LATE CAMBRIAN BRACHIOPODA, MOLLUSCA, AND TRILOBITA FROM NORTHERN VICTORIA LAND, ANTARCTICA

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ABSTRACT. The discovery of late Cambrian fossils in the Bowers Group of Northern Victoria Land, Antarctica, provides the first reliable evidence for the age of basement sedimentary rocks in the region. Together with a previously reported fauna of generally similar over-all composition and age, from the Heritage Range of the Ellsworth Mountains on the opposite side of the continent, they are the only late Cambrian fossils known in Antarctica and the youngest yet reported from the pre-Devonian basement.

Seventeen taxa of trilobites (including representatives of *Pseudagnostus*, *Stigmatoa*, *Pedinocephalus*, *Prochuangia*, and *Proceratopyge*), four of molluscs (*Contitheca webersi*, sp. nov., *Hyolithes*, *Pelagiella*, *Scaevogyra*), and three of brachiopods (*Schizambon reticulatus*, sp. nov., *Billingsella*, *Prototreta*) are described; they represent a single fauna of late Idamean (*Erixanium sentum* Zone; late Dresbachian, late Tuorian) age.

The fauna bears affinity with faunas of Australia, China, and Kazakhstan, in agreement with affinities indicated by previously described early and middle Cambrian trilobite faunas of Antarctica.

THE Antarctic continent has yielded very few fossils from its pre-Devonian rocks. Early and mid-Cambrian trilobite faunas, described by Palmer and Gatehouse (1972), are known only from the Pensacola Mountains (Argentina and Neptune Ranges) and the Harold Byrd Mountains of the Transantarctic Mountain Range (text-fig. 1). Ten faunules were recognized in morainic boulders, ranging in age from late in the early Cambrian (late Aldanian to Botomian Stages and their equivalents) to late in the middle Cambrian (mid-Mayan Stage). Late Cambrian trilobites have been previously reported from the Heritage Range of the Ellsworth Mountains (Webers 1970), where they are associated with Monoplacophora, Gastropoda, Brachiopoda, and other forms (Webers 1970, 1972; Yochelson *et al.* 1973). Early Cambrian Archaeocyatha are known from several localities in or near the Transantarctic Mountains, including Southern Victoria Land (Laird 1962, 1963; *in* Laird *et al.* 1971; Hill 1964*a*, 1964*b*, 1965).

All previously known Cambrian fossils thus come from that sector of Antarctica containing the Ellsworth Mountains and the Transantarctic Mountains, from the south-west edge of the Ross Ice Shelf to the Weddell Sea. The discovery of a late Cambrian fauna containing trilobites, brachiopods, and molluscs in Northern Victoria Land (Laird *et al.* 1972), over 1500 km away on the other side of the continent, and over 2500 km from the Heritage Range upper Cambrian locality, is thus of considerable interest. It represents the youngest fossils from the basement of East Antarctica, and the only definite fossils in Northern Victoria Land, thus establishing for the first time the precise age of part of the sedimentary basement in the region. The Ross Orogeny (Laird *et al.* 1972) which deformed the basement before the basal, Devonian, beds of the platform-cover sequence were deposited, is shown to be post late Cambrian.

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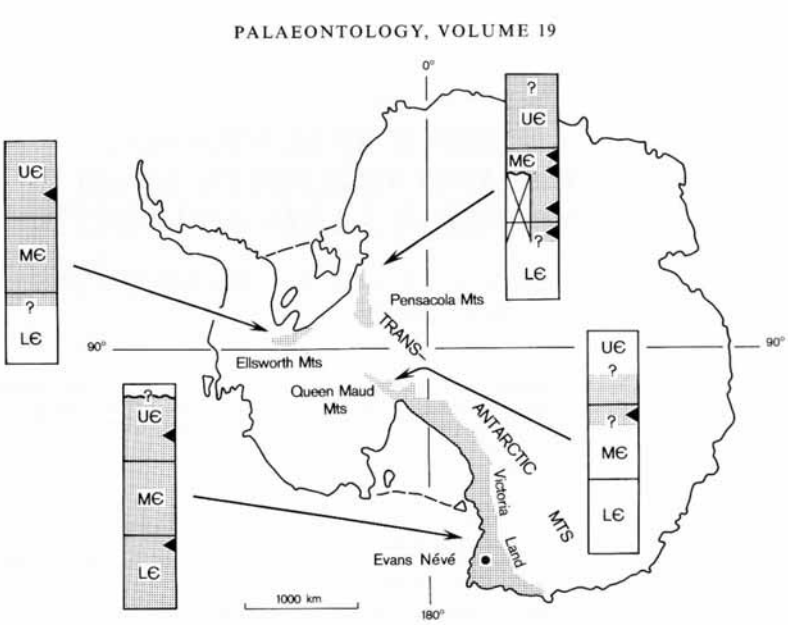

TEXT-FIG. 1. Locality diagram indicating regions with fossiliferous Cambrian rocks; the known or inferred range of Cambrian sedimentation (light stipple) and general horizon from which fossils have been obtained (solid triangles) are shown in diagrammatic form for each region. The lower Cambrian fossiliferous horizon indicated for the Victoria Land region refers to archaeocyathids from Southern Victoria Land. Evans Névé, from which were obtained the fossils described in this report, is also shown.

The geographic affinities of the new fauna are of particular interest in view of its postulated proximity to the fossiliferous Cambrian beds of South-east Australia and New Zealand in reconstructions of Gondwanaland in the Lower Palaeozoic (Crawford and Campbell 1973; Harrington *et al.* 1973; Cooper 1975).

Stratigraphy

The fossils described here represent the entire recognizable fauna collected by Dr. M. G. Laird, New Zealand Geological Survey, and his field party during the southern summer of 1971/2. They are from 'the southernmost known outcrops of the Bowers Group, where it flanks the eastern side of the Evans Névé' (Laird *et al.* 1972; see also Gair *et al.* 1969; text-fig. 1). A stratigraphic section 1600 m thick is given by Laird *et al.* 1972; the lower 900 m comprises predominantly dark fissile mudstones with scattered thin sandy beds and horizons with trilobites and brachiopods. The succeeding 650 m is composed mainly of grey, green-grey, or red well-bedded quartz sandstone with scattered fossiliferous horizons, and one muddy band containing lenses of oolitic hyolithid limestone. All rocks to this level are regarded by Laird *et al.* 1972, as probably equivalent in stratigraphic position to part of the Sledgers Formation of Crowder (1968), mapped 150 km to the north-east; they have been named Mariner Formation by Andrews and Laird (1976). Overlying beds consist of about 100 m of light yellow-grey cross-bedded unfossiliferous quartzose conglomerate and pebbly sandstone referred to the Camp Ridge Quartzite (Le Couteur and Leitch 1964). Sedimentology and general geology of the Bowers Group rocks in the region are described by Andrews and Laird (in press) and Laird *et al.* (1974).

Lithology of the fossiliferous beds ranges from fissile non-calcareous siltstone with poorly preserved complete trilobite impressions (collections from locality MS/f270) to fine sandstone, calcilutite, and calcarenite containing much broken brachiopod shell material and, in some beds, complete but separated *Billingsella* valves (collections from locality MS/f267). Petrographically, sediments containing the best-preserved material, the float slabs of locality MS/f266, are richly fossiliferous, oolite-bearing, packed biomicrite, and calcilutite. Trilobite parts are disarticulated but not noticeably abraded, and brachiopod valves are separated. Delicate orthothecoids are generally undamaged and the sediments are likely to have been deposited in conditions of some current agitation but not strong current activity. Ooliths up to 0·8 m diameter are present in shelly calcilutite at localities MS/f267 and MS/f266.

The trilobites and molluscs of this study are from two float slabs of shelly calcilutite (locality MS/f266) derived from a horizon 400 m above the base of the measured section of Laird *et al.* (1972), all outcrop material being too poorly preserved for identification. The brachiopods are from localities MS/f266, MS/f271, and MS/f272, at the 400-m, 900-m, and 1100-m levels respectively in the stratigraphic column of Laird *et al.* 1972. In addition, brachiopods collected by Cooper, Jago, and Simes in 1974 from a new locality, MS/f274, representing a horizon approximately equivalent to that of MS/f271, are included. The quantity of trilobite and mollusc material available for study is small, but because of the inaccessibility of the locality and difficulty in obtaining further material, and the importance of the fauna, both groups are described fully here. The brachiopod *Billingsella* is less sparsely represented. Although quality of preservation is generally good, much material, particularly the trilobites, is fragmentary and a conservative attitude towards nomenclature has been adopted. Only two new species are erected, *Schizambon reticulatus* MacKinnon and *Contitheca webersi* Yochelson; however, several of the trilobites are likely to represent new species.

All fossils are held in the collection of the New Zealand Geological Survey, Lower Hutt; specimen numbers prefixed with AR, TM, and BR being catalogued in the Trilobite, Mollusc, and Brachiopod registers respectively. Locality numbers are listed in the New Zealand Fossil Record File. In Plates 38–42, all specimens except those examined under the Scanning Electron Microscope have been coated with ammonium chloride.

Authorship

For convenience of reference new taxa are erected under the name of the author responsible rather than under the names of all four joint authors. Responsibility is as follows: Shergold, trilobites; Yochelson, molluscs; MacKinnon, brachiopods. Work was organized by Cooper who wrote the introduction, and Shergold compiled the final manuscript from individual authors' contributions.

FAUNAL COMPOSITION: AFFINITIES AND AGE

Composition of the fauna is:

Brachiopoda: *Schizambon reticulatus* MacKinnon, sp. nov., *Prototreta* sp., *Billingsella* sp.

Mollusca: *Contitheca webersi* Yochelson, sp. nov., *Hyolithes* sp., *Pelagiella* sp., *Scaevogyra* sp.

Trilobita: *Pseudagnostus* sp., *Stigmatoa* sp., *Olentella* cf. *olentensis* Ivshin, *Irvingella*? sp., *Pedinocephalus* sp. cf. *P. bublichenkoi* Ivshin, Aphelaspid sp. 1, Aphelaspid sp. 2, Aphelaspid sp. 3, *Talbotinella*? sp., Olenid sp., *Prochuangia* sp. aff. *P. granulosa* Lu, *Proceratopyge* sp. cf. *P. lata* Whitehouse, Trilobita sp. 1, Trilobita sp. 2, Trilobita sp. 3, Trilobita sp. 4, Trilobita sp. 5.

Data for assessing age and regional affinity of the trilobites are summarized in Table 1; each taxon is listed alongside the species or higher group with which it is most closely allied. The locality or general region of the allied form is shown together with its age or stratigraphic horizon.

Affinities are shown with trilobites previously described from Australia, China, and central Kazakhstan. Apart from the questionable presence of the cosmopolitan genus *Irvingella*, and the aphelaspidinids similar to '*Aphelaspis buttsi*', there is little affinity with North American faunas; and apart from the cosmopolitan *Pseudagnostus* and *Proceratopyge* there is nothing in common with European faunas.

TABLE 1. Affinities of Antarctic trilobites.

