* has tiny palpebral lobes situated well forward and the pygidial marginal spines are situated well back (i.e. the fourth pleural furrow, if continued, reaches the margin well in front of the spine). *A. annamensis* and *A. elegantulus* are too poorly known for comparison. Of Chinese species, almost all are clearly distinguished by their long slender marginal spines but *A. planispiniger* appears very close to *A. florentinensis* although the rear of the hypostome appears to have a slightly different configuration (Lu, 1975, pl. 26, fig. 20), pygidial pleural furrows extend across the border almost to the margin and the third rather than the fourth pleural furrow reaches the margin just behind the marginal spine (Lu *in* Lu *et al.*, 1965, pl. 111, fig. 14).

A number of juvenile cranidia and pygidia are available but show no significant differences from the adults except perhaps they have more relief, more elevated palpebral lobes and furrows, and in at least one specimen the fifth pleural furrow reaches the margin just behind the spine. This may be interpreted as the final meraspid stage; as one more thoracic segment moves out into the thorax so the fourth furrow will be adjacent to the spine.

Family HARPEDIDAE Hawle & Corda, 1847

Scotoharpes Lamont, 1948

Type species (by original designation): *Scotoharpes domina* Lamont, 1948 from the Upper Llandovery of Scotland.

Remarks: Despite the brief original description of the type species a detailed appraisal of that species, including illustration of the holotype is now available (Norford, 1973). Norford also recognised *Selenoharpes* Whittington, 1950 and *Aristoharpes* Whittington, 1950 as junior subjective synonyms of *Scotoharpes*. Although efforts to recognise stratigraphically useful generic morphotypes are laudable the relatively large collections of the Tasmanian species and of *Australoharpes* (Jell, 1985) suggesting that cephalic shape and development of alae are variable with growth make the generic concepts of a number of harpedid genera appear to be too typological in their definition. Accordingly we accept Norford's synonymy and assign the new Tasmanian species to *Scotoharpes* because of the close comparison in all observable features. The extent of the girder along the prolongation and occurrence of slightly coarser pits along the girder and the upper and lower rims are important features in common.

Scotoharpes lauriei sp. nov.

Plate 11, figures 4-14

Etymology: The species is named for John Laurie who was involved in the original biostratigraphic study of the Gordon River Road section and helped collect much of the material.

Material: Holotype UTGD121586, paratypes UTGD95922, 96007, 96008, 96010, 121496, and 122566-122569 all from NMVPL1602.

Diagnosis: Member of *Scotoharpes* with only very faint 1p furrow evident on glabella, an occipital node, very faint alae evident as extremely weak depressions or not evident at all, with short posteriorly directed spine on posterior of prolongation.

Description: Cephalon subcircular to subovate, moderately convex. Glabella narrow (less than 20% of cephalic width), and approximately half cephalic length (without prolongation), broadly rounded anteriorly; palpebral lobes of moderate size, highly arcuate laterally, situated at or behind glabellar midlength; pygidium with narrow tapering axis of at least seven rings and a long terminal piece which may represent several more rings; marginal spines small, inconspicuous, widely separated; posterior margin broadly rounded.

Description: Up to very large size (pygidia 80 mm wide known). Cranidia relatively flat except for convex glabella; glabella with lateral margins parallel-sided to slightly converging forward; glabellar anterior broadly rounded with deeper wide apodemal pits (fossulae) in the preglabellar furrow laterally making those parts of the furrow quite straight; three pairs of well impressed lateral glabellar furrows on the steep lateral slope of the glabella, close to but not confluent with axial furrow; occipital furrow distinct but shallow; occipital ring of uniform length, with low median node at midlength; preglabellar part of cranidium (considered to be greatly expanded anterior border as doublure extends back to front of glabella) flat with faint epiborder furrow evident on some individuals, with transverse ridge evident at inner margin of doublure (possibly compaction feature) on other specimens; palpebral lobe prominently bulging laterally, slightly raised above rest of cheek, relatively close to glabella; palpebral furrow not parallel to lateral margin of lobe but rather almost straight, nearly exsagittal diverging slightly posteriorly and rather shallow; facial sutures anterior to eye diverging forward to converge again forward of the midlength of border in well rounded arch to meet the margin apparently not far from midline; posterior cephalic limb very wide, with long posterior border elongating laterally, well impressed transverse border furrow shallowing and shortening laterally and short band of fixed cheek before facial suture that is transverse from rear of palpebral lobe until it curves sharply to the posterior where it meets margin at right angles.

Hypostome large, more or less equidimensional median body markedly convex at anterior where it has almost vertical slope in the midline; border furrow very short anteriorly, wider and deeper laterally, running prominently into well-impressed middle furrow, almost imperceptible across shoulder past short posterior lobe of median body, well impressed posterolaterally but shallowing posteromedially; border short and continuous across midline anteriorly, expanding laterally into large flat triangular wings, contracting to a narrow ridge near midlength of anterior lobe of median body, expanding again posteriorly into a flat expansive shoulder approximately as wide as the anterior wing and tapering strongly into a short rim-like posterior border.

Pygidium relatively flat with only real convexity in axis, pleural areas sloping gently to margin with no border furrow impressed; axis straight-sided, tapering posteriorly, with well rounded posterior at inner edge of doublure, a considerable distance from margin, with variable (i.e. between specimens and between internal and external surfaces) number of rings visible (6-12 in available material); transaxial furrows straight, weakly impressed but distinct becoming less so posteriorly, with only very weak apodemal depressions laterally away from the axial furrow; pleural area with at least 7 (sometimes a weak eighth) pleural furrows that recurve posteriorly approaching the border and are almost exsagittal posteriorly; fourth pleural furrow if continued in regular curve meets margin just behind the spine; border wide, not crossed by pleural furrows (may be an artefact of flattening after burial); margin smoothly rounded, with pair of short flat or weakly convex posterolateral spines, broadly rounded and sometimes with a pair of very wide short bulges symmetrically placed about the midline between the spines (pl. 10, figs 4, 7); doublure quite wide and ornamented with continuous parallel terrace lines most numerous near the inner edge.

Remarks: Every specimen observed is distorted to some degree and almost all previous observations have been made on internal moulds. Each of the features quoted by Kobayashi (1940) as distinguishing his Tasmanian specimen from Etheridge's (1905) is greatly influenced by one of these factors. Kobayashi's *A. ? gracicostatus* (1940, pl. 11, fig. 10) is almost certainly an exmoderately convex, tapering gently forward to narrowly rounded anterior, with extremely faint 1p furrow the only glabellar furrow present. Axial furrow well impressed laterally but little more than a change of slope in front of the glabella, also shallower posteriorly just in front of the border furrow where alae are situated. Occipital furrow shallow with gentle anterior and posterior slopes into it. Occipital ring of uniform length, rising to the highest point at the posterior, with high median tubercle standing like a post on the anterior of the ring. Alae small and very subtly depressed if at all evident. Eye tubercles just behind anterior of glabella, large and round, elevated almost to height of glabellar rear; eye ridge transverse, straight, long and low in section, joining axial furrow but not crossing it just behind glabellar anterior; weak fossular depression in front of eye ridge. Preglabellar field and anterior cheek roll about equal in length, together sloping very gently down to the brim, cheek roll of uniform width except posterolaterally where it is extended in both directions along the posterior margin into a triangular area. Girder prominent as a ventrally projecting ridge, meeting inner rim at about one-third of the distance from the posterior of the occipital ring to the tip of the brim prolongation, represented on upper lamella by broad caecum from which issue smaller diameter radial caeca that are separated immediately against the girder by pits of the same diameter as those elsewhere. Brim flat to gently concave, covered by radially arranged anastamosing caecal network, caeca separated by pits of fairly uniform size, pits against rim also of same size; brim prolongation tapers posteriorly as the outer rim curves adaxially towards the posterior, with spine of circular section on posterior extremity, including spine as long as axial length of cephalon.

Thorax of 14 or more segments, tapering posteriorly; axis tapering markedly towards the posterior, just slightly narrower than width of each pleuron.

Pygidium transverse, of low convexity; axis tapering markedly, of 7 rings and minute terminus situated some distance in front of border furrow; axial furrow not impressed, only a change of slope; pleural areas smooth except for anterior border furrow, distinct articulating facet developed; border furrow broad and shallow but distinct; border very narrow, tapering posteriorly, horizontal.

Remarks: *Scotoharpes lauriei* may be distinguished from *S. domina* by the shape of its prolongation, and its weak alar development; from *S. latior* (Poulsen, 1934) by its glabellar shape, weak alae and prominent girder; from *S. vetustus* Zhou & Zhang, 1978 by the prominent alae of that species although that species is too poorly known for useful comparison; it differs from all other species of the genus in its weaker alae but resembles juvenile specimens of *S. loma* (Lane, 1972) (see Norford, 1973, pl. 3, fig. 6) in this as well as most other features. This last resemblance indicates its ancestral relationship to Lane's Silurian species.

Family PILEKIIDAE Sdzuy, 1955

Although Lane (1971) advocated inclusion of this group as a subfamily of the Cheiruridae we prefer to retain it as a separate family mainly on the basis of the type of thoracic pleural furrows and on the commonly four segments in the pygidium. This arrangement is also favoured to accommodate a number of phylogenetic possibilities that will be discussed in another paper (Jell, 1985).

Pilekiidae gen. et sp. nov.

Plate 12, figures 1-4

Material: Two cranidia (UTGD122570 and 122571) and two pygidia (UTGD122572 and 122573) all external moulds from NMVPL1601.

Description: Glabella almost as wide as long; tapering only slightly forward from widest point at furrow 1p, with broadly rounded anterior, highly convex in anterior profile, with three pairs of lateral glabellar furrows; glabellar furrows wide, slit-like, almost transverse or directed back adaxially, dividing glabella into lobes of equal length except for the slightly longer frontal lobe; axial furrow well impressed, narrow, continuing forward as the preglabellar furrow without change; preglabellar field absent; anterior border extremely short, convex, like a rope running across the front of the glabella, elongate a little towards facial suture, curved back strongly around anterolateral corners of glabella; palpebral lobe broad, short, at small angle to exsagittal line, meeting axial furrow just behind level of furrow 3p, curving evenly back fairly close to the axis to near the level of furrow 1p, convex and uniform in section throughout; palpebral furrow well impressed, parallel to lobe and curving out around posterior of palpebral lobe; fixigena behind palpebral lobe as wide as base of glabella, but quite narrow between palpebral lobes, sloping down strongly abaxially, with pitted ornament; facial suture proparian very short and curving adaxially in front of palpebral lobe, running transversely behind palpebral lobe to meet lateral margin at about level of furrow 1p; ventral sutures unknown; posterior border convex both in posterior profile and in section with the latter flattening out laterally, becoming elongate laterally and extended into apparently short (full extent not evident on only available specimen) fixigenal spine at the genal angle; posterior border furrow well impressed, short, of uniform cross-section laterally to beyond the genal angle, similar to the glabellar furrows in cross-section.

Hypostome, rostral plate and thorax not known.

Pygidium small, transverse; axis of four rings and small semicircular terminus reaching posterior margin; rings slightly longer towards posterior, of uniform length, separated by well-impressed transaxial furrows becoming shallower towards the posterior; pleural areas crossed by well-impressed pleural and interpleural furrows; interpleural furrows curved posteriorly and deeper towards margin; pleural furrows shallowing towards margin and not curved; posterior pleural band extended into short blunt free spine on each segment, turning sharply posteriorly at the base of the spine; fourth segment with very weak pleural furrows, with its short spines enclosing the axial terminus laterally; all marginal spines directed posteriorly. Surface of cranidium and pygidium (except in furrows) covered with fine widely-spaced granules.

Remarks: This species is closely related to *Pilekia* but we consider that it will be found to represent a separate genus based on its less bulbous 1p glabellar furrow, its lack of a strong genal or fixigenal spine, the tiny semicircular pygidial axial terminus, and the transverse pleural furrows in front of posterior pleural bands that turn sharply back at the base of the marginal spines. The combination of these features separates it from all those assigned to either *Pilekia* Barton, 1915 or *Parapilekia* Kobayashi, 1934.

Pilekia Barton, 1915

Type species (by original designation): *Cheirurus apollo* Billings, 1860.

Pilekia sp. nov.

Plate 12, figures 8-12

Material: UTGD95987, 95989, 96664, 122577, 122578 all from NMVPL1600.

