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TREMADOC TRILOBITES OF THE DIGGER ISLAND FORMATION, WARATAH BAY, VICTORIA

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Abstract

Trilobites of the Digger Island Formation at Digger Island, 1.5 km south of Walkerville on Waratah Bay, South Gippsland are described and assigned an early Tremadoc age approximately equivalent to the *Kainella meridionalis* zone of Argentina. It is impossible to correlate directly with any known Australian sequence but indirectly it is considered older than La 1.5 zone of the Victorian graptolite sequence and approximately contemporaneous with the *Oneotodus bicuspatus-Drepanodus simplex* zone of western Queensland. Four new genera, *Natmus* (Hystricuridae), *Barachyhipposiderus* (Harpedidae), and *Landyia* and *Victorispina* (Pilekiidae) are erected with eleven new species, *N. victus*, *N. tuberus*, *B. logimus*, *L. elizabethae*, *V. holmesorum*, *Neoagnostus eckardti*, *Onychopyge parkerae*, *Pseudokainella diggerensis*, *Australoharpes singletoni*, *A. expansus*, and *Protopliomerops lindneri*. New taxa left in open nomenclature are referred to *Pilekia*, *Tessalacauda*, and the Hystricuridae. The Argentinian species *Micragnostus hoeki* (Kobayashi, 1939), *Shumardia erquensis* Kobayashi, 1937, and *Leiostegium douglasi* Harrington, 1937 are identified.

Introduction

Digger Island is a small stack approximately 75 m in diameter, isolated from the mainland above half-tide, and situated approximately 1.5 km south of Walkerville on the western shore of Waratah Bay, South Gippsland; it consists of brown, largely decalcified mudstones containing a rich faunule of trilobites, brachiopods, gastropods, hyolithids, and isolated cystoid plates. The first detailed account of the geology of this coastline (Lindner, 1953), to which readers are referred for details of locality and geological setting, contained a list of trilobite identifications by O. P. Singleton with nine specific and two generic *nomina nuda*. He assigned the faunule an early Tremadoc age on the basis of identifications of *Leiostegium* and *Kainella*.

Singleton (1967) divided the formation informally into three parts; 1, a lower portion of massive recrystallised grey limestone without fossils except for a single nautiloid; 2, brown decalcified mudstone with the trilobites and associates; and 3, upper shales and muddy limestones with orthoid brachiopods. On this occasion he listed only six trilobites at generic level and reiterated the Tremadoc age of the beds.

Kennedy (1971) recorded *Cordylodus rotundatus*, *Onetodus* sp., and *Drepanodus* spp. from the formation and concurred with the Tremadoc age. These conodonts were derived from samples taken some distance along strike from the trilobite locality; they come from near locality 2 of Lindner (1953, fig. 3) (D. J. Kennedy pers. comm.). Webby *et al.* (1981) using *Kainella* and *Leiostegium* made a direct correlation between the *Kainella-Leiostegium* zone (i.e. trilobite zone D of Ross (1951) and Hintze (1953) in North America) and the Digger Island Formation fauna; they also made an indirect correlation between this North American zone and the LA 1.5 zone of *Psigraptus* of Cooper and Stewart (1979). At the same time, however, they showed the Australian trilobite fauna of the pre-Lancefieldian Datsonian stage as Leiostegiid/Kainellid/Ceratopygid (*Onychopyge*) whereas the Warrendian (contemporary of the Lancefieldian), had only a Leiostegiid component mentioned. If the association of leiostegiid with kainellid is so important then the text and chart of Webby *et al.* (1981) seem incongruous.

Jones *et al.* (1971, p. 23) suggested a late Tremadoc to early Arenig age for the Digger Island Formation.

None of the attempts to date the trilobite faunule has been based on detailed taxonomic study as evidenced by the description herein of 18 separate taxa; all were collected in decalcified mudstone in the middle of the Digger Island Formation, on the northern and western sides of Digger Island below or just above high tide level (Fig. 1).

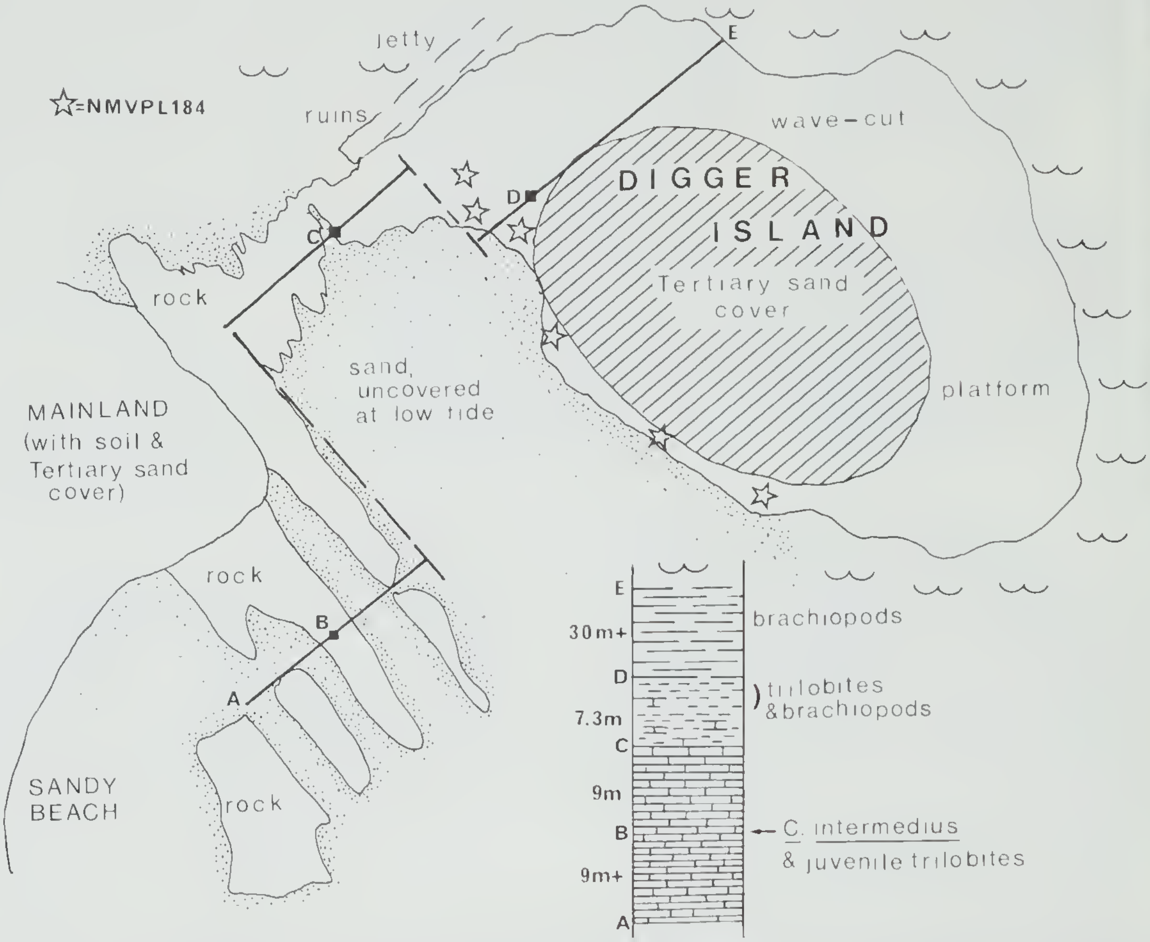

Figure 1. Sketch of Digger Island area showing position of section illustrated below as well as fossil collecting sites. Not drawn to scale and with north point approximately up page. C and D mark boundaries between members within the formation.

All illustrated material and other studied material are housed in the Palaeontological Collections of the Museum of Victoria (prefix NMVP) and the collecting site is designated NMVPL184 on the locality register of the same institution.

I am grateful for all the kindnesses listed below as well as any that I have inadvertently overlooked. Several people made collections for the Museum over a number of years, principally R. J. Paton, Eric Wilkinson, Peter Corcoran, Frank and Enid Holmes, Steve Eckardt, and John Talent. Other visitors, too numerous to mention have helped me to collect on various occasions. Des Strusz, Bureau of Mineral Resources, loaned material for study from the BMR collections. Tom Bolton, Geological Survey of Canada provided photographs of *Pilekia apolla*. Richard Fortey, British Museum (Natural History), provided useful correspondence. Mr and Mrs Tony Landy of Walkerville South allowed access through their property and showed a keen interest in the project. Charlotte Parker assisted with sorting collections, some preparation and some photography. Penny Clark printed most of the photographs from my negatives. Annette Jell gave constant support especially on several collecting trips and with curation of specimens. Heather Martin typed the manuscript.

Stratigraphy

A section (Fig. 1) was measured through part of the lower portion of the Digger Island Formation on the mainland opposite the southern side of Digger Island then offset along strike to measure the remainder of the Formation exposed along the northern side of the island. The description of lithology (Singleton, 1967) is verified but in view of the large component of mudstone and variety of lithologies, Lindner's (1953) original designation, Digger Island Formation, is retained.

Age

The trilobites of the Digger Island Formation described below are:

Micragnostus hoeki (Kobayashi, 1939)
Neoagnostus eckardti sp. nov.
Shumardia erquensis Kobayashi, 1937
Parahystricurus sp. cf. *P. fraudator* Ross, 1951
Hystricuridae gen. et sp. nov.
Natmus victus gen. et sp. nov.
Natmus tuberus gen. et sp. nov.
Leiostegium douglasi Harrington, 1937
Onychopyge parkerae sp. nov.
Pseudokainella diggerensis sp. nov.
Australoharpes singletoni sp. nov.
Australoharpes expansus sp. nov.
Brachyhipposiderus logimus gen. et sp. nov.
Landyia elizabethae gen. et sp. nov.
Victorispina holmesorum gen. et sp. nov.
Pilekia sp.
Tessalacauda ? sp.
Protopliomerops lindneri sp. nov.

Correlation of this faunule on the basis of trilobites is much more difficult than previously thought and reference to the North American *Kainella-Leiostegium* zone cannot be considered certain; it does not contain *Kainella*, but rather *Pseudokainella* and *Leiostegium* is now known to be a longer ranging genus then previously thought (Chugaeva & Apollonov, 1982; Druce *et al.*, 1982).

Of species found elsewhere *P. fraudator* suggests late Tremadoc while *M. hoeki*, *S. erquensis* and *L. douglasi* occur together in the early Tremadoc zone of *Kainella meridionalis* in Argentina. *Onychopyge*, considered by Robison and Pantoja-Alor (1968) to be indicative of earliest Tremodoc and also occurring in the *K. meridionalis* zone, occurs with *K. meridionalis* in New Zealand (Shergold *et al.*, 1982) although that identification is not yet substantiated by description or illustration. Four of the genera (*Leiostegium*, *Parahystricurus*, *Pilekia*, and *Tessalacauda*) occur in trilobite zone E (Ross, 1951; Hintze, 1953). *Pilekia* sp. is not unlike *Pilekia* sp. nov. from OT3 on the Gordon Road section (Jell & Stait, 1985) but none of the other 17 species from Digger Island even resemble any of the other species from the relatively close (geographically) Tasmanian fauna so a correlation would be difficult to accept.

In China Zhou and Zhang (1978) established an *Alloleiostegium-Onychopyge* Zone (*Alloleiostegium* = *Leiostegium*) based on a fauna containing *Onychopyge* similar to *O. parkerae*, a punctate species of *Leiostegium*, and a species of *Micragnostus* not unlike *M. hoeki*. This assemblage is the most likely to correlate with the Digger Island assemblage described below. The Chinese assemblage occurs within 15 m of *Dictyonema flabelliforme* in a section in Jilin Province (Chen *et al.*, 1983). However those authors considered that zone to correlate with the conodont zone immediately older than the one with which I correlate the Digger Island horizon. While their correlation may well be correct it does not take into account the occurrence of *Cordylodus intermedius* to the base of the *C. proavus* zone (Fortey *et al.*, 1982) nor does it acknowledge a range for *Onychopyge* as suggested by the Argentinian occurrences (Harrington & Leanza, 1957).

I consider that the Digger Island Formation trilobite fauna may best be correlated with the *Kainella meridionalis* zone of Argentina. They both contain the species *M. hoeki*, *S. erquensis*, and *L. douglasi* and have similar species of *Australoharpes*, *Pseudokainella*, and *Onychopyge* (Harrington & Leanza, 1957, pp. 16, 24, 246, 250). It should be noted that although *Onychopyge* is not tabulated by Harrington and Leanza (1957, table 1) as occurring in the *K. meridionalis* zone they (1957, p. 246) do list *Onychopyge* sp. in association with a *K. meridionalis* fauna from Rio Bocoya (upper Rio

Iruya) Santa Victoria Department of Salta Province (S. Vic-4). Further, the fauna from dark green and blue shales with dark blue marls and marly limestone in the Rio Volcancito section downstream from Puesto Nuevo (Harrington & Leanza, 1957, pp. 15, 16) on closer examination does not clearly belong to the *Parabolina argentina* zone. Of 22 species recorded nine occur at this locality only and a further eight have been found to range into the *K. meridionalis* zone already, so the older age is based on five species of which only two are widespread. It is possible that the range of these five species was greater than Harrington and Leanza (1957) thought. It should be noted also that Harrington & Leanza (1957, p. 250) recorded *Kainella* cf. *meridionalis* as coming from this locality which may indicate mixing of the two faunas in the collections from this 250 m of section. The association of *Dictyonema flabelliforme* with trilobites of the *K. meridionalis* zone suggests that this zone is older than the *Clonograptus-Psigraptus* zone (Cooper, 1979) and the basis for time equivalence of these zones (Ludvigsen, 1982a) is not clear although it is not impossible.

Assigning the Digger Island Formation trilobites to the *K. meridionalis* zone may explain the complete distinction between the Tasmanian and Victorian faunas—the latter is older, albeit only slightly older, than any Tasmanian Ordovician trilobite faunas so far described of which the oldest has been correlated with the *Psigraptus* zone (Jell & Stait, 1985). It would also suggest that the generic similarity with North American trilobite zone E refers to long ranging genera that migrated from Australia and Argentina to North America during the middle Tremadoc. I suggest that the species level correlation with Argentina is more significant than the generic level correlation with Utah even though it is based on fewer taxa at these levels. However, at the generic level the Argentinian correlation is based on more taxa.

The section (Fig. 1) shows that the level from which *Cordylodus intermedius* was extracted (K. Kenna, pers. comm.) was below the trilobite horizon and also, the horizon from which Kennedy (1971) extracted *C. rotundatus* was probably in the lower member, but some 300 to 400 m along strike, with no guarantee of continuity of the bedding (D. Kennedy, pers. comm., on site, August 1983).

Cordylodus intermedius ranges to the base of the *C. proavus* zone (Fortey *et al.*, 1982) so it is not useful for correlation in this case. The occurrence of *C. rotundatus*, if it is found to be in a continuous sequence with trilobites, suggests correlation with the zone of that name in the Black Mountain section of western Queensland and with North American conodont and trilobite zones B. The latter is compatible with Ludvigsen's (1982a, fig. 6) correlation of the *K. meridionalis* zone of Argentina also with North American zone B. However if the morphological similarities between *Leiostegium douglasi* from Victoria and *L. floodi* Shergold, 1975 from Queensland (see below) have any significance then the fauna could correlate with the *Oneotodus bicuspatus-Drepanodus simplex* zone (Shergold, 1975). The cited occurrence of *L. floodi* in the *C. oklahomensis-C. lindstromi* zone (Druce *et al.*, 1982) is in error (J. H. Shergold, pers. comm. Nov. 1983). In fact direct correlation with any other Australian fauna is impossible at present.

Based on this information I assigned the Digger Island Formation fauna an early Tremadoc age, correlative with the *Kainella meridionalis* zone of Argentina and thereby probably contemporaneous with Lancefieldian 1 zone faunas of the Victorian graptolite sequence and possibly *O. bicuspatus-D. simplex* zone faunas of western Queensland, i.e. it is older than suggested by Webby *et al.* (1981).

Preservation

The trilobites are preserved as moulds in very fine-grained decalcified mudstone but in many specimens a white mineral replacement has filled the void left after the exoskeleton; this mineral has come out of the mould with the latex cast in many instances (Pl. 19, figs 9, 10, 14; Pl. 20, fig. 12A, Pl. 27, fig. 1B).

The fossils have undergone considerable distortion after burial as evidenced by compression in all directions on different specimens. This, along with observations during collection, indicates that the fossils were not strictly in bedding planes but were oriented at any angle to

Figure 2. Pygidium (NMVP74460) of *Protopliomerops lindneri* illustrating the difference in appearance between internal mould (left) and latex cast from external mould (right).

the horizontal very often in small pockets of individuals lying on top of each other. Most of the individuals illustrated, came not from these agglomerations but rather from the less crowded areas where preservation was more complete. Distortion also took the form of fracture of exoskeletons in almost every species, certainly the larger ones. This fracturing affected some individuals but not others of the same species and flexibility of the exoskeleton is shown by some unfractured individuals (e.g. Pl. 27, fig. 1A). Long delicate spines are retained and many articulated specimens are preserved so the environment must have been quite tranquil. Presumably, therefore, the fracturing was immediately post-depositional before lithification and the distortion by compression could have been anytime during diagenesis. Large flat cranidia of *Australoharpes expansus* (Pl. 28, figs 2, 4B) show that a weak cleavage was just beginning to develop.

The pygidia of *Landyia elizabethae* (Pl. 30, fig. 8; Pl. 31, fig. 2) and of *Protopliomerops lindneri* (Fig. 2) show clearly the different morphologies of internal mould and external surface when the exoskeleton has some thickness; they warn against the use of internal moulds only, when describing decalcified specimens.

Systematic palaeontology

Terminology follows Harrington, Moore and Stubblefield (1959) as far as possible; 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). Occipital ring is included in the glabella. 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 explanations of the plates and most distinguishing characters are not measurements.

Class Trilobita

Family AGNOSTIDAE McCoy, 1849

Subfamily Agnostinae McCoy, 1849

Micragnostus Howell, 1935

Type species (by original designation): *Agnostus calvus* Lake, 1906.

Remarks: I follow Fortey (1980) in the concept of this genus with the transverse glabellar furrow well in front of the glabellar node being particularly distinctive.

Micragnostus hoeki (Kobayashi, 1939)

Plate 19, figures 6-14

1937 *Geragnostus tullbergi* Novak; Kobayashi, p. 464, pl. 2, figs 3-5.
1938 *Geragnostus tullbergi* Novak; Harrington, p. 160, pl. 4, fig. 2 (NOT fig. 1).
1939 *Geragnostus hoeki* Kobayashi, p. 169, 171.
1957 *Geragnostus (Micragnostus) hoeki* Kobayashi; Harrington & Leanza, p. 68, fig. 11-3, 4, 5, 6.

Material: Lectotype (designated Harrington & Leanza, 1957, p. 68), cranidium figured by Kobayashi (1937, pl. 2, fig. 3), paralectotypes cranidium and pygidium figured by Kobayashi (1937, pl. 2, figs 4, 5) from Bolivia. Some 40 to 50 internal and external moulds from NMVPL

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184 including NMVP74324 to 74332 are assigned to this species.

Description: Cephalon with inverted U-shaped margin forward of genal angles, moderately convex; glabella tapering gently forward, to rounded or subacuminate anterior, convex and raised above cheeks, 0.7 of cephalic length and 0.4 of width, with well-impressed transverse transglabellar furrow isolating anterior glabella lobe 0.3 of total glabellar length, with prominent median node situated well behind transglabellar furrow, with two pairs of rounded muscle scars evident on posterior lobe of internal moulds with more posterior pair at level of node; axial furrow extending a little forward as the basal part only of a median preglabellar furrow; basal lobes small, triangular; cheeks smooth or with faint radial furrows (scrobiculations) on anterolateral parts of internal moulds; border furrow long and shallow anteriorly, virtually only a change in slope; border tapering and twisting to become steeper posteriorly, virtually a flange around the cheeks with very little convexity.

Pygidium U-shaped in outline, strongly convex, wider than long; axis parallel-sided, flaring slightly anteriorly adjacent to first segment, rounded posteriorly, occupying 0.6 of length and 0.7 of width of pygidium; anterior segment consisting of pair of subtrapezoidal lobes isolated by first transaxial furrow swinging forward to articulating furrow (not connected across axis at all); second segment longer than first, with short wide teardrop-shaped median tubercle encroaching slightly over terminus with small median pointed extension; second transaxial furrow transverse, continuous, very poorly impressed to obsolete; axial furrow poorly impressed but becoming less distinct posteriorly around terminus especially on external surface; border furrow defined by marked change of slope only; border and border furrow forming wide flange that tapers anteriorly and slopes gently laterally, with pair of small marginal spines situated just forward of the level of the posterior of the pleural areas, with border of considerable length and uniform between spines.

Remarks: Although Kobayashi's (1937) illustrations and description are inadequate as noted by Harrington and Leanza (1957), the amplifying illustrations of the latter authors make identity of this species clear. There can be little doubt about the identity of the Victorian material as all features are in agreement when some allowance is made for the compression of the Argentinian specimens relative to the full relief of the Victorian ones. The articulated specimen (Pl. 19, fig. 7) is illustrated only to show the association of head and tail; its surface is badly abraded even by applying colloidal graphite for photography.

This species may be distinguished within the genus by the combination of wide border, axis occupying relatively small part of pygidium, course of first transaxial furrow on pygidium and development of posterior part of median preglabellar furrow. Features outlined by Fortey (1980) as characteristic of this genus are all readily apparent, in particular the position of the glabellar node and transglabellar furrow.

Family DIPLAGNOSTIDAE Whitehouse, 1936

Subfamily PSEUDAGNOSTINAE Whitehouse, 1936

Neoagnostus Kobayashi, 1955

Type species (by original designation): *Neoagnostus aspidoides* Kobayashi, 1955.

Neoagnostus eckardti sp. nov.
Plate 19, figures 1-5

Etymology: This species is named for Mr Steve Eckardt who donated material towards this study.

Material: Holotype NMVP74323, paratypes NMVP74319 to 74322, all from NMVPL184.

Diagnosis: Members of *Neoagnostus* with wide border furrow and border, with median preglabellar furrow, with chevron-shaped median lateral furrows on posterior glabellar lobe, with glabellar node in angle of the chevron, with rounded glabellar anterior. Pygidium with elongate bulbous but not bifid axial node on second segment, with almost circular areas in the third axial ring just posterolateral to glabellar node well-defined by discontinuous transaxial furrows, with prominent median node just forward of border furrow, with short marginal spines at a level as far forward of the posterior median node as the length of the posterior border.