Antarctica taxa	Affinities
Pseudagnostus sp.	'*Pseudagnostus communis*' Lu *et al.* 1965; 'China'
Stigmatoa sp.	*Stigmatoa tysoni* Öpik, 1963; Idamean; *Erixanium sentum* Zone; western Queensland, Australia
Olentella cf. *olentensis*	*Olentella olentensis* Ivshin, 1956; Tuorian; *G. reticulatus* Zone; *Aphelaspis–Kujandaspis* fauna, Kazakhstan, U.S.S.R.
?*Irvingella* sp.	*Irvingella major* Ulrich and Resser, 1924; Franconian; *Elvinia* Zone; many localities, U.S.A.
Pedinocephalus cf. *bublichenkoi*	*Pedinocephalus bublichenkoi* Ivshin, 1956; Tuorian; *G. reticulatus* Zone; *Aphelaspis–Kujandaspis* fauna; Kazakhstan, U.S.S.R.
Aphelaspid 1	'*Aphelaspis buttsi* (Kobayashi, 1936)'; Dresbachian; *Aphelaspis* Zone; Ala, Nevada, U.S.A.
Aphelaspid 2	'*Aphelaspis buttsi* (Kobayashi, 1936)'; as above
Aphelaspid 3	'*Aphelaspis granulata* Kuo, 1963'; 'China'
?*Talbotinella* sp.	*Talbotinella notulata* Öpik, 1963; Mindyallan; *G. stolidotus* Zone; western Queensland, Australia.
Olenid 1	*Hancrania brevilimbata* Kobayashi, 1962; early Upper Cambrian; *Hancrania* Zone; South Korea
Prochuangia sp.	*Prochuangia granulosa* Lu, 1956; ?Paishanian; eastern Kueichou, China
Proceratopyge cf. *lata*	*Proceratopyge lata* Whitehouse, 1939; Idamean; *E. sentum–I. tropica* with *A. inconstans* Zones; western Queensland, Australia
Specimen 1	??*Pedinocephalus simplex* Ivshin, 1962; Tuorian; *G. reticulatus* Zone; Kazakhstan, U.S.S.R.
Specimen 2	??*Litocephalus*; late Dresbachian–early Franconian; *Dunderbergia–Elvinia* Zones; Nevada, U.S.A.
Specimen 4	??*Stigmatoa*; late Idamean; *E. sentum–I. tropica* with *A. inconstans*; western Queensland, Australia

The brachiopods and molluscs show less-pronounced regional affinity but generally agree with that shown by the trilobites. In particular, the gastropod *Scaevogyra* is a characteristic late Cambrian genus in North America and North-east Asia.

Interestingly, the trilobite affinities are similar to those of early and middle Cambrian Antarctic faunules (Palmer 1970, 1972; Palmer and Gatehouse 1972) that are most closely allied to faunas from Australia, China, and Siberia, and to those of the late Cambrian Antarctic fauna noted by Webers (1970, 1972), which also contains aphelaspidinid trilobites of Siberian affinity. The general composition of Webers's fauna is apparently similar to that described here; detailed comparison, however, must await the full description of his material.

The trilobites indicate a late Idamean age on the Australian biostratigraphic scale, equivalent to latest Tuorian or earliest Shidertan on the Siberian scale and latest Dresbachian or earliest Franconian on the North American scale. If the specimen described here as *Irvingella*? sp. is a true *Irvingella*, it suggests that the fauna may be of earliest Franconian age (*Elvinia* Zone), equivalent to early Shidertan: the lower boundaries of both stages are marked by the first appearance of *Irvingella*. In Australia *Irvingella* first appears in the youngest zone (*I. tropica* with *Agnostotes inconstans*) of the Idamean Stage. On the other hand, the genera *Olentella*, *Pedinocephalus*, *Stigmatoa*, and *Talbotinella* and the aphelaspidinids suggest a horizon no younger than the preceding *Erixanium sentum* Zone of the Australian Idamean, that is, late Dresbachian in North America and late Tuorian in Siberia. The Bowers Group fauna is here regarded as of probable late Idamean, *E. sentum* Zone, age, equivalent to latest Dresbachian (*Dunderbergia* Zone) and latest Tuorian.

SYSTEMATIC PALAEONTOLOGY

Phylum BRACHIOPODA (by D. I. MacKinnon)

Class INARTICULATA Huxley, 1869

Order ACROTRETIDA Kuhn, 1949

Superfamily SIPHONOTRETACEA Kutorga, 1848

Family SIPHONOTRETIDAE Kutorga, 1848

Genus SCHIZAMBON Walcott, 1884

Type species. Schizambon typicalis Walcott (1884, pp. 70–71, pl. 1, fig. 3*a–d*), early Ordovician, Goodwin Formation, Eureka district, Nevada; by original designation.

Other species. Species assigned to *Schizambon* are too numerous to list here. Cambrian to early Ordovician species described prior to 1938 by Walcott (1884, 1905, 1912, 1924*a*), Matthew (1901), Poulsen (1927), and Ulrich and Cooper (1936) have been listed by Ulrich and Cooper (1938, pp. 60–63), who added a further four new species. Subsequently, early and middle Ordovician *Schizambon* species, described by Hudson (1904) and Willard (1928), have been discussed by Cooper (1956) who described six more species and left two under open nomenclature. Also left under open nomenclature are specimens described by Termier and Termier (1950, p. 36, pl. 68) and Henderson (*in* Hill *et al.* 1971, p. Cm2, pl. Cm1, figs. 28–29) from the late Cambrian Gola Beds of western Queensland, Australia. With the erection of the genus *Multispinula* (Rowell 1962, p. 147) to embrace the majority of the large middle Ordovician species which have been referred to *Schizambon*, the species of *Schizambon sensu stricto* appear to range in age from late Cambrian to early Ordovician. Of all the species described to date the bulk are of North American provenance.

Schizambon reticulatus MacKinnon, sp. nov.

Plate 38, figs. 1–2

Name. *Reticulatus* (L.) refers to the reticulate pattern of intersecting growth lines and costellae of the external surface of the shell.

Types. Holotype, pedicle valve, BR 1902; measured paratypes, pedicle valves, BR 1903 (subsequently damaged), BR 1904.

Material. Available material consists of seven pedicle valve exteriors, three of which can be measured. The holotype, BR 1902, has a length of 4·7 mm and a width of 4·5 mm; BR 1903 is 4·5 mm long and 4·0 mm wide; and BR 1904 is 3·8 mm long and 3·5 mm wide.

Diagnosis. Average-sized *Schizambon* (up to approximately 5 mm in length) with finely reticulate micro-ornament. Median fold lacking in pedicle valve.

Description. The pedicle valve is gently convex and roughly subcircular in outline, slightly longer than wide. The pedicle foramen, which lies anterior to the beak, is moderate in size and widens anteriorly. It is bounded posteriorly by a sunken, elongate, triangular pedicle track. The beak is situated marginally.

The surface ornament is finely reticulate and consists of fine concentric growth lines and radial costellae; it is inconspicuous near the beak and pedicle foramen and becomes more distinctive toward the valve margin. At a distance of 2 mm from the umbo of the holotype, the radial costellae have a frequency of approximately 16 per mm.

The brachial valve is unknown.

Discussion. Of species described and figured in sufficient detail, the Argentinian early Ordovician *S. australis* Ulrich and Cooper (1936, p. 619; 1938, p. 60, pl. 4E, figs. 14–22) bears closest resemblance to the Antarctic specimens. This species differs principally from *S. reticulatus* because its exterior is dominated by fine, radiating costellae with minor concentric threads, whereas *S. reticulatus* is characterized by a much more even development of costellae and fine growth lines which produce a reticulate pattern. Also, the pedicle valve of *S. reticulatus* lacks a median fold,

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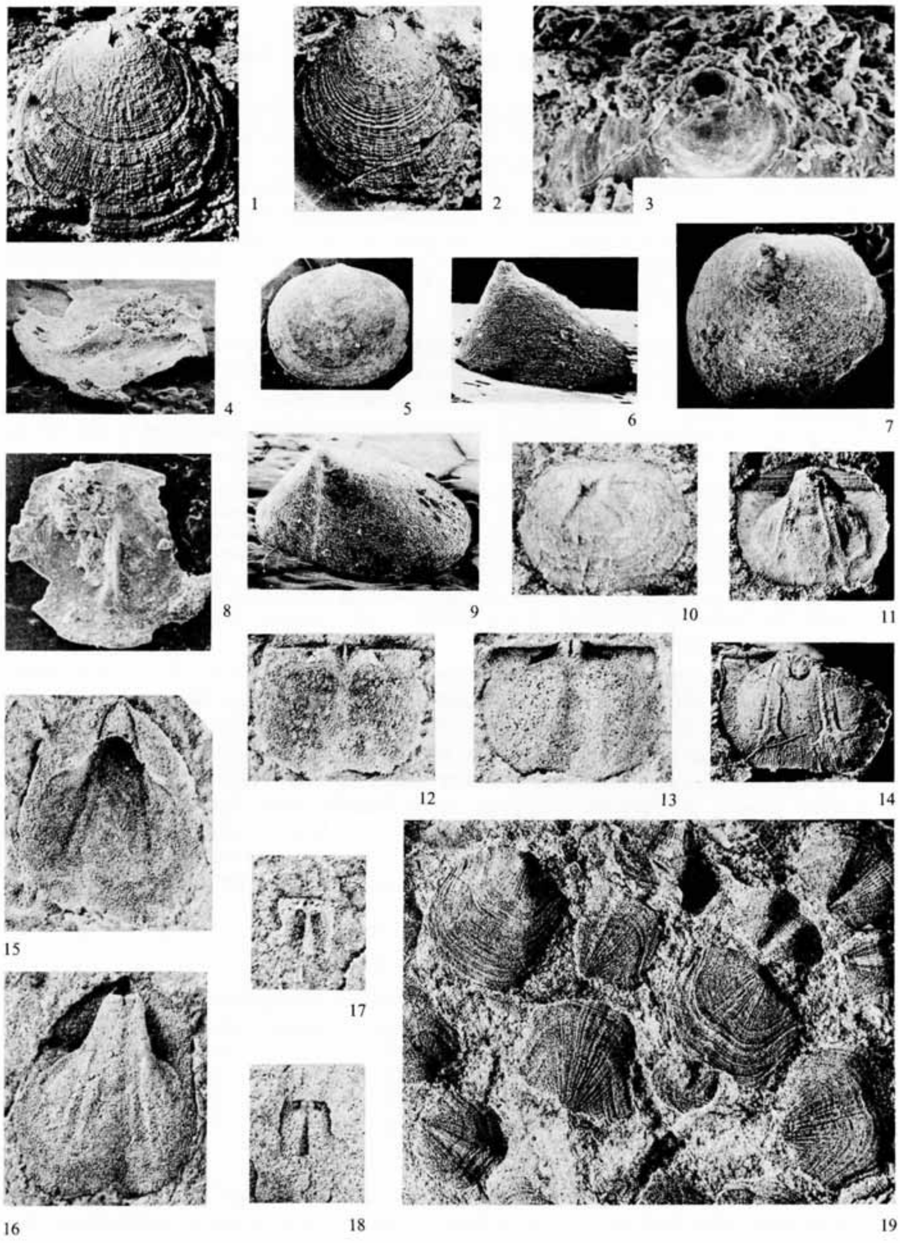
EXPLANATION OF PLATE 38

Figs. 1–2. *Schizambon reticulatus* MacKinnon, sp. nov. 1, BR 1902, holotype, external view of pedicle valve, ×8. 2, BR 1903, paratype, external view of pedicle valve, ×7.