Description: Glabella with widest point near anterior of lobe 1p or rear of lobe 2p, with well rounded anterior, with well impressed almost transverse occipital furrow becoming slightly longer medially and with lateral parts running forward from axial furrow, with occipital ring only marginally longer than occipital furrow and shorter laterally with convex lateral profile rather than the flatter profile medially, with ornament of coarse tubercles except in furrows; lateral glabellar furrows well-impressed, weakly convex forward, becoming shallower shorter and directed posteriorly towards the axis, with long flat bottoms near axial furrow and steep almost vertical sides, with furrow 1p reaching back almost to the occipital furrow and isolating a large prominent 1p lobe; lobes becoming progressively shorter forward with anterior lobe being quite short and subrhombic in shape with arcuate anterior; anterior border furrow short and deep; anterior border short, rising strongly forward, of uniform length on cranidium; eye ridge running out and slightly back from axial furrow near level of midlength of lobe 3p, straight, convex in section; fixed cheeks wide, subtriangular, with strong reticulate ornament of caecal ridges separated by prominent pits and bearing sparsely scattered tubercles on top of the ridges; palpebral lobe relatively small, curved posteriorly, defined by prominent furrow that extends along rear of eye ridge; posterior border furrow well-impressed, becoming slightly longer abaxially, continuing around genal angle as slightly narrower lateral furrow, beginning in axial furrow at occipital furrow not at posterior margin; posterior border short near axial furrow, becoming longer and flatter laterally, bearing strong posterolaterally directed fixigenal spine (Pl. 12, fig. 8b) some distance adaxial to the genal angle; course of facial suture not clear on any specimen.

Librigena, rostrum, hypostome, and thorax unknown.

Pygidium transverse to subsemicircular, with convex axis standing above pleural areas; axis of four rings and terminus; each ring of uniform length, fourth only slightly shorter than first; terminus almost twice as long as a ring, considerably narrower than fourth ring, reaching margin posteriorly, descending steeply to posterior; pleural area with well impressed pleural and interpleural furrows, tapering posteriorly, with pleural area of fourth segment absent; pleural furrows beginning near anterior of segment at axial furrow, running transversely in two anterior segments then curving a little to the posterior to finish in line with the anterior part of the marginal spine, running transversely across narrow third pleura towards the anterior part of the marginal spine; interpleural furrows transverse for most of their course before turning slightly posteriorly abaxially and meeting margin between marginal spines; four pairs of evenly spaced marginal spines present; first and second pairs of marginal spines tapering evenly from base but quite long (about as long as pygidium), circular to slightly flattened in section; third marginal spine with parallel sides through the part preserved and inferred to be considerably longer than others; fourth marginal spine shortest, almost exsagittal, widely separated from axial terminus and hence from matching spine on other side; ornament on pygidium of fine sparsely scattered tubercles.

Remarks: The species taxobases are the different sized pygidial marginal spine and the fixigenal spine situated adaxially from the genal angle. There is not sufficient material available to propose a new specific name but its novelty is not in doubt. Assignment to *Pilekia* is based in particular, on the enlarged 1p lobes and the greatest width of the glabella being near the anterior of lobe 1p but all other features are consistent with this assignment. Relative sizes of pygidial spines seem to separate this material from any described species of *Pilekia*.

Family PLIOMERIDAE Raymond, 1913

Whittington (1961) removed the pilekiids from this family and noted that division of the remaining taxa into subfamilies was unwarranted. Nothing has happened during the intervening years to alter that view.

Protopliomerops Kobayashi, 1934

Type species (by original designation): *Protopliomerops seisonensis* Kobayashi, 1934 from the late Tremadoc *Protopliomerops* Zone at Saisho-ri, South Korea (Tomkol Shale of Kobayashi, 1966).

Remarks: This genus was diagnosed by Kobayashi (1934) and extensively discussed by Ross (1951) with additions to the diagnosis. The species described below adds only an articulated thorax to the generic concept so further discussion is unnecessary.

Protopliomerops hamaxitus sp. nov

Plate 13, figures 1-14

1974 *Cybelopsis* sp. Corbett & Banks, pl. 2, figs 15, 16.
1980 ?*Pliomerina subquadrata* (Kobayashi); Stait & Laurie, fig. 3, appendix 1.

Etymology: From Greek *hamaxitos* meaning highway; referring to type locality on a highway.

Material: Holotype UTGD122585, paratypes UTGD95886, 95999, 96003, 96625, 121491, and 122579-122587 all from NMVPL1602. Numerous other specimens from each of the localities indicated in the introduction were also available.

Diagnosis: Member of *Protopliomerops* with axial furrows diverging very weakly forward; lateral glabellar furrows slit-like, 3p reaching axial furrow at anterolateral corner of glabella; occipital furrow with strong anterior curve medially over the axis; occipital ring without node; palpebral lobe not markedly expanded, long extending back to level of 1p furrow; genal spines short; ornament over whole cephalon of fine pustules, cheek areas with numerous pits between a network of ridges. Thorax of 12 segments; pleural tips spinose, curved slightly posteriorly. Pygidium with axis tapering strongly posteriorly, of five rings and triangular terminus drawn out to reach posterior margin; five pairs of marginal spines with tips well apart; anterior border very short.

Description: Small trilobite, tapering posteriorly throughout the axis and in the lateral spinose margin. Cephalon semicircular, moderately convex, proparian; glabella approximately 0.33 of cephalic width, widest anteriorly, with broadly rounded anterior, straight sides, and three pairs of lateral glabellar furrows; 1p furrow longest of three, angling backwards towards axis; 3p furrow most oblique, meeting axial furrow at or in front of the anterolateral corner of the glabella; occipital furrow swinging strongly forward near adaxial end of furrow 1p, in an even curve across axis, deep, with U-shaped cross-section; occipital ring with slightly oblique posterior margin laterally becoming transverse medially, without node, elongate medially; anterior border short and convex medially, slightly flatter and longer lateral to glabella; anterior border furrow short and slit-like medially, elongate lateral to the glabella in front of the palpebral ridge; palpebral ridge narrow but relatively long, continuing unchanged into the palpebral lobe; palpebral lobe not greatly expanded, swung back strongly to be almost exsagittal, almost reaching back to 1p furrow; facial suture running forward from palpebral lobe close to axial furrow only a short distance to margin, running almost transversely behind eye but curving back distally to meet the margin just in front of the genal angle; interocular cheeks very narrow; posterior border becoming elongate near genal angle, drawnout at genal angle into short spine that extends only slightly laterally but strongly posteriorly. Fixigena triangular, with well-impressed border furrow, convex border and high curved doublure. Hypostome with prominent convex median body occupying most of its area; anterior wings wide, tapering laterally, flattened in a plane at approximately 60° to the plane of the main body of the hypostome; border furrows well impressed running into distinct median furrows very close to posterior; posterior lobe short but longer than posterior border, isolated completely by median furrows; shoulder only slightly expanded; entire surface covered with fine pustulose ornament.

Thorax of 12 segments; axis short, highly convex with very short articulating half ring, with strong bulbous apodemes laterally in articulating furrow; pleurae with very short anterior pleural bands not evident on most specimens (as they are concealed by the next anterior segment deep within the pleural furrow); pleural furrows well impressed, dividing the short low anterior pleural band from the long high posterior pleural band that occupies almost all the exposed part of the pleura; pleural extremities are long, hollow, free spines that taper gradually and curve posteriorly from the articulating line (clearly evident on internal moulds (Pl. 10, fig. 10)); articulating lines converging posteriorly, with narrow distinct doublure beneath.

Pygidium semicircular, weakly convex; axis of five rings of equal length, becoming progressively narrower posteriorly and a terminus; terminus triangular, longer than wide, reaching posterior margin, much narrower than last axial ring, enclosed laterally by fifth pleurae, separated from fifth pleurae by very shallow furrows; transaxial furrows deep, becoming shallower and shorter posteriorly, weakly convex anteriorly; articulating half ring and anterior border extremely short and low, latter of uniform length; anterior pleural band visible low in first pleural furrow of some specimens; pleural furrows very deep, more posterior ones curving posteriorly, with fifth pair exsagittal to converging; posterior pleural band dominating pleural areas as high ridges extending beyond margin as large spines; marginal spines finishing with tips of successive spines well apart and sharply pointed, in five pairs of which second and third seem longest; all raised areas covered by pustulose ornament but furrows smooth.

Remarks: The ornament, occipital furrow, lack of occipital node, widely spaced tips of the pygidial marginal spines and longer palpebral lobes distinguish *P. hamaxitus* from the type species. *Protopliomerops granulatus* and *P. punctatus* both from Korea (Kobayashi, 1934, pl. 7, figs 2-5) may be distinguished by their pygidia having six pairs of marginal spines. The three species assigned to *Protopliomerops* by Ross (1951) from Utah may be distinguished by their expanded palpebral lobes and different combinations of other features in the pygidium. *Protopliomerops rossi* Harrington & Leanza, 1957 may be distinguished by its glabellar shape, and the widely separated fifth pair of pygidial marginal spines without the discrete triangular terminus between them. Glabellar shape varies in the five illustrated internal moulds of cranidia to the same extent as in the Gordon Road collections so this may not be a distinguishing feature. In members of this family morphology is so different depending on whether internal moulds or external surfaces are used that *P. rossi* may ultimately prove to be synonymous with *P. hamaxitus*. Features most distinctive of *P. hamaxitus* seem to be its lack of an occipital node, long palpebral lobes, five pairs of well spread pygidial marginal spines and almost no expression of anterior pleural bands in pleural areas.

A complete morphogeny is not available but one juvenile pygidium plus posterior thorax (Pl. 13, fig. 4) does give some insight into growth of that part of the exoskeleton.

Protopliomerops sp. cf. **P. punctatus** Kobayashi, 1934

Plate 11, figures 1-3; plate 12, figures 5-7

Material: Three cranidia (UTGD122562-122564) and three pygidia (UTGD122574-122576) all from a single block of shale at NMVPL1602.

Remarks: The comparison of this material with Kobayashi's species is based almost exclusively on the pygidium because the tiny fragment of a cranidium assigned by Kobayashi, could scarcely be considered to provide an adequate basis for comparison. The six pairs of pygidial spines, the way the pleural ribs are close together and the structure of the axis are all significant features that are shared by *P. punctatus* and this Tasmanian material. In fact there are no observable differences. Essential features of the cranidium are the almost isolated 1p glabellar lobes, the almost transverse glabellar furrows with 3p meeting the axial furrow behind the anterolateral corner of the glabella, the long palpebral lobe (or rather palpebro-ocular ridge), and short genal spine. These features do not compare with any known cranidia and certainly not with the short palpebral lobe of Kobayshi's *P. punctatus*. However, his representation does show transverse glabellar furrows with 3p behind the anterolateral glabellar corner. These cranidia may prove to have the features of *P. punctatus* when cranidia of that species are better known.

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Explanation of Plates

PLATE 1

Hystricurus timsheaensis sp. nov. All from NMVPL1600.

Figure 1. Latex cast of damaged cranidium distorted by compression in the longitudinal direction; showing wide palpebral lobe and deep fossulae, UTGD122500, ×2.

Figure 2. Internal mould of two damaged cranidia lying one on top of the other with axes at right angles so that distortion is clearly shown by difference between the two, UTGD122501 and 122502, ×2.

Figure 3. Latex cast of damaged cranidium showing posterior expansion of palpebral lobe, the coarse ornament and a few terrace lines near the anterior margin, UTGD122503, ×4.

Figure 4. Latex cast from only slightly disarticulated, damaged holotype specimen including cranidium, part of thorax, and pygidium, UTGD95867, ×2.

Figure 5. Latex cast of part of cranidium (UTGD122504) and free cheek (UTGD122505) showing ornament completely subdued by distortion in shale after burial, and lateral compression of cheek border near anterior, ×3.

Figure 6. Latex cast from complete free cheek except for incomplete genal spine showing visual surface, caecal network, terrace lines on border and distinct eye socle, UTGD122506, ×6.

Figure 7. Latex cast from damaged external mould of pygidium in posterolateral view showing strongly divided axial terminus and high marginal band with well developed terrace lines, UTGD122507, ×3.5.

Figure 8. Latex cast of damaged pygidium (UTGD 122508) and cranidium (UTGD122509), ×3.