Description: Cephalon with evenly curved margin, widest at level of anterior glabellar lobe; glabella occupying 0.75 of cranidial length, anteriorly rounded, with anterior and posterior glabellar furrows joined by short sag-gittal furrow isolating two large lobes giving spectaculate appearance in sense of Shergold (1977); anterior transglabellar furrow in waveform, with anterior crests laterally and angular posterior crest medially; posterior transglabellar furrow ('median lateral furrow of posterior glabellar lobe' of Shergold, 1975) chevron shaped, well-impressed throughout; prominent glabellar node in angle of chevron; posterior half of glabella rounded (in sense of Opik, 1967), with small posteromedian node barely evident (clearly evident upon examination with microscope); basal glabellar lobes triangular, joined behind glabella; preglabellar median furrow shallow but distinct, continuing to border furrow; cheeks smooth; border furrow wide, shallow, tapering posteriorly; border only a narrow marginal rim barely raised but convex, also tapering posteriorly to almost nothing at genal angle; posterior border furrow sharp, at angle to transverse, dividing off subtriangular posterior border.

Pygidium subquadrate to subovoid, strongly convex; internal mould showing distinct axial furrows converging posteriorly but reaching only as far as rear of the axial node, with division between first and second axial rings (in front of node) not evident, with prominent teardrop-shaped undivided median node on second ring, with transaxial furrow at rear of node transverse laterally then curving back behind node near axis, with subcircular lobes (probably muscle attachment scars) anterolaterally on third ring outlined by distinct furrows; anterior margin of first axial ring convex forward laterally, arched back medially; prominent medial node just above posterior border furrow; border furrow shallow, of uniform width; border wide, not markedly differentiated from border furrow, tapering forward over anterior half of pygidium, with faint epiborder furrow (Pl. 19, fig. 1A) posteriorly between the spines ('zonate' in the terminology of Opik, 1967), with pair of short marginal spines situated well in front of the posteromedian node just in front of border furrow.

Remarks: Morphological features described place this species in the *bilobus* Group of *Neoagnostus* as defined by Shergold (1977). The only feature that needs emendation in the light of this new species and which distinguishes the species from others is the reference to the level of the pygidial marginal spines; whereas in all species noted by Shergold (1977, p. 79) these spines are level with the rear of the pleural areas or behind it, *N. eckardti* has the marginal spines the length of the posterior border in front of that transverse line. The epiborder furrow posteriorly on the pygidium (Pl. 19, fig. 1A) is also unique within the Group. *Pseudagnostus quasibilobus* Shergold, 1975 may be distinguished by its less distinct glabeller furrows, more angular glabellar rear, lack of third pair of muscle scars on pygidial axis (on exfoliated specimens) and by the posterior position of the pygidial marginal spines. Other Australian species of *Neoagnostus* have been assigned to different species groups of the genus and the diagnoses of the species groups. (Shergold, 1977) distinguish each of them from *N. eckardti*, making direct comparisons unnecessary.

Movement forward of pygidial marginal spines between Late Cambrian species of the Group and *N. eckardti* might appear to be the lineage that was suggested to exist by Fortey (1980) leading to *Arthrorhachis* and/or the rest of the Metagnostinae in which the forward position of the spines is normal. However, the fact that the first transaxial furrow in *Arthrorhachis* is well impressed and the third pygidial axial ring is undivided suggest that the Metagnostinae arose by another lineage and that the migration of the marginal spines was a phenomenon of each. It is however, further support for Fortey's (1980) contention that they need to be included within the same higher taxon.

Family SHUMARDIIDAE Lake, 1907

Shumardia Billings, 1865

Type species (by original designation): *Shumardia granulosa* Billings, 1865.

Shumardia erquensis Kobayashi, 1937

Plate 19, figures 15-19

Material: The specimen figured by Kobayashi (1937, pl. 6, fig. 1) is herein designated lectotype and the other cranidium and pygidium figured by Kobayashi (1937, pl. 6, figs 2, 3) become paralectotypes. Five cranidia NMVP 74333 to 74337 are known from NMVPL184.

Remarks: Kobayashi's (1937, p. 483) description reiterated by Harrington and Leanza (1957, p. 79) is adequate for the material in hand. The slightly expanded frontal glabellar lobe, two pairs of lateral glabellar furrows, preglabellar field of identical length, well-impressed occipital and posterior border furrows, fine border and broadly rounded glabellar anterior are all evident on one or other specimen. It should be noted that the preglabellar field in the Argentinian material appears longer than in the Victorian because of compression in the former but the full length, mostly in an almost vertical slope, in the latter is apparent in anterior view (Pl. 19, fig. 19A). The close similarity and possible synonymy with the Swedish species *S. bottnica* Wiman, 1905 as discussed by Harrington and Leanza (1957) needs further investigation as the apparent absence of glabellar furrows on the Swedish species may simply be due to lack of detail in the wash drawing or to poor preservation. In the Victorian material the degree of expansion of the frontal glabellar lobe is variable so that at least one specimen has a parallel-sided glabella with virtually no expansion. Taking this degree of variability into account it appears almost impossible to generically separate *S. erquensis* from *Eoshumardia cylindrica* Shergold, 1971 in which the faint lateral glabellar furrows are illustrated (Shergold, 1975, pl. 58, figs 2, 3). However, *S. erquensis* could not be assigned to *Koldinioidia* Kobayashi, 1931 in the light of Shergold's (1975) emended diagnosis of that genus.

Family HYSTRICURIDAE Hupe, 1953

Parahystricurus Ross, 1951

Type species (by original designation): *Parahystricurus fraudator* Ross, 1951, from Zone 'F' of the Garden City Formation in northeastern Utah.

Parahystricurus sp. cf. **P. fraudator** Ross, 1951

Plate 20, figures 1-3

Material: Four (three internal moulds and one external mould) damaged cranidia including NMVP74338 to 74340 in various states of completeness from NVMPL184.

Remarks: These cranidia provide an incomplete understanding of the Victorian population. However, there are few points of disagreement with material figured by Ross (1951). The preglabellar field is apparently a little longer in the Utah population but appears to be variable in the Victorian population and this may not be a distinctive feature. The 1p lateral glabellar furrow appears to be more deeply impressed in the internal moulds from Victoria than on the external surfaces from Utah; this difference appears to be more than mere surficial differentiation but is not considered to be specifically distinct. Glabellar sides taper more noticeably in the Victorian than American material. Of particular note are the short laterally bulging palpebral lobes and their position at the level of the 2p glabellar furrow; this feature and the resultant long triangular posterior cephalic limb are the main features used to separate the genus from *Hystricurus* Raymond, 1913.

Hystricuridae gen. et sp. nov.

Plate 20, figures 4-8

Material: Eleven incomplete, generally poorly preserved cranidia from NMVPL184 including NMVP74341 to 74345.

Description: Smooth cranidium with convex glabella standing above cheeks; glabella tapering forward with convex sides to rounded anterior, with poorly impressed shallow 1p glabellar furrow low on side of glabella and at high angle to transverse line; occipital furrow well impressed, curving forward near extremity, and distinct apodemal pits laterally also angling forward abaxially, extremely shallow beyond apodeme; occipital ring short, convex, tapering laterally as it curves forward with furrow, running across axial furrow as marked ridge into posterolateral corner of fixed cheek; axial furrow well-impressed (shallower in front of glabella) deep, with prominent fossular pits at anterolateral corners of glabella, running into occipital furrow posteriorly seemingly without reaching posterior border; cheeks narrow, horizontal in anterior profile but sloping anteriorly in lateral profile; palpebral lobe of moderate length, situated opposite midlength of glabella, only gently convex and slightly upturned laterally, without palpebral furrow; preglabellar field short, convex; anterior border furrow poorly impressed but distinct, almost transverse on cranidium; anterior border as long medially as preglabellar field, gently convex, gently arched in anterior profile, tapering strongly laterally along facial suture; facial suture convex out and converging slightly anteriorly from palpebral lobe, turning sharply adaxially from border furrow to run diagonally across border apparently reaching margin at or near midline, running just behind transversely for short distance behind palpebral lobe before curving back to run to the margin diagonally.

Remarks: Rather standard features, inadequate material and poor preservation make assignment of this species impossible. Although it is probably the species referred to by Singleton (in Lindner, 1953) and by Beavis (1976) as *Onchonotus* Raymond, 1924 it may not be assigned to that genus as the fixed cheeks do not slope laterally, there is a distinct preglabellar field, fossulae are distinct, the glabella is not so convex, and the palpebral lobe is longer, less convex, and situated further forward. It is not unlike *Onchopeltis* Rasetti, 1944 but may be distinguished by its ornament, and the course of the facial suture across the anterior border. *Onchonotina* Lu 1964 (see Lu *et al.*, 1965, pl. 38, fig. 7) has no preglabellar field or fossulae. It is not unlike *Pseudotalbotina* Benedetto, 1977 but may be distinguished by the course of the facial suture across the anterior border. Most of the features of this species are evident in one or more species of hystricurid described by Ross (1951) but the combination is not achieved in any of them. I prefer to acknowledge this species as representative of an undescribed genus within the Hystricuridae that must await discovery of better material for formal definition.

Natmus gen. nov.

Etymology: The genus and species names are for the National Museum of Victoria which became the Museum of Victoria in July 1983 and within which this work was begun.

Type species: *Natmus victus* sp. nov.

Diagnosis: Glabella long, with two pairs of lateral furrows low on steep slope into axial furrow, with broadly rounded anterior, with short horizontal occipital spine; anterior border strongly upturned and very short; anterior border furrow with row of pits; palpebral lobes extremely short, situated posteriorly level with glabellar lobe 1p, markedly elevated although flat on top and higher than glabella, with eye ridge running to axial furrow at level of furrow 2p. Librigena with very long genal spine and border furrow discontinuous around genal angle. Thorax of more than 16 segments, with median node on each axial ring, with well-impressed pleural furrow running in midlength and with steep wide articulating facets.

Remarks: The affinities of this genus are entirely obscure with a resemblance to *Psalikilus* Ross, 1951 the only clue. Like *Psalikilus* it has no preglabellar field, two pairs of well-impressed lateral glabellar furrows, a long genal spine and short arcuate palpebral lobes situated posteriorly. However, the two are distinguished by the ornament, level at which the eye ridge meets the axial furrow, and details of the position and size of the palpebral lobe. For the moment it is left with *Psalikilus* in the Hystricuridae, but further discoveries of related genera and better material of this genus may necessitate erection of a family to accommodate this lineage which seems separate from the several others that are thought to originate in the Hystricuridae.

Natmus victus sp. nov.

Plate 21, figures 1-15

Material: Holotype NMVP74352, paratypes NMVP74350, 74351, 74353 to 74364.

Diagnosis: Member of *Natmus* with anterior of glabella almost reaching border furrow, with preglabellar field either absent or up to length of anterior border if present.

Description: Glabella subquadrate (probably longer than wide) with broadly rounded anterior, strongly convex, with straight parallel sides and with two pairs of well-impressed lateral glabellar furrows; furrow 1p beginning in axial furrow, running posteroaxially at approximately 45 degrees to transverse line up steep side of glabella, narrow but relatively long, not reaching occipital furrow but close to it; furrow 2p narrower than 1p, low on side of glabella, longer than 1p, joining axial furrow, with deeper pit at adaxial end, transverse; lobes 1p and 2p of equal length but frontal lobe more than twice as long as either; occipital furrow long shallow and transverse medially, shorter with deep apodemal pit and curved forward abaxially; occipital ring only slightly longer than furrow, slightly shorter laterally, with short tapering spine rising from full length of ring axially then turning posteriorly with most of spine lying in horizontal plane, with ornament of fine terrace lines more or less parallel to posterior margin; axial furrow very deep, crossed by low ridges from occipital ring and lobe 1p into proximal part of fixigena, splitting anteriorly to run directly forward to the border furrow and also curve around the anterior of the glabella; anterior border extremely short, highly convex, transverse, with fine terrace lines parallel to the margin; anterior border furrow short, distinct mainly as a change of slope to the upturned border; fixigena rising up very steeply from axial furrow, flattening off abaxially, of uniform width in front of palpebral lobe where lateral rise is less steep and where it slopes anterolaterally to border furrow; eye ridge prominent, leaving axial furrow at level of furrow 2p, appearing to issue from posterolateral corner of glabellar lobe 3p, running up fixigena at about 30 degrees to transverse line to meet anterior of posteriorly placed palpebral lobe; palpebral lobe short, semielliptical and well rounded abaxially, in horizontal plane above highest point of glabella, gently convex in section and defined by distinct palepbral furrow parallel to the abaxial margin of palpebral lobe, situated opposite glabellar lobe 1p; posterior cephalic limb wide, short, with convex in section and defined by distinct palpebral furrow parallel to the abaxial margin of uniform length to the facial suture; facial suture almost exsagittal forward of palpebral lobe but with slight convexity opposite frontal glabellar lobe then curving strongly across border so that border extends laterally only a short distance beyond axial furrow, transverse behind palpebral lobe for considerable distance then curving through 90 degrees and meeting posterior margin in short distance. Ornament on fixigena and glabella except for furrows eye ridge and broad zone around lateral glabellar furrows of coarse reticulate ridges, with that on glabella and behind eye ridge on fixigena being much finer ridges than anteriorly on fixigena, with that on glabella less reticulate and more like terrace lines. Librigena with strong, long, curving, advanced, genal spine deflected laterally for some distance; eye surface small, bulbous, standing vertically; eye socle very low, merely a convex rim beneath the eye, separated from genal field by high wide furrow without ornament; genal field sloping steeply to border furrow, with ornament of coarse reticulate ridge and punctate interspaces; border furrow well-impressed and narrow anteriorly, becoming wider and shallower posteriorly, virtually discontinuous around genal angle, with posterior border furrow extending laterally to near base of genal spine but with discrete termination; border narrow highly convex anteriorly, becoming wider and flatter posteriorly, with fine comarginal terrace lines extending down length of genal spine and onto border behind genal spine.

Thorax of more than 16 segments; axis of relatively low convexity, with deep distinct apodemal pits laterally in articulating furrow, with median node on each segment, tapering posteriorly especially in posterior part, with length of segments becoming progressively less posteriorly; pleural areas horizontal to articulating line then only gently downturned abaxially. Transverse near anterior but curving posteriorly just in front of pygidium; pleural furrow with steep anterior and gentle posterior walls, distinct, running diagonally from anterior margin at axial furrow to midlength in articulating line, extending abaxially in midlength almost to pleural tip; articulating facet wide, extending from articulating line to tip, steeply sloping, gently concave; pleural tip pointed but not spinose.

Remarks: *Natmus victus* is distinguished from *N. tuberus* sp. nov., in that the latter species has a long preglabellar boss and a fixigenal spine. Assignment of the thorax is based on the damaged internal mould (Pl. 21, fig. 11) having precisely the same pleural morphology as the external mould of the thorax with only damaged cranidium attached.

Although superficially similar, the ornament on the glabella and on the cheeks may be different functionally. On the cheeks there appear to be two sets of ridges with a set of normal caeca running into the eye ridge or the base of the eye etc. and a second set more or less at right angles and parallel to the margin overlying the former (Pl. 21, fig. 12). However, those on the glabella do not have the same regularity and may well be terrace line ornament evolved to give a uniform appearance to the whole head. Such a uniformity could well have been selected for in the face of predation. These glabellar terraces are interpreted as identical with the second set of ridges mentioned on the cheeks; caeca are not developed on the glabella. It should be noted that on a number of internal cranidial moulds of *N. victus* and *N. tuberus*, the ridges are present on the cheeks but absent from the glabella (Pl. 20, fig. 12B; Pl. 21, fig. 11) indicating that those on the glabella were an external surface feature only, whereas those on the cheeks (or at least some of them) represent internal organs close against the exoskeleton.

Natmus tuberus sp. nov.

Plate 20, figures 9-12

Etymology: From the Latin *tuber* meaning a swelling or lump and referring to the preglabellar boss.

Material: Holotype NMVP74349, paratypes NMVP74346 to 74348 from NMVPL184.

Diagnosis: Member of *Natmus* with prominent preglabellar boss and fixigenal spine at abaxial tip of posterior cephalic limb.

Remarks: As this species is known from damaged and incomplete material only, it is difficult to give a full description and moreover, the two characters used in the diagnosis are the only ones observed that vary from the description of *N. victus* given above. Since there is a range of variation in development of a preglabellar field in *N. victus* it is not difficult to imagine the transition from one form to the other. Although the librigena of this species is not positively identified it may be confidently assumed to be the same as or similar to that of *N. victus* and so, with the fixigenal spine this species would have two posteriorly directed spines in the genal region. One internal mould of *N. victus* exhibits the beginning of a fixigenal spine so that progression in this feature may also be available if enough well preserved specimens were to be found. It therefore seems likely that this is a dithyrial population with the two morphs being termed species in this case and some evidence of intermediate morphs but not an intergrading series. A larger sample of the population is needed to say more.

Although a preglabellar boss develops in a number of different trilobite groups and similar prominent ridged ornament is known in several of these other groups none of the other forms combines the small posteriorly situated palpebral lobes and pitted anterior border furrow. The close similarity with *N. victus* indicates a lineage separate from any of the other boss-bearing forms and direct comparison is superfluous.

Family LEIOSTEGIIDAE Bradley, 1925

Leiostegium Raymond, 1913

Leiostegium douglasi Harrington, 1937

Plate 22, figures 1-10

Material: Holotype No 4356 in the collection of the Department of Geology, University of Buenos Aires, Argentina; paratypes Nos 4354 and 4357 in the same collection; more than 100 cranidia, librigenae, hypostomes, thoracic segments and pygidia from NMVPL184 where it is one of the commonest species.

Description: Only alterations or additions to the already comprehensive description of Harrington (1937) and Harrington & Leanza (1957) are provided. One exfoliated cranidium shows four pairs of lateral glabellar furrows that are not evident on the exterior of the exoskeleton. Furrow 1p is indistinct, relatively large, forked adaxially and occupies almost one-third of the glabella in front of the occipital furrow; furrow 2p is more distinct, situated near anterior of palpebral lobe, close to axial furrow, with transverse anterior fork and posteroaxially directed rear fork, as wide as long (length measured across adaxial tips of furrows); furrow 3p short, wide but narrowest of all furrows, situated well away from axial furrow close to 4p just in front of junction of eye ridge and axial furrow; 4p rising up side of glabella from axial furrow, transverse or directed a little forward. A strong ridge runs out of the anterolateral corners of the glabella across the axial furrow and into the anteroproximal corner of the fixigena; in front of this ridge is a deep pit (fossula) and behind it is another pit whose impression is greater on the external surface than the internal mould. On the internal moulds described from Argentina the pit behind the ridge is accordingly almost imperceptible but I suggest it would be present on the exterior of the exoskeleton of that material as it appears to be a familial character. The anterior border is relatively quite long by comparison with other species of the genus. The eye ridge is well developed but only evident on the internal mould; fine caeca run out of the eye ridge both anteriorly and posteriorly. Fine caeca may also be seen running forward from the anterior border furrow onto the posterior part of the anterior border (Pl. 22, fig. 1). In lateral profile the palpebral lobes are horizontal and elevated though not as high as the axial ridge of the glabella and there is a distinct anterior drop down to the much lower but also flat anterior border. On the surface of the internal mould are numerous pustules and/or circular depressions with small medial pustules representing pits or fine rimmed pits on the inner surface of the exoskeletons. These presumably correspond to the fine pits on the exterior surface seen in some specimens (e.g. Pl. 22, fig. 2) so that the exoskeleton is essentially perforate. The librigena has fine terrace lines on the doublure extending dorsally over the margin in some specimens.

Thorax of eight segments has very wide pleural areas that are flat to the articulating line then turn down only slightly. Pleural furrow is well-impressed and runs through midlength of each segment petering out just beyond articulating line. Pleura beyond articulating line extended as free spines curved slightly back with amount of curvature increasing posteriorly. The spine is circular in section with the doublure extending almost to the articulating line ventrally.

Remarks: Harrington and Leanza (1957) noted the similarity of this species to *L. manitouensis* Walcott, 1925 but the distinguishing features quoted by those authors now seem inappropriate. Only the length of the anterior border is distinctive of Walcott's (1925, pl. 21, figs 12-19) material but the illustrated material of Berg and Ross (1959) may be further distinguished by its extremely short palpebral lobe. *Leiostegium floodi* Shergold, 1975 appears separable only on the shorter anterior border and the possible synonymy of *L. floodi* and *L. manitouensis* deserves further consideration as the features quoted by Shergold appear not to be distinctive; the palpebral lobes are in precisely the same position in both species, and the glabellar furrows and eye ridges, which depend greatly on preservation, are faintly visible on one of Walcott's (1925, pl. 21, fig. 18) and both of the cranidia of Berg and Ross (1959) and these features may also change with growth.

Leiostegium sp. cf. **L. manitouensis** Walcott, 1925
Plate 22, figures 11, 12

Material: Two cranidia NMVP74374 and 74375 from NMVPL184.

Remarks: Two damaged cranidia from the middle of the size range of specimens of *L. douglasi* exhibit extremely short anterior borders suggesting assignment to *L. manitouensis* as all other observable characters are comparable with the associated *L. douglasi* and the length of the border is the only feature distinguishing these two species as discussed above. However, since the specimens are distorted by lateral compression and as features of the palpebral area are not known, I hesitate to make a definite assignment. These two cranidia also exhibit fine terrace lines on the anterior border near, and parallel to the margin.

Family CERATOPYGIDAE Raymond, 1913

Onychopyge Harrington, 1938

Type species (by original designation): *Onychopyge riojana* Harrington, 1938 from the early Tremadoc of Argentina.

Diagnosis: Glabella of low convexity, broad, with straight sides parallel to gently tapering forward; palpebral lobes long, semicircular, situated posteriorly close to axis; preglabellar field absent; anterior border short, strongly upturned, transverse to very gently curved on cranidium; posterior cephalic limb short and very wide. Librigena with strong genal spine continuing the curve of the cephalic margin. Pygidium of variable shape, with pair of prominent marginal spines from anterior segment, extending posteriorly in most cases; axis of 5-7 segments, usually relatively short, with low median ridge extending from it posteriorly across border area; pleural area dominated by first segment, with well-impressed first pleural and interpleural furrows and wide anterior pleural band, with more posterior furrows indistinct or absent; border ill-defined by change of slope only; doublure wide, with prominent terrace lines.