Figs. 3–10. *Prototreta* sp. indet. All except fig. 10 are scanning electron micrographs. 3, BR 1912, external view of pedicle valve showing details of protegular region and pedicle foramen, ×200. 4, BR 1916, oblique lateral view of brachial valve interior, ×18. 5, BR 1546, external view of brachial valve, ×17. 6, BR 1911, pedicle valve in lateral profile, ×19. 7, BR 1911, external view of pedicle valve, ×19. 8, BR 1916, internal view of brachial valve, ×18. 9, BR 1911, oblique posterior view of pedicle valve showing pseudointerarea with intertrough, ×19. 10, BR 1913, external view of partly decorticated pedicle valve, ×16.

Figs. 11–19. *Billingsella* sp. indet. 11, BR 1555, internal mould of pedicle valve, ×2·5. 12–13, BR 1556, rubber-latex cast and internal mould of brachial valve, ×3. 14, BR 1556, internal mould of pedicle valve showing development of mantle canal system, ×4. 15–16, BR 1549, rubber-latex cast and internal mould of pedicle valve, ×3. 17–18, BR 1551, rubber-latex cast and internal mould of small brachial valve, ×3. 19, BR 1552, part of slab with several external moulds of brachial and pedicle valves, ×2.

PLATE 38



SHERGOLD *et al.*, Antarctic Cambrian brachiopods a feature faintly discernible in *S. australis* and variably developed in many other species of *Schizambon*.

A single specimen of a small inarticulate brachiopod bearing a reticulate surface pattern was figured by Walcott (1912, p. 679, pl. 79, fig. 5, 5*a*) who named it *Acrotreta*? *cancellata*. Ulrich and Cooper (1938, p. 62) listed this specimen from the early Ordovician of Nevada as a *Schizambon* without adding further to Walcott's inconclusive description. Although similarities in micro-ornament suggest specific affinity, the development of angular cardinal extremities in *S. cancellata* (as observed in Walcott's fig. 5) serves to distinguish this species from *S. reticulatus* which has more evenly arcuate posterolateral margins.

Superfamily ACROTRETACEA Schuchert, 1893
Family ACROTRETIDAE Schuchert, 1893
Genus PROTOTRETA Bell, 1938

Type species. Prototreta trapeza Bell (1938, p. 405, pl. 1, figs. 1-6; 1941, pp. 229-230, pl. 31, figs. 34-38), middle Cambrian, *Bathyuriscus* Zone, Big Belt Mountains, Montana; by original designation.

Other species. A. attenuata Meek (1873, p. 463, footnote), middle Cambrian Meagher Limestone, Gallatin, Montana; also figured by Bell (1941, p. 223, pl. 31, figs. 20-23) and Robison (1964, p. 559, pl. 91, figs. 10-15) who give synonymies. *P. flabellata* Bell (1941, pp. 223-226, pl. 31, figs. 49-58), middle Cambrian, *Ehmania* Zone, Meagher Limestone, Wyoming and Montana. *Homotreta interrupta* Bell (1941, pp. 230-231, pl. 30, figs. 19-26), middle Cambrian, 'Pagoda' Limestone, Montana. *P. mimica* Bell (1941, pp. 226-228, pl. 31, figs. 24-33), middle Cambrian, Meagher Limestone, Big Belt Mountains, Montana. *P. subcircularis* Bell (1941, pp. 228-229, pl. 31, figs. 10-14), middle Cambrian, *Bathyuriscus* Zone, Meagher Limestone, Horseshoe Hills, Montana.

Comments. The concept of *Prototreta* has been discussed at length by Bell (1938, 1941). Robison (1964, p. 559) and Rowell (1965, p. 276) place *Homotreta* in junior synonymy with *Prototreta*. *Angulotreta* Palmer (1954, p. 769) has brachial valves indistinguishable from those assigned to *Homotreta*. The pedicle valve of *Angulotreta* has a deltoid interarea instead of the intertrough seen in *Prototreta*. Previously well-known species of *Prototreta* appear to be mainly from the middle Cambrian, *Bathyuriscus-Elrathina* Zone and *B. fimbriatus* and *Bolaspidella contracta* Subzones of the *Bolaspidella* Zone (Robison 1964, pp. 559-560). The occurrence here documented thus extends the upper range of the genus well into the late Cambrian.

Prototreta sp. indet.

Plate 38, figs. 3-10

Material. Five pedicle and three brachial valves which have the following dimensions (in mm):

		Length	Width	Height
Pedicle valves	BR 1911	1·5	1·7	0·9
	BR 1912	2·0	2·1	1·4
	BR 1913	1·8	2·0	0·8
	BR 1914	1·0	1·5	0·7
Brachial valves	BR 1916	1·7	1·8	
	BR 1546	1·1	1·3	

Description. Both valves are transversely suboval in outline. The pedicle valve is moderately high and proconical in lateral profile. Apart from a small apical protuberance, the curvature of the shell in lateral profile is gently and evenly convex. The maximum height of the pedicle valve, at the valve apex, is about one-third of the length from the posterior valve margin. The pedicle foramen is small, circular, apical, and directed ventrally, not posteriorly. The posterior sector of the valve forms a broadly triangular pseudointerarea which is planar in lateral profile. The pseudointerarea is interrupted medially by a well-defined intertrough which widens gradually from apex to commissure. Valve ornamentation consists of numerous distinct fila (approximately 40 fila per mm). Fila are absent on or very close to the apex of the valve. Almost no internal details are discernible owing to sediment infilling, but in one partly decorticated specimen (BR 1913) a pair of posterolaterally situated cardinal muscle scars could be distinguished when viewed from the exterior. At the apex of this specimen there is a small depression which may have accommodated skeletal material in the form of a short apical process.

The brachial valve possesses a low, gently convex profile. Anacline dorsal propareas are separated by a triangular, concave, median groove. A pair of subelliptical cardinal muscle scars diverge anterolaterally in front of the propareas. Lateral to the apex of the median septum are two small, faintly impressed anterior muscle scars. The median septum is blade-like and subtriangular in profile, with its maximum height of about 0·25 valve length occurring at about 0·6 of valve length. In all three specimens the median septum is damaged to some extent so that the possibility of some digitation of the anterior edge cannot be excluded. At its posterior extremity the septum buttresses the concave median groove.

Discussion. The lack of sufficiently clean and undamaged pedicle and brachial valve interiors renders an identification to species level difficult. In the possession of a protoconical lateral profile, a relatively planar pseudointerarea with well-marked intertrough, finely concentric ornament, and a high, blade-like subtriangular medium septum, this Antarctic acrotretid closely resembles *P. interrupta* (Bell) (1941, p. 230, pl. 30, figs. 19–26).

Class ARTICULATA Huxley, 1869
Order ORTHIDA Schuchert and Cooper, 1932
Suborder ORTHIDINA Schuchert and Cooper, 1932
Superfamily BILLINGSELLACEA Schuchert, 1893
Family BILLINGSELLIDAE Schuchert, 1893
Genus BILLINGSELLA Hall and Clarke, 1892

Type species. Orthis pepina Hall (1863, p. 134, pl. 6, figs. 23–27), late Cambrian, Franconia Formation, Wisconsin; designated by Hall and Clarke (1892, p. 230).

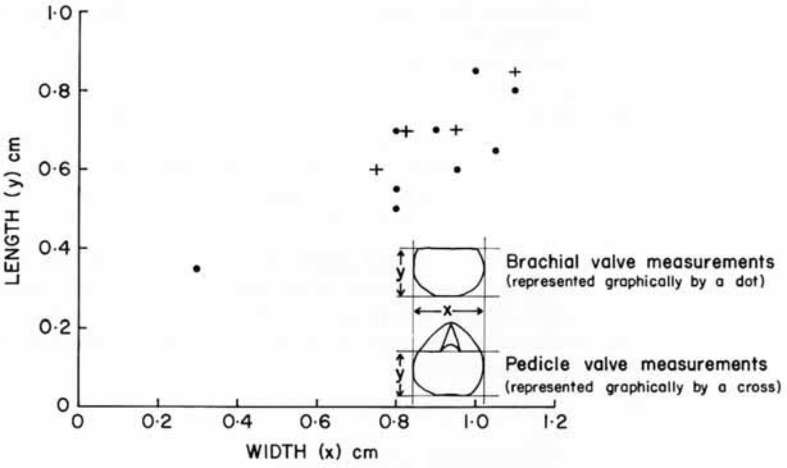
Other species. Other species of *Billingsella* are too numerous to list here: to date fifty species and subspecies can be assigned to the genus whose concept has been reviewed by Schuchert and Cooper (1932), Ulrich and Cooper (1938), Bell (1941), and Nikitin (1956). The last lists twenty-four species definitely assigned to *Billingsella*, and nine possible ones (1956, pp. 25–26), but this listing is incomplete.

Comment. Billingsella is a cosmopolitan genus of middle Cambrian to early Ordovician age, which occurs in Europe, U.S.S.R., China, Korea, Vietnam, Iran, U.S.A., Canada, Argentina, and Australia. It has been recorded previously from Antarctica by Webers (1972, p. 237). The majority of *Billingsella* species are from the late Cambrian of North America.

Billingsella sp. indet.

Plate 38, figs. 11–19

Material. Except for a few, rather worn pedicle valve exteriors, all material consists of internal and external moulds. Twenty-one disarticulated internal moulds were recorded from two slabs of very calcareous muddy fine sandstone (MS/f272). Several disarticulated internal and external moulds were recorded from small fragments of fissile wavy laminated siltstone (MS/f266). One internal and one external mould, both brachial valves, were recorded from fragments of a massive, very fine sandstone (MS/f271). A number of internal and external moulds were recorded from a calcareous siltstone (MS/f274). Figured specimens have measurements as follows: BR 1549 has a length of 13 mm and a width of 11 mm; BR 1551 is 3·5 mm long and 3 mm wide; BR 1553 is 8 mm long and 11 mm wide; BR 1555 is 9·2 mm long and 9·5 mm wide. Length/width parameters for nine brachial and four pedicle valves are illustrated in text-fig. 2.



TEXT-FIG. 2. Graph showing the relationship of brachial and pedicle valve length to width in *Billingsella* sp. indet.

Description. The outline of the pedicle valve is subquadrate or elongate subrectangular, with the width of the hinge line slightly more than, equal to, or slightly less than, the width at about mid valve. The interarea, which is orthocline to slightly apsacline, is generally one-third to one-half as long as wide. The posterolateral margins of the interarea are slightly convex outward. The delthyrium, whose sides subtend angles of 27–30°, is restricted for about half its length by a convex pseudodeltidium. No pedicle foramen is apparent within the pseudodeltidium. The cardinal extremities are sharply angular and range from obtuse to right angled. In lateral profile, valve convexity is slight, with greatest curvature at the umbo. The posterolateral flanks are flat or slightly concave. In some valves a slight median fold may be developed. The external ornamentation is variable, being unequally parvicostellate with fila distinct and numerous. Concentric growth lines are variably developed. On the pedicle valve interior, the central muscle field is narrow and anteriorly arcuate, and extends anteriorly for about 0·4 of the valve length. Posteriorly the muscle field is slightly bilobed. The mantle canal system is saccate, with the anterior extremities of the *vascula media* divergent. Around the periphery of some pedicle valves the *vascula media* are seen to be finely branched. The teeth are small and lacking in any support.