Figure 9. Latex cast of damaged pygidium in posterolateral view showing narrow doublure, marginal terrace lines, and strong medial tubercle on anterior axial ring, UTGD122510, ×5.

Figure 10. Latex cast of pygidium with ornament and furrows subdued by tectonic distortion, UTGD122511, ×4.

Figure 11. Latex cast of pygidium showing axial tubercles, extent of pleural furrows, posteromedial marginal indentation, and extent of axis, UTGD122512, ×4.

Figure 12. Latex cast of damaged fixigena (UTGD122513) and cranidium (UTGD122514), showing the tuberculate ornament, upturned palpebral lobe, and anterior structure, ×2.5.

Figure 13. Internal mould of distorted pygidium showing furrows on pleural areas and divided axial terminus, UTGD122515, ×5.

Figure 14. Latex cast of damaged pygidium showing marginal band in posterior oblique view, UTGD96680, ×3.5.

Figure 15. Internal mould of pygidium (UTGD122516) and librigena (UTGD122517) with external mould of another librigena in upper right (UTGD122518) ×2.

PLATE 2

Hystricurus lewisi (Kobayashi, 1940).

Figure 1. Latex cast of damaged cranidium from NMVPL182 showing flattened anterior border (exaggerating length of border) and wide palpebral lobes, UTGD96055, ×5.

Figure 2. Latex cast of damaged flattened holotype cranidium from limonite encrusted external mould (obliterating surface ornament), Z151, ×6.

Figure 3. Latex cast of an incomplete cranidium from the type locality, Kobayashi's original material, Z995 (=B1423), ×4.

Figure 4. Internal mould of damaged and distorted cranidium from the type locality of *H. lewisi* (holotype of *Tasmanaspis longus* Kobayashi, 1940), Z150, ×4.

Figure 5. Latex cast of small cranidium from NMVPL1601, showing long preglabellar field and wide palpebral lobes, UTGD122519, ×4; A, anterior oblique view; B, dorsal view.

Figure 6. Latex cast of small cranidium from NMVPL 182, UTGD122520, ×3.

Figure 7. Latex cast of small cranidium from NMVPL182 crushed down on right antero-lateral corner so that palpebral lobe appears narrow because most of its width is turned directly down and preglabellar field appears short because it it depressed and compressed with border strongly upturned, UTGD122521, ×3.5.

Figure 8. Latex cast of cranidium from 5 Road, showing ornament, anterior course of facial suture, and palpebral lobes, UTGD81067, ×3.

Figure 9. Internal mould of librigena from NMVPL182 showing coarse ornament and anterior extent of doublure, UTGD122522, ×3.5.

Figure 10. Internal mould (A) and latex cast (B) of small librigena from NMVPL183, in dorsal view, showing difference of ornament on inner and outer surfaces of exoskeletons, terrace lines on the border and anterior extension of border, UTGD122523, ×5.

Figure 11. Internal mould of a cranidium from NMVPL1602, UTGD81062, ×3.5.

Figure 12. Latex cast of damaged librigena from NMVPL1602, in lateral oblique view showing visual surface and eye socle, UTGD96710, ×5.

Figure 13. Latex cast of damaged cranidium from 5 Road showing wide palpebral lobes and posterior cephalic limb, UTGD81049, ×5.

Figure 14. Latex cast of librigena with most of genal spine missing from NMVPL182, in lateral oblique view, showing border furrow shallowing at rear and high eye socle, UTGD98084, ×4.

Figure 15. Latex cast of two cranidia and a pygidium with a cranidium of *Asaphopsoides florentinensis* lying between the cranidia of this species, from NMVPL182, showing the different morphologies produced by the different orientation relative to the slatey cleavage—compression has been in the direction up and down the page so that the upper cranidium is compressed laterally whereas lower one is compressed in sagittal line, also showing weak 1p furrow, UTGD122524, 122525, 122526 and 122527 from top to bottom respectively, ×3.

PLATE 3

Figures 1-7. *Tanybregma tasmaniensis* sp. nov. All from NMVPL1600.

Figure 1. Latex cast of damaged librigena showing visual surface, anterior extent of doublure and denticles on adaxial margin of genal spine, UTGD122528, ×4.

Figure 2. Internal mould of distorted cranidium, UTGD96674, ×4.

Figure 3. Internal mould of holotype cranidium showing long preglabellar length, palpebral lobes, 1p furrow, and course of facial suture, UTGD 95983, ×3.5.

Figure 4. Latex cast of librigena in ventral view showing terrace lines on the doublure, ridge running down genal spine, and denticles on genal spine, UTGD96676, ×2.

Figure 5. Latex cast of incomplete librigena showing extent of doublure forward of facial suture and width of doublure, UTGD122529, ×3.

Figure 6. Internal mould of librigena showing visual surface, course of facial suture, and mould of ridge on underside of genal spine, UTGD 122530, ×4.

Figure 7. Internal mould of damaged cranidium showing caecal network on preglabellar area, concave border, and posterior limb, UTGD122531, ×2.

Figures 8, 11, 12, 14. *Hystricurus* sp. cf. *H. robustus* Ross, 1951

Figure 8. Latex cast of pygidium from NMVPL1602 showing axial structure, extent of furrows on pleurae, and occasional coarse tubercles on axial rings and pleural ribs, UTGD95885, ×6.

Figure 11. Internal mould of pygidium from NMVPL 1602 showing fine tubercles representing pits on the inner surface of exoskeleton, and the width of the doublure, UTGD122532, ×3.

Figure 12. Latex cast of part of thorax and posterior of cranidium from Adams Falls, UTGD96040, ×4.

Figure 14. Internal mould of pygidium from Adams Falls, UTGD96620, ×3.

Figures 9, 10, 13. *Hystricurus lewisi* Kobayashi, 1940 all from NMVPL182.

Figure 9. Latex cast of incomplete pygidium showing rim-like anteriorly tapering border, the strong ridge at the geniculation, and steeply sloping outer part of pleura, UTGD122533, ×4.

Figure 10. Internal mould of pygidium showing doublure and structure of axis, UTGD96049, ×7.

Figure 13. Latex cast of slightly distorted pygidium showing pleural and interpleural furrows, and sharp geniculation, UTGD98080, ×7.

PLATE 4

Figures 1-7. *Hystricurus* sp. cf. *H. robustus* Ross, 1951.

Figure 1. Internal mould of damaged cranidium from NMVPL1602 showing coarse ornament and long posterior limb, UTGD122534, ×4.

Figure 2. Internal mould of librigena from Adams Falls showing the visual surface, doublure, and deflected genal spine, UTGD95913, ×3.

Figure 3. Internal mould of damaged cranidium from Adams Falls showing extremely short preglabellar field, UTGD96626, ×2.5.

Figure 4. Internal mould of cranidium from Adams Falls showing palpebral lobe and posterior course of facial suture, UTGD96603, ×3.5.

Figure 5. Latex cast of librigena from NMVPL1602 showing terrace lines on the border, eye socle and collapsed visual surface, UTGD98114, ×4.

Figure 6. Latex cast of damaged cranidium from Adams Falls showing palpebral lobes, extremely short preglabellar field with median furrow, and posteriorly shallowing axial furrow, UTGD 96708, ×3.

Figure 7. Latex cast of small librigena from Adams Falls showing visual surface, eye socle, shallowing in border furrow just in front of genal angle, and coarse ornament, UTGD122588, ×7.

Figures 8-11. *Chosenia adamsensis* sp. nov. All from Adams Falls.

Figure 8. Latex cast of damaged pygidium showing terrace lines on marginal spines and axial structure, UTGD95175, ×4.

Figure 9. Latex cast of cranidium showing long glabellar furrows and marginal terrace lines on anterior border, UTGD96027, ×3.

Figure 10. Latex cast of incomplete pygidium showing curved marginal spine with terrace lines, ridges on pleural ribs in position of interpleural furrows, and marginal spine coming from third pygidial segment, UTGD96611, ×2.

Figure 11. Internal mould of pygidium distorted by shortening, showing apodemal pits in transaxial furrows, anterior border furrow reaching margin in front of marginal spine, and doublure, UTGD96602, ×3.

Figure 12. *Asaphellus etheridgei* sp. nov. Internal mould of pygidium from Adams Falls showing terrace lines on doublure, apodemal pits in transaxial furrows, and axial shape, UTGD96032, ×1.5.

Figure 13. Nileidae gen. et sp. indet. Internal mould of pygidium and five thoracic segments from Adams falls, UTGD96030, ×2.5. (NOT DESCRIBED).

PLATE 5

Chosenia adamsensis sp. nov. All from Adams Falls except Fig. 1 which is from NMVPL1602.

Figure 1. Latex cast of damaged holotype cranidium showing long glabellar furrows and ridge crossing axial furrow from anterolateral corner of glabella, UTGD122535, ×2.

Figure 2. Latex cast of damaged librigena showing terrace lines, and course of border furrow, UTGD95945, ×4.

Figure 3. Internal mould (A) and latex cast from external mould (B) showing sparse tuberculate ornament, strong caecum from anterolateral corner of glabella, ten thoracic segments with wide pleural spines, and characteristic long anterior border furrow on pygidium, UTGD96023, ×3.

Figure 4. Latex cast of damaged cranidium showing anterior marginal terrace lines, posterior palpebral lobe, and tuberculate ornament on glabellar lobes, UTGD96029, ×4.5.

Figure 5. Latex cast of librigena showing structure of border, eye socle, terrace lines and genal spine, UTGD96646, ×5.

Figure 6. Internal mould of damaged cranidium, UTGD95927, ×3.

Figure 7. Internal mould of damaged laterally compressed pygidium showing long marginal, spine arising from second pygidial segment, anterior border furrow running to margin forward of marginal spine, and axis of six segments plus terminus, UTGD95942, ×2.

Figure 8. Latex cast of damaged, sagitally compressed pygidium showing marginal spines with longitudinal terrace lines and issuing from third pygidial segment, seven axial rings plus terminus, and interpleural furrows, UTGD 96644, ×3.

Figure 9. Internal mould of diagonally distorted pygidium, UTGD96025, ×2.

Figure 10. Internal mould of sagitally compressed pygidium showing terrace lines on doublure, axis of seven rings and terminus, and marginal spine issuing from third segment, UTGD96637, ×2.

PLATE 6

Asaphellus sp. cf. *A. trinodosus* Chang, 1949. All from NMVPL1602

Figure 1. Latex cast from incomplete external mould of cranidium showing palpebral lobe and course of facial suture, UTGD98111, ×2.

Figure 2. Latex cast from incomplete external mould of hypostome showing concentric terrace lines, median furrows, shape of the median body, and slight medial expansion of the posterior border, UTGD98137, ×4.5.

Figure 3. Latex cast from external mould of holotype cranidium showing weakly defined glabella, palpebral lobes, facial suture barely diverging in front of palpebral lobes, and faint node posteromedially on glabella, UTGD96005, ×2.

Figure 4. Latex cast of ventral surface of librigena showing terrace lines on wide convex doublure, UTGD95917, ×1.

Figure 5. Latex cast of incomplete librigena showing eye socle, short genal spine, and fine terrace lines near margin, UTGD95895, ×2.

Figure 6. Latex cast of damaged cranidium showing weak axial furrow, and palpebral lobes, UTGD96002, ×3 (thoracic segment of some other trilobite impressed through the cranidium just forward of palpebral lobes).

Figure 7. Latex cast of damaged librigena showing anterior termination of doublure in sagittal suture, eye socle, and marginal terrace lines, UTGD98117, ×2.

Figure 8. Internal mould of pygidium showing wide doublure, low convexity and terrace lines on the doublure (on right), UTGD122536, ×1.5.

Figure 9. Internal mould of damaged cranidium showing axial furrow, palpebral lobes, and posterior course of facial suture, UTGD122537, ×1.5.

Figure 10. Latex cast of right posterolateral part of hypostome showing deep median furrow, terrace lines on the border with narrow upturned margin and short posterior margin, UTGD 122538, ×2.

Figure 11. Internal mould of pygidium showing axial structure including transverse apodemes, pleural and interpleural furrows and wide doublure with terrace lines, UTGD95877, ×2.

Figure 12. Latex cast of pygidium and librigena, UTGD95915 and 122539, respectively, ×1.5.

PLATE 7

Megistaspis (Ekeraspis) euclides (Walcott, 1925). All from NMVPL1601.

Figure 1. Internal mould of damaged cranidium, UTGD122540, ×1.5.