Remarks: With the several species now described (Harrington & Leanza, 1957; Robison & Pantoja-Alor, 1968; Shergold, 1975; Benedetto, 1977; Zhou & Zhang, 1983; Peng, 1983) it is possible to provide a more extensive diagnosis than originally given.

The very close resemblance between *O. sculptura* Robison & Pantoja-Alor, 1968 and *Haniwa ambolti* Troedsson, 1937 suggests that reassignment of the latter species from central Asia may be necessary but I hesitate to do so until a pygidium can be associated with Troedsson's cranidium. Certainly the glabellar shape, palpebral lobes, and preglabellar structure more closely resemble *Onychopyge* than *Haniwa*.

The cranidium of *Macropyge chermi* Stubblefield figured by Owens *et al.* (1982, pl. 2h) closely resembles that of *O. parkerae* described below (cf. Pl. 23, fig. 9 for glabellar furrows and early development of baccula) but Owens *et al.* (1982, p. 15) suggest an origin for *Macropyge* via *Aksapyge* Lisogor, 1977 which seems entirely reasonable. So *Onychopyge* and *Macropyge* are inferred to belong to separate lineages whose origins are presumably close together.

Homeomorphous similarities to the Kainellidae include the size and position of the palpebral lobes but most strikingly the pygidial structure (cf. Ross & Shaw, 1972, pl. 1) where the postaxial ridge, ridges on the pleural bands, wide terrace-lined doublure and posteriorly directed segments with well-impressed pleural furrows are evident. However the certatopygid identity seems assured when compared with *C. forficuloides* Harrington & Leanza, 1957 and *C. forficula* Sars (see Moberg & Segerberg, 1906).

Onychopyge parkerae sp. nov.

Plate 23, figures 1-16; plate 24, figures 1-4

Etymology: The species is named for Charlotte Parker who assisted me with initial sorting and preparation of the collection.

Material: Holotype NMVP74392, paratypes NMVP74376 to 74391 and 74393 to 74395 from NMVPL184.

Diagnosis: Member of *Onychopyge* with subrectangular glabella bulging slightly laterally at level of lobe 2p, glabella reaching anterior border furrow; librigena with slightly advanced genal spine, coarse terrace lines on border and genal spine with chevron-shaped terrace lines over margin, with posterior border furrow entirely on librigena; thorax of more than eight segments with pleural tips spinose, with spines exsagittal at pygidium. Pygidium longer than wide, subrectangular; axis of five rings and terminus, with low postaxial ridge extending to posterior margin; pleural field with well-impressed first pleural and interpleural furrows defining slightly raised first segment extending into long marginal spine; with surface ornament of terrace lines on axis and proximal parts of pleural field also; posterior margin between spines only gently convex.

Description: Glabella of low convexity in both anterior and lateral profiles, subrectangular in outline, with rounded anterolateral corners, bulging slightly near midlength adjacent to glabellar lobe 2p, with margins generally ill-defined by poorly-impressed axial furrow, with two or three pairs of faint lateral glabellar furrows evident in some specimens; furrow 1p round pit-like depression close to axial furrow, near rear of palpebral lobe; 2p furrow wider than long, angled posteroaxially from near axial furrow, extremely faint; furrow 3p just in front of anterior of palpebral lobe, running slightly anteroaxially from axial furrow, extremely faint; occipital ring of uniform length, gently convex in lateral profile, descending laterally without apparent division into posterior border; anterior border short, flat, rising up forward, of uniform length; anterior border furrow shallow but distinct, concurrent with preglabellar furrow, almost transverse on cranidium; palpebral lobe semicircular, narrow, defined by poorly-impressed palpebral furrow, flat so that posterior elevated above posterior cephalic limb and anterior elevated above anterior section of fixigena, both ends of lobe reaching axial furrow close to glabella; eye ridge not present; palpebral lobe terminating against outer margin of axial furrow; posterior cephalic limb wider than palpebral lobe, very short, with only posterior border and beginnings of slope into posterior border furrow included; facial suture diverging gently forward from the anterior of the palpebral lobe, transverse behind palpebral lobe before turning to margin at right angle. Librigena with high convex eye socle standing up vertically from smooth gently convex genal field; border furrow well-impressed, sharp and narrow anteriorly, becoming extremely wide posteriorly near genal spine (where it appears to bifurcate in one specimen (Pl. 23, fig. 13)) around an island before joining again at the genal angle, long and shallow along posterior; part of the posterior border also present on librigena laterally; border narrow and highly convex anteriorly, becoming less convex posteriorly, continuing posteriorly into long gently curved slightly advanced librigenal spine; spine with rounded cross-section, with prominent longitudinal terrace lines continuing along full length of lateral border; terrace lines at low angle to margin, all turning sharply back in anteriorly-directed chevron-shaped turns all in line parallel to margin and on vertical marginal roll. Thorax of more than eight segments; articulating furrow transverse; articulating half-ring less than half length of axial ring; pleura with well-impressed furrow from anterior margin at axial furrow to midlength in articulating line then down posterior part of spines; free pleura with long spinose tip, tranverse anteriorly, becoming exsagittal in front of pygidium. Pygidium longer than wide, subrectangular, flat except for markedly convex axis standing above pleural areas and weakly raised first segment on pleural field; axis of five rings and terminus defined by extremely poorly impressed transaxial furrows, with asymmetrical terrace lines having vertical posterior slope running across the top of each axial ring and quite a number on the terminus the latter extending on to the proximal parts of pleural field, occupying only a little more than half pygidial length, tapering to rounded posterior in overall inverted bell shape, continuing posteriorly in low postaxial ridge to or very near to posterior margin; axial furrow expressed as change of slope only; pleural field narrower than axis anteriorly, with anterior segment well defined by first interpleural furrow and slightly raised with distinct pleural furrow on it; anterior segment curved anteriorly from axial furrow so that in posterior part it is exsagittal, extended into long slender spine from posterolateral corner, with parallel longitudinal symmetrical terrace lines around entire circumference of spines; with two terrace lines on dorsal surface extending along crest of pleural bands of first segment as far as axial furrow; posterior margin between spines weakly convex with transverse central section; border and border furrow not evident; doublure extremely wide extending beneath almost entire pleural area and terminus of axis, small posteroproximal area of pleural area without doublure beneath it; doublure covered with prominent comarginal asymmetrical terrace lines having vertical posterior slope; terrace lines on underside of marginal spines extending forward on doublure to lateral margin or recurving posteriorly to parallel the posterior margin.

Remarks: *Onychopyge parkerae* may be distinguished from *Onychopyge assula* Shergold, 1975 from Queensland because that species has a pygidial border furrow and more distinct pygidial furrows in general. The fragmentary cranidium of the Queensland species prevents comparison of that shield. The Mexican species *O. sculptura* may be distinguished by its more rounded glabellar anterior not extending so close to the border furrow, its better impressed transaxial furrows, more extensive development of terrace lines on pleural areas and strongly convex posterior margin between spines. It should be noted that the fragmentary librigena illustrated by Robison & Pantoja-Alor (1968, pl. 100, fig. 3) has the same peculiar border furrow as the Victorian species. Of the Argentinian species only *O. longispina* Harrington & Leanza, 1957 has comparable pygidial shape but it may be distinguished by the convex medially pointed posterior margin between the spines. *Onychopyge longispina* is the closest morphological match for *O. parkerae* of known species.

Although assignment of the thoracic fragment is not certain, the association with a pygidium of *O. parkerae* lying on the posterior of the thorax and prepared away to expose the thoracic pleural tips as well as the terrace lines laterally and the style of pleural furrows in comparison with that on the pygidium give considerable confidence to the assignment.

Family KAINELLIDAE Ulrich & Resser, 1930

Pseudokainella Harrington, 1938

Type species (by original designation): *Pseudokainella keideli* Harrington, 1938 from the Late Tremadoc of Argentina.

Diagnosis: Kainellids with glabella tapering gently forward to broadly truncated anterior, may be laterally swollen between palpebral lobes or constricted at level of junction of palpebral lobe with axial furrow; pregabellar field of variable length both through ontogeny and between species; interocular cheeks narrow with palpebral furrow merging with or coming close to axial furrow; palpebral lobes long and crescent-shaped; angle of divergence of facial suture forward of palpebral lobe variable within and between species. Librigena wide, with long normal or advanced genal spine. Thorax of 12 segments; eighth ring bearing long posterior spine; pleural tips spinose. Pygidium elliptical to quadrate in outline; axis of two to four rings and terminus, standing high above pleural areas, not reaching margin; pleural area with three or four pleural furrows; interpleural and border furrows faint; anterior pleural band of each segment extended into three, four or five pairs of free marginal spines decreasing in size posteriorly.

Remarks: Ludvigsen (1982b) erected *Elkanaspis* for a group of American species that had earlier been referred to *Pseudokainella* (Shergold, 1975; Taylor, 1976) but of the five features that he quoted to distinguish the two genera the new Victorian species described below gives reason to remove three and the other two may reasonably be considered specific taxobases. In *P. diggerensis* the smaller cranidia (Pl. 25, fig. 3) lack a preglabellar field as in three illustrated specimens of *P. keideli* (Harrington & Leanza, 1957, fig. 52-5, 7, 10) that are of comparable size but in larger specimens (Pl. 24, figs 5, 11) the preglabellar field appears and becomes progressively longer with increasing size. In the larger holotype of *P. keideli* (Harrington & Leanza, 1957, fig. 52-6) the prelabellar area is obscured by matrix but from the position of the anterior border it would seem that a short field may be present. Although some species may be uniform in this feature (e.g., *Elkanaspis futile* Ludvigsen, 1982b) the fact that the two states exist in the ontogenetic series of one species makes it an extremely doubtful generic taxobase at least until considerably more is known about ontogenstic development in other species of the genus. In *P. diggerensis* even after allowing for distortion, the angle of divergence of the anterior parts of the facial suture varies from that shown by *E. futile* (i.e., at about 30 degrees to exsagittal line) (Pl. 24, fig. 6) to almost transverse (Pl. 25, fig. 2); therefore this feature which also varies considerably due to tectonic distortion should not be used as a generic taxobase in this case. Ludvigsen (1982b) has attached significance to the anterior constriction of the glabella but once again *P. diggerensis* shows a considerable range of variation in development of this feature. Moreover the constriction is associated with the point at which the anterior end of the palpebral lobe reaches the axial furrow so that it is at the anterior in *E. futile* only because that is where the palpebral lobe ends. In *P. diggerensis* and other species the palpebral lobe reaches the axial furrow well back from the anterior of the glabella and the constriction is removed posteriorly accordingly. I submit that this is not a suitable generic taxobase because of the intraspecific variation in *P. diggerensis*. I consider the posterior merging or otherwise of the palpebral and axial furrows to be a specific taxobase not of generic significance, because in the related genus *Richardsonella* Raymond, 1924 there are species with these two furrows merging (e.g., *R. arctostriatus* Raymond, 1937, pl. 1, fig. 6) and others (e.g., *R. laciniosa* Shergold, 1971, pl. 6, fig. 2) where they do not merge. Moreover, Ludvigsen (1982b) appears to concede that this may not be a generic taxobase when he is not prepared to separate *P. lata* Harrington & Leanza, 1957 with the furrows merging from *P. impar* (Salter) in which the two furrows are clearly not merging (Whitworth, 1969, pl. 75, fig. 5). The macropleural pygidial spine is a valid taxobase of *P. keideli* but is unlikely to be a generic taxobase especially in the absence of support from the other features quoted. For these reasons *Elkanaspis* could be considered a junior synonym of *Pseudokainella* but that question is tied to the more difficult problem of the limits of the genus *Richardsonella* Raymond, 1924 which has been discussed by Palmer (1968). Palmer suggested generic groupings based on the pygidia and in particular on the length and composition of the axis and the length of the marginal spines; interestingly the two species quoted by Palmer as provisional types were included by Ludvigsen (1982b) in his genus *Elkanaspis* apparently mainly on cranidial features. Palmer mentioned the multisegmented pygidial axis of his species *R. quadrispinosa* and the paucisegmented short axis of *R. unisulcata* Rasetti, 1944 as representing two generic groups but the four and three axial rings respectively of these two species are only part of a series from *P. futile* with two through *P. diggerensis* with two and sometimes a weak third. The length and direction of the marginal spines is seen to vary with growth in *P. diggerensis* so that feature must be considered of doubtful value as a generic taxobase. Given the difficulty of interpreting the type species of *Richardsonella* and the fact that the best preserved specimen upon which the concept of *Pseudokainella* has been commonly based (Harrington & Leanza, 1957, fig. 52-5) is a juvenile individual (with the holotype more poorly preserved and illustrated) the assignment of a considerable number of species is very doubtful at present. Whereas the pygidia of *P. diggerensis* and *R. quadribrachiatus* or the cranidia of *P. keideli* and *P. futile* may appear quite distinct they must be viewed in the broader spectrum of species morphologies and it is in this light that generic distinctions have not yet been convincingly established. For the present I concur with Shergold (1971) and Taylor (1976) in assigning most of these North American species to *Pseudokainella* as an interim measure. *Elkanaspis* is considered a junior subjective synonym of *Pseudokainella*. This synonymy should be reviewed again when a fuller size range is available for more of the species involved, in particular for *P. futile*, *P. keideli* and the other Argentinian species.

I do not accept that the posterior cephalic margin of *P. futile* runs forward from the axial furrow as depicted by Ludvigsen (1982b, fig. 38) as the librigenae illustrated by Ludvigsen (1982b, fig. 64N, O) show clearly that the posterior part of the facial suture is transverse or even running posterolaterally from the posterior of the palpebral lobe and the posterior margin of the posterior cephalic limb which parallels the suture must be transverse or at only the very slightest angle to transverse; considering the articulation of the first thoracic segment it must be assumed to have been transverse. Similarly I do not accept the reconstruction of *P. impar* provided by Whitworth (1969, fig. 1a) with the posterior of the cephalon lying over the first and most of the second thoracic segments. The specimen upon which this reconstruction is based (Whitworth, 1969, pl. 75, figs 7, 8) shows clearly that the posteroproximal corner of the librigena has overridden the axial furrow onto the glabella, particularly on the lefthand side and that there has been dislocation along the anterior section of the facial suture. This anticlockwise rotation of the left librigena to greater degree than the clockwise rotation of the right librigena is illustrated by the genal spine being closer to the thorax on the left side than on the right. The overriding and dislocations of this specimen probably occurred during moulting or compaction of the sediment and the relationships of the various parts during life may safely be assumed to have been the normal trilobite arrangement with a transverse posterior margin to the cephalon opposed to a transverse anterior margin on the first thoracic segment as far as the articulating line.

Cranidial features of *Fatocephalus* Duan & An (in Kuo *et al.*, 1982) from available description and illustration fall within the generic morphotype of *Pseudokainella*. Although no pygidium has been assigned to any species of *Fatocephalus* it is considered a junior subjective synonym of *Pseudokainella* pending its further understanding.

Pseudokainella diggerensis sp nov.

Plate 24, figures 5-14; plate 25, figures 1-13

Etymology: The species is named for Digger Island where the fossils were collected.

Material: Holotype NMVP74416, paratypes NMVP74396 to 74415, 74417, and 74418, from NMVPL184.

Diagnosis: Member of *Pseudokainella* with glabella constricted slightly at junction of axial furrow with eye ridge some distance (almost a quarter of the length) behind glabellar anterior; preglabellar field absent in small specimens (cranidia 3 mm long) increasing in length with growth; anterior border furrow with row of conspicuous perforations apparently matching a set on the doublure of librigena; anterior border becoming shorter with growth; palpebral lobes extremely close to glabella, enclosing tiny interocular cheeks, with palpebral furrow merging with axial furrow both anteriorly and posteriorly; librigena with advanced genal spine and long forward extension of doublure to median connective suture. Pygidium transverse; axis of two well-defined rings and terminus, extending to inner edge of doublure as low postaxial ridge, with terminus weakly divided by further transaxial furrow in some specimens; pleural area with three pleural furrows and one interpleural furrow weakly impressed; border narrow, with four or five pairs of marginal spines directed either posteriorly or curving posteroaxially with curvature increasing posteriorly.

Description: Glabella subrectangular to tapering gently forward, with slight lateral bulge between palpebral lobes and slight constriction at level of anterior of palpebral lobe, with rounded anterolateral corners and transverse preglabellar furrow, with three pairs of faint lateral glabellar furrows rarely apparent, strongly convex decreasing in larger specimens; glabellar furrows short and wide, at low angle to transverse, with 3p meeting axial furrow near anterior of palpebral lobe; occipital ring moderately long, flat in lateral profile, with almost imperceptible anteromedian node on external surface of exoskeleton, tapering laterally in most abaxial parts; occipital furrow shallowing and curving forward laterally, transverse medially; axial furrow distinct as a marked change of slope for most of its course but well-impressed between palpebral lobes, concurrent with palpebral furrow or with small narrow island in middle of furrow representing last remnant of interocular cheek, shallower near midlength of palpebral lobe than at ends; preglabellar field absent to less than half length of border in smaller specimens but considerably longer in larger specimens, sloping forward but actual angle of inclination not certain due to distortion; anterior border of variable length, generally longer in smaller specimens but also considerably affected by distortion, tapering laterally along facial suture; palpebral lobe very close to glabella, with both ends reaching axial furrow, arcuate, situated near midlength of glabella, widest near midlength, tapering more to anterior than to posterior, gently convex in section; posterior cephalic limb wide and short, with well-impressed border furrow, short fixigenal spine at extremity; facial suture diverging forward from palpebral lobe at approximately 45 to 60 degrees to transverse, (variations in this angle are due to distortion of the exoskeleton during compaction and subsequent tectonic disturbance), running across border at very low angle to anterior margin to sagittal line then over anterior margin as median connective suture, running just behind transverse from posterior of palpebral lobe and meeting posterior margin in acute angle. Librigena wide, sloping gently into border furrow; eye socle, low, arcuate, differentiated from genal field by marked change of slope only; border furrow well-impressed, turning through an obtuse angle at base of genal spine; border convex, of uniform width, with fine comarginal terrace lines near margin; genal spine advanced, curving gently adaxially towards tip, circular in section, with fine longitudinal terrace lines near base; doublure, convex in section, with fine terrace lines well developed, extending forward to median connective suture, with row of pits along inner margin of this extension corresponding to pits in border furrow on dorsal side (so exoskeleton is perforated along this line).

Thorax of 12 segments with prominent long median spine on eighth segment; articulating halfring longer than furrow, tapering only slightly laterally; articulating furrow well impressed, almost U-shaped in section, with lateral apodemal pits, curving forward over sagittal line; axial ring longer laterally than sagittally, with posterior margin curving forward over axis; pleural furrow having steep anterior wall and gentler posterior wall, running from axial furrow at anterior margin to midlength at articulating line, straight and well impressed; free pleura extended in short spine, curving gently back with curvature increasing posteriorly; doublure on free pleura extending adaxially almost to articulating line.

Pygidium transversely semioval, relatively flat except for markedly convex axis standing high above pleural areas; axis of three axial rings with prominent pseudoarticulating halfrings; first two transaxial furrows well impressed, third very weak and often not evident; rings with prominent pseudoarticulating halfrings; first two transaxial furrows well impressed, third very weak and often not evident; pleural area with two anterior pleural and first interpleural furrows distinct, more posterior furrows indistinct, pleural furrows running laterally to gap between first two marginal furrows (although one specimen (Pl. 25, fig. 9) shows it running onto the spine); border furrow shallow, not always evident, discontinuous behind axis; border of uniform width, weakly convex, with comarginal terrace lines, bearing four of five pairs of marginal spines; marginal spines of variable length but never very long, decreasing in length posteriorly, directed posteriorly or curved adaxially especially near the axis at the rear, varying from a flat section anteriorly to rounded at rear, evenly spaced except for posterior pair which are very close together when five pairs are present but well separated when only four are present; doublure narrow, with comarginal terrace lines.

Remarks: This species seems to be most similar to the Canadian *P. futile* and the Chinese species mentioned below but may be distinguished from the former by its virtual lack of glabellar furrows, prominent anterior border pits and generally longer pygidial marginal spines. *Fatocephalus latus* Duan & An in Kuo *et al.*, 1982 from north China appears very similar to *P. diggerensis* being distinguished only by its palpebral lobes reaching the axial furrow closer to the glabellar anterior. However, the Chinese species is illustrated only by two distorted cranidia so full comparison is impossible. The Argentinian species *P. lata* and *P. keideli* may also be distinguished by the glabellar furrows and pygidial spine arrangement.

Family HARPEDIDAE Hawle & Corda, 1847

Australoharpes Harrington & Leanza, 1957 has been assumed to be the most primitive harpedid because of its age. However, the discovery of *Brachyhipposiderus* gen. nov. in association with *Australoharpes* in the early Tremadoc of Victoria, probably contemporaneous with the Argentinian *A. depressus*, and some of the characteristics of *Brachyhipposiderus* suggest that it may well be the more primitive harpedid and may have evolved from the Late Cambrian

Entomaspis Ulrich in Bridge, 1930. Particularly important is the short prolongation which is very similar to that of *Entomaspis* (Rasetti, 1952) and to that of juvenile harpedids (Chatterton, 1980). The facial suture on *Brachyhipposiderus* is similar to that on *Entomaspis* in that it leaves the genal spine on the lower lamella and the only difference is that the re-entrant to the eye tubercle in *Entomaspis*—a feature that was obsolescent and apparently without functional value—has been lost completely. Although there are some other features of difference and the lineage certainly did not evolve directly between the two known species there are sufficient features in common to suggest that the Entomaspididae gave rise to the Harpedidae and that *Brachyhipposiderus* was close to the origin of the latter family. This position for *Brachyhipposiderus* is supported by the retention of most of its adult characters in juveniles of younger harpedids (Chatterton, 1980).

Whereas Rasetti (1952) suggested that *Entomaspis* may be an ancestor to the Trinucleidae the less regular but still radial pitting of the brim, lower overall cranidial convexity, strongly developed girder, weakly developed alae, and glabellar and palpebral organisation of *Brachyhipposiderus* all suggest that *Entomaspis* gave rise to the Harpedidae.

Brachyhipposiderus gen. nov.

Etymology: From the Greek *brachys* meaning short and *hipposideros* meaning horseshoe and referring to the abbreviated prolongation which develops into an elongate horseshoe shape as in *Australoharpes* and *Scotoharpes*.