The brachial valve is transversely subrectangular in outline, with the width of the hinge approximately equal to the width about the mid valve. The cardinal extremities are roughly rectangular. Valve convexity is the same as or slightly greater than in the pedicle valve. Close to the hinge line a median sulcus is developed but this dies out toward the anterior valve margin. The interarea is short and vertical or slightly anacline. No chilidium is visible. The external ornamentation is unequally parvicostellate, with costellae most prominent on the flanks of the sulcus. Concentric growth lamellae are variably developed. Socket ridges are present on the brachial valve interior as widely divergent, unsupported blades which extend no further than the anterolateral edges of the cup-like sockets. A notothyrial platform is well developed and extends forward as a median ridge toward the centre of the valve. A simple ridge-like cardinal process is located posteromedially on the notothyrial platform. Adductor muscle scars are not discernible.

Discussion. As noted by Bell (1941, p. 245), the general form and ornamentation within many species of *Billingsella* vary widely, and it is often difficult to assign a small sample, such as the one under consideration, to any particular species with any degree of confidence. In addition, the problem is compounded by the lack of adequate published data on the form and variability of any southern-hemisphere species of *Billingsella*. With a substantial number of species of *Billingsella* recorded from the North American continent alone, it is evident that genetic variability was high both temporally and spatially. Morphologic characteristics of the Antarctic species are reflected in several North American species of *Billingsella* described by Ulrich and Cooper (1938), Bell (1941), and Bell and Ellinwood (1962). In particular, there is resemblance to *B. perfecta* Ulrich and Cooper (1936, p. 619; 1938, pp. 74–75, pl. 7, figs. 11–21) and *B. coloradoensis* (Shumard 1860) *sensu* Walcott (1912 (*pars.*), pp. 751–752, pl. 85, fig. 1, 1*c*, 1*e*, 1*f*, 1*i*, 1*k*, 1*s*, and 1*v*) (see also Bell and Ellinwood 1962, p. 410, pl. 62, figs. 1–10) in the nature of its valve profiles and, in part, external ornament. Some specimens, such as BR 1549, have a high interarea imparting an outline reminiscent of *B. perfecta pyriformis* Bell (1941, pp. 247–248, pl. 35, figs. 22–24). *B. texana*, a rather elongate form described by Bell and Ellinwood (1962, p. 413, pl. 62, figs. 11–21) from the late Cambrian of Texas, and considered gradational with *B. coloradoensis*, possesses a similar pedicle valve outline. However, until additional and better-preserved material from the Antarctic is forthcoming, further comparison cannot be made.

The discovery of a small brachial valve internal mould sheds some light on ontogenetic development. Whereas in gerontic forms the median ridge extending anteriorly from the notothyrial platform lies only in the posterior half of the valve, in the neanic form the ridge is much more strongly developed and extends to the valve margin. On the pedicle valve exterior this may well indicate the development of a pronounced median sulcus during the early stages of shell growth, a feature which diminishes progressively with maturity.

Phylum MOLLUSCA (by E. L. Yochelson)
Class HYOLITHA Marek, 1963
Order HYOLITHIDA Matthew, 1899
Family HYOLITHIDAE Nicholson, 1872
Genus HYOLITHES Eichwald, 1840

Type species. Hyolithus acutus Eichwald (1840, p. 97), early Ordovician, late Arenigian, Zone with *Asaphus eichwaldi* (see Öpik 1952, p. 6), Odensholm, Estonia.

Hyolithes sp. indet.

Plate 39, figs. 11-12, 21

Material. Several hyolithid conchs occur along with the more abundant specimens of orthothecoids. The following are figured: TM 5414, 5415, 5425.

Description. All specimens belong within the typical genus and all are conspecific. They are semilenticular in cross-section but the dorsal surface is significantly more inflated than the ventral (Pl. 39, fig. 11); there is no dorsal crest or even a change of curvature. The juncture of the dorsal and ventral surfaces at the lateral edge is relatively sharp and forms a small acute angle (Pl. 39, fig. 11). The apical area is unknown, but the angle of expansion is nearly 22°. Curvature of the ventral surface from apex to aperture is exceedingly slight, and, in the mature part of the conch preserved, is nearly imperceptible. The ligula is prominent and smoothly curved at the ventral apertural margin; this margin seems to occupy about one-sixth of the circumference of a circle (Pl. 39, fig. 12). Growth lines on the dorsal surface are straight from one edge to the other, indicating a simple orthogonal aperture. Except for the closely spaced growth lines there is no ornament. No operculum is known.

EXPLANATION OF PLATE 39

Figs. 1-9. *Contitheca webersi* Yochelson, sp. nov. 1-5, TM 5411, right side, left side, dorsal, ventral, and apical views of holotype, a steinkern, ×5. 6-7, TM 5413, a very slightly oblique natural cross-section of a small paratype, a steinkern and natural cross-section of the larger end, ×5. 8-9, TM 5410, dorsal views of paratype showing fine thread-like longitudinal lirae when illuminated from side and fine transverse growth lines when illuminated from the aperture, ×5.

Fig. 10. '*Pelagiella*' sp. indet. TM 5407, oblique view of steinkern tilted to show profile, ×5.

Figs. 11-12. *Hyolithes* sp. indet. 11, TM 5414, 12, TM 5415, side view of two specimens in profile and ventral view, the one in the lower centre slightly oblique. Fig. 12 also shows TM 5418, a paratype of *Contitheca webersi* with base exposed, ×5.

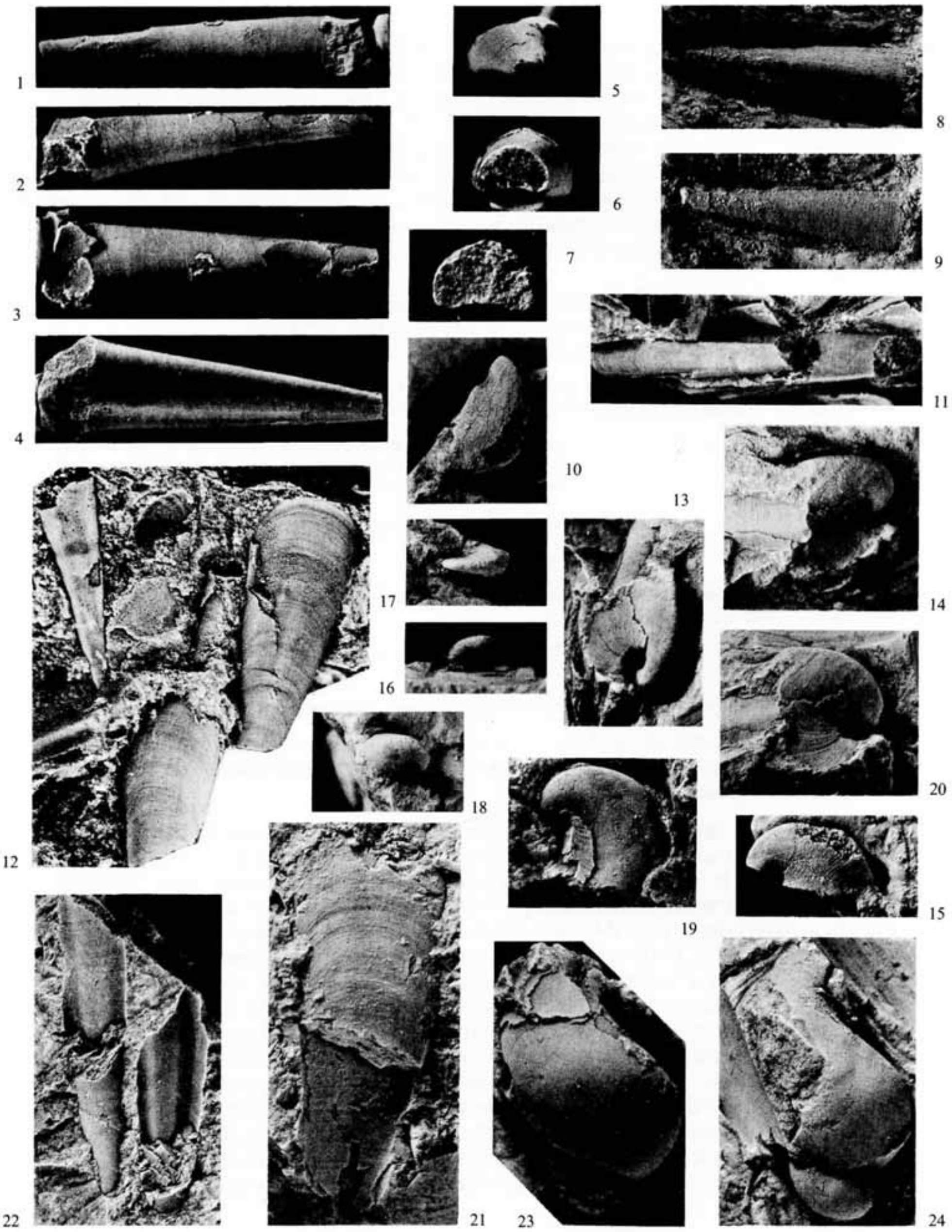
Figs. 13-20. '*Pelagiella*' sp. indet. 13-14, 20, TM 5406, side view, tilted, oblique basal view and basal view of specimen retaining patch of shell on basal surface, ×5. 15, TM 5407, top of steinkern showing markings which are not growth lines, ×5. 16-18, TM 5408, oblique top view, oblique side view reversed in orientation to show lenticular profile, and basal view of a steinkern, ×5. 19, TM 5409, top view of specimen retaining patch of shell, ×5.

Fig. 21. *Hyolithes* sp. indet. TM 5425, ventral view of a broken specimen with steinkern removed and growth lines of dorsal surface visible towards the apex, ×5.

Fig. 22. *Contitheca webersi* Yochelson, sp. nov. Slab with two incomplete paratypes, TM 5423, 5424, both showing the curvature of the ventral surface, ×5.

Figs. 23-24. *Scaevogyra* sp. indet. 23, TM 5417, side view of a steinkern showing two whorls, ×5. 24, TM 5416, oblique basal view of elongated steinkern; the sharp line to the left intersecting the specimen is a tool mark, ×5.

PLATE 39



SHERGOLD *et al.*, Antarctic Cambrian molluscs

Discussion. The hyolithids are wider and somewhat longer than associated orthothecoids but probably are not significantly different in terms of hydraulic equivalency. On one small rock slab, similar orientation of these two elongate forms is apparent (Pl. 39, fig. 12). No opercula are known from this assemblage.

Although the material may be well-enough preserved to name formally, it is left in open nomenclature. Literally hundreds of specific names have been applied to Cambrian hyolthids (Sinclair 1946). Many species are poorly understood and likely to be conspecific; it therefore seems inadvisable to add further names to the literature until some of the older named species are better known.

Order ORTHOTHECIDA Marek, 1966
Family ORTHOTHECIDAE Sysoiev, 1958
Genus CONTITHECA Sysoiev, 1972

Type species. *Hyolithes cor* Holm (1893, p. 58, pl. 1, figs. 60–62; pl. 6, fig. 10), from the middle Cambrian, *Paradoxides forchhammeri* Zone, Andrarum, Sweden; designated by Sysoiev (1972, p. 94).