Figure 2. Latex cast of incomplete cranidium showing course of the facial suture, palpebral lobe, and low convexity of the cranidium, UTGD122541, ×2.

Figure 3. Latex cast of ventral side of librigena showing long genal spine with ridge running down it, wide doublure with terrace lines, and sagittal suture terminating doublure anteriorly, UTGD122542, ×1.

Figure 4. Internal mould of cranidium, UTGD122543, ×1.

Figure 5. Internal mould of incomplete librigena showing eye socle, facial suture and wide anterior doublure, UTGD98095, ×2.

Figure 6. Latex cast from incomplete external mould of hypostome showing dorsally projecting anterior wings, terrace lines, and deep median furrow, UTGD122544, ×2.

Figure 7. Latex cast of damaged librigena showing eye socle, flat border, and course of facial suture, UTGD122545, ×1.5.

Figure 8. Latex cast form incomplete external mould of cranidium showing extent of glabella, anterior part of facial suture and its most posterior part, UTGD122546, ×2.

Figure 9. Internal mould of small pygidium showing long posterior spine, UTGD122547, ×2.

Figure 10. Latex cast of posterior part of hypostome showing terrace lines on the shoulder and short posterior lobe of median body, UTGD122548, ×4.

Figure 11. Latex cast of large pygidium showing axial and pleural structure, UTGD95994, ×1.

Figure 12. Latex cast of damaged hypostome, UTGD 122549, ×3.

Figure 13. Latex cast of sagitally compressed pygidium showing shorter posterior spine, UTGD98102, ×3.

Figure 14. Latex cast of small distorted pygidium, UTGD122550, ×3.

Figure 15. Internal mould of laterally compressed pygidium plus posterior five thoracic segments showing pygidial doublure with terrace lines, and style of thoracic segment, UTGD122551, ×2.

PLATE 8

Dikelokephalina asiatica Kobayashi, 1934. All from NMVPL1600.

Figure 1. Latex cast of small fragment of a librigena probably referable to this species showing low eye socle and ornament of subtle terrace lines on genal field, UTGD122552, ×2.

Figure 2. Internal mould of damaged laterally compressed pygidium showing axial structure and posterior spines, UTGD95981, ×3.

Figure 3. Internal mould of pygidium, UTGD95979, ×3.

Figure 4. Latex casts from internal or ventral (A) and external (B) moulds of damaged pygidium showing subtle terrace lines on border region, width of doublure and its terrace lines, posterior notch in inner edge of doublure and posterior spines, UTGD96689, ×2.5.

Figure 5. Internal mould of damaged pygidium, UTGD95982, ×3.

Figure 6. Latex cast of damaged cranidium showing palpebral lobe, glabellar furrows and fine tuberculate ornament, UTGD95980, ×3.

Figure 7. Internal mould of cranidium showing palpebral lobes, glabellar furrows, occipital node and preglabellar structure, UTGD122553, ×3. (Cranidium of *Tanybregma tasmaniensis* sp. nov. in upper left UTGD122554).

Figure 8. Internal mould of damaged cranidium, UTGD95978, ×3.

PLATE 9

Asaphopsoides florentinensis (Etheridge, 1905). All from NMVPL182 except Figures 5, 6, 8, 11 which come from 5 Road.

Figure 1. Internal mould of juvenile cranidium, UTGD122555, ×7.

Figure 2. Internal mould of juvenile cranidium larger than previous one, UTGD98053, ×5.

Figure 3. Internal mould of damaged hypostome, UTGD122556, ×4.

Figure 4. Latex cast from incomplete external mould of cranidium showing fine terrace lines on anterior border, UTGD81086, ×2.5.

Figure 5. Latex cast of hypostome showing ornament, median furrow, pits in posterior border furrow, and short posterior border, UTGD81019, ×6.

Figure 6. Latex cast of incomplete cranidium and librigena, UTGD80990 and 122557 respectively, ×3.

Figure 7. Internal mould of cranidium showing posterolateral limbs, and fossulae, UTGD 122558, ×2.5.

Figure 8. Latex cast of right pleura of thoracic segment showing ornament, facet, and pointed tip, UTGD122559, ×3.

Figure 9. Latex cast of damaged sagitally compressed cranidium showing glabellar furrows, terrace lines on anterior border, palpebral lobes, and occipital node, UTGD98075, ×5.

Figure 10. Latex cast of damaged cranidium diagonally distorted, UTGD122560, ×3.

Figure 11. Internal mould of damaged cranidium, UTGD80999, ×3.

PLATE 10

Asaphopsoides florentinensis (Etheridge, 1905).

Figure 1. Internal mould of laterally compressed holotype pygidium from near 'The Gap' in the Florentine Valley AMF9232, ×2.

Figure 2. Internal mould of incomplete librigena from Adams Falls showing broad genal spine and wide doublure, UTGD96022, ×4.

Figure 3. Latex cast of joined librigenae and anterior border of cranidium from 5 Road showing facial suture, genal spines and border furrow, UTGD81001, ×1.5.

Figure 4. Internal mould of laterally compressed pygidium from Adams Falls showing wide doublure with terrace lines and pleural and interpleural furrows, UTGD96036, ×3.

Figure 5. Latex cast (A) and internal mould (B) of pydigium and nine thoracic segments from NMVPL182 showing increasing curvature of pleural spines posteriorly, UTGD96652, ×3.

Figure 6. Latex cast of ventral side of librigena from 5 Road showing sagittal suture terminating doublure anteriorly, wide doublure and course of facial suture, UTGD96650, ×2.

Figure 7. Internal mould of damaged pygidium from NMVPL182 showing axial structure and broadly excavated margin posteromedially between marginal spines, UTGD98060, ×4.

Figure 8. Internal mould of laterally compressed pygidium from Adams Falls showing terrace lines on doublure and posterior marginal spines, UTGD80995, ×3.

Figure 9. Latex cast of pygidium from NMVPL182, showing axial and pleural structure, UTGD 122561, ×2.5.

Figure 10. Internal mould of damaged pygidium from Adams Falls showing width of doublure with terrace lines and posterior marginal spines, UTGD96038, ×2.5.

PLATE 11

Figures 1-3. *Protopliomerops* sp. cf. *P. punctatus* Kobayashi, 1934. All from NMVPL1602.

Figure 1. Latex cast from incomplete external mould of cranidium, UTGD122562, ×6.

Figure 2. Internal mould of cranidium and anterior thoracic segments of enrolled individual showing transverse glabellar furrows, UTGD 122563, ×8.

Figure 3. Internal mould of two cranidia showing transverse (lower) and oblique (upper) glabellar furrows, UTGD122564 and 122565, ×5.

Figures 4-14. *Scotoharpes lauriei* sp. nov. All from NMVPL1602.

Figure 4. Internal mould of damaged cranidium, UTGD95922, ×9.

Figure 5. Latex cast from incomplete external mould of cranidium showing glabellar furrows, occipital node, eyes, and eye ridges, UTGD121496, ×11. (Broken off just outside girder).

Figure 6. Latex cast of ventral surface of incomplete cranidium showing extent of girder, projecting rim at margin, inner extent of doublure and caecal network, UTGD98116, ×6.

Figure 7. Latex cast from damaged external mould of cranidium with three thoracic segments attached showing spine on tip of prolongation, eyes and caecal network, UTGD122566, ×4.

Figure 8. Internal mould of damaged cranidium showing extent of girder, UTGD122567, ×10.

Figure 9. Latex cast from damaged external mould of holotype specimen, UTGD121586, ×6.

Figure 10. Latex cast from damaged external mould of small cranidium in anterolateral oblique view showing marginal rim and eye, UTGD122568, ×7.

Figure 11. Latex cast from damaged external mould of small cranidium showing spine on tip of prolongation, UTGD96007, ×10.

Figure 12. Latex cast of dorsal (A) and ventral (B) surfaces of damaged cranidium showing caecal network and girder, UTGD122569, ×5 and ×6 respectively.

Figure 13. Internal mould of pygidium and posterior thoracic segment showing tapering axis, narrow border and smooth pleural areas, UTGD96010, ×9.

Figure 14. Internal mould of a cranidium, UTGD96008, ×8.

PLATE 12

Figures 1-4. Pilekiidae gen. et sp. nov. From NMVPL1601.

Figure 1. Latex cast of damaged cranidium in anterior (A), anterolateral oblique (B), and dorsal (C) views, UTGD122570, ×3, ×3 and ×5, respectively.

Figure 2. Latex cast of damaged cranidium, UTGD 122571, ×5.

Figure 3. Latex cast of pygidium showing pleural and interpleural furrows and marginal spines, UTGD122572, ×6.

Figure 4. Latex cast of pygidium in dorsal (A) and left lateral oblique (B) views, UTGD122573, ×7.

Figures 5-7. *Protopliomerops* sp. cf. *P. punctatus* Kobayashi, 1934. From NMVPL1602.

Figure 5. Latex cast of pygidium showing six marginal spines on left side, UTGD122574, ×10.

Figure 6. Latex cast of pygidium showing six marginal spines on right side, UTGD122575, ×6.

Figure 7. Latex cast of pygidium showing six marginal spines on both sides, UTGD122576, ×8.

Figures 8-12. *Pilekia* sp. nov. All from NMVPL1600.

Figure 8. Internal mould of sagittally compressed cranidium showing prominent 1p lobes and strong genal spine (detailed in (B) where its external mould is visible), UTGD122577, ×2.5.

Figure 9. Latex cast of incomplete and distorted cranidium showing pitted ornament of cheek and nature of palpebral lobe, UTGD96664, ×2.

Figure 10. Latex cast of damaged cranidium showing ornament and glabellar furrows, UTGD122578, ×3.

Figure 11. Internal mould of damaged cranidium showing genal spine, glabella and ornament, UTGD 95987, ×2.

Figure 12. Internal mould of damaged holotype pygidium showing four marginal spines of different sizes, interpleural furrows, and ornament, UTGD 95989, ×4.

PLATE 13

Protopliomerops hamaxitus sp. nov. All from NMVPL1602.

Figure 1. Latex cast of cranidium showing genal spines, UTGD95999, ×8.

Figure 2. Latex cast of pygidium showing five pairs of well separated marginal spines and pustulose ornament, UTGD95886, ×10.

Figure 3. Latex cast of hypostome showing anterior wings and pustulose ornament, UTGD96003, ×20.

Figure 4. Latex cast of rear of thorax and pygidium of juvenile individual, UTGD122579, ×12.

Figure 5. Latex cast of sagittally compressed cranidium showing glabellar furrows, palpebral lobe, and punctate ornament on cheek, UTGD121491, ×8.

Figure 6. Latex cast of damaged cranidium with librigena in place, UTGD122580, ×11.

Figure 7. Latex cast of damaged cranidium and thorax, UTGD122581, ×8.

Figure 8. Latex cast of hypostome showing ornament and faint median furrow, UTGD122582, ×8.

Figure 9. Latex cast of damaged complete specimen showing 13 segments, UTGD96625, ×10.