Type species: *Brachyhipposiderus loginus* sp. nov. from NMVPL184.

Diagnosis: Cephalon sub-semicircular; 1p furrow well impressed; alae distinct but low; occipital tubercle prominent; radial anastamosing caecal network on cheeks and brim with moderately large pits between caeca on brim gradually decreasing towards glabella; brim prolonged only a very short distance behind posterior of occipital ring, markedly concave posterolaterally; long genal spine at rear of prolongation; girder prominent, extending to tip of prolongation; cheek roll widened at level of posterior border furrow, extending adaxially almost as far as exsagittal line of outer edge of eye tubercle.

Remarks: The distinctive features of this genus are its abbreviated prolongation, consequent semicircular shape and long strong genal spine. As discussed above, these features reflect its place at or near the base of the radiation of the harpedids. Only the course of the facial suture, not reaching the eye tubercle, prevents this genus from being classified in the Entomaspididae.

Brachyhipposiderus logimus sp. nov.

Plate 26, figures 1-8

Etymology: From the Greek *logimus* meaning notable and referring to its importance in harpedid phylogeny.

Material: Holotype NMVP74419, and paratypes NMVP74420 to 74426 from NMVPL184.

Diagnosis: As for genus.

Description: Cephalon semicircular to semi-ovate, of relatively low convexity, with central part (i.e. within the girder) somewhat sunken by virtue of the concave distally-upturned brim. Glabella tapering gently forward to a broadly rounded anterior, strongly convex with almost vertical flanks in anterior profile, sloping in lateral profile in both directions from the high point just lower than eye tubercles near its midlength; 1p furrow well impressed on lateral slope of glabella, at low angle to exsagittal line, slightly offset abaxially then joining occipital furrow adaxially to isolate convex almost bean-shaped 1p lobe; 2p furrow barely evident as slight indentation in axial furrow at level of eye tubercles; occipital furrow long, shallow, with gentle anterior and posterior walls in medial section, with deeper apodemes having steep anterior wall behind 1p lobes, running transversely; occipital ring from virtually nothing at axial furrow to quite elongate medially, with evenly curved posterior margin, with prominent median tubercle close to occipital furrow. Axial furrow well impressed but shallowing forward, with usually much gentler rises to the cheeks than up the near-vertical glabellar sides, with steep slope abaxially up to eye tubercles. Preglabellar field relatively short but longer than cheek roll in sagittal line, gently convex, not expanded into a boss. Cheeks convex, with radial caecal network well developed; alae small, semicircular, smooth, depressed a little below rest of cheek, rising with the cheek abaxially; eye tubercles, situated well behind glabellar anterior opposite 2p furrow, surmounting highest points of cheeks, elevated above cheeks and just above highest point of glabella, with steep adaxial side continuing slope up from axial furrow so tubercle appearing to lean abaxially, with concave abaxial slope, with visual surface apparently on upper part of abaxial side; eye ridge distinct, consisting of two strong caeca widely separated (by 1 or 2 mm) and posterior one transverse but anterior one markedly oblique from near glabellar anterior. Cheek roll relatively low, with fine ridge around inner margin, adaxially only a short distance along posterior border and down prolongation the same distance as the brim. Posterior border furrow well-impressed, of uniform length, with gentle anterior wall but steep posterior wall; posterior border highly convex, short, of uniform length, with angular bend near its midwidth, distal part running back to end of prolongation. Brim of uniform width, concave in radial profile especially posterolaterally, with outer part much higher than girder, with gentle arch over sagittal line and lateral parts most ventral in anterior profile, with well developed radial anastamosing caecal network having intervening pits of fairly uniform size; outer rim upturned quite high dorsally but not projecting ventrally, with distinct furrow on the marginal band apparently accommodating the facial suture; girder distinct, extending ventrally a short distance from brim in particular over the sagittal arched section, extending to tip of prolongation, with strong caeca running into it or out of it on both sides; prolongation very short (less than 0.2 of cephalic length), highly concave, sunken between high rims; genal spine strong, long, directed posterolaterally; facial suture running up from marginal band anterior to the genal spine, crossing the outer rim and descending into posterior of prolongation, crossing posterior border (or inner rim) just in front of genal spine.

Remarks: All available specimens are distorted in some way so that the description is based on a number of specimens. The holotype is fractured on the left side with the genal spine and posterior of brim pushed adaxially over parts of the cheek so giving a narrower shape to the cephalon; it is also distorted and fractured in the preglabellar area. Although in discussion of *Australoharpes singletoni* sp. nov. I caution against too much use being made of convexity of brim, the degree of upturning to the outer part of the brim and its uniformity through so many specimens are such that it must be a consistent character and must have considerable significance. If this upturning were tectonically induced a great deal more fracturing of the brim would be evident.

The specimens are preserved in very soft mudstone which has had to be hardened with dilute bedacryl solution to allow latex casts to be taken; this treatment decreases penetration by or absorption of the latex, and this accounts for the greater than normal number of air bubbles in finer structures.

Australoharpes Harrington & Leanza, 1957

Type species (by original designation): *Australoharpes depressus* Harrington & Leanza, 1957 from the *Parabolinella argentina* and *Kainella meridionalis* zones of the Tremadocian sediments in Salta and La Rioja Provinces of Argentina.

Remarks: This genus is very closely related to the European *Eoharpes* Raymond 1905; indeed taking into consideration the several morphological features of the new Australian species described below a strong case may be put for synonymy of the two genera. Although I choose to retain the two names for the time being, only the size of the pits in the brim appears to retain any validity as a generic taxobase and on its own, that seems an inadequate determinant. Other features quoted by Harrington & Leanza (1957, p. 195) as distinguishing *Australoharpes* from *Eoharpes* (namely development of eye ridges, slight difference in position of eyes, and possession of a preglabellar boss) are almost certainly minor specific features. The wide genal roll, quoted as distinctive of *Eoharpes*, is present in *A. expansus* so eliminating that distinction. For the moment *Australoharpes* is distinguished by its smaller pits in the brim, lack of eye ridges, more anteriorly situated eyes, and a preglabellar median swelling.

Australoharpes singletoni sp. nov.

Plate 27, figures 1, 3-8

Etymology: The species is named for Dr O. P. Singleton who first identified trilobites from Digger Island in Lindner's (1953) paper on the geology of the area.

Material: Holotype NMVP74427, paratypes NMVP74429 to 74435 all from NMVPL184.

Diagnosis: Member of *Australoharpes* without alae; eye tubercles situated behind glabellar anterior; preglabellar boss extremely low; girder fading out just before tip of prolongation; spine present on tip of brim prolongation; cheek roll on prolongation relatively wide; thorax of at least 18 segments.

Description: Exoskeleton elongate oval, with convex central cephalic area, thorax, and pygidium standing well above brim. Glabella tapering very slightly forward to a rounded anterior, raised above cheeks posteriorly, strongly convex in anterior profile; 1p furrows poorly impressed, low on glabella at axial furrow, at low angle to exsagittal line in postero-axial direction. Occipital furrow transverse, short, distinct, shallow; occipital ring flat in lateral profile, elongate sagittally to more than twice lateral length, with evenly curved posteriorly-convex posterior margin, its doublure approximately half length of ring. Preglabellar field very weakly inflated into a boss as is cheek roll in front of the glabell; inflation of the cheek roll sagittally extending it slightly forward into brim so breaking even curve of girder. Axial furrow well impressed laterally, shallowing forward and represented only by a change of slope in front of the glabella, with much lower slope out of axial furrow away from glabella than onto glabella. Eye tubercles relatively large and prominent, standing higher than anterior of glabella, situated with anterior behind glabellar anterior, longer than wide, with indistinct longitudinal furrow along the vertical abaxial slope near its mid height and a more distinct furrow at the base of the abaxial slope swinging around anterior and posterior ends; palpebral lobe flat and highly arcuate; visual surface apparently over upper half of lateral slope, of uniform width, highly arcuate (Pl. 27, figs 1A, 3A). Girder horizontal, not projecting below brim at all, extending along the prolongation before running into the inner rim some distance (2 mm in cephala 27 or 38 mm long) from the tip of the brim prolongation. Cheek roll relatively low around cheeks, slightly higher on either side of preglabellar boss anteriorly, lowest anterolaterally then highest at the level of the posterior border furrow and anterior part of prolongation, tapering rapidly along prolongation. Brim with irregularly-radial repeatedly-anastamosing caeca leaving only very fine pits between them, horizontal to gently concave, of even width except for tapering end of prolongation and sagittally as described above, with spine on posterior end of prolongation. Outer rim strongly upturned dorsally but not projecting ventrally, with only very low outer vertical marginal band bearing the suture. Hypostome unknown.

Thorax of at least eighteen segments, tapering posteriorly, with convex axis, horizontal pleurae within fulcral lines and steeply downturned pleural extremities; axis with shallow distinct articulating furrow, short articulating half ring only slightly lower than axial ring, with posterior margin of axial ring curving very gently forward over medial part of axis. Pleurae with well impressed pleural furrows running in midlength of segment throughout to finish against well developed articulating facets near the midlength of the facet; articulating facet large, half segment length, flat; pleural tip apparently rounded. Pygidium unknown.

Remarks: *Australoharpes singletoni* may be distinguished from the type species by its posterior eyes, its less developed alae, its higher cheek roll and spine on the tips of the prolongation although available illustrations do not preclude their presence in *A. depressus*. It should also be noted that the girder in *A. depressus* appears (Harrington & Leanza, 1957, fig. 103-3) to terminate just before the tip of the prolongation as in *A. singletoni*.

One specimen (Pl. 27, fig. 1A) shows the outer brim distinctly flexed, not fractured, where it is lying on an exoskeletal fragment of another trilobite. This suggests strongly that there was a certain amount of flexibility in the brim which may have been the case with harpedids in general.

Australoharpes expansus sp. nov.

Plate 27, figure 2; plate 28, figures 1-10

Etymology: From the Latin *expansus* spread out—referring to the expanded brim.

Material: Holotype NMVP74439, paratypes NMVP74428, 74436, 74438, 74440-74444 all from NMVPL184.

Diagnosis: Alae absent; eye tubercles small, situated level with anterior of glabella; preglabellar boss present; girder fading out just before tip of prolongation; brim wide anteriorly, tapering rapidly along relatively short prolongation; spine present on tip of prolongation.

Description: This species is described only where it differs from *A. singletoni*.

Glabellar furrow 2p is impressed low on side of glabella just forward of 1p. Eye tubercles small, situated level with glabellar anterior, circular, joined to glabella by faint eye ridge, without furrows. Cheek roll very low except at posterior border furrow where it is more than twice as high as at anterior but lower than in *A. singletoni*. Brim wide anteriorly but tapering markedly posteriorly, with generally less distinct outer rim, flat with only slightly upturned margin (if at all), with relatively short prolongation, pointed posteriorly and with only short posterior spine.

Thorax, pygidium and hypostome unknown.

Remarks: This species is much closer to *A. depressus* Harrington & Leanza, 1957 than *A. singletoni* in so far as the brim is flat and wide, the eye tubercles are futher forward and the cheek roll is quite low; it is distinguished from the Argentinian species by its lack of alae, its short tapering prolongation and impression of glabellar furrows.

Family PILEKIIDAE Sdzuy, 1955

The affinities of the pilekiids were shifted from the Pliomeridae (Harrington *et al.*, 1959) to the Cheiruridae (Whittington, 1961; Lane 1971) and there is little doubt that the Pilekiidae gave rise to the Cheiruridae. However, Lane's (1971) placement of the pilekiids as a subfamily of the Cheiruridae failed to consider any possible relationship between the pilekiids and pliomerids which might have an effect on the family classification of these groups. Even without any phylogenetic considerations the Pilekiidae may be distinguished from the Cheiruridae by the style of pleural furrows on the thorax and pygidium (as noted by Lane (1971)) and by the usual four pairs of pygidial spines as opposed to three or fewer in the Cheiruridae. A few exceptions to the latter distinction are noted but affinities of these genera are clear from the full morphology of each. It should also be noted that a number of pliomerid species "fall naturally into the diagnosis of the Cheiruridae" provided by Lane (1971) (e.g., *Protopliomerops quattnor* Hintze, 1953, *Pliomera tmetophrys* Harrington & Leanza, 1957).

The very clear pilekiid affinities of *Rossaspis* Harrington, 1957 have been demonstrated by Demeter (1973) through his species *R. pliomeris*. The four pairs of pygidial spines, retention of extremely short anterior pleural bands on pygidial segments, thoracic pleural furrows, large fixigenal spine and size and position of the palpebral lobe are unmistakably pilekiid and I agree with Demeter (1973, p. 53) that *R. pliomeris* and *R. superciliosa* show affinities to the Pilekiidae and Pliomeridae respectively. However, I suggest that rather than giving rise to the pilekiids *R. pliomeris* has evolved from the Pilekiidae (older pilekiids are known e.g. in the fauna described herein) and is an offshoot from the lineage that gave rise to *Protopliomerops* and the Pliomeridae. Providing the correlation of the Digger Island Formation given above is correct, the initial evolution of *Rossaspis* to the Pliomeridae occurred elsewhere sometime in the earliest Tremadoc and *R. pliomeris* may have been the first immigrant to reach the Great Basin. The similarity between *R. pliomeris* and *Protopliomerops lindneri* sp. nov. also suggests that this morphology is close to the origin of the Pliomeridae.

The suggestion of Demeter (1973) that *Rossaspis* gave rise to the Pilekiidae would imply that thoracic pleural furrows developed strongly in the Pilekiidae and then disappeared again in the Sphaerocoryphinae. However, my suggestion that the Pilekiidae gave rise to both the Cheiruridae and Pliomeridae implies a reduction and loss of thoracic pleural furrows in at least two descendant lineages with marked modification in others.

Given the ability to distinguish pilekiids and given this possible phylogeny, with another family involved which is also distinguishable, I prefer to retain the Pilekiidae as a distinct family. The three related families may be grouped into some suitable higher-level taxon such as the Suborder Cheirurina Harrington & Leanza, 1957 as has been proposed previously (Harrington *et al.*, 1959).

Landyia gen. nov.

Etymology: The genus is named for Mr Tony Landy and family who own the adjacent property and facilitated my collecting; the specific name for the type species is given for his wife Mrs Elizabeth Landy.

Type species: *Landyia elizabethae* sp. nov.

Diagnosis: Small pilekiid with highly convex anterior profile; glabella tapering very slightly forward to broadly rounded anterior, with three pairs of sharp slit-like lateral furrows; glabellar furrows at low angle to transverse line for most of their width but curving strongly posteriorly in most adaxial part, with 3p having short often indistinct anterior fork or expansion; palpebral lobes short, far from axial furrow; posterior cephalic limb long and wide. Thorax of 13 segments; pleurae with sharp, slit-like pleural furrows running along the midlength of the segment for most of course, fading out just beyond articulating line; pleural tips broad, flat, curved posteriorly, with posterolateral projection into short spine.

Pygidium with axis of four rings and long triangular terminus reaching posterior margin but otherwise entirely enclosed by fourth pygidial segment; pleural and interpleural furrows sharp and slit-like; interpleural furrows running to margin; posterolateral corners of segments extended into short flat spines, with spines becoming longer on more posterior segments.

Remarks: As with many pilekiid and pliomerid genera the distinctive features of this new taxon are to be found in the pygidium and thorax rather than the head. Most distinctive of all are the pleural furrows, marginal spines and completely surrounded axial terminus. On the cranidium the combination of an anterior fork in furrow 3p, the curved adaxial end of furrow 1p, lack of genal spine, large fixigena, and almost transverse eye ridge are a unique combination of characters but each is found in at least one other pilekiid genus. Relationships with known genera are impossible to discern as the style of pleural furrow and pygidial structure appear to be completely new in the family.

Landyia elizabethae sp. nov.

Plate 30, figures 5-11; plate 31, figures 1-5

Material: Holotype NMVP74474, paratypes NMVP74463-74473 from NMVPL184.

Diagnosis: As for genus.

Description: Cranidium convex in anterior profile, with anteriorly sloping frontal glabellar lobe, with smooth surface except for punctate cheeks having small granules in some places on the ridges between the pits; glabella narrowest at base of lobe 1p, widest at anterior of lobe 1p then parallel-sided or very weakly tapering forward to broadly rounded anterior, with three pairs of sharp slit-like and very wide lateral glabellar furrows; furrows 1p and 2p at low angle to transverse line, slightly sigmoidal, with adaxial end curving posteriorly with 1p furrow not reaching occipital furrow but nevertheless lobe 1p often somewhat bulbous and rounded (as in *Pilekia*); furrow 3p straight, parallel to central portion of 2p, with slight expansion in length abaxially where an anterior fork is barely preserved; lobes 1p, 2p, and 3p of equal length, with frontal lobe subtriangular and longer than others; occipital furrow short and deep, curving very gently forward at abaxial ends and over axis; occipital ring with transverse posterior margin except for slight anterior curve abaxially, with flat lateral profile medially but convex laterally; preglabellar furrow absent; axial furrow relatively narrow, with deep pit just anterior to eye ridge, appearing scalloped around glabellar lobes in most specimens; anterior border shorter than occipital ring, becoming more elongate near anterolateral corners of glabella; eye ridge meeting axial furrow at level of posterior of frontal glabellar lobe, transverse or sloping gently posterolaterally, of uniform length, continuing directly into palpebral lobe; palpebral lobe situated anteriorly opposite lobe 3p, palpebral furrow slit-like, continuing behind eye ridge to axial furrow; facial suture proparian, with anterior section running across border at very low angle to meet margin close to sagittal line, posterior section running almost transversely from posterior of palpebral lobe to meet margin well in front of genal angle; fixigena as wide as glabella, relatively large; posterior border furrow short, sharp, becoming less distinct around genal angle; posterior border becoming elongate laterally, quite wide at genal angle, without genal spine but with angular extremity in some specimens.

Hypostome longer than wide, with strongly convex median body bearing ornament of close-spaced fine granules most obvious on anterior part and decreasing in granule size laterally and posteriorly; anterior margin transverse to gently arched forward, depressed dorsally over axis; anterior wings triangular, bent strongly dorsolaterally, smooth, with broad shallow furrow adjacent to median body cutting off distal part; median furrow at very high angle to transverse line, curving and fading out adaxially to define the large inflated anterior lobe and short sloping horseshoe-shaped posterior lobe of the median body; lateral and posterior border narrow, of uniform width, raised and convex, with fine granulose ornament, beginning just behind the lateral notch on the very posterior of the anterior wing as a low rising ridge; border furrow well-impressed, very narrow laterally adjacent to the anterior of the lateral border, becoming wider and deeper posteriorly.

Thorax of 14 segments, strongly convex, with axis approximately as wide as each pleural field in dorsal view; articulating half ring short, much lower than axial ring, merely a flange rising up from the anterior of the well-impressed almost transverse articulating furrow; axial ring of uniform length, gently convex in lateral profile; axial furrow expressed only as a change of slope from axis to pleura; pleura crossed by short slit-like pleural furrow running from the axial furrow just in front of the midlength of the segment along the midlength of the pleura and fading out beyond the articulating line well before the pleural tip, strongly downturned in articulating line, swung posteriorly with amount of swing increasing posteriorly to be almost exsagittal at pygidium; pleural tips pointed but not spinose, with wide steeply inclined weakly concave articulating facets.

Pygidium subtriangular, with lateral margins downcurved and posterior sloping back only gently with four pairs of marginal spines; axis of four rings and large triangular terminus, only gently convex in anterior profile, wider than each pleural field; anterior ring longer laterally than axially; second ring with prominent pseudoarticulating half ring; each ring very broadly convex forward; axial furrow weakly impressed but distinct, running in zig-zag out to the pleural furrow then adaxially back to the next posterior transaxial furrow; terminus elongate triangular, completely enclosed by the fourth segment except for posterior tip reaching posteromedial margin; transaxial furrows well-impressed and distinct anteriorly becoming shallower but still distinct posteriorly; pleural area crossed by short slit-like pleural and interpleural furrows, convex with downturned margin, without border furrow and border; interpleural furrows curving posteriorly with first at about 45° to transverse and third almost exsagittal, reaching lateral margin between spines; pleural furrows almost straight, near or just behind midlength of segment, finishing laterally soon after crossing articulating line well inside tips of segments; four pairs of marginal spines posterolaterally, with posterior pair longest, with spinose tip central rather than posteriorly on segment; pleural ribs short near axial furrow, becoming longer near articulating line then tapering to tip (fourth segment in particular, with this shape).

Victorispina gen. nov.

Etymology: The generic name refers to the spinose nature of the exoskeleton found in Victoria.

Type species: *Victorispina holmesorum* sp. nov.

Diagnosis: Pilekiid with extremely long fixigenal spine issuing from posterior cephalic border at the articulating line, with opisthoparian facial suture, without genal spine, with parallel-sided subrectangular glabella bearing three pairs of wide short slit-like glabellar furrows, with furrow 3p having short but distinct anterior fork, with long upwardly-directed slightly reclined spines situated on each thoracic segment in the articulating line, with transverse pygidium having four pairs of posteriorly directed marginal spines, with anterior band of each pygidial pleural rib greatly reduced in favour of the posterior band which is elongate into the marginal spine, and with extremely coarse granulose ornament over entire exoskeleton except for furrows and spines.

Remarks: This genus has a combination of features some of which are known in *Pilekia* Barton, 1915 and others which are characteristic of *Parapilekia* Kobayashi, 1934; however the opisthoparian facial suture and position of the fixigenal spine may prove to be unique to this genus. *Victorispina holmesorum* has the glabellar shape, style of glabellar furrows, and reduced anterior pleural bands of pygidial pleural ribs characteristic of *Parapilekia* Kobayashi, 1934, but that genus has proparian facial suture, genal spine, and presumably lacks thoracic spines in the articulating line. *Pilekia apollo* (Billings, 1860), has the spines in the articulating line on the thorax (seen on specimen figured by Raymond (1913, pl. 4, fig. 1) from photographs kindly provided by Dr T. E. Bolton), but has distinctive glabellar features and has the anterior band of each pygidial pleural rib much less reduced relative to the posterior band. Other genera of Pilekiidae may not be confused with this genus and need no comment. The doubly spinose thoracic pleurae are reminiscent of a number of odontopleurid genera but any phylogenetic links must be discounted and the resemblance attributed to homeomorphy as the major cephalic spines consistently arise from different positions in each group.