Other species. *Hyolithus* (*Orthotheca*) *lineatulus* Holm (1893, p. 59, pl. 1, figs. 53–56; pl. 5, figs. 64–66), middle Cambrian, *P. forchhammeri* Zone, Andrarum, Skaane, Sweden. *H. kotoi* Saito (1936, p. 361, pl. III, figs. 20–23), middle Cambrian, Chunghwa, North Korea.

Contitheca webersi Yochelson, sp. nov.

Plate 39, figs. 1–9, 22

Name. The species is named for G. F. Webers, Macalister College, St. Paul, Minnesota, who initially reported late Cambrian fossils in Antarctica.

Types. Holotype, TM 5411, the steinkern illustrated on Plate 39, figs. 1–5; paratypes, TM 5410, 5412, 5413, 5423, 5424.

Dimensions. The holotype, the only complete specimen available, has a length of 10 mm.

Diagnosis. *C. webersi* sp. nov. is an orthothecoid with a concavo-convex profile, ornamented longitudinally by numerous fine lirae along the dorsum and sides, but not along the venter.

Description. The nucleus and earliest parts of the shell are unknown, the principal length of which is without septa. The shell is bilaterally symmetrical; the sides diverge at an angle close to 9°; dorsal and ventral surfaces diverge at a smaller angle. Though the dorsum is straight throughout growth, the ventral surface near the anterior margin expands slightly. In side view the mature shell curves downwards. The height to width ratio is 2:3. In cross-section the shell is concavo-convex, superficially resembling that of a kidney bean. The inner two-thirds of the ventral surface, in cross-section, is very gently curved downward from the median line to an abrupt angulated change in slope; the outer part of the ventral surface curves strongly downward, outward, and then upward for an extremely short distance following the arc of a small circle, so that there is a distinct change between the ventral and dorsal surfaces but no development of an angulated lateral edge. The dorsal surface joins the rounded edge smoothly and has a much more gentle curvature; the entire dorsum is nearly a semicircle in cross-section with flanks and median line differentiated, but with a greater degree of curvature than that shown on the inner part of the ventral side. The inner part of the ventral surface is covered with faint, fine, closely spaced growth lines, trending at right angles to the plane of symmetry. An ornament of fine thread-like lirae is present; more than 40 lirae cover the dorsum and rounded ventral margins, but lirae are absent on the gently curved inner face of the ventral surface. At maturity the interspaces between lirae are about twice the width of the threads. The shell is thin, composed of at least two layers.

The operculum is unknown.

Discussion. Presumably the unusual cross-section (Pl. 39, figs. 6–7) is a consequence of the need to keep the aperture above the sediment–water interface and free from sediment. The distinctly curved basal lateral edges (Pl. 39, fig. 4) are obvious; they effectively raise the main part of the shell above the substrate. Presumably the slight downward extension seen in the larger of the shells (Pl. 39, figs. 1–2) is a development of maturity to compensate for the increased weight of the growing animal. The well-rounded dorsum covered by fine ornament (Pl. 39, figs. 8–9) is not easily explained from the viewpoint of functional morphology, though ornament on the rounded lateral edges might serve to lower adhesion of the shell to fine-grained sediments.

Although hyolithids are widespread, the collections of the National Museum of Natural History (formerly U.S. National Museum) contain virtually no undoubted specimens of American orthothecids. Accordingly, comparison is limited to material described by Walcott (1905, 1913) from China. None of his middle Cambrian species show any traces of longitudinal ornament. His only late Cambrian species, *Orthotheca cyrene*, lacks ornament and has a flat ventral surface rather than one concave in outline.

Several dozen Cambrian species of *Orthotheca* (*sensu lato*) were erected before the Second World War (Sinclair 1946) and more have been named since. *C. webersi* is closest to *C. lineatulus* (Holm) from the middle Cambrian *Paradoxides forchhammeri* Zone of southern Sweden. The cross-section of that species is unknown, but the concave venter is more gently curved than in *C. webersi* and is ornamented by longitudinal threads.

The ornament of *C. webersi* is uncommon for the group, and the absence of these threads on the inner part of the ventral surface appears to be unique. I prefer to use a new name rather than to include this excellent material in any ill-defined older named species. For orthothecoids to become useful as stratigraphic tools, monographic treatment is needed. The recent work by Sysoiev (1972) provides an excellent model.

Class GASTROPODA Cuvier, 1797
Order ARCHAEOGASTROPODA Thiele, 1925
Family ONYCHOCHILIDAE Koken, 1925
Genus SCAEVOGYRA Whitfield, 1878

Type species. Scaevogyra swezeyi Whitfield (1878, p. 61; 1882, p. 198, pl. 3, figs. 7–8), late Cambrian, Mendota, Wisconsin, U.S.A.; designated Miller (1889).

Scaevogyra sp. indet.

Plate 39, figs. 23–24

Material. Two specimens, TM 5416, 5417, both steinkerns retaining only small patches of shell near the columellar area.

Description. The specimens are subglobose in outline, possessing few whorls, which expand at a rapid rate (Pl. 39, fig. 23). The nucleus and earliest whorls are unknown, and only two complete whorls remain. The pleural angle on one specimen is nearly 40°; on the second it is nearly 30° but the specimen may have been distorted (Pl. 39, fig. 24). Coiling is hyperstrophic or sinistral, rather than dextral. On the steinkerns the sutures are distinct but not greatly sunken. The whorl profile is generally arcuate, being quite well rounded near the suture, much less obviously curved throughout most of the length of the side, and again well arched across the periphery which is low on the whorl. The basal area is not well known but seems to be in smooth continuous curvature with the periphery so that a depression is formed. However, because the specimens are steinkerns there is no certainty that any umbilicus was present on the shell. So many critical features cannot be determined that a formal name is unwarranted.

Discussion. Scaevogyra is a characteristic late Cambrian genus in North America and north-eastern Asia. Although some of the described species are lower-spired than this new form, a few specimens attributed to the type species *S. swezeyi* Whitfield and others attributed to *S. elevata* Whitfield (1882, p. 199, pl. 3, fig. 11) have the same spire height as the Antarctic material. In spite of the limitations imposed by the quality of the Antarctic specimens, they can be confidently assigned to *Scaevogyra* and thus indicate a late Cambrian, possibly even Trempealeauan, age for the faunule.

Matherella Walcott, 1912, another hyperstrophic late Cambrian genus, is only slightly higher-spired than the Antarctic species; it has a sharp periphery, however, and a distinctly inclined basal surface. *Matherellina* Kobayashi, 1937*a*, an early Ordovician hyperstrophic genus, is lower-spired, but has more flattened whorls on which ribs are prominent.

Mollusca INCERTAE SEDIS
Family PELAGIELLIDAE Knight, 1956
Genus PELAGIELLA Matthew, 1895

Type species. Cyrtolithes atlantoides Matthew (1894, p. 64, pl. 16, fig. 8*a–b*), early Cambrian, Hanford Brook, New Brunswick; designated Matthew (1895).

'*Pelagiella*' sp. indet.

Plate 39, figs. 10, 13–20

Material. Five specimens of which the following are figured: TM 5406, 5407, 5408, 5409.

Description. Compressed, asymmetrical, rapidly expanding shells with fine growth lines; nucleus unknown. The shell expands at a rapid rate and completes little more than one whorl, which apparently remains in contact along its inner margin through its growth. The upper suture is depressed with the whorl profile rising strongly upward from it for only a short distance, then following a gentle arch across most of the width, curving downward somewhat more strongly in the outer part of the surface and then dropping abruptly, but smoothly, to form a narrow well-rounded periphery. The profile below the periphery curves strongly inward and more gently downward, shell width below periphery being about twice that above it. The lowest part of the base is near midwhorl, beyond which the surface is arched gently upward and continues inward with little curvature for most of the distance, but at a faint angulation it bends abruptly upward to form the wall of a shallow, narrow umbilicus. Growth lines are unknown on the upper surface and across the periphery, possibly of sweeping opisthocline type below the periphery, but orthocline for at least the inner one-third of the base. Ornament is unknown except for fine, closely spaced growth lines on the inner part of the base. The shell is thin but its structure unknown.

Discussion. Generic assignment of the Antarctic form is uncertain, for the pelagiellids are in need of revision. The type of *Pelagiella*, *C. atlantoides* Matthew, is an early Cambrian species with a strongly inflated lower profile, whereas the Antarctic form is quite lenticular (Pl. 39, fig. 16). Because the specimens cannot be freed from the matrix (Pl. 39, figs. 17, 20) it is difficult to convey their relative compression.

One of the interesting peculiarities of the pelagiellids is the rapid rate of expansion of the coil. The Antarctic species seems to have the whorl in contact (Pl. 39, fig. 18), but others do not complete one full volution. If one assumes that all the Antarctic material is conspecific and then projects the smallest specimen (Pl. 39, fig. 18) on to the largest (Pl. 39, fig. 14) scarcely more than one full volution is completed. This rapid rate of expansion is quite atypical of gastropods and there is no compelling reason to assign *Pelagiella* and its allies to that class. It is therefore left here as *incertae sedis*.

Most of the few Antarctic specimens are steinkerns; only two (Pl. 39, figs. 13–14, 20) retain patches of the shell. The apparent difference between the Antarctic steinkerns (Pl. 39, figs. 15–16), which show a pattern superficially resembling growth lines in some areas but chevron-shaped in other areas, and the patches of shell (Pl. 39, fig. 20) of this species, in which true growth lines are preserved, demonstrates the need to deal with well-preserved material in studying the group. Horny (1964) described two genera of middle Cambrian pelagiellids differentiated to a large extent on their growth lines and ornament.

A survey of the literature suggests that the pelagiellids might have some stratigraphic potential when they are thoroughly monographed; meanwhile, because so many of the species and genera are poorly known, they cannot be used for dating rocks with any degree of confidence.

Phylum ARTHROPODA (by J. H. Shergold)
Class TRILOBITA Walch, 1771
Order MIOMERA Jaekel, 1909
Suborder AGNOSTINA Salter, 1864
Family DIPLAGNOSTIDAE Whitehouse, 1936 emend. Öpik, 1967
Subfamily PSEUDAGNOSTINAE Whitehouse, 1936
Genus PSEUDAGNOSTUS Jaekel, 1909 *sensu lato*

Type species. Agnostus cyclopyge Tullberg (1880, p. 27, pl. 2, fig. 15*a–c*), designated Jaekel (1909, p. 400), from the late *Olenus* and *Parabolina spinulosa* with *Orusia lenticularis* Zones, Andrarum, Skaane, Sweden (see Westergaard 1922, pp. 116–17).

Other species. Other species of *Pseudagnostus* are too numerous to list here: eighty-eight specific taxa can be incorporated in *Pseudagnostus sensu lato*.

Age and distribution. Cosmopolitan, occurring in Alaska, Canada, U.S.A., South America, Europe, U.S.S.R., China, Manchuria, Korea, Vietnam, Australia, and now recorded from Antarctica, during the time span of earliest late Cambrian to early Ordovician.

Pseudagnostus sp. undet.

Plate 41, figs. 9–11

Material. Two cephala and fragments of three pygidia; specimens are preserved with shell, are exfoliated, or preserved as moulds. The two complete cephala have lengths of 3·20 and 3·60 mm; and two assessable pygidia have lengths exclusive of the articulating half-ring, of 3·20 and 3·40 mm. Specimens AR 601–603 are illustrated.