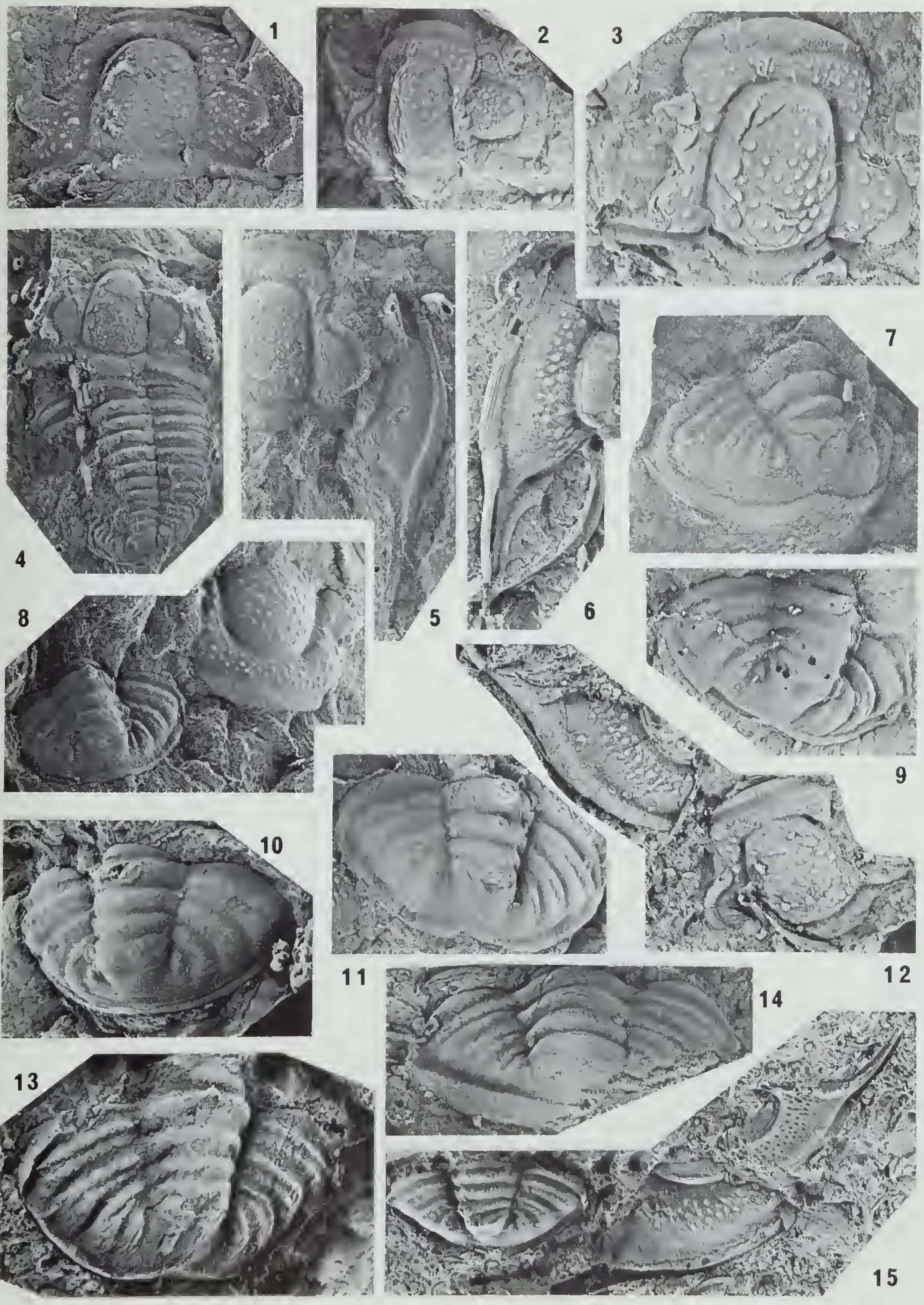
Figure 10. Internal mould of damaged individual showing position of hypostome, free pleural spines and strong thoracic apodemes in articulating furrows, UTGD122583, ×9.

Figure 11. Latex cast of two cranidia, UTGD95884 (upper) and 122584 (lower), ×6.

Figure 12. Latex cast of damaged holotype cranidium showing ornament, glabellar furrows, 1p joining occipital furrow, and short anterior border, UTGD122585, ×9.

Figure 13. Latex cast of pygidium with large quadrate axial terminus, UTGD122586, ×8.