As some species of *Pilekia* apparently do not have the thoracic spines in the articulating line and as the spines are unlikely to be a primitive character it seems reasonable to speculate that both *P. apollo* and *V. holmesorum* evolved from some forms without thoracic spines. I suggest that *Victorispina* may have arisen from *P. apollo* or at least some species of *Pilekia* with thoracic spines in the articulating line and that *Parapilekia* arose from some different species of *Pilekia* without thoracic spines. The features common to *Victorispina* and *Parapilekia* are therefore probably homeomorphous.

Victorispina holmesorum sp. nov.

Plate 29, figures 1-13; plate 30, figures 1, 3-5

Etymology: The specific epithet is for Frank and Enid Holmes who donated several important specimens of this taxon.

Material: Holotype NMVP74446, paratypes NMVP74445, 74447-74459, 74461, 74462 and a further 20 to 30 fragmentary specimens of cranidia and pygidia from NMVPL184.

Diagnosis: As for genus.

Description: Glabella subrectangular, with frontal lobe and occipital ring narrower than rest, with transverse anterior margin and rounded anterolateral corners, with three pairs of lateral glabellar furrows, having axial ridge between evenly sloping sections and sharp narrow drop into axial furrow in anterior profile; glabellar furrows straight, slit-like, at low angle to transverse line, parallel to each other; furrow 1p not reaching occipital furrow; furrow 3p with distinct anterior fork extending a short distance forward from the abaxial half of the furrow; occipital furrow well-impressed, arching very subtly forward over the axis and at the axial furrow; occipital ring slightly elongate medially, convex in lateral profile; axial furrow well-impressed, U-shaped in section, straight and exsagittal except for adaxial curve posteriorly to the occipital ring and anteriorly where a sharp turn adaxially occurs just behind the junction with the eye ridge before the furrow becomes exsagittal again; preglabellar furrow well-impressed, shorter than axial furrow is laterally, of uniform length; anterior border very short medially, becoming more elongate laterally, strongly convex, with ornament of extremely fine pustules medially being replaced laterally by the general coarse tubercles; eye ridge convex in section, narrow, meeting axial furrow at level of anterior of glabellar lobe 3p, continuing laterally directly into palpebral lobe; palpebral lobe slightly wider than eye ridge in section, gently arcuate, curving posteriorly from line of eye ridge, defined by well-impressed palpebral furrow continuing behind eye ridge to axial furrow and continuing behind palpebral lobe onto librigena beneath eye socle; facial suture running in exsagittal line forward of palpebral lobe for short distance then curving adaxially across border, sigmoidal behind palpebral lobe, with wide middle limb, meeting posterior margin in right angle; fixigena large, wide, almost horizontal adaxially but strongly downsloping lateral to articulating line through posterior of palpebral lobe, covered with strongly interconnecting maze of caeca separated by distinct pits, with sparse coarse tubercles surmounting caeca; posterior border furrow well-impressed, of uniform length throughout; posterior border short, becoming elongate laterally, without ornament, with strong spine at least as long as cranidium issuing from top of the border in the articulating line and rising up almost vertically in posterolateral direction. Librigena long and narrow, virtually flat, with ornament of caecal ridges and intervening pits as on fixigena, with coarse tubercles on caeca and on adaxial part of border, with fine pustulose ornament towards margin; eye socle low but distinct, border furrow deep, with steep almost vertical slope up to border but much gentler slope to genal field; border flat adaxially rolling over margin, continuing unchanged around spineless rounded genal angle. Surface of cranidium except for furrows or unless stated otherwise covered with widely separated coarse tubercles.

Thorax of more than 10 segments; articulating halfring and axial ring of approximately same length; pleura with short sharp pleural furrow running in midlength as far as articulating line, with long almost vertical spine arising from posterior pleural band at the articulating line; free pleura downturned, with spinose tip, with short inclined articulating facet; line of coarse tubercles on axial ring and pleural bands.

Pygidium transverse; axis of four rings and short subtriangular terminus reaching posterior margin and enclosed laterally by bases of fourth marginal spines, with short pseudoarticuating halfring on first ring, tapering posteriorly, with convex lateral margins, convex in anterior profile but not standing too far above pleural field; pleural field crossed by two pleural and three interpleural furrows, with anterior pleural band of first two segments greatly reduced, with posterior pleural bands extended into four pairs of marginal spines directed posteriorly; marginal spines round in section, becoming progressively shorter posteriorly; axial rings and pleural bands with rows of coarse tubercular ornament.

Pilekia Barton, 1915

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

Pilekia sp.

Plate 32, figures 2-6

Material: Three cranidia NMVP74476, 71216, 71217 and two pygidia NMVP71215, 71218 from NMVPL184.

Remarks: The glabella tapers forward strongly with convex lateral margins, three pairs of wide short lateral furrows and the 1p lobe quite bulbous. The anterior border is short, convex and separated from the glabella only by a short deep border furrow. The palpebral lobe is slightly expanded distally, curves posteriorly so that the interocular cheek is narrower than in most species. The fixigena behind the palpebral lobe is quite large and bears a strong genal spine on the posterior border some distance behind the facial suture. The pygidium bears four pairs of large slightly curved marginal spines directed posteriorly. Anterior pleural bands of the first two segments are not markedly reduced as they are in third and fourth segments. The axis has four rings and a terminus; termination of the latter is not seen on available material.

No particularly distinctive features present themselves on this material that is too poorly preserved for formal description. *Pilekia* sp. nov. (Jell & Stait, 1985) from Tasmania is distinguished by its non-uniform pygidial marginal spines but distinctions from *Pilekia apollo* and *P. trio* Hintze, 1953 are not at all easy on available material and in the absence of knowledge of a pygidium for the latter species. Reduction of the anterior pleural band of the third pygidial rib on the Victorian material may separate it from *P. apollo*. This material records the presence of the genus in Victoria and, when better material becomes available, will probably form the basis of a new species.

Tessalacauda Ross, 1951

Type species (by original designation): *Tessalacauda depressa* Ross, 1951.

Tessalacauda ? sp.

Plate 32, figure 1

Material: One incomplete and distorted internal cranidial mould, NMVP74475 from NMVPL184.

Remarks: This single fragment resembles *Tessalacauda* in the parallel-sided to slightly anteriorly expanding glabella, with short lateral glabellar furrows, very large fixigena, course of the posterior border furrow, and cheek ornament. Although these features are not sufficiently distinctive to make a positive identification they do suggest this genus above all others described to date. The only feature which does not fit with *T. depressa* is the position of the palpebral lobe closer to the glabella but that would be a specific taxobase if in combination with other distinctive features. For the present this specimen suggests the occurrence of the genus in Australia but confirmation of that distribution must await better material.

Family PLIOMERIDAE Raymond, 1913

Protopliomerops Kobayashi, 1934

Type species (by original designation): *Protopliomerops seisonensis* Kobayashi, 1934.

Protopliomerops lindneri sp. nov.

Plate 30, figure 2; plate 32, figures 7-10; plate 33, figures 1-4; text-fig. 2

Etymology: The species is named for Mr A. W. Lindner who first recorded the occurrence of these trilobite fossils in 1953.

Material: Holotype NMVP71225, paratypes NMVP71219-71224, 71227, 74460 from NMVPL184.

Diagnosis: Member of *Protopliomerops* with palpebral lobes close to glabella, with 3p glabellar furrow reaching axial furrow at anterolateral corner of glabella at same level as eye ridge, with pointed genal angle (not spinose). Pygidium with axis of four rings and small triangular terminus not reaching posterior margin, with short anterior pleural band on first segment but only posterior band present on subsequent segments, with pleurae extended into four pairs of strong marginal spines, with marginal spines well separated and anterior ones curving back but posterior ones exsagittal.

Description: Cranidium semicircular, of moderate convexity, with axis standing well above pleurae; glabella with straight and parallel to very gently converging sides, with broadly rounded anterior, with three pairs of wide, short well-impressed lateral furrows; occipital furrow deep, with U-shaped section, becoming elongate and with anterior margin curving forward over axis, shortest and deepest in narrow lateral part curving forward to axial furrow; occipital ring long, with flat lateral profile, slightly elongate medially, continuing across axial furrow as very low ridge into posteroproximal corner of fixigena; lateral glabellar furrow 1p at greater angle to transverse line than 2p or 3p, turning sharply back and shallowing at adaxial end to reach occipital furrow; furrows 2p and 3p with same posterior turn in shallowing adaxial end, 3p at anterolateral corner of glabella; anterior border very short and convex anteriorly, merely a rim on glabellar anterior, more elongate and then of constant cross-section as far as genal angle; palpebral lobe large, bean-shaped, oriented almost exsagittally close to axial furrow, elevated almost to height of glabella, with very narrow eye ridge connecting it to axial furrow, situated lateral to 2p and 3p glabellar furrows; posterior cephalic limb wide and long, punctate with fine pustules on ridges surrounding pits, with well-impressed transverse border furrow isolating convex border becoming flatter and longer laterally; genal angle pointed and slightly drawn out but not truly spinose; facial suture proparian, converging forward from palpebral lobe to run across border very obliquely in slight furrow just lateral to axial furrow, transverse behind palpebral lobe but convex forward near border furrow then curving back across border but still well in front of genal angle. Librigena with vertical visual surface, low steep eye socle, sloping narrow genal field ornamented as on fixigena, with convex pustulose border almost as wide as genal field.

Pygidium subtriangular, with four pairs of marginal spines; axis of four segments and very small triangular terminus not reaching margin, rings becoming shorter and narrower posteriorly, of inverted conical shape with pointed tip, with transaxial furrows longer medially than laterally; pleural areas crossed by deep interpleural furrows and ribs extending into marginal spines, with short anterior border and short border furrow low on anterior of first rib; anterior spines curving posteriorly beyond edge of pygidium but posterior ones virtually exsagittal, full extent of spines not known; doublure narrow, becoming longer posteromedially, smooth and inclined up away from the margin; marginal spines arising from dorsal surface of pygidium not interfering with doublure; pygidial surface finely pustulose.

Discussion: *Protopliomerops lindneri* is distinguished most easily by its large palpebral lobes situated almost exsagittally close to the axial furrow, by its anteriorly rounded glabella, sigmoidal 1p glabellar furrow, by its 4 pairs of pygidial spines and by the fourth pair of spines enclosing the axial terminus. It most closely resembles *P. quattuor* Hintze, 1953 from the late Tremadoc of western Utah but differs in ornament on cheeks, glabellar shape, length of palpebral lobe, shape of 1p glabellar furrow, more transverse pygidium and smaller axial terminus. *Rossaspis pliomeris* Demeter, 1973 has some features in common with *P. lindneri* namely the pitted ornament of the cheeks, shape of the 1p glabellar furrow, glabellar shape and transverse pygidium with 4 pairs of spines and small enclosed axial terminus. However, the species from Utah has distinctly different palpebral lobes, genal spine, and much finer and shallower furrows throughout. Nevertheless, this may be the most similar species so far described.

Unassigned hypostomes

Plate 33, figures 5-16

Remarks: A variety of hypostomes occurred in this fauna that were not found in direct association with any cranidia and could not be assigned to any species with confidence. Of the illustrated hypostomes five (Pl. 33, figs 5-9) appear to belong to one species which may be *Pseudokainella diggerensis* as the type of ornament is known in that family and the size range available seems to fit also. One type of hypostome (Pl. 33, fig. 11) reaches very large size and may belong to the largest species—*Leiostegium douglasi*. Of the others Pl. 33 figs 13 and 16 each represent different species but those in figures 10, 12, 14 and 15 may belong to a single species that could be one of the pilekiids by comparison with that of *Tessalacauda* (see Ross, 1951, pl. 31, fig. 30).

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Explanation of Plates

PLATE 19

Figs 1-5. *Neoagnostus eckardti* sp. nov.

Figure 1. Latex cast of slightly incomplete external mould of pygidium in dorsal (A) and posterior (B) views showing posteromedian node, zonate posterior border and degree of convexity, NMVP74319, ×10.

Figure 2. Exfoliated internal mould of damaged cranidium, NMVP74320, ×10.

Figure 3. Partially exfoliated cranidium, NMVP74321, ×10.

Figure 4. Exfoliated pygidium showing axial nodes and transaxial furrows, NMVP74322, ×10.

Figure 5. Internal mould of HOLOTYPE cranidium showing preglabellar furrow, glabellar segmentation, and glabellar node, NMVP74323, ×10.5.

Figs 6-14. *Micragnostus hoeki* Kobayashi, 1939

Figure 6. Internal mould of cranidium showing glabellar node well back from transglabellar furrow, NMVP74324, ×7.

Figure 7. Damaged internal mould of complete specimen showing association of head and tail, NMVP74325, ×5.

Figure 8. Exfoliated latex cast from imperfect external mould showing faint preglabellar median furrow, faint caecal impressions on right side and straight transglabellar furrow, NMVP74326, ×10.

Figure 9. Partially exfoliated latex cast from imperfect slightly distorted external mould of cranidium showing glabellar node and lateral lobes on posterior glabellar lobes, NMVP74327, ×8.

Figure 10. Partially exfoliated latex cast from incomplete external mould of pygidium showing exsagittal lobation of second axial ring, NMVP74328, ×7.

Figure 11. Pygidium showing external surface in posterior (A) and dorsal (B) views marginal spines, large axial node, general convexity, and poorly defined axial furrow at rear of axis well in front of and above border furrow, NMVP74329, ×10.

Figure 12. Slightly distorted internal mould of pygidium showing marginal spines, and extent of axis, NMVP74330, ×10.

Figure 13. Exfoliated latex cast from slightly distorted and incomplete pygidium showing lobation of axis both transversely and exsagittally, NMVP 74331, ×7 (faint parallel lines on surface are

result of ammonium chloride forming in pattern probably induced by finger prints on the latex before whitening—they do not reflect a feature of the trilobite).

Figure 14. Latex cast of partially exfoliated slightly compressed (in transverse direction) pygidium showing narrow axial node, long border and anteriorly placed marginal spines, NMVP 74332, ×8.

Figs 15-19. *Shumardia erquensis* Kobayashi, 1937

Figure 15. Internal mould of slightly distorted cranidium, NMVP74333, ×15.

Figure 16. Internal mould of slightly damaged cranidium, NMVP74334, ×15.

Figure 17. Latex cast from imperfect external mould of cranidium, NMVP74335, ×15.

Figure 18. Internal mould of slightly damaged cranidium, NMVP74336, ×13.

Figure 19. Latex cast from imperfect external mould of cranidium in anterior (A) lateral oblique (B) and dorsal (C) views showing fine border as a marginal rim, NMVP74337, ×15.

PLATE 20

Figs 1-3. *Parahystricurus* sp. cf. *P. fraudator* Ross, 1951

Figure 1. Fragmentary internal mould of cranidium showing short, wide, forward-placed palpebral lobes, NMVP74338, ×6.

Figure 2. Internal mould of cranidium showing glabellar furrows, preglabellar connection to border furrow, long posterior cephalic limb and anteriorly-converging facial suture, NMVP 74339, ×6.

Figure 3. Latex cast of fragmentary cranidium in anterior (A) and dorsal (B) views showing ornament, furrows, border, and palpebral lobe in anterior of cranidium, NMVP74340, ×6.

Figs 4-8. Hystricuridae gen. et sp. nov.

Figure 4. Latex cast from slightly incomplete external mould in dorsal (A) and anterior (B) views showing fossulae, anterior border shape, glabellar furrows, and long narrow posteriorly-situated palpebral lobe, NMVP74341, ×7.

Figure 5. Latex cast from incomplete distorted (dextral strain) external mould of cranidium, NMVP 74342, ×7.

Figure 6. Internal mould of distorted (laterally compressed) cranidium, NMVP74343, ×6.

Figure 7. Largely exfoliated latex cast of small cranidium, NMVP74344, ×8.

Figure 8. Latex cast from imperfect distorted (foreshortened) cranidium showing course of occipital and axial furrows, NMVP74345, ×6.

Figs 9-12. *Natmus tuberus* gen. et sp. nov.

Figure 9. Incomplete latex cast (A) and internal mould (B) of damaged cranidium showing anterior border furrow pits, preglabellar boss, high extended posterior palpebral lobes, and markedly different expression of the ornament on external and internal surfaces of exoskeleton, NMVP74346, ×9.

Figure 10. Latex cast from fragmentary external mould of cranidium, NMVP74347, ×13.

Figure 11. Latex cast from damaged slightly distorted external mould showing the fixigenal spine, NMVP74348, ×10.

Figure 12. Latex cast (A) and internal mould (B) of damaged holotype, cranidium showing occipital node, fixigenal spine, glabellar furrows and large smooth area posteroproximally on fixed cheek, NMVP74349, ×7.

PLATE 21

Natmus victus gen. et sp. nov.

Figure 1. Latex cast from small damaged external mould of cranidium, NMVP74350, ×8.

Figure 2. Latex cast from incomplete external mould of cranidium in dorsal (A) and anterolateral oblique (B) views showing ornament, NMVP 74351, ×6.

Figure 3. Latex cast from incomplete external mould of holotype cranidium in anterior (A) and dorsal (B) views showing elevated palpebral lobes, occipital spine, and glabellar furrows, NMVP74352, ×7.

Figure 4. Latex cast from incomplete external mould of cranidium (latex imperfect at occipital spine), NMVP74353, ×5.

Figure 5. Internal mould of damaged cranidium, NMVP74354, ×8.

Figure 6. Latex cast from incomplete external mould of cranidium, NMVP74355, ×7.

Figure 7. Internal mould of damaged cranidium, NMVP74356, ×7.

Figure 8. Latex cast from incomplete external mould of cranidium showing wide posterior cephalic limb, NMVP74357, ×10.

Figure 9. Latex cast from fragmentary external mould of cranidium showing difference in ornament between glabella and cheeks, NMVP74358, ×8.

Figure 10. Latex cast from slightly incomplete external mould of complete specimen showing at least 16 thoracic segments each with median node, and becoming narrower and curved to the posterior (also indicating that the pygidium was tiny), NMVP74359, ×7.

Figure 11. Damaged internal mould of complete specimen showing mould of long genal spine, NMVP74360, ×2.5.

Figure 12. Latex cast from incomplete external mould of librigena in oblique lateral view showing eye surface, eye socle, ornament, discontinuous border furrow, and genal spine, NMVP74361, ×10.

Figure 13. Latex cast from imperfect external mould of librigena showing long genal spine, NMVP 74362, ×6.

Figure 14. Internal mould of librigena, NMVP74363, ×8.

Figure 15. Internal mould of damaged cranidium in dorsal (A) and anterolateral oblique (B) views showing short wide posterior cephalic limb and glabellar furrows, NMVP74364, ×6.

PLATE 22

Figs 1-10. *Leiostegium douglasi* Harrington, 1937

Figure 1. Almost completely exfoliated latex cast from damaged slightly distorted (sinistral strain) cranidium showing glabellar furrows, and caecal development in anterior border and forward of eye ridge, NMVP74365, ×3.

Figure 2. Latex cast from imperfect external mould of librigena showing perforated exoskeleton, eye socle, marginal terrace lines extending down genal spine, and course of facial suture to margin, NMVP74366, ×2.5.

Figure 3. Partly exfoliated latex cast from imperfect external mould of librigena showing course of facial suture across doublure anteriorly, posteriorly shallowing border furrow and long genal spine, NMVP15629, ×2.

Figure 4. Partially exfoliated latex cast from imperfect external mould of cranidium showing casts of pits in inner surface of exoskeleton, NMVP74367, ×4.

Figure 5. Latex cast from external mould of cranidium showing palpebral lobe, and posterolateral limb, NMVP74368, ×5.

Figure 6. Latex cast from incomplete slightly imperfect external mould of cranidium in anterolateral (A) and dorsal (B) views, NMVP74369, ×4.

Figure 7. Latex cast from incomplete external mould of pygidium, NMVP74370, ×3.

Figure 8. Latex cast from incomplete external mould of pygidium, NMVP74371, ×2.

Figure 9. Internal mould of large damaged pygidium and articulated thoracic segments, NMVP74372, ×1.

Figure 10. Latex cast from fragmentary external mould of whole specimen (A) showing the eight thoracic segments and their tips and internal mould (B) of several pleural tips showing extent of doublure ventrally, NMVP74373, ×5.

Figs 11, 12. *Leiostegium* sp. cf. *L. manitouensis* Walcott, 1925

Figure 11. Latex cast from imperfect external mould showing short border, NMVP74374, ×4.

Figure 12. Latex cast from imperfect external mould, NMVP74375, ×4.

PLATE 23

Onchopyge parkerae sp. nov.

Figure 1. Latex cast from imperfect external mould of cranidium showing bulging 2p glabellar lobe, 1p furrow, and large palpebral lobe, NMVP74376, ×6.

Figure 2. Latex cast from distorted (sinistral strain and flattening out) incomplete external mould of cranidium, NMVP74377, ×6.

Figure 3. Internal mould of damaged cranidium, NMVP74378, ×5.

Figure 4. Internal mould of distorted (sinistral strain) cranidium, NMVP74379, ×7.

Figure 5. Internal mould of cranidium showing posterior cephalic limb, NMVP74380, ×5.

Figure 6. Internal mould of librigena showing extension of doublure forward (suggesting kainelliform suture), NMVP74381, ×6.

Figure 7. Latex cast from imperfect external mould of cranidium, NMVP74382, ×8.

Figure 8. Latex cast from imperfect external mould of pygidium, NMVP74383, ×8.

Figure 9. Damaged internal mould of cranidium showing glabellar furrows, NMVP74384, ×7.

Figure 10. Mostly exfoliated latex cast from damaged external mould of pygidium, NMVP74385, ×5.

Figure 11. Exfoliated latex cast from incomplete external mould of pygidium, NMVP74386, ×6.

Figure 12. Latex cast from incomplete external mould of librigena, NMVP74387, ×8.

Figure 13. Latex cast from external mould of librigena showing advanced genal spine, border furrow, and terrace lines on border and spine, NMVP74388, ×3.

Figure 14. Latex cast from incomplete external mould of pygidium, NMVP74389, ×6.

Figure 15. External mould of doublure on pygidium, NMVP74390, ×4.

Figure 16. Latex cast from incomplete external mould of part of thorax, NMVP74391, ×3.

PLATE 24

Figs 1-4. *Onychopyge parkerae* sp. nov.

Figure 1. Latex cast from incomplete external mould of holotype pygidium in dorsal (A) and lateral oblique (B) views showing transverse ridges on axis, posteromedial ridge, and ridges on pleural ribs leading down spines, NMVP74392, ×6.