Description. The cephalon is subovate, en grande tenue (Öpik 1961, p. 55; 1967, p. 56), with deliquiate (Shergold 1975, p. 41) marginal furrows. The cephalic acrolobe is unconstricted laterally, and is divided sagittally by a median preglabellar furrow. The glabella, occupying about 75% of the cephalic length (sag.), possesses a sagittally pointed anterior lobe fully 33% of the glabellar length (sag.). The anterior lobe is separated from the remainder of the glabella by a transverse anterior furrow, arched backwards and deepened abaxially around the front of the anterolateral lobes. The axial glabellar node lies behind the anterior furrow and behind the anterolateral lobes. Basal lobes are small and triangular. The external cephalic surface bears a finely araneavelate prosopon.

The pygidium, like the cephalon, is subovate, en grande tenue, with deliquiate marginal furrows. The acrolobe is gently constricted. Axial furrows defining the anterior two segments of the rhachis converge rearwards to the level of the second transverse furrow. Accessory furrows are well developed; thus the species is plethoid (Shergold 1972, p. 15) and deuterolobate. Although the deuterolobe is relatively narrow (tr.) on the illustrated specimens, the pleural areas are restricted. Posterolateral spines are situated in front of a transverse line drawn across the rear of the deuterolobe. The pygidial prosopon, where preserved, appears to be similar to that of the cephalon.

Discussion. The species cannot be accurately determined from the available material, but it exhibits similarity with the type species, *P. cyclopyge* (Tullberg), and its immediate allies, e.g. *P. communis* (Hall and Whitfield) *sensu* Lu *et al.* (1965, pp. 41–42, pl. 4, figs. 6–8) from China; *P. idalis* Öpik (1967, p. 153, pl. 63, figs. 1, 3; pl. 62, figs. 8–9) and *P. ampullatus* Öpik (1967, p. 150, pl. 61, figs. 7–11) from Australia; *P. leptoplastorum* Westergaard (1944, p. 39, pl. 1, fig. 1) from Sweden; and *P. pseudocyclopyge* Ivshin (1956, pp. 17–19, pl. 1, figs. 1–8, 10, 16–17; 1962, p. 18, pl. 1, figs. 19–22) from Kazakhstan. The pygidium of the North American species *P. gyps* Clark (1923, p. 124, pl. 1, fig. 9; 1924, p. 16, pl. 3, fig. 2; Rasetti 1944, p. 234, pl. 36, figs. 20–22) resembles that of the Antarctic specimens.

The combination of cephalon and pygidium represented in the Victoria Land collection is most similar to that described in Lu *et al.* (1965) as *P. communis* (Hall and Whitfield). The only difference appears to be that the Chinese specimen lacks a median preglabellar furrow. Pygidial and cephalic shapes, acrolobes, glabellar proportions, degree of incision of furrows and visibility of lobes, position of axial nodes, and the nature of the marginal furrows are similar. Our material is not referred to the Chinese species, however, as (1) the Chinese species is not conspecific with the

North American *P. communis*, which in general is more effaced and has narrower and shallower marginal furrows, and (2) the provenance of the Chinese form is not known to us, all reference details being published in Chinese.

Both Antarctic and Chinese species differ from *P. cyclopyge* (Tullberg) in cephalic shape; their axial glabellar nodes are situated further rearwards and their anterior glabellar furrows are decidedly transverse. *P. idalis* Öpik and *P. ampullatus* Öpik have similar cephala, but the pygidia of *idalis* have posterolateral spines situated further rearwards, and pygidia of *ampullatus* possess a more bulbous deuterolobe completely encircled by accessory furrows. Some comparison may be made with the pygidia referred by Ivshin (1962) to *P. pseudocyclopyge*, but the cephalon of that species appears to possess V-form anterior glabellar furrows.

The observed prosopon of *Pseudagnostus* sp. probably sets it apart from most other described species. Often, however, these have been previously described from indifferent or inadequate material, or are parietal surfaces which do not show the external prosopon. *P. araneavelatus* Shaw (1951, p. 113, pl. 24, figs. 12–16), from Vermont, has a comparable prosopon, albeit somewhat heavier. This species differs quite substantially, however, in both glabellar and pygidial characteristics from that treated here, and also occurs at a considerably later date (early Ordovician). I hesitate to erect yet another species of an already abused genus; the collection of further material, however, might aid interpretation substantially.

Order PTYCHOPARIIDA Swinnerton, 1915
Superfamily PTYCHOPARIACEA Matthew, 1887
Family EULOMATIDAE Kobayashi, 1955
(*pro* EULOMIDAE Kobayashi, 1955, *sensu* Öpik, 1963)
Genus STIGMATOA Öpik, 1963

Type species. By original designation, *Stigmatoa diloma* Öpik (1963, pp. 89–90, pl. 4, fig. 2), from the *Erixanium sentum* Zone, Georgina and Pomegranate Limestones, western Queensland, Australia.

Other species. S. silex Öpik (1963, pp. 90–91, pl. 4, fig. 4), *E. sentum* Zone, O'Hara Shale, Pomegranate Limestone, western Queensland, Australia. *S. sidonia* Öpik (1963, pp. 91–92, pl. 4, fig. 1), *Irvingella tropica* with *Agnostotes inconstans* Zone, Pomegranate Limestone, western Queensland, Australia. *S. tysoni* Öpik (1963, pp. 92–93, pl. 4, fig. 3), *E. sentum* Zone, Georgina Limestone, western Queensland, Australia.

Age and distribution. All previously known species occur in Australia, mainly in carbonate sequences of western Queensland, where their age is early late Cambrian, late Idamean, Zones of *E. sentum* and *I. tropica* with *A. inconstans.*

Stigmatoa sp. undet.

Plate 41, figs. 1–2

Material. A single cranidial fragment, AR 604, which has a glabellar length of 3·70 mm.

Discussion. Stigmatoa sp. is characterized by a stout occipital spine (Pl. 41, fig. 2), sigmoidal preoccipital glabellar furrows, large palpebral lobes situated close to the glabella, and a finely granulose prosopon.

Although neither preglabellar area nor posterolateral limbs are preserved on the only available specimen, the combination of characteristics is sufficient to differentiate *Stigmatoa* sp. from other species of the genus. *S. diloma* has a similarly stout occipital spine, but wider (tr.) palpebral areas, and hence longer ocular ridges. *S. silex* has similarly sited palpebral lobes and similarly stout occipital spine, but appears to have a punctate test. *S. sidonia* has only a short occipital spine and a minutely punctate test. *S. tysoni*, perhaps the closest species to *Stigmatoa* sp. in terms of gross morphology, has a similar relationship of palpebral lobes to glabella, but possesses a shorter occipital spine and apparently a 'cambric prosopon' (Öpik 1963, p. 92), presumably having a woven rather than granular appearance.

Family ELVINIIDAE Kobayashi, 1935 *sensu* Palmer, 1960

Subfamily ELVINIINAE Kobayashi, 1935 *sensu* Palmer, 1960

Genus OLENTELLA Ivshin, 1956

Type species. By original designation, *Olentella olentensis* Ivshin (1956, pp. 66–67, pl. V, figs. 1–11; pl. VI, figs. ?6, ?10; *in* Nikitin 1956, pl. XI, fig. 7), from the late Tuorian (Ivshin and Pokrovskaya 1968, p. 101), *Aphelaspis–Kujandaspis* Zone, Tortkuduk Suite, central Kazakhstan, U.S.S.R.

Other species. O. shidertensis Ivshin (1956, pp. 68–69, pl. VI, figs. 1–11; pl. VII, figs. 1–8), locality and horizon as for the type species. *O. illustris* Lazarenko (1966, pp. 64–65, pl. VIII, figs. 4–8), Kyutyungd depression, River Olenek, North Siberian Platform, Zone of *Irvingella/Cedarellus felix*.

Age and distribution. U.S.S.R., Kazakhstan, late Tuorian, *Aphelaspis–Kujandaspis* Zone; North Siberian Platform, early Shidertan, *Irvingella/Cedarellus felix* Zone; Antarctica, Northern Victoria Land, probably late Idamean/early Franconian.

Discussion. As far as cranidial characteristics are concerned, *Olentella* Ivshin, 1956, together with *Kujandaspis* Ivshin, 1956, *Pedinocephalus* Ivshin, 1956, *Pedinaspis* Ivshin, 1962, and possibly *Apheloides* Ivshin, 1962 appear to form a morphologically related group. Their closest affinities seem to lie with Elviniinae of the *Dunderbergia–Elburgia–Elvinia* generic group, and Dokimocephalinae (*Iddingsia*) of North America, with which it is proposed that they be classified.

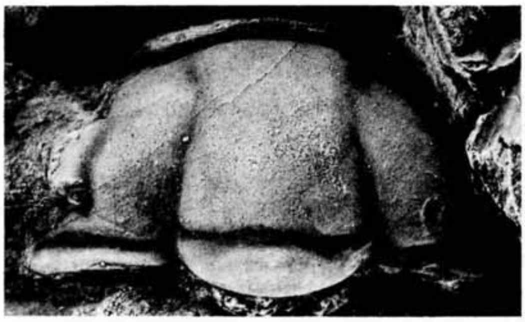
Cranidia of *Olentella* and *Dunderbergia* have much in common; they have similar shapes and segmentation and preglabellar areas of similar appearance. The preoccipital furrows are sagittally discontinuous in both genera. *Olentella* is distinguished by possessing a relatively narrower (tr.) preglabellar area, relatively shorter (sag.) preglabellar field but, a thicker (sag.) anterior cranidial border. The palpebral lobes of *Dunderbergia* are further from the glabella. The closely spaced palpebral lobes of *Olentella*, and proportions and relationships of the components of the preglabellar area, relate the Kazakhstan genus to *Iddingsia*, but the latter has a more inflated, less-tapered glabella, and stronger glabellar furrows.

EXPLANATION OF PLATE 40

Figs. 1–6. *Prochuangia* sp. aff. *P. granulosa* Lu, 1956. 1, AR 617, cranidium retaining test, showing faint granulosity, dorsal view, ×8. 2, AR 617, as above, lateral view, ×8. 3, AR 618, partially exfoliated cranidium with granulose prosopon, dorsal view, ×8. 4, AR 620, pygidium retaining external test, granulose, dorsal view, ×18. 5, AR 621, latex cast from mould of exfoliated pygidium showing traces of caecal network, dorsal view, ×6. 6, AR 619, librigena retaining test, oblique dorsal view, ×8.

Figs. 7–9. *Proceratopyge* (*Proceratopyge*) cf. *P. lata* Whitehouse, 1939. 7, AR 622, early holaspid cranidium with test, dorsal view, ×12. 8, AR 622, as above, lateral view, ×12. 9, AR 623, pygidial fragment, oblique dorsal view, ×12.

PLATE 40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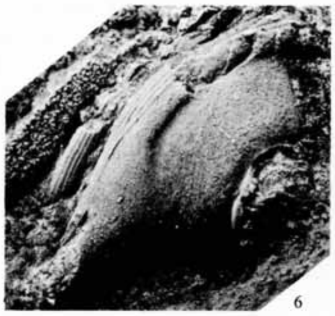
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Olentella cf. *olentensis* Ivshin, 1956

Plate 42, figs. 1–2, 3?, 7?, 9–10

cf. 1956 *Olentella olentensis* gen. et sp. nov., Ivshin 1956, pp. 66–67, pl. V, figs. 1–11; pl. VI, figs. ?6, ?10.