Figure 14. Latex cast of damaged cranidium and thorax, UTGD122587, ×6.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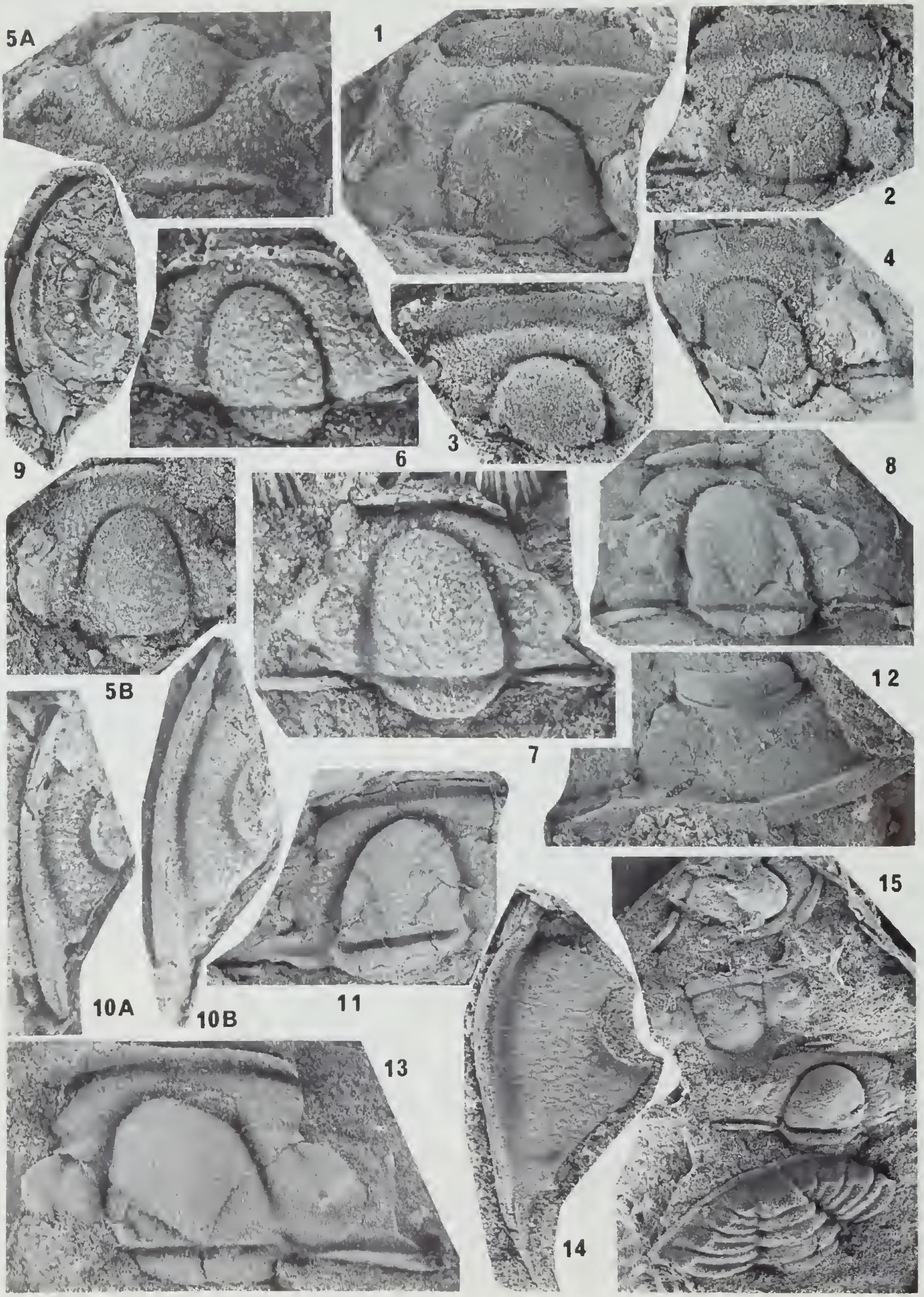
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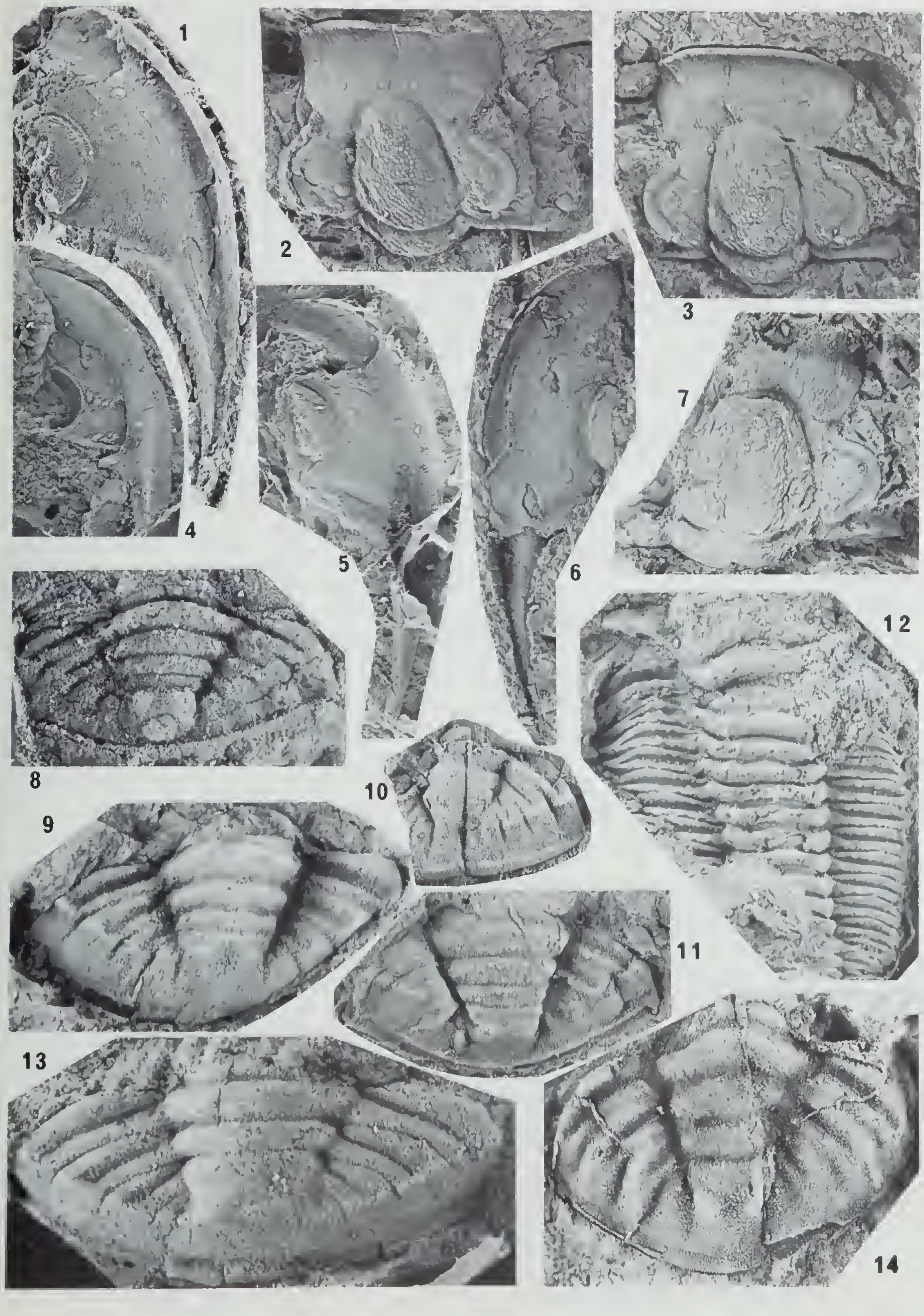
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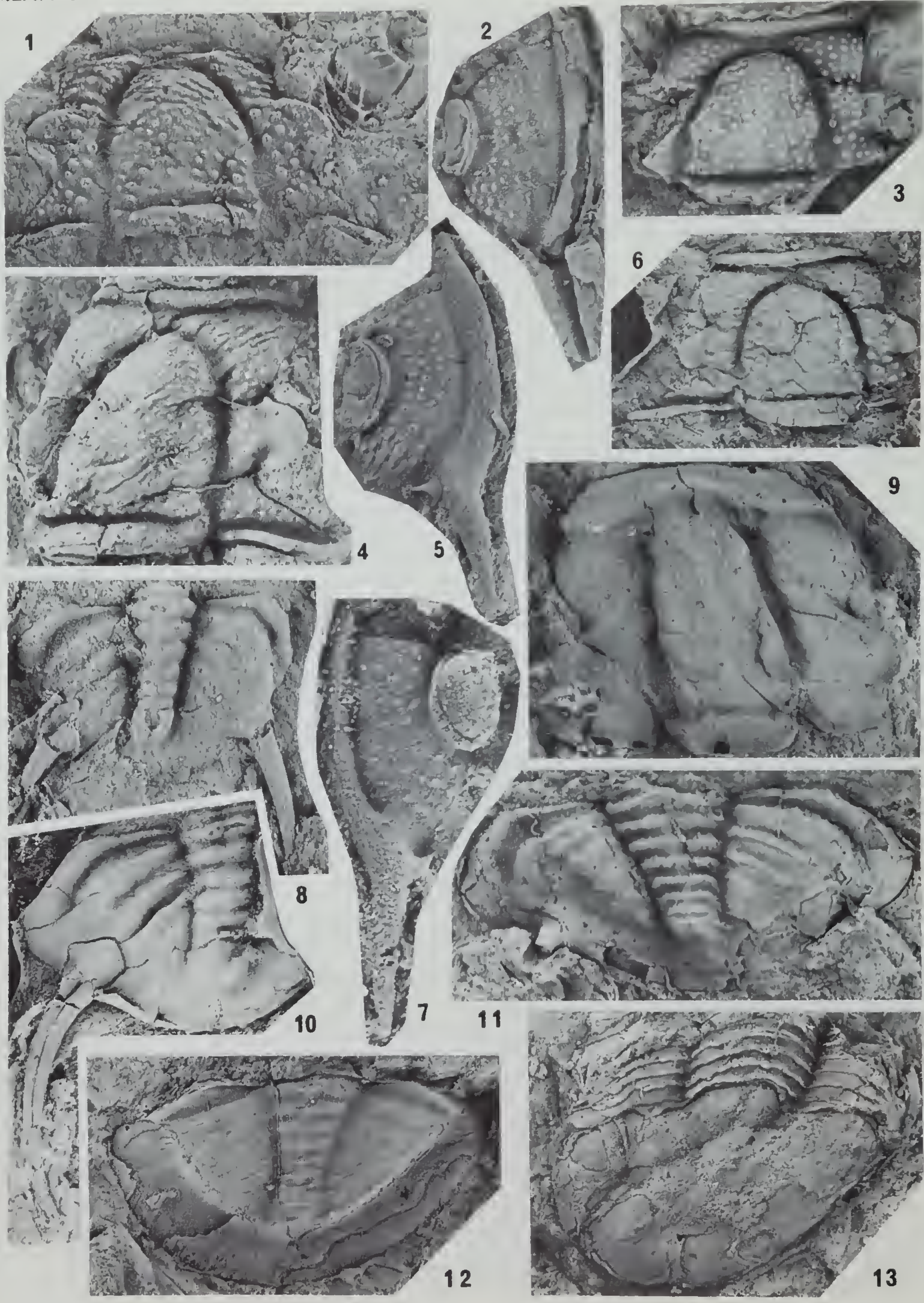
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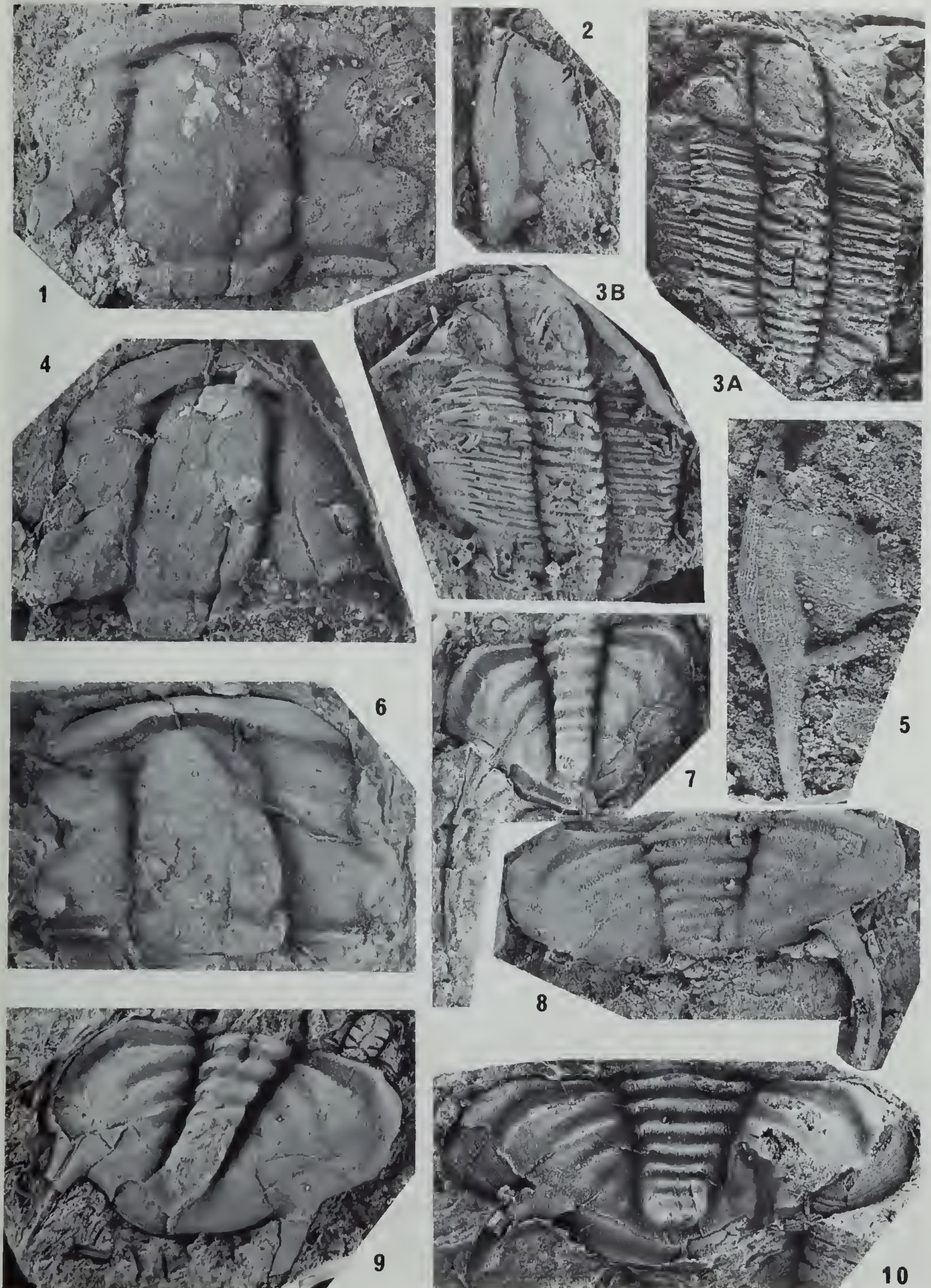
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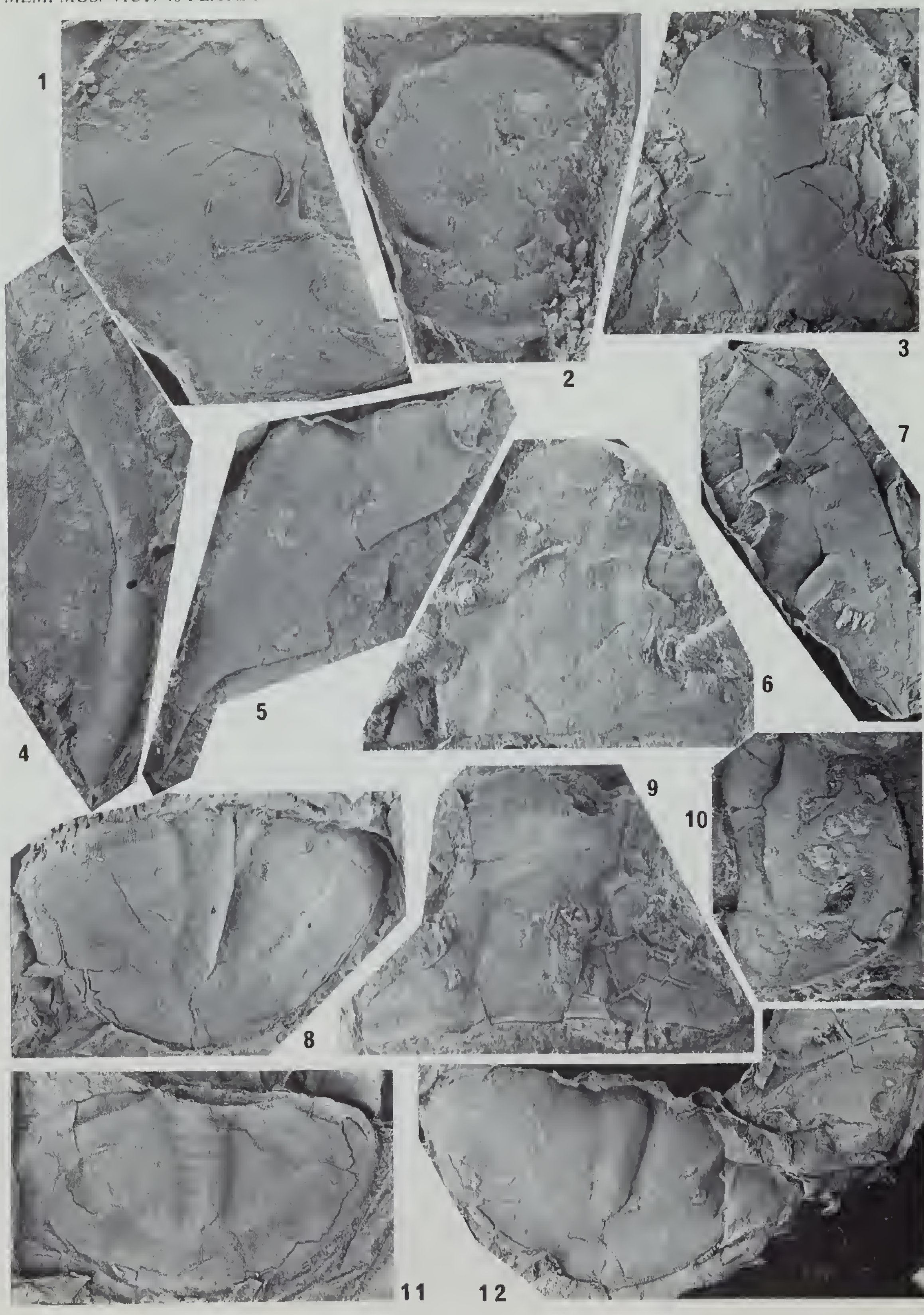
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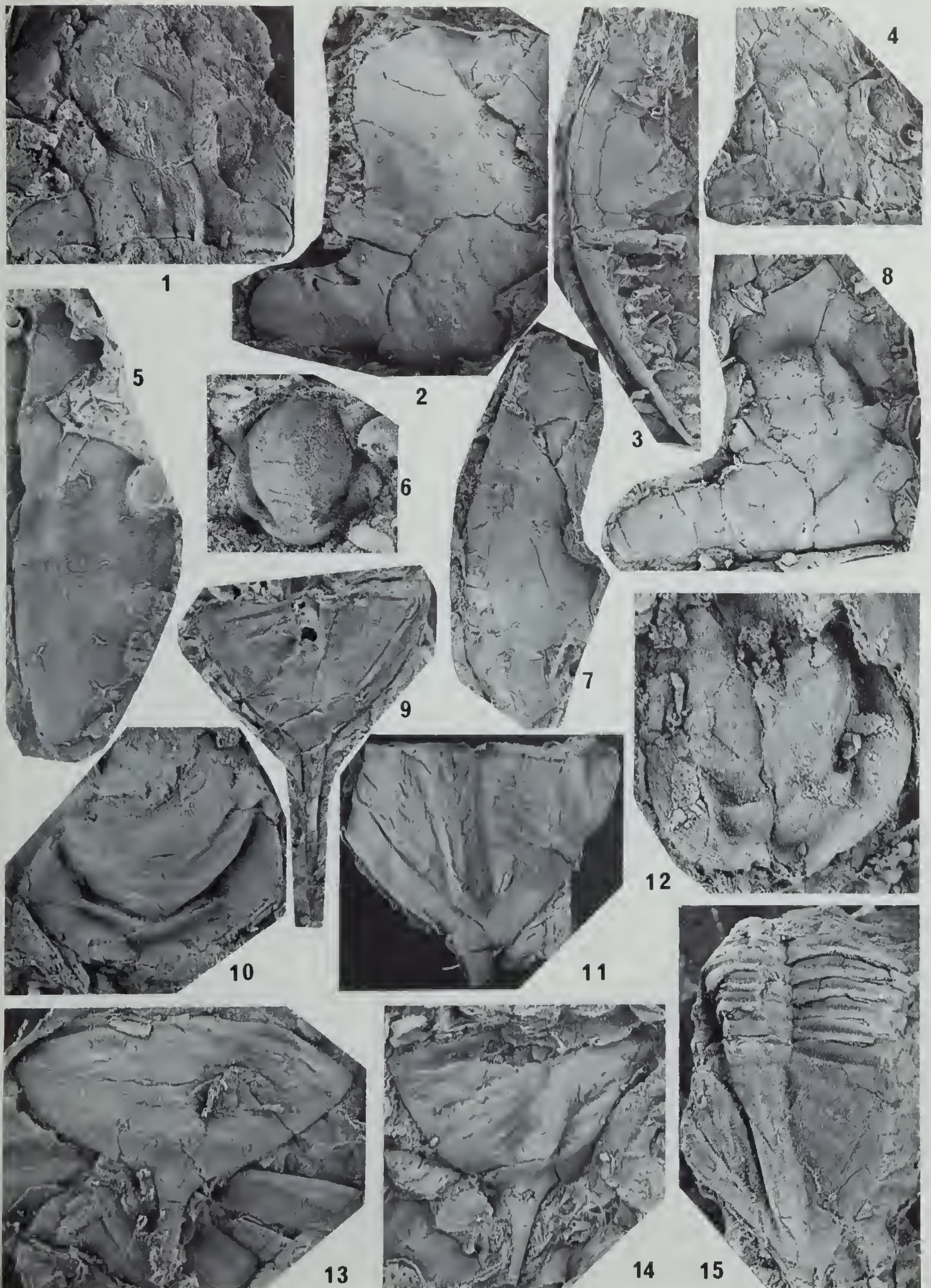
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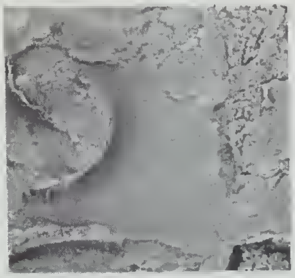