Figure 2. Latex cast from imperfect external mould of pygidium showing long spines, NMVP74393, ×7.

Figure 3. Latex cast from incomplete external mould of pygidium, NMVP74394, ×6.

Figure 4. Latex cast from incomplete external mould of pygidium, NMVP74395, ×8.

Figs 5-14. *Pseudokainella diggerensis* sp. nov.

Figure 5. Latex cast from incomplete external mould of crumpled cranidium showing border furrow pits and diverging anterior parts of suture, NMVP74396, ×6.

Figure 6. Latex cast from incomplete distorted external mould of cranidium, NMVP74397, ×5.

Figure 7. Latex cast from external mould of librigena, NMVP74398, ×3.

Figure 8. Latex cast from incomplete external mould of librigena, NMVP74399, ×3.

Figure 9. Latex cast from incomplete external mould of librigena showing median suture across doublure and row of pits at posterior edge of doublure apparently complementary with those in border furrow dorsally, NMVP74400, ×6.

Figure 10. Latex cast from slightly distorted external mould of small cranidium showing glabellar furrows, NMVP74401, ×7.

Figure 11. Internal mould of large flattened and damaged cranidium, NMVP74402, ×3.

Figure 12. Latex cast from damaged and distorted (sinistral strain) external mould of cranidium, NMVP74403, ×5.

Figure 13. Latex cast from damaged and distorted (anterior border has been forced back under front of glabella so eliminating preglabellar field and greatly increasing convexity of glabella) external mould of cranidium, NMVP74404, ×2.

Figure 14. Latex cast from damaged and distorted external mould of cranidium, NMVP74405, ×3.5.

PLATE 25

Pseudokainella diggerensis sp. nov.

Figure 1. Latex cast from incomplete distorted (foreshortened) external mould of cranidium in dorsal (A) and anterolateral oblique (B) views, NMVP74406, ×4.

Figure 2. Internal mould of small cranidium, NMVP 74407, ×5.

Figure 3. Latex cast from imperfect external mould of juvenile cranidium, NMVP74408, ×10.

Figure 4. Latex cast from incomplete external mould of whole specimen, NMVP74409, ×3.

Figure 5. Latex cast of ventral surface of librigena showing pits at inner edge of doublure anteriorly, forward extension of doublure to medial suture, and terrace lines on doublure, NMVP74410, ×5.

Figure 6. Latex cast from incomplete, damaged external mould of pygidium with five pairs of marginal spines and fine ornament of terrace lines, NMVP74411, ×5.

Figure 7. Latex cast from incomplete external mould of whole specimen, NMVP74412, ×2.

Figure 8. Latex cast from imperfect external mould of pygidium with five pairs of marginal spines, NMVP74413, ×6.

Figure 9. Internal mould of pygidium with four pairs of marginal spines and showing doublure and its ornament, NMVP74414, ×3.

Figure 10. Incomplete internal mould of whole specimen, NMVP74415, ×3.

Figure 11. Latex cast from incomplete and damaged external mould of holotype specimen showing median spine on eighth thoracic segment, and thoracic segment in pygidium just about to move out into thorax, NMVP74416, ×2.

Figure 12. Latex cast from incomplete external mould of pygidium with four pairs of marginal spines, NMVP74417, ×6.

Figure 13. Pygidium with four pairs of marginal spines, NMVP74418, ×10.

PLATE 26

Brachyhipposiderus logimus gen. et sp. nov.

Figure 1. Latex casts of ventral (A) and (B) and dorsal (C) and (D) surfaces from external moulds of holotype cranidium in ventral (A, B), anterolateral oblique (C), and dorsal (D) views, NMVP74419, ×4.

Figure 2. Latex cast from incomplete external mould of deformed cranidium showing strong ridge and epiborder furrow, NMVP74420, ×4.

Figure 3. Latex cast from ventral external mould of deformed cranidium showing girder extending to end of prolongation and major caecum extending beyond eye lobe, NMVP74421, ×5.

Figure 4. Latex cast from deformed incomplete external mould of cranidium in dorsal (A) and anterolateral oblique (B) views, NMVP74422, ×4.

Figure 5. Latex cast from imperfect external mould of ventral surface of whole specimen showing typical thoracic segments and extent of girder, NMVP74423, ×6.

Figure 6. Internal mould of slightly deformed cranidium retaining internal mould of caeca in girder and brim on right prolongation, NMVP74424, ×4.

Figure 7. Latex cast from deformed (sinistral stress) external mould of cranidium, NMVP74425, ×4.

Figure 8. Latex cast from deformed (sinistral stress) external mould of cranidium, NMVP74426 ×4.

PLATE 27

Figs 1, 3-8. *Australoharpes singletoni* sp. nov.

Figure 1. Latex cast from slightly deformed external mould of holotype specimen in anterolateral oblique (A) and dorsal (B) views (Note: Mould of rear of cephalon was cleared after latex in (B) had been pulled. Note also way brim drapes over separate exoskeletal fragment at lower right), NMVP74427, ×3.

Figure 3. Latex cast from incomplete external mould of small cephalon in dorsal (A) and anterolateral oblique (B) views, NMVP74429, ×2.

Figure 4. Latex cast from incomplete external mould of damaged cephalon in dorsal (A) and lateral oblique (B) views, NMVP74430, ×3.

Figure 5. Latex cast from incomplete external mould of ventral surface of cephalon showing girder, NMVP74431, ×2.

Figure 6. Internal mould of damaged cephalon showing long prolongations and spines extending further back, NMVP74432, ×2.

Figure 7. Latex cast from incomplete external mould of ventral surface of cephalon showing girder ending well before tip of prolongation and without reaching either margin of prolongation, NMVP74433, ×3.

Figure 8. Latex cast from slightly distorted external mould of thorax and brim (right) and of ventral surface of another brim (left), NMVP74434 and 74435, ×4.

Figure 2. *Australoharpes expansus* sp. nov. Latex cast from external mould of ventral surface of brim showing girder finishing before tip of prolongation, without reaching either margin and spine on prolongation, NMVP74428; A, ×3; B, ×1.5.

PLATE 28

Australoharpes expansus sp. nov.

Figure 1. Latex cast from incomplete external mould of ventral surface of cephalon showing girder finishing before tip of prolongation, NMVP74436, ×3.

Figure 2. Latex cast from incomplete external mould of cephalon showing tiny eye lobes, NMVP74437, ×3.

Figure 3. Latex cast from incomplete external mould of ventral surface of brim showing median notch (possibly overemphasised by distortion), NMVP74438, ×3.

Figure 4. Internal mould (A) and latex cast from external mould (B) of holotype cephalon showing small eye lobes and short prolongations on very wide brim, NMVP74439, ×4.

Figure 5. Latex cast from incomplete external mould of distorted cephalon, NMVP74440, ×4.

Figure 6. Latex cast from incomplete external mould of distorted cephalon showing small eye lobe, wide brim, and a spine on the short prolongation, NMVP74441, ×4.

Figure 7. Latex cast from external mould of brim in dorsal (A) and anterolateral oblique (B) views, NMVP74428, ×2.

Figure 8. Latex cast from incomplete external mould of cephalon showing small eye lobe (with fragment of another individual, inverted on anterior, showing prominent girder), NMVP74442, ×3.

Figure 9. Latex cast from imperfect external mould of cephalon, NMVP74443, ×4.

Figure 10. Latex cast from incomplete external mould of distorted cephalon, NMVP74444, ×3.

PLATE 29

Victorispina holmesorum sp. nov.

Figure 1. Internal mould of incomplete cranidium in anterior oblique (A) and dorsal (B) views, NMVP74445, ×5.

Figure 2. Latex cast in dorsal view (A) and internal mould in anterior oblique view (B) of incomplete holotype cranidium showing glabellar furrows and long fixigenal spine, NMVP74446, ×2.5.

Figure 3. Internal mould of damaged cranidium in lateral view showing base of fixigenal spine in articulating line and downturned cheek in foreground, NMVP74447, ×5.

Figure 4. Latex cast from incomplete external mould of thoracic segment showing high spine in articulating line, NMVP74448, ×5.

Figure 5. Latex cast from incomplete external mould of thoracic segment in anterior view showing high spine in articulating line and downturned free pleura, NMVP74449, ×7.

Figure 6. Internal mould of thoracic segment in anterior view, NMVP74450, ×3.5.

Figure 7. Internal mould of librigena, NMVP74451, ×4.5.

Figure 8. Imperfect latex cast from external mould of slightly distorted pygidium, NMVP74452, ×7.

Figure 9. Latex cast from external mould of librigena (lower) with anterior to left and cranidium of *Natmus victus* sp. nov. (upper), NMVP74453 and 74454, ×4.

Figure 10. Latex cast from incomplete damaged external mould of cranidium, NMVP74455, ×2.5.

Figure 11. Latex cast (A) from incomplete external mould and internal mould (B) of pygidium showing ornament, four pairs of spines, reduced anterior pleural bands on first two segments, and shape of axis, NMVP74456, ×8 and ×6 respectively.

Figure 12. Latex cast from incomplete external mould of distorted pygidium, NMVP74457, ×9.

Figure 13. Internal mould of pygidium, NMVP74458, ×7.

PLATE 30

Figs 1, 3, 4. *Victorispina holmesorum* gen. et sp. nov.

Figure 1. Internal mould of damaged but articulated specimen showing spines on cephalic border, thorax and pygidium, NMVP74459, ×3.

Figure 3. Internal mould of pygidium, NMVP74461, ×5.

Figure 4. Latex cast from distorted incomplete external mould of cranidium, NMVP74462, ×3.5.

Figure 2. *Protopliomerops lindneri* sp. nov. Internal mould of pygidium, NMVP74460, ×5.

Figs 5-11. *Landyia elizabethae* gen. et sp. nov.

Figure 5. Latex cast from incomplete damaged external mould of articulated juvenile specimen, NMVP74463, ×10.

Figure 6. Latex cast from incomplete damaged external mould of cranidium in anterolateral oblique (A) and dorsal (B) views, NMVP74464, ×8.

Figure 7. Latex cast from incomplete external mould of ventral surface of pygidium showing narrow raised rim around inner edge of doublure, NMVP74465, ×10.

Figure 8. Latex cast from external mould of pygidium, NMVP74466, ×5.

Figure 9. Latex cast from external mould of thorax and pygidium, NMVP74467, ×8.

Figure 10. Latex cast from incomplete external mould of cranidium, NMVP74468, ×6.

Figure 11. Latex cast from imperfect external mould of cranidium, NMVP74469, ×8.

PLATE 31

Landyia elizabethae gen. et sp. nov.

Figure 1. Latex cast from slightly imperfect and external mould of distorted cranidium in dorsal (A) and anterior oblique (B) views, NMVP74470, ×6.

Figure 2. Internal mould of pygidium in posterior (A) and dorsal (B) views, NMVP74471, ×6.

Figure 3. Latex cast from external mould of hypostome in dorsal (A) and lateral oblique (B) views, NMVP74472, ×11.

Figure 4. Latex cast from external mould of librigena, NMVP74473, ×10.

Figure 5. Latex cast from incomplete external mould of whole holotype specimen in lateral (A), anterior oblique (B) and dorsal (C) views; latex cast (D) and external mould (E) of ventral surface of holotype, NMVP74474, ×5.

PLATE 32

Figure 1. *Tessalacauda* ? sp. Internal mould of fragment of cranidium, NMVP74475, ×2.

Figs 2-6. *Pilekia* sp.

Figure 2. Internal mould of large damaged cranidium in anterior (A) and dorsal (B) views, NMVP74476, ×2.

Figure 3. Internal mould (A) and latex cast (B) from external mould of incomplete pygidium, NMVP71215, ×2.5.

Figure 4. Incomplete internal mould of small cranidium, NMVP71216, ×4.

Figure 5. Latex cast from external mould of fragment of left posterior fixigena, NMVP71217, ×3.

Figure 6. Incomplete internal mould of pygidium, NMVP71218, ×2.

Figs 7-10. *Protopliomerops lindneri* sp. nov.

Figure 7. Latex cast from imperfect incomplete external mould of cephalon showing large eye lobe close to axial furrow, glabellar furrows, and librigena in place, NMVP71219, ×12.

Figure 8. Incomplete internal mould of cephalon, NMVP71220, ×11.

Figure 9. Slightly imperfect latex cast from external mould of pygidium showing four pairs of marginal spines, NMVP71221, ×5.

Figure 10. Latex cast from external mould of ventral surface of pygidium showing rim on doublure with steep dorsal slope on inner side and spines arising well above level of doublure, NMVP71222, ×4.5.

PLATE 33

Figs 1-4. *Protopliomerops lindneri* sp. nov.

Figure 1. Latex cast from imperfect external mould of enrolled specimen with pygidium in dorsal (A) and posterior (B) views, NMVP71223, ×10.

Figure 2. Latex cast from fragmentary external mould of cephalon, NMVP71224, ×8.

Figure 3. Internal mould of holotype cephalon in lateral oblique (A) and dorsal (B) views, NMVP71225, ×9.

Figure 4. Incomplete internal mould of cranidium, NMVP71226, ×7.

Figs 5-9. Hypostome unassigned No. 1

Figure 5. Latex cast from external mould of partially exfoliated hypostome, NMVP71227, ×10.

Figs 6, 7, 8. Latex casts from external moulds of hypostomes, NMVP71228, 71229, 71230, ×11, ×8, and ×5, respectively.

Figure 9. External surface of hypostome retaining its calcareous exoskeleton, NMVP71231, ×8.

Figs 10, 12, 14, 15. Unassigned hypostome No. 2

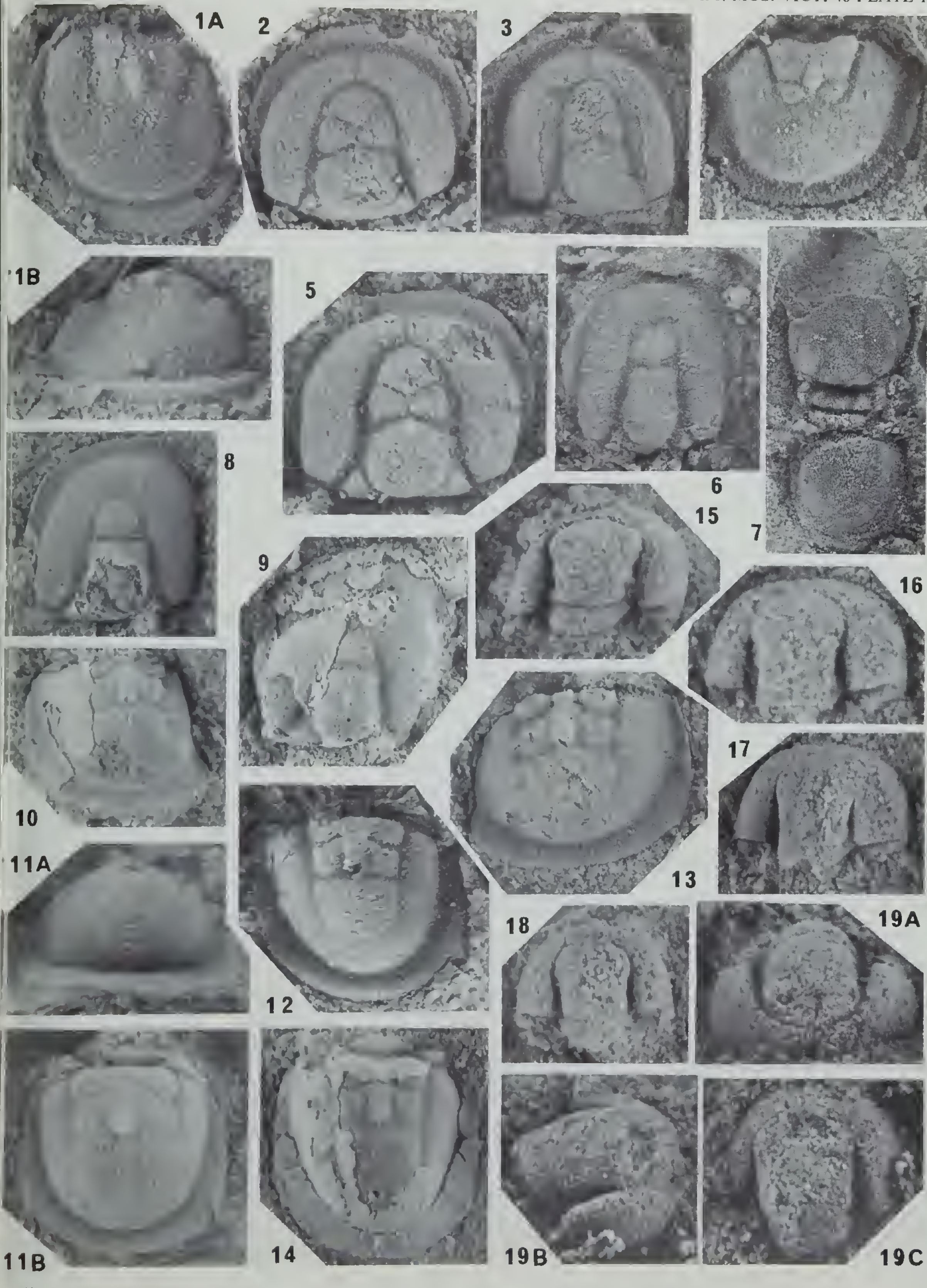
Figs 10, 12, 14. Latex casts from external moulds of hypostomes, NMVP71232, 71234, and 71236, ×4, ×4, and ×5, respectively.

Figure 15. Internal mould of hypostome, NMVP71237, ×7.

Figure 11. Unassigned hypostome No. 3. Mostly exfoliated internal mould of hypostome, NMVP71233, ×3.

Figure 13. Unassigned hypostome No. 4. Latex cast from external mould of hypostome, NMVP71235, ×8.