Material. Four cranidial fragments, a possible librigena, a thoracic fragment, and six pygidial fragments. Specimens AR 605–609 are figured. Measured cranidia vary in length between an estimated 3·40 and 5·60 mm; the lengths of the pygidia, excluding the articulating half-ring, vary between 2·20 and 7·40 mm.

Description. The cranidium is sagittally very convex (Pl. 42, fig. 2) in profile. Its glabella is conical, bounded by anteriorly converging axial furrows. Glabellar furrowing is ill-defined, three pairs of furrows being faintly discernible, all sloping adaxially and rearwards. The preoccipital furrows are apparently sigmoidal; their extremities very nearly merge sagittally.

The occipital ring is broken on all the available specimens, but appears to be slightly wider (tr.) than the preoccipital glabellar lobes, and differentiated from the glabella by a clearly defined occipital furrow.

Preocular facial sutures diverge strongly forwards, enclosing a wide (sag.) anterior cranidial border and shorter (sag.), gently convex (sag.) preglabellar field. The anterior cranidial contour (plan view) is strongly arched forwards, as is the anterior marginal furrow. Postocular sections of the facial suture enclose short (tr.) triangular posterolateral limbs bearing distally widened (exsag.) marginal furrows.

The palpebral lobes are arcuate, situated close to the glabella, and long, extending forwards from the anterior part of the preoccipital lobes to the level of the very faint anterior lateral furrows. Ocular ridges are short, slope rearwards, and are faintly duplicated. Where they intersect the axial furrows the glabella and preocular areas are joined, presumably by an underlying caecal diverticulum. The palpebral areas are narrow (tr.).

The prosopon of exfoliated cranidia is punctate, but that of testaceous specimens is composed of irregularly and sparsely scattered granules set in a very fine dense matrix of smaller granules.

The librigena (Pl. 42, fig. 3), which is tentatively placed in the species, is aphelaspidinid in aspect, possessing prominent lateral and posterior borders defined by

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EXPLANATION OF PLATE 41

Figs. 1–2. *Stigmatoa* sp. undet. 1, AR 604, cranidial fragment retaining test, finely granulose prosopon, dorsal view, ×8. 2, AR 604, as above, oblique lateral profile to show occipital spine, ×8.

Fig. 3. *Pedinocephalus* cf. *bublichenkoi* Ivshin, 1956. AR 611, testaceous cranidial fragment, dorsal view, ×6.

Fig. 4. Aphelaspid sp. 1. AR 612, cranidial fragment, dorsal view, ×8.

Fig. 5. Trilobita genus et species incertae sedis, sp. 4. AR 626, partially exfoliated librigena, dorsal view, ×6.

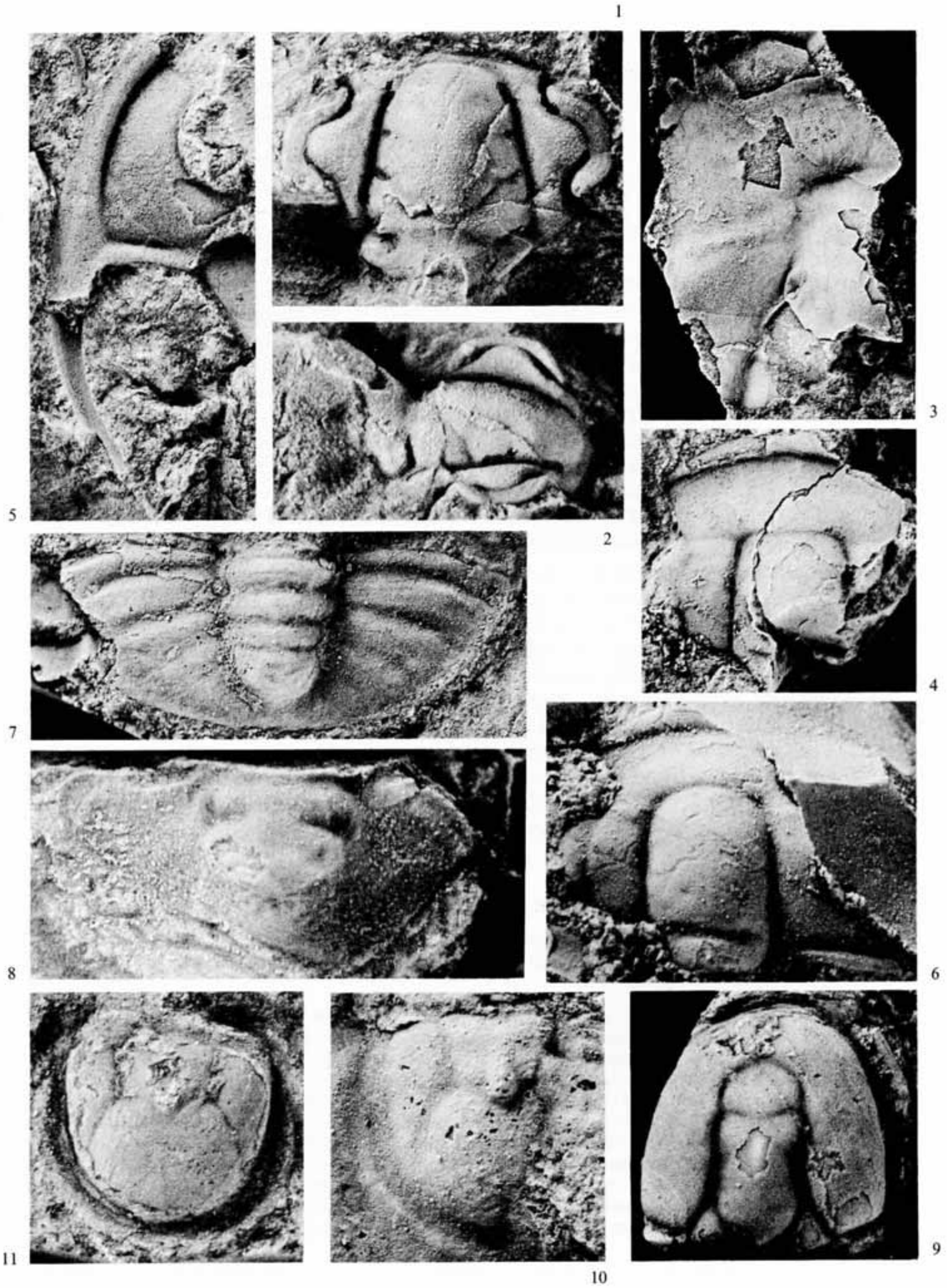
Fig. 6. Olenid sp. undet. AR 616, latex cast from external mould of incomplete cranidium, dorsal view, approx. ×12.

Fig. 7. Aphelaspid sp. 2. AR 613, mainly exfoliated pygidium, dorsal view, ×8.

Fig. 8. *Irvingella*? sp. undet. AR 610, damaged pygidial fragment, dorsal view, ×8.

Figs. 9–11. *Pseudagnostus* sp. undet. 9, AR 601, testaceous cephalon with finely granulose prosopon, dorsal view, ×12. 10, AR 603, latex cast from external mould of exfoliated pygidium, dorsal view, ×12. 11, AR 602, mainly exfoliated pygidium, dorsal view, ×12.

PLATE 41



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shallow marginal furrows which combine at the genal spine base and continue a short distance along the centre of the spine. The genal spine, although broken off, appears to have been long and stout. The genal field has low convexity (tr., exsag.) and bears a radiating caecal system which is suppressed at the lateral marginal furrow. The lateral margins bear terrace lines. Other visible portions of the librigena carry a fine dense granulation.

The thoracic segment (Pl. 42, fig. 7), tentatively included in the species, has a similar prosopon to that of the cranidium. It is weakly fulcrate, but anterolaterally bears a broad articulating facet. Its pleural furrow is wide (exsag.), very clearly defined, striking obliquely across the pleuron. The axial portion of the segment bears a sagittal node. Although it is bluntly pointed, the segment appears to lack a free distal spine.

The six associated pygidia are semicircular in shape. All possess wide (tr., exsag.) flange-like borders, widened out laterally. The borders are well delineated from the furrowed pleural zone by shallow and prominent marginal furrows. There is evidence for three pleural segments bearing shallow pleural furrows which terminate at the marginal furrows. Interpleural furrows are present, but faint. The axis contains three, possibly four, segments and a fused terminal piece. The species lacks a post-axial ridge. The pygidial prosopon is similar to that of the cranidium: the axial rings bear small fine granules, and larger scattered ones occur along the pleural 'ribs'.

Discussion. Although referred to *Olentella* cf. *olentensis*, the illustrated cranidia share properties of both that species and *O. shidertensis* Ivshin, 1956; they have the acutely rounded glabella of *O. olentensis* combined with the convexities of *O. shidertensis*. The Antarctic material possesses characteristics of the preglabellar area similar not only to *Olentella*, but also to material which Ivshin (1962, pl. III, figs. 1-12) referred to *Aphelaspis nobilis*. Pygidia referred here to *Olentella* are most comparable to that which Ivshin also assigned to *A. nobilis* (loc. cit., fig. 13). The librigena illustrated here resembles that of *A. subditus* Palmer (1965, pl. 8, fig. 24). The parts here assembled to represent *Olentella* cf. *olentensis* may, therefore, be erroneously associated. Taxonomic assessment is made difficult by the fact that such trilobites appear to bridge the concepts of the families Elviniidae and Pterocephaliidae as presently understood.

Genus IRVINGELLA Ulrich and Resser, 1924

Type species. By original designation, *Irvingella major* Ulrich and Resser (*in* Walcott 1924*b*, p. 58, pl. 10, fig. 3), type locality and formation not stated. Full discussion and synonymy associated with this species are given by Palmer (1965, p. 48).

Other species. Palmer (1965, p. 45) has noted that '39 specific names have been applied to trilobites having the characteristics of *Irvingella*'. Those listed here are the few species in which the pygidium is known with some certainty: *I.* (*Irvingellina*)? sp. undet., Kobayashi (1938, p. 176, pl. XV, fig. 3*a*), *Elvinia* Limestone, Mount Hunter, B.C., Canada. *Irvingella media* Resser, 1942 (*sensu* Wilson 1949, p. 39, pl. 11, figs. 16-17, 19-20), *Elvinia* Zone, Wilberns Formation, central Texas, U.S.A. *I. obliquoensis* Rusconi, 1953 (*sensu* Rusconi 1954, p. 31, pl. 2, figs. 8-9; text-figs. 17-18), Quebradita Oblicua, Argentina. *I. tropica* Öpik (1963, pp. 96-97, pl. 4, figs. 5-8), Zone of *I. tropica* with *Agnostotes inconstans*, Pomegranate Limestone, western Queensland, Australia. *I. flohri* Resser, 1942 (*sensu* Palmer 1965, pp. 47-48, pl. 6, figs. 16, 19-20, 24), *Elvinia* Zone, Nevada and Utah, U.S.A. *I. major* Ulrich and Resser, 1924 (*sensu* Palmer 1965, p. 48, pl. 6, figs. 9-15), *Elvinia* Zone, Nevada, U.S.A. *I. nuneatonensis* (Sharman, 1886) (*sensu* Rushton 1967, pp. 339-348, pl. 52, figs. 1-12), *Olenus* Zone (younger than *O. dentatus*), Outwood Shales, Warwickshire, U.K. *I. perfecta*

Tchernysheva (1968, pp. 207–210, pl. 22, figs. 1–8), Chopkin Suite, Norilsk region, North-west Siberian Platform.