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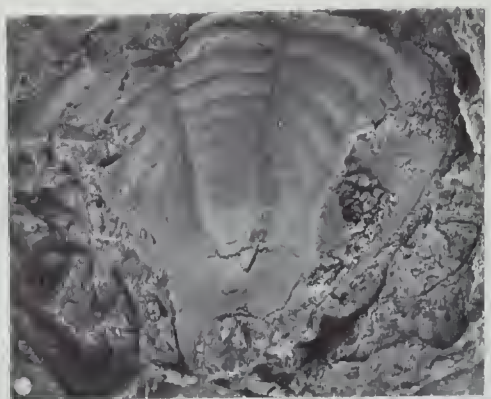

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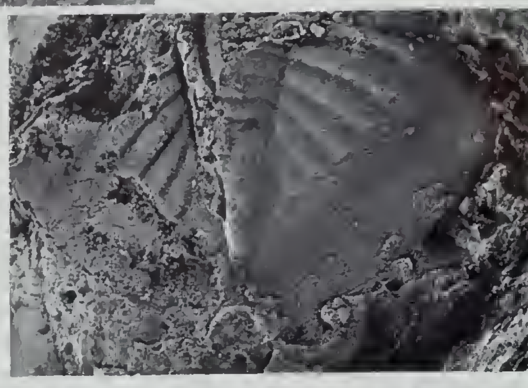

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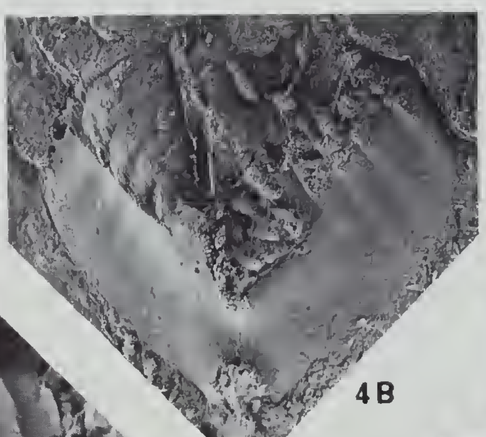

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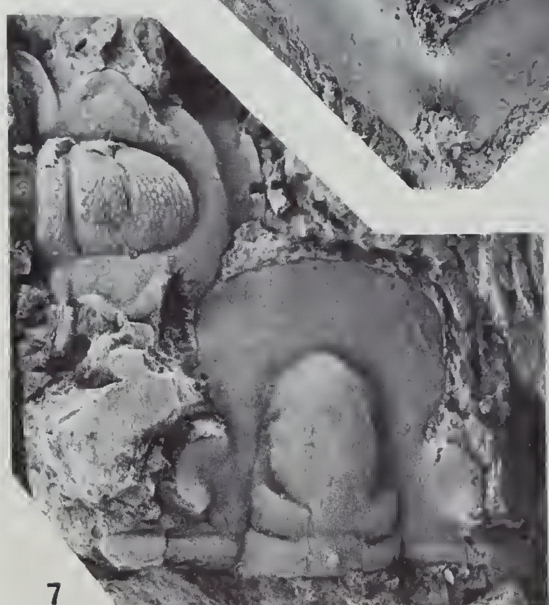

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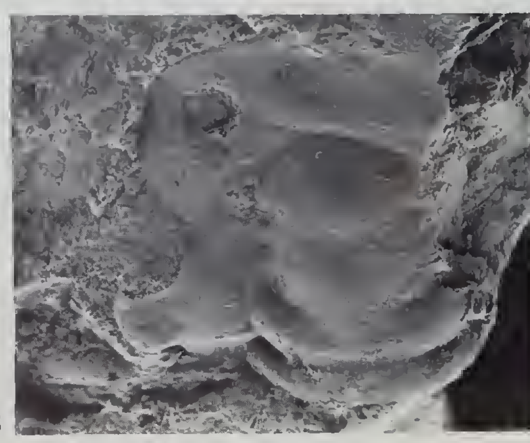