Figure 16. Unassigned hypostome No. 5. Internal mould of hypostome, NMVP71238, ×10.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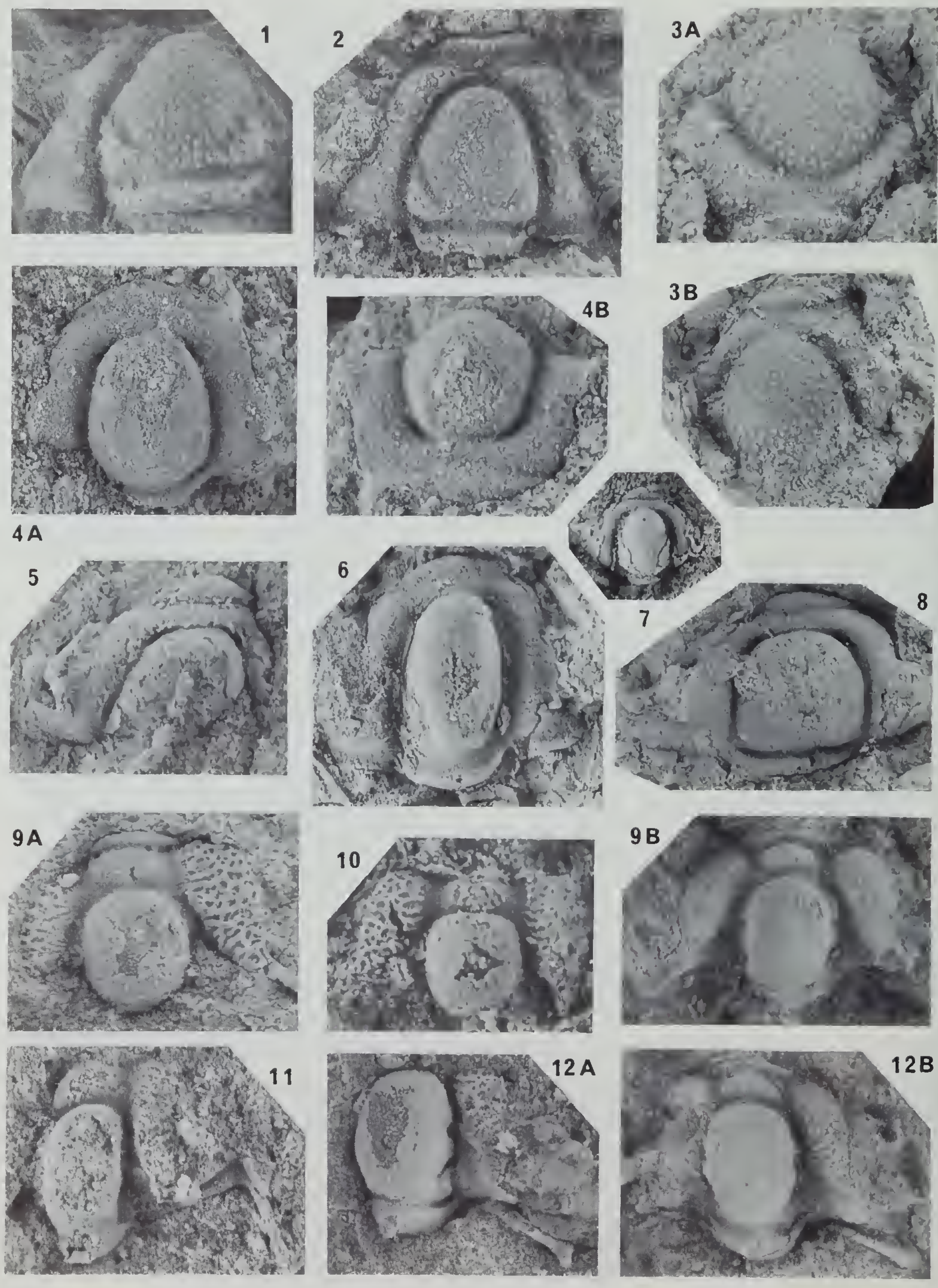
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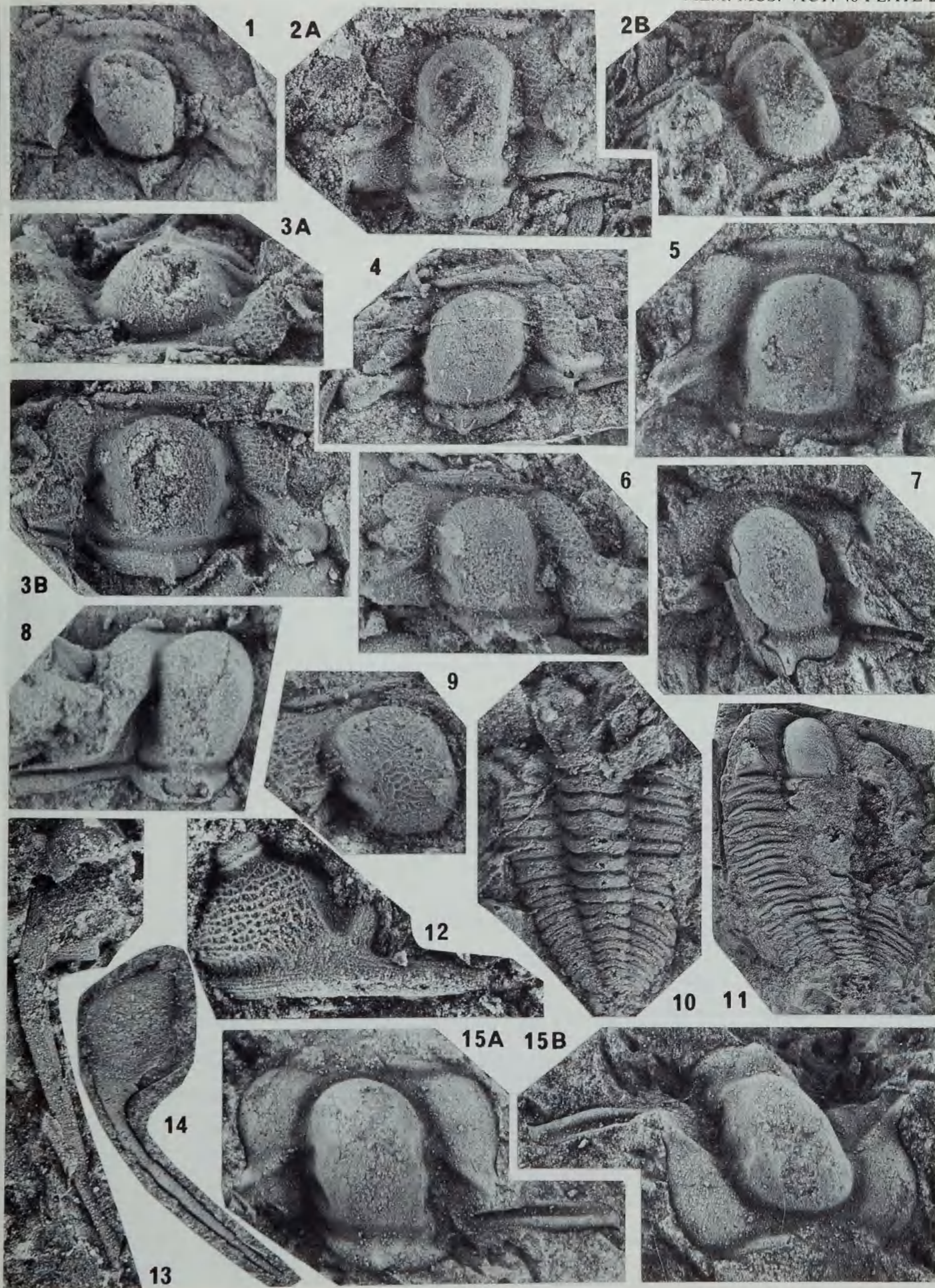
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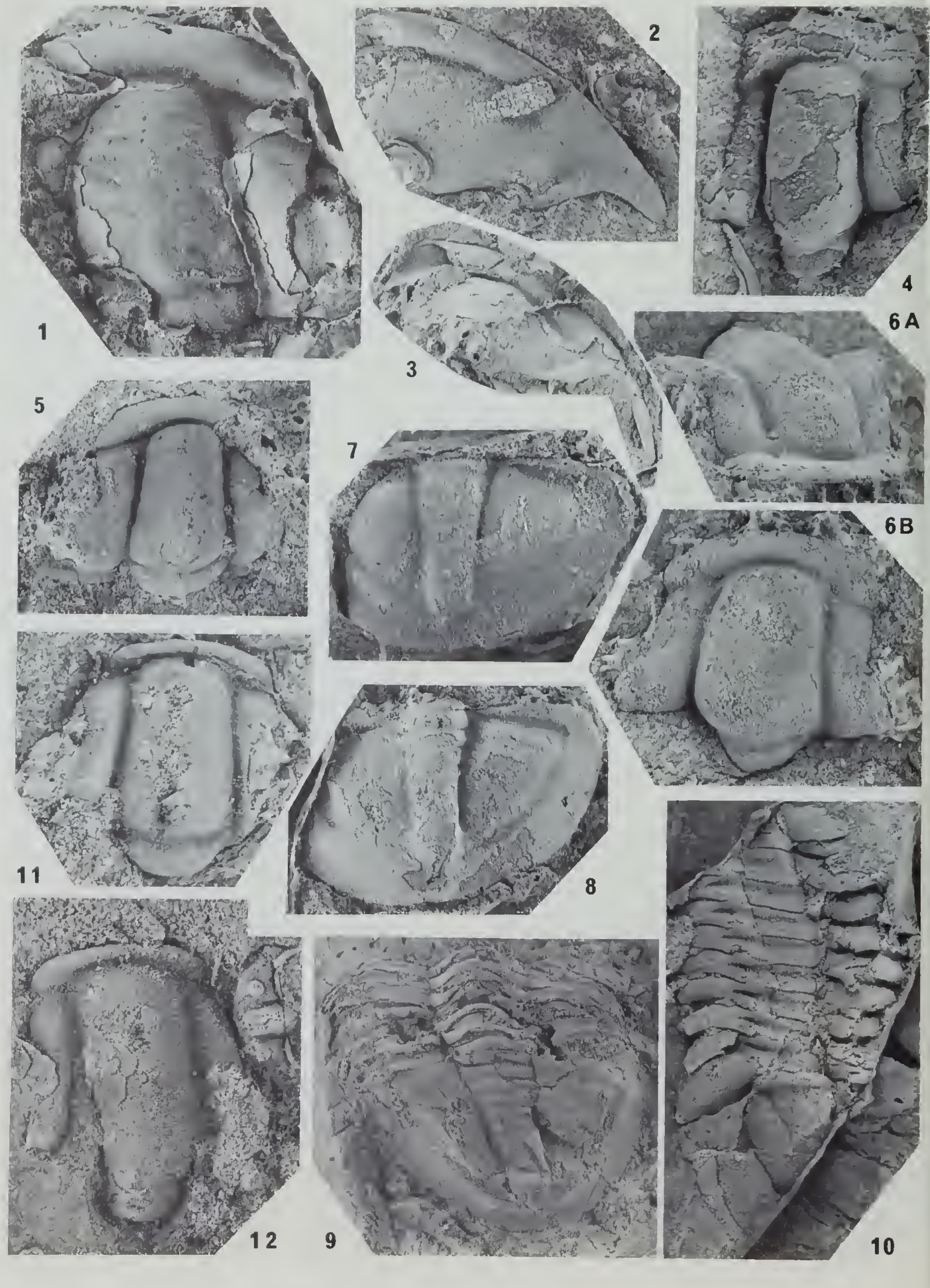
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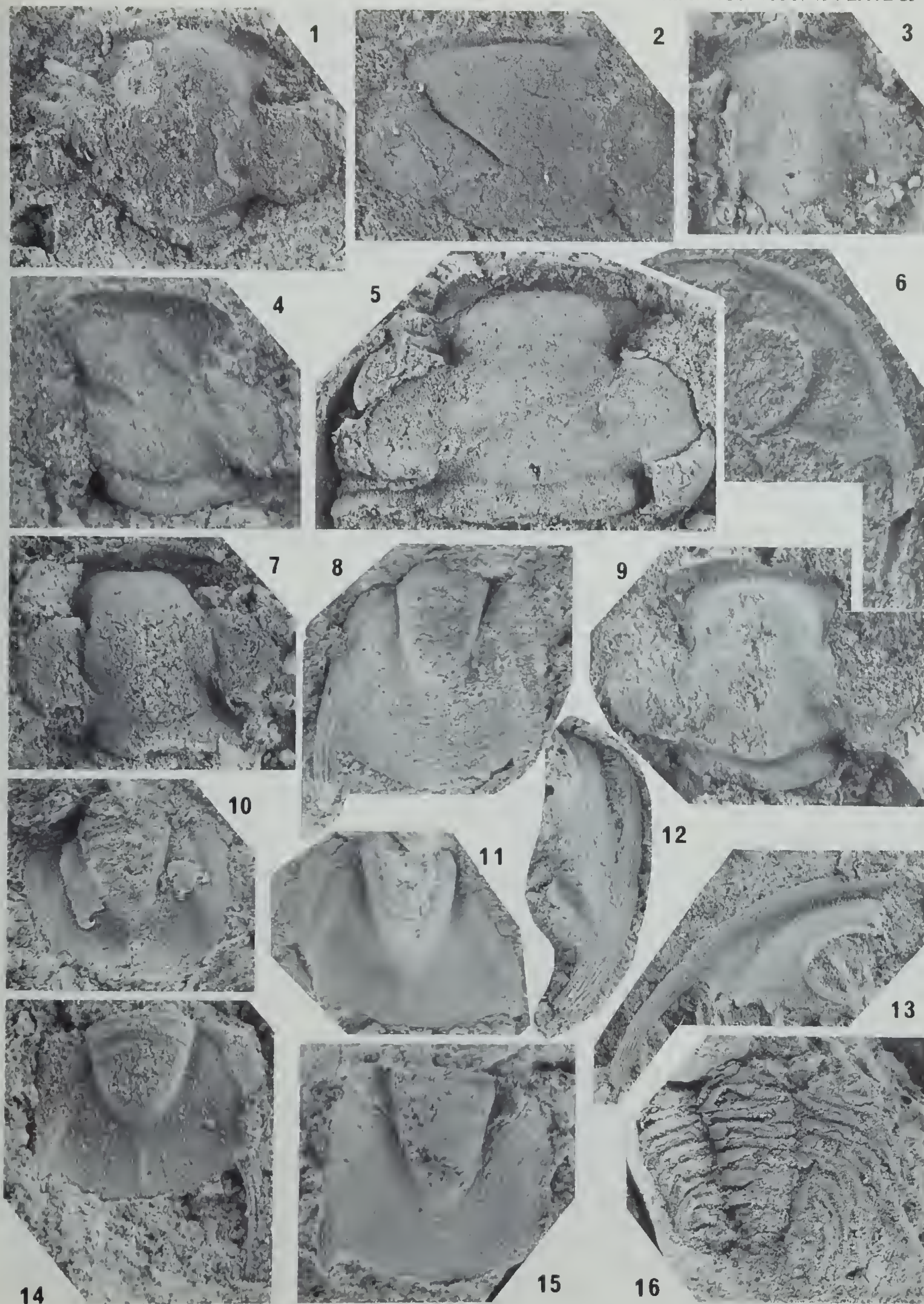
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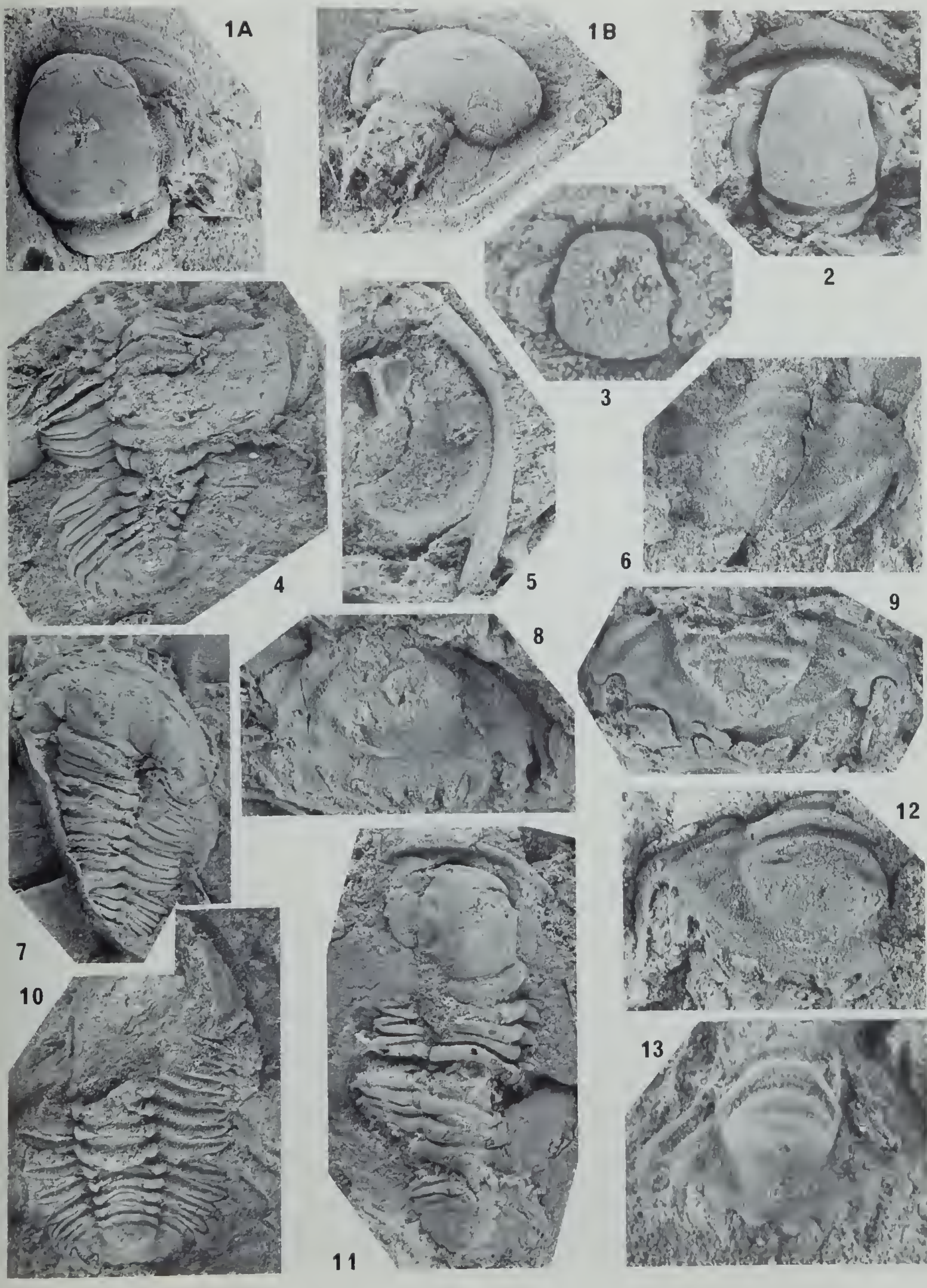
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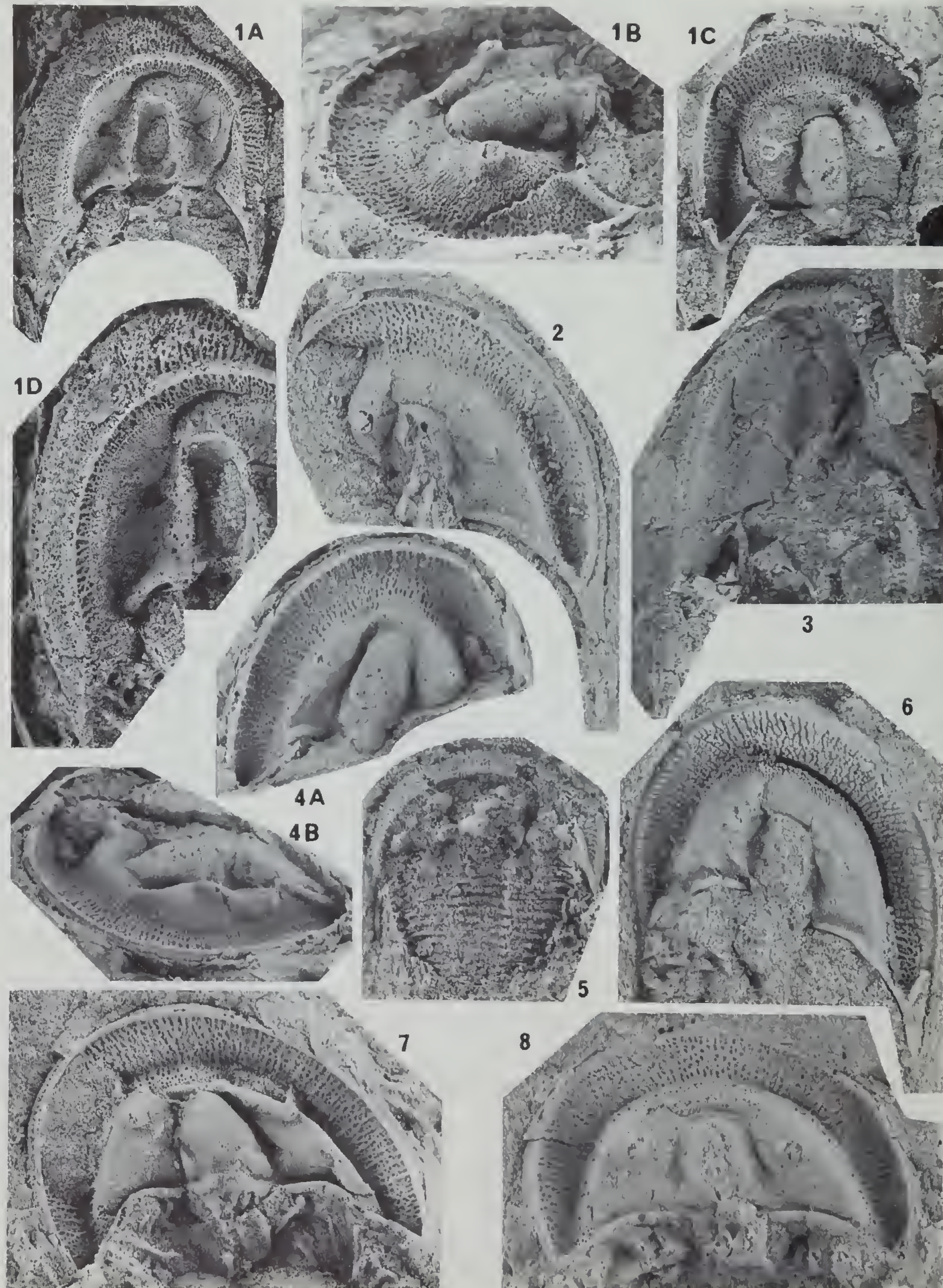
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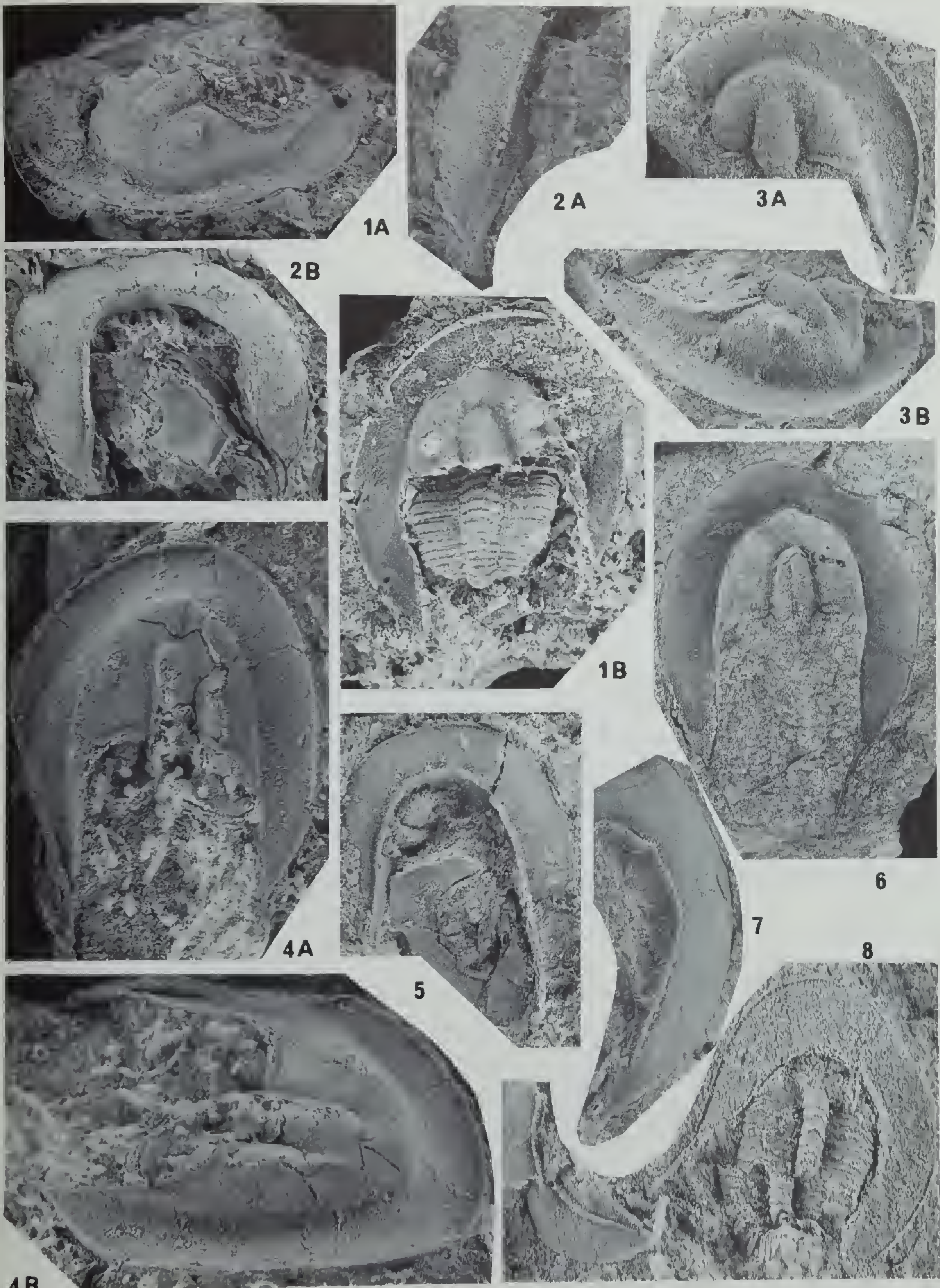
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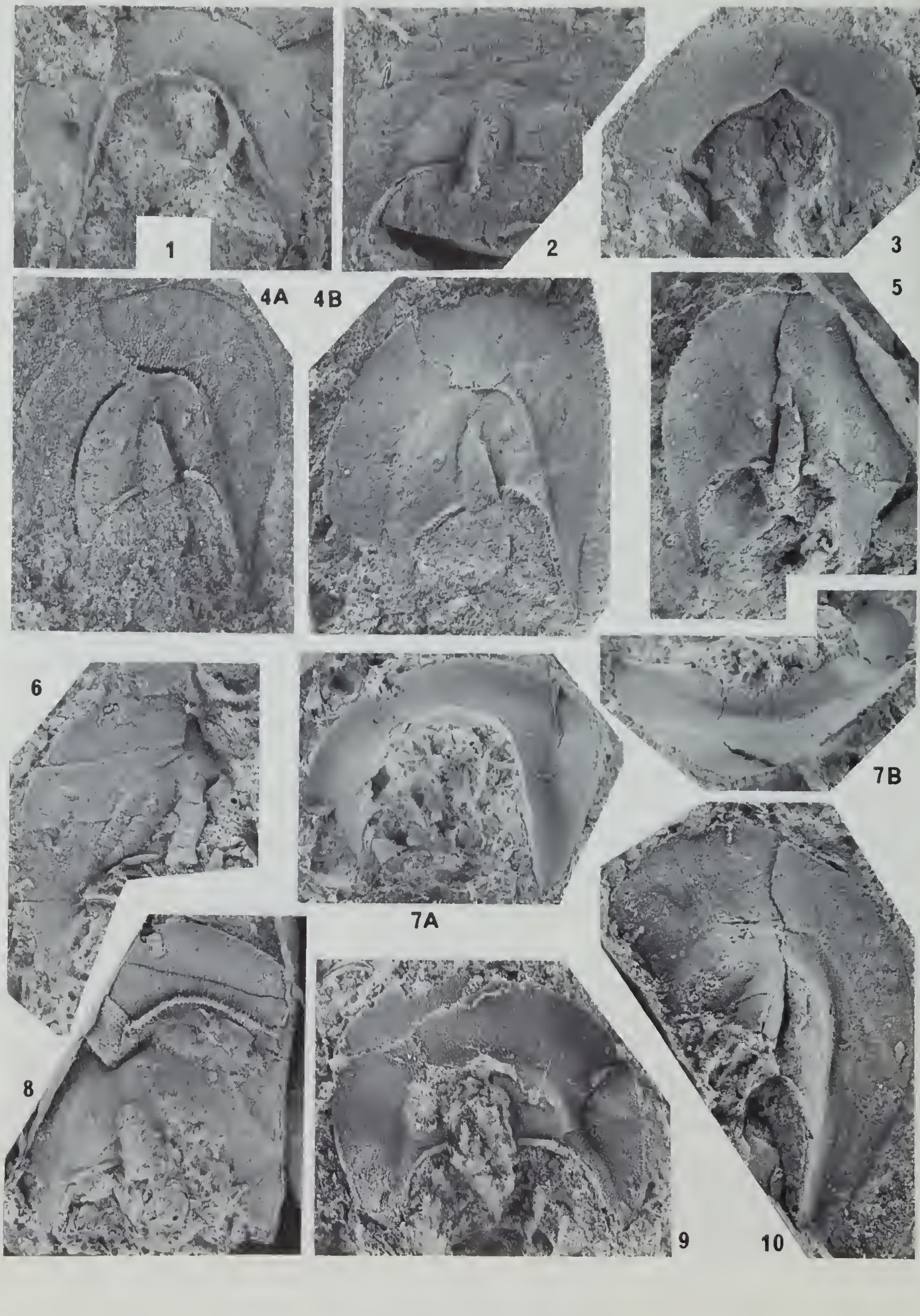
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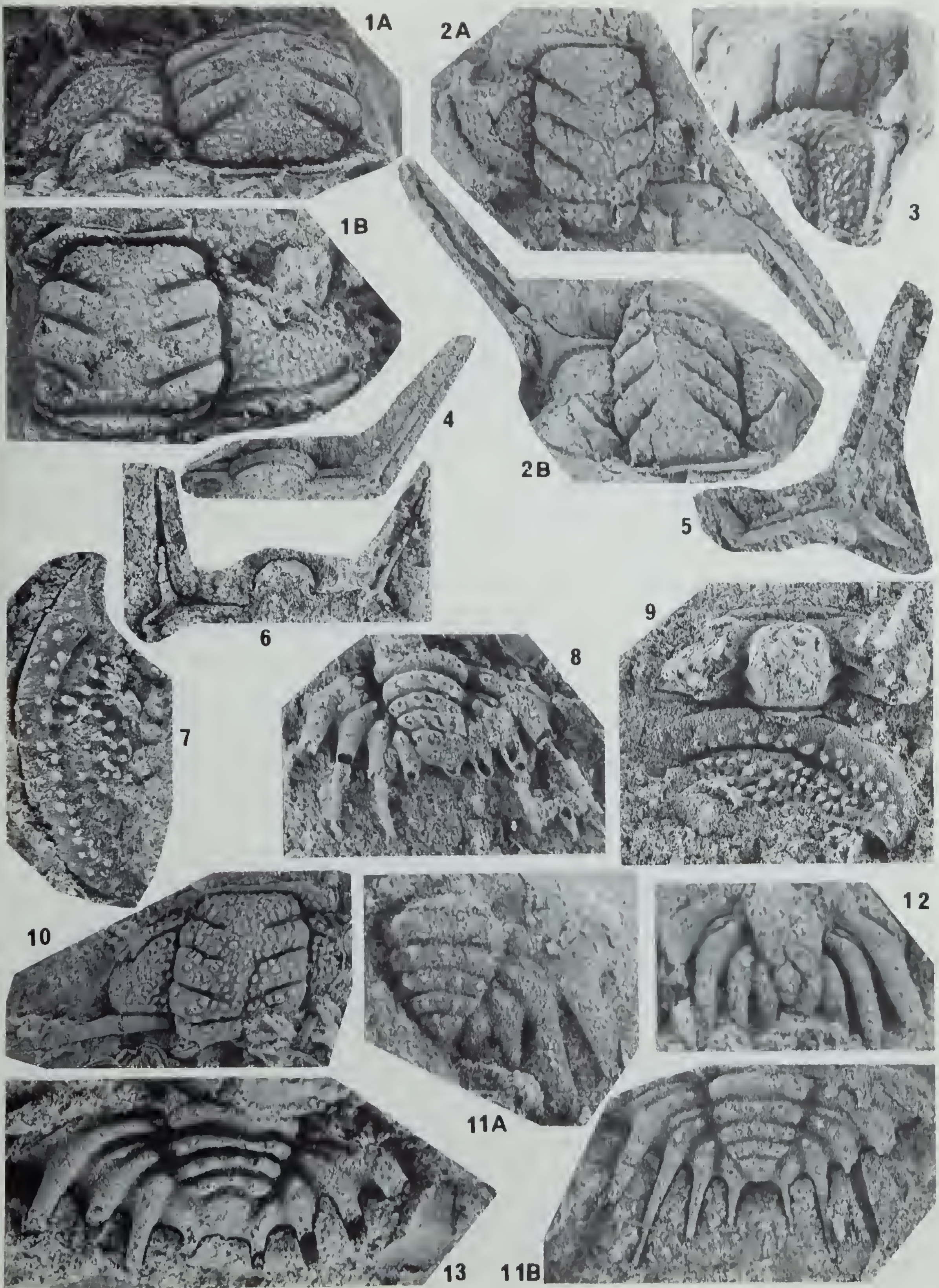
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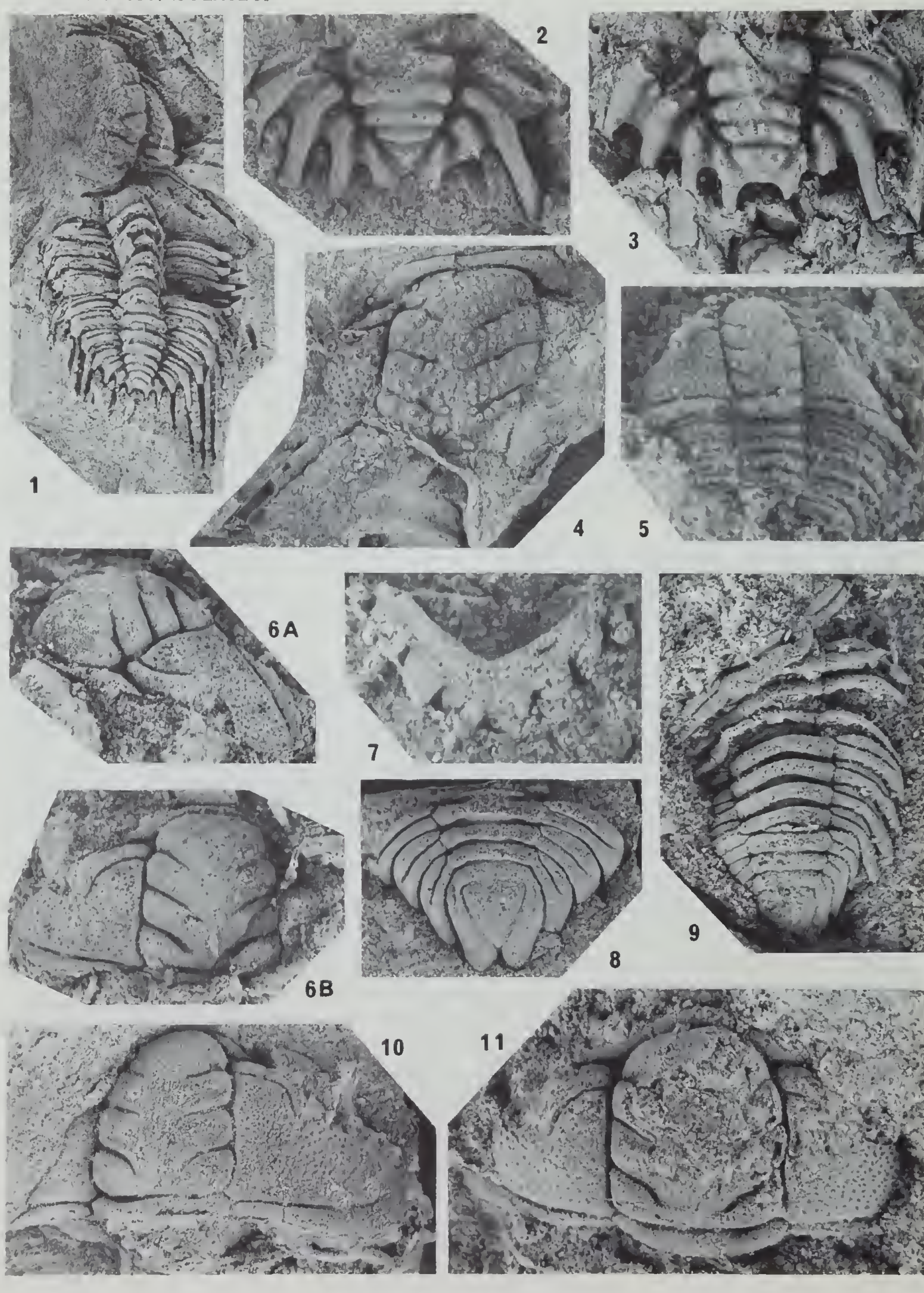
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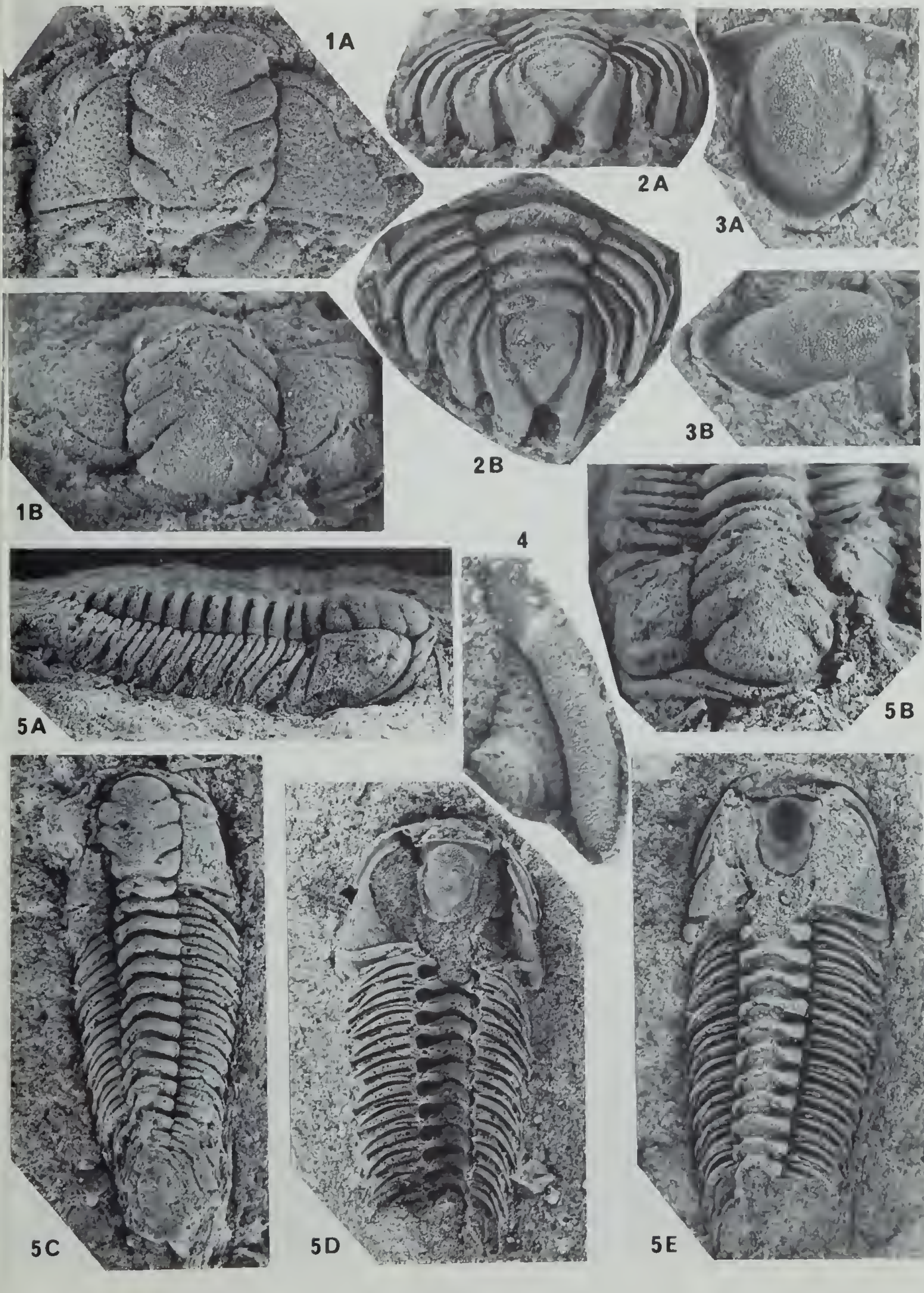
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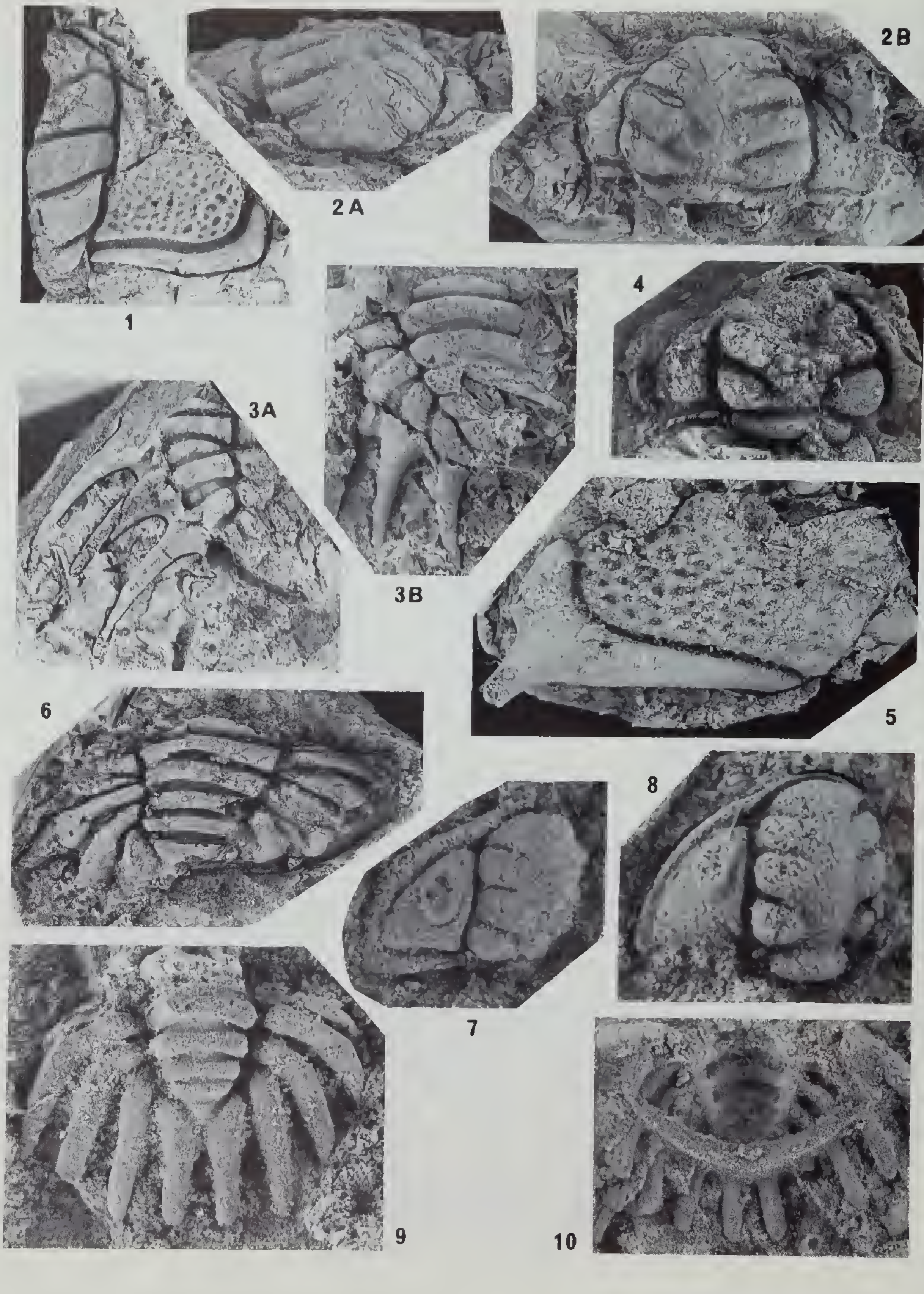
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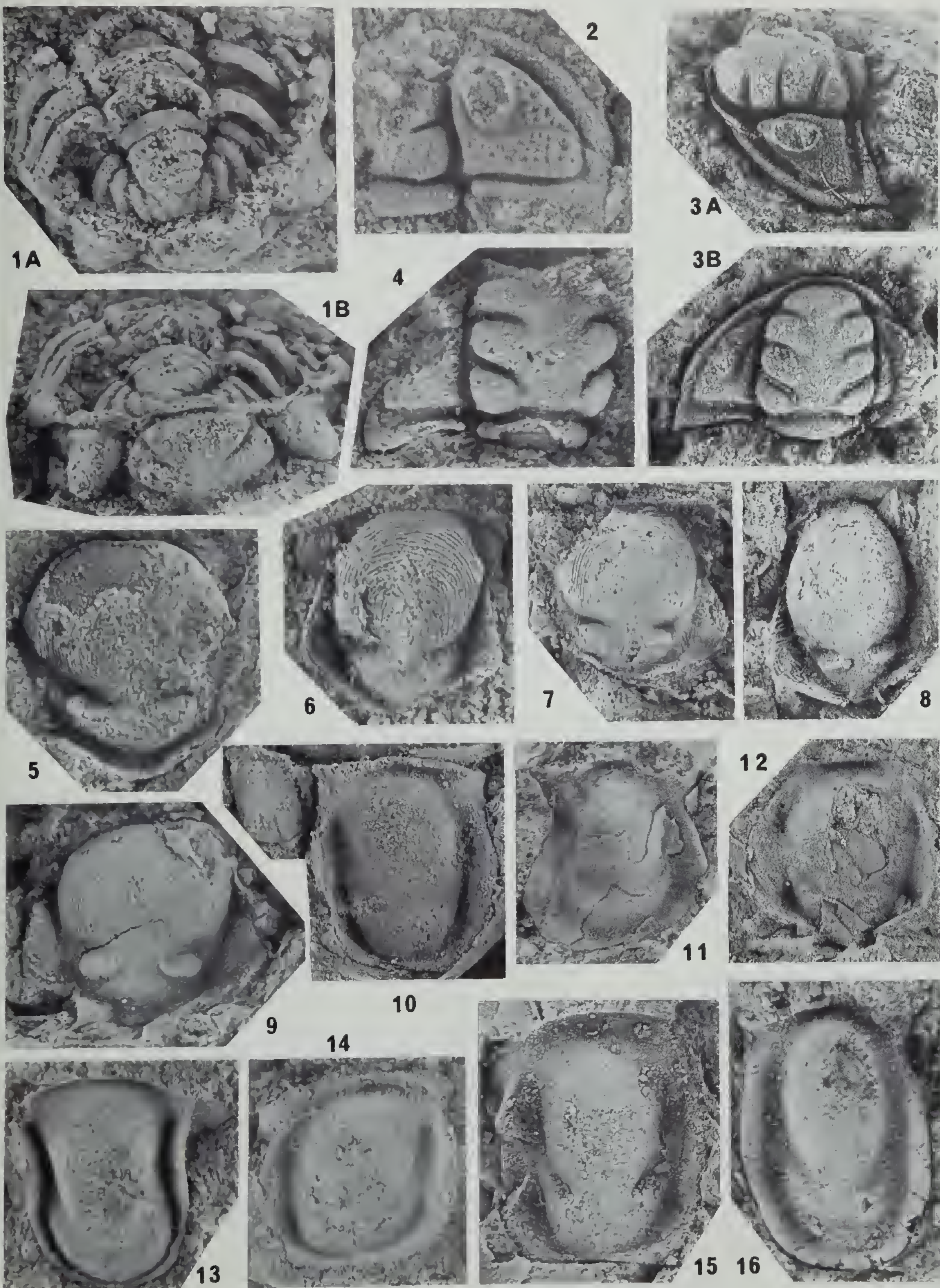
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