Age and distribution. Irvingella is a cosmopolitan genus occurring in or about the *Elvinia* Zone and its time equivalents in Europe, Siberia, China, Australia, South America, U.S.A., and Canada.

Irvingella? sp. undet.

Plate 41, fig. 8

Material. A single incomplete exfoliated pygidium, AR 610, with sagittal length of 2 mm.

Description. The pygidial outline is trapezoidal, with a slightly indented posterior margin. Borders are not preserved laterally. The pleurae are appreciably convex (tr.); only the first pleural segment bears a pleural furrow; interpleural furrows are completely effaced. The axis is strongly raised above the pleurae and was originally composed of two segments and a rather prominent bulbous terminal piece; the articulating half-ring and the anterior portion of the first axial segment are, however, broken away. A faint post-axial ridge is present.

Discussion. Although the pygidial fragment is inadequate for detailed comparison, the Antarctic *Irvingella*? appears to be most similar in segmentation to the North American species *I. major* (as interpreted by Palmer 1965, pl. 6, figs. 9 and 11) and the Australian *I. tropica* Öpik (1963, pl. 4, fig. 8). *I. nuneatonensis* (Sharman) has, according to Rushton (1967, p. 342), three axial segments, as has *I. perfecta* Tchernysheva (1968). *I. tropica* and *I. flohri* Resser have considerably thicker (sag., exsag.) posterior borders than that evident from *Irvingella*? sp.

The over-all appearance of *Irvingella*? sp. is somewhat similar to that of species of *Dunderbergia* described by Palmer (1960). Although pygidia of *D. variagranula* Palmer (1954, p. 761, pl. 88, fig. 7; 1960, p. 68, pl. 4, figs. 22, 25–26, 29), *D. polybothra* Palmer (1960, pp. 67–68, pl. 5, figs. 1–4, 6–7, 9, 14), and *D. bigranulosa* Palmer (1960, pp. 66–67, pl. 5, figs. 10–13, 15–23) have similar shapes to that of *Irvingella*? sp., they differ in having longer (sag.) axes with at least three distinct segments and less bulbous terminations.

Family PTEROCEPHALIIDAE Kobayashi, 1935
Subfamily PTEROCEPHALIINAE Kobayashi, 1935
Genus PEDINOCEPHALUS Ivshin, 1956

Type species. By original designation, *Pedinocephalus bublichenkoi* Ivshin (1956, pp. 58–60, pl. II, figs. 1–8), late Tuorian, *Aphelaspis–Kujandaspis* Zone, Tortkuduk Suite, central Kazakhstan, U.S.S.R.

Other species. P. kasachstanensis Ivshin (1956, pp. 60–62, pl. II, figs. 9–10, ?11, 12), horizon and locality as for type species. *P. bykovae* Ivshin (1956, pp. 62–64, pl. I, figs. 24–26, 28–29), locality as for type species. *Taenicephalus*? *peregrinus* Henningsmoen (1957, pp. 167–169, pl. 1, figs. 1–6), Subzone of *Olenus gibbosus* with *O. transversus*, Västergötland, Sweden. *P. simplex* Ivshin (1962, pp. 96–98, pl. IV, fig. 2), horizon as for type species.

Age and distribution. U.S.S.R., central Kazakhstan, late Tuorian, *Aphelaspis–Kujandaspis* Zone; Sweden, Västergötland, *Olenus* Series, *O. gibbosus–O. transversus* Subzone; Antarctica, Northern Victoria Land, late Idamean/early Franconian.

Pedinocephalus cf. *bublichenkoi* Ivshin, 1956

Plate 41, fig. 3

cf. 1956 *Pedinocephalus bublichenkoi* sp. nov., Ivshin 1956, pp. 58–60, pl. II, figs. 1–8.

Material. A single incomplete cranidial fragment preserved with shell, AR 611. The left posterolateral limb and the whole of the right-hand side of the specimen, including the occipital ring, are broken away. The specimen is insufficiently complete for measurement; an estimated length is 11 mm.

Description. The glabella tapers markedly towards its anterior end, which is gently and obtusely rounded. Glabellar furrowing is indistinct on the available fragment, preoccipital and median lateral furrows being poorly preserved. The anterior lateral furrows, which lie just behind the intersection of the ocular ridges and the axial furrows, are short and faint, and directed anteriorly and adaxially.

Palpebral lobes are not preserved, but nevertheless appear to have been short (exsag.), probably sited a little anterior of the mid-point of the glabella. Ocular ridges are long, abaxially and posteriorly inclined. They appear to be continuous across the axial furrows, connecting with the anterolateral corners of the glabella.

The preglabellar area is long (sag.), composed of a gently convex (sag.) preglabellar field and equally convex (sag.) anterior cranidial border, about half as long (sag.) as the preglabellar field. The preglabellar furrow is pitted on each side of the sagittal line and faint traces of a parafrontal band are present between the pits. The preglabellar field bears a caecal system which radiates from the vicinity of these pits.

The cranidium has a punctate prosopon.

Discussion. Pedinocephalus cf. *bublichenkoi* is best compared with the holotype of the species (Ivshin 1956, pl. II, fig. 1). The two specimens have similarly strong glabellar taper and degree of anterior rounding, and similarly pitted preglabellar furrow. Preservation of the Antarctic fragment prevents further comparison. By the same characteristics, *P.* cf. *bublichenkoi* can be compared with *P. kasachstanensis* and probably *P. bykovae. P.* cf. *kasachstanensis* (see Ivshin 1956, pl. II, fig. 11) has a narrower (tr.), more acutely rounded glabella. *P. simplex* has a glabella with less anterior taper and presumed larger palpebral lobes; and *P. peregrinus* (Henningsmoen) has a considerably shorter (sag.) preglabellar field with less sagittal convexity.

Subfamily APHELASPIDINAE Palmer, 1960

This taxon is used as emended by Palmer in 1962 (p. F32). Three Antarctic taxa are temporarily assigned to it, and are left under open nomenclature.

Aphelaspid species 1

Plate 41, fig. 4

Material. A single cranidial fragment, AR 612, lacking the greater part of the right palpebral area, palpebral lobe, and posterolateral limb. The left posterolateral limb cannot be exposed because the specimen lies adjacent to the *Prochuangia* cranidium figured on Plate 40, fig. 1.

Description. The illustrated cranidium is characterized by diverging preocular facial sutures, short (sag.) anterior cranidial border, and well-defined anterior marginal furrow; in lateral profile the preglabellar field is gently sigmoidal. The glabella is rectangular, parallel-sided, squared off anteriorly, and faintly furrowed. The occipital ring is not preserved. Linear transverse ocular ridges run abaxially from the corners of the frontal lobe. The preserved palpebral lobe has slightly over half the glabellar length (exsag.), and is anteriorly situated. Anterior and posterior palpebral widths (tr.) are equivalent. A fine caecal network radiates across the preglabellar field, otherwise the test is smooth.

Discussion. Aphelaspid sp. 1 is difficult to classify, but is referred to Aphelaspidinae on account of its partial similarity to *Aphelaspis buttsi* (Kobayashi). It can be equally well compared with certain species of *Eugonocare* Whitehouse and *Olenaspella* Wilson.

The available specimen has a preglabellar area of similar appearance to that of holotype of *A. buttsi* (see *Proaulocopleura buttsi*, Kobayashi 1936, p. 93, pl. 15, fig. 6; Resser 1938, p. 95, pl. 16, fig. 8) from Alabama, as refigured by Palmer (1962, p. 35, pl. 4, fig. 31). The palpebral lobes of *A. buttsi* are somewhat shorter (exsag.), but they are connected to the axial furrows by ocular ridges of similar length (tr.) and orientation. *A. buttsi* has a similarly truncate glabella which is less parallel-sided than that of the Antarctic species. Comparison with the many species of *Aphelaspis* is not undertaken as these, in general, have anteriorly tapered and rounded glabellae, and usually their preglabellar areas are structurally and proportionately different.

The nature of the preglabellar area links Aphelaspid sp. 1 with both *Eugonocare* and *Olenaspella*, which have morphologically identical cranidia—being differentiated solely on the absence of pygidial spines in the former (Palmer 1965, p. 64). As in the case of the North American species of *Aphelaspis*, the glabellae of *Eugonocare* and *Olenaspella* are anteriorly tapered and rounded, and glabellar furrowing is generally well defined. The ocular ridges of these genera are less transverse than those of *A. buttsi* and the aphelaspidinid at hand, usually having a gentle inclination to the palpebral lobes which lie somewhat more posteriorly on the genae.

The glabellar and ocular characteristics of Aphelaspid sp. 1 are similar to those of *Olenus asiaticus* Kobayashi, 1944 (see Kobayashi 1962, pp. 54–55, pl. IX, fig. 16*a*–*b*) but the preocular facial sutures diverge more strongly.

Aphelaspid species 2

Plate 41, fig. 7

Material. A single, mostly complete, mainly exfoliated pygidium, AR 613, whose length, including the articulating half-ring, is 3·80 mm.

Description. The pygidium determined as Aphelaspid sp. 2 has a semicircular shape, with length (sag.), including the articulating half-ring, about 42% of the estimated width (tr.). The axis, which occupies about 85% of the length (sag., including the half-ring), is conical, and composed of three well-delineated segments, a poorly defined fourth, and a terminal piece which may contain one additional fused segment. There is no post-axial ridge. Three pleural segments separated by very faint interpleural furrows are present. They bear wide and shallow pleural furrows which extend close to the pygidial margins. A very narrow border is perhaps present laterally, but merges into the post-axial convexity of the shield posteriorly. The pygidial margins are entire, non-spinose. The articulating half-ring is a simple bar, and fulcration is weak. Faint traces of a caecal network are present post-axially.

Discussion. Shape and segmentation indicate classification within Aphelaspidinae; *A. buttsi* (Kobayashi) as illustrated by Palmer (1962, pl. 4, figs. 26, 31) again offers closest comparison. Aphelaspid sp. 2 may in fact represent the pygidium of the cranidium described as Aphelaspid sp. 1. With *A. buttsi* there is comparable degree of segmentation, similar style of pleural furrowing, and narrow borders. Aphelaspid sp. 2, however, has a more fully rounded shape, less triangular than that of *A. buttsi*. *A. brachyaspis* Palmer (1962, p. 33, pl. 4, figs. 1–19), from the *Aphelaspis* Zone of Nevada, has a similar shape, albeit with outline somewhat indented post-axially, but has fewer segments in both axial and pleural zones.

Aphelaspid species 3

Plate 42, fig. 6

Material. Mould and counterpart of a single incomplete cranidium, AR 614, the specimen lacking palpebral lobes and posterolateral limbs with estimated cranidial length of 6 mm.

Description. Aphelaspid sp. 3 is characterized by widely divergent preocular facial sutures which enclose a preglabellar area comprising a convex (sag.) preglabellar field, narrow (sag.) but deeply and sharply incised anterior cranidial marginal