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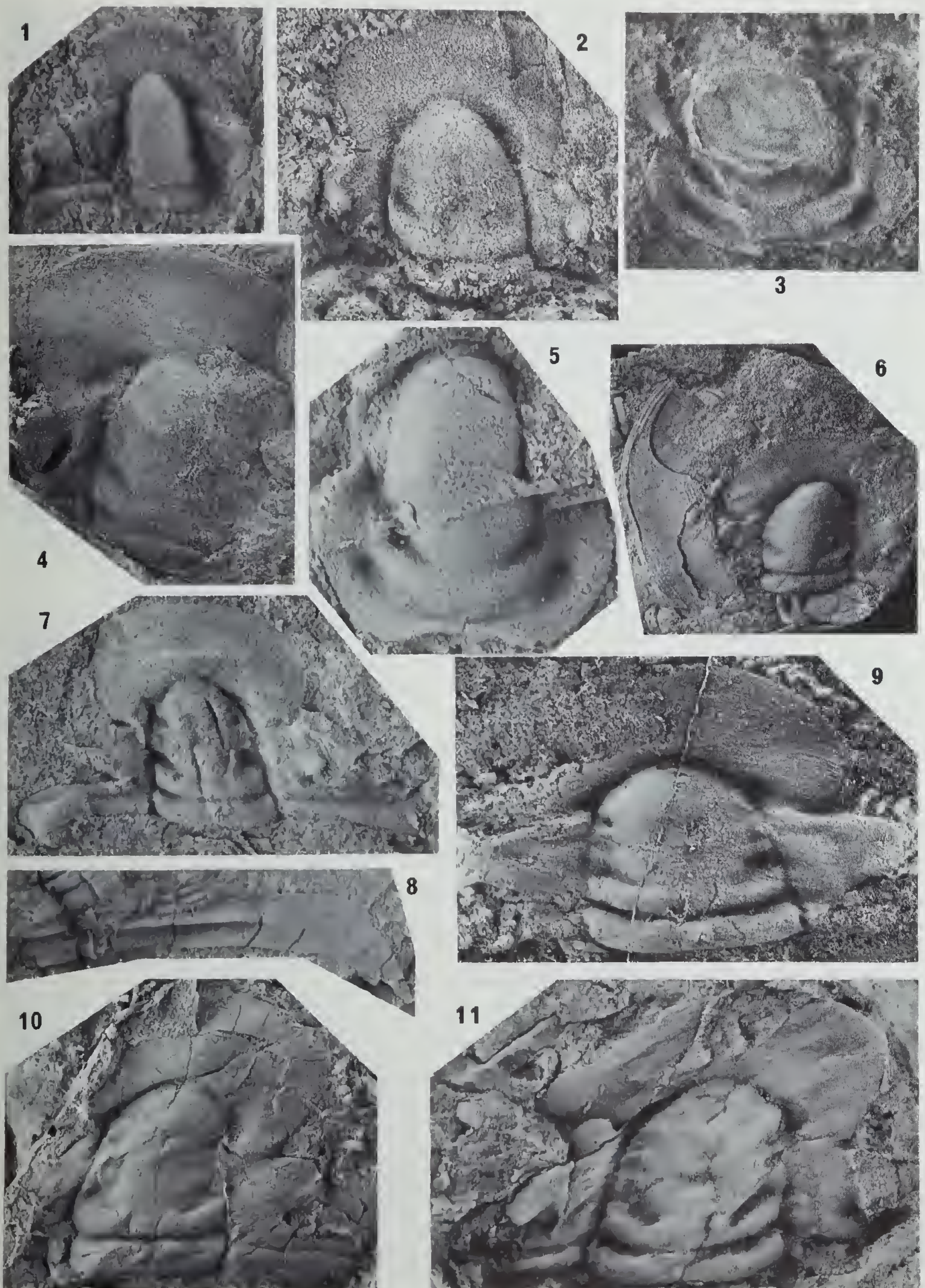
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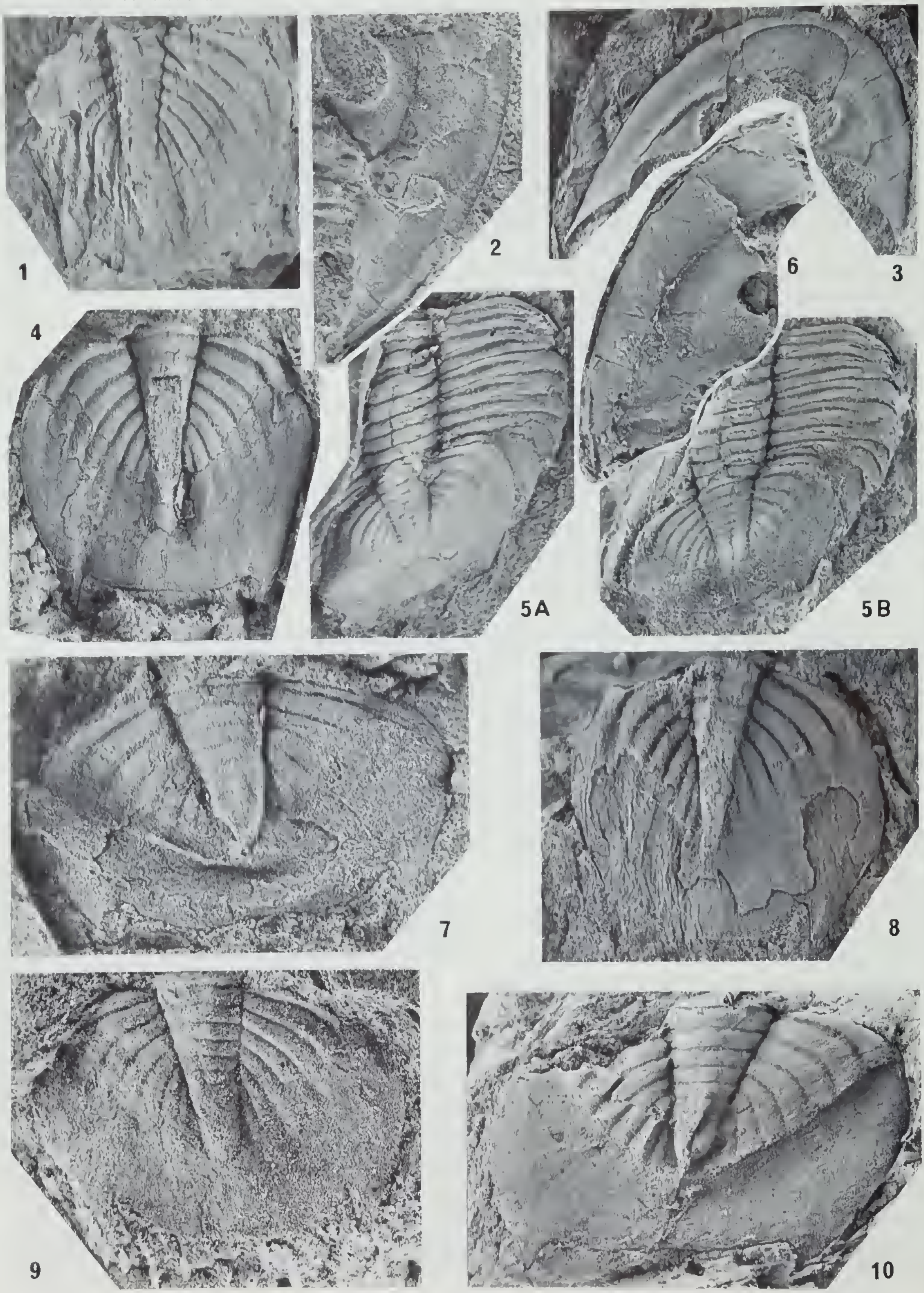
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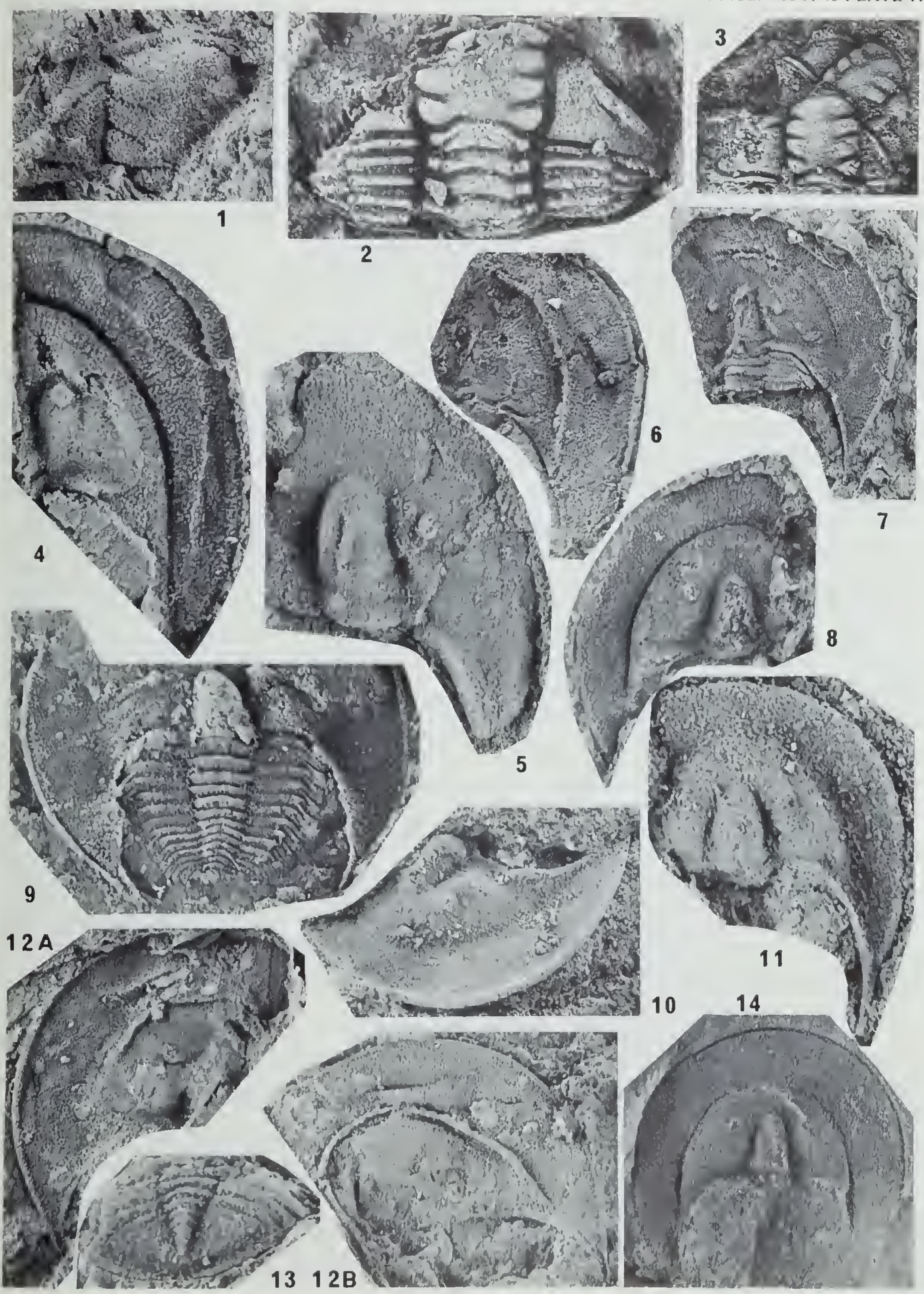
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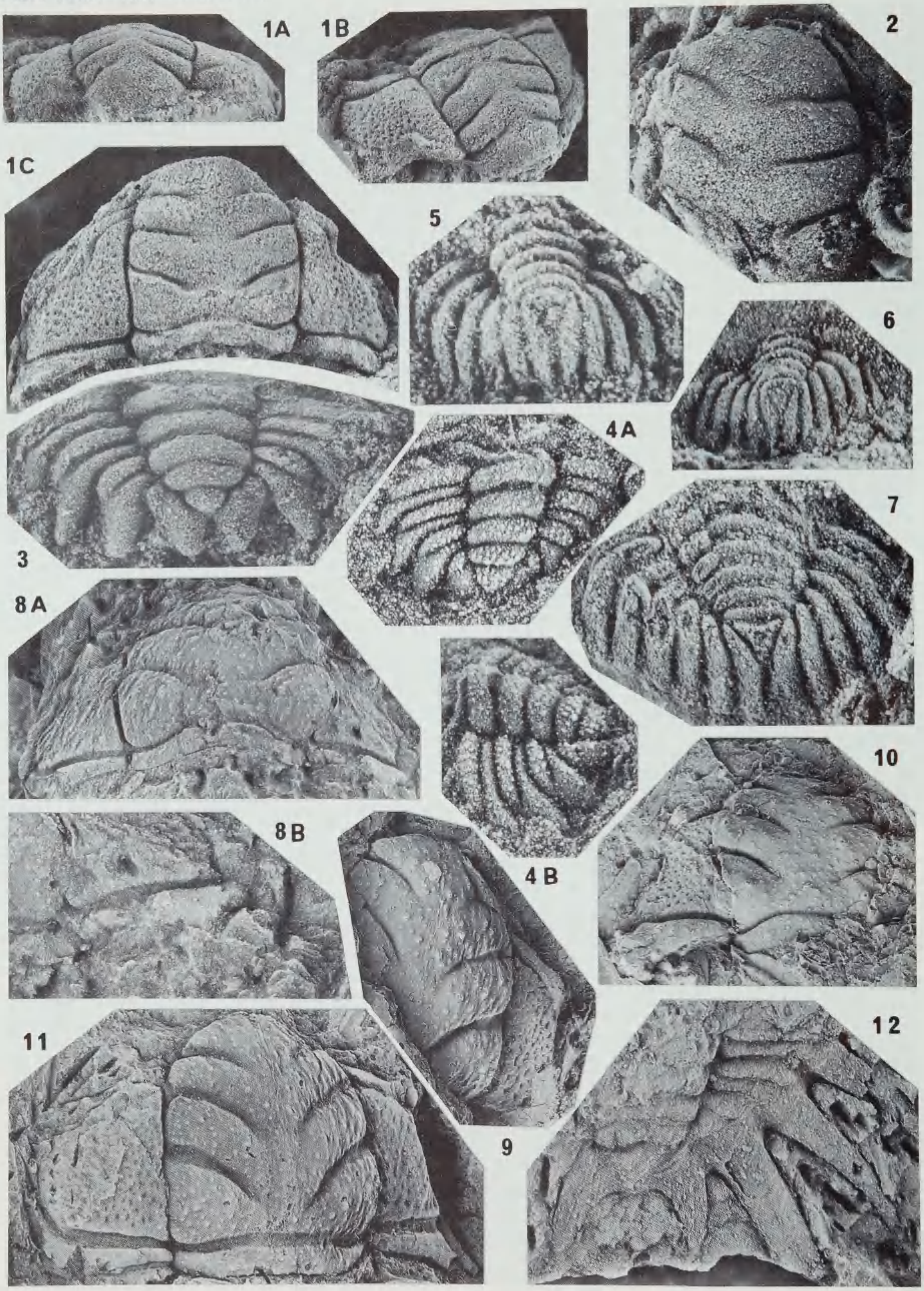
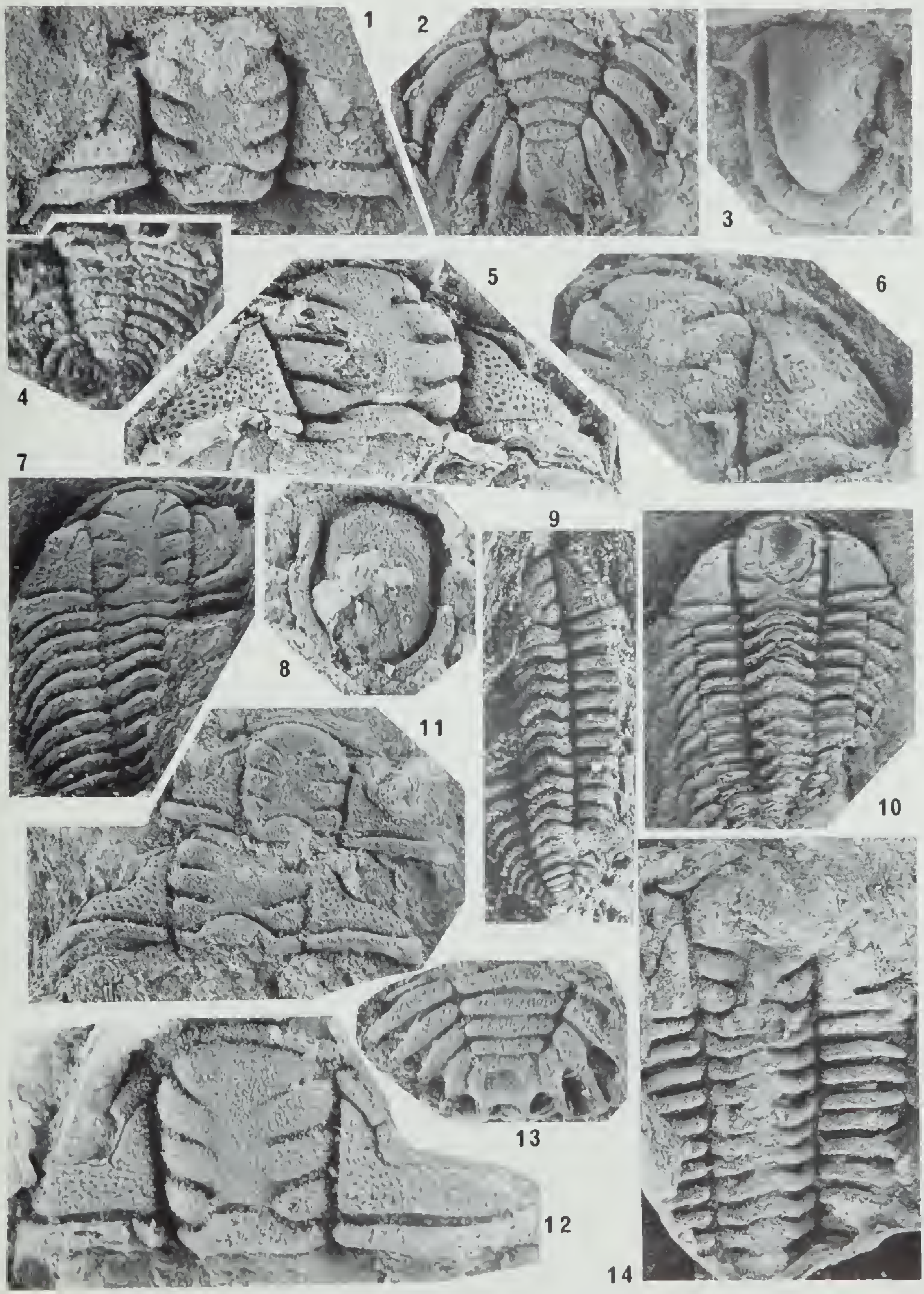

1A
1B
2
1C
5
6
4A
7
3
8A
10
8B
4B
11
12
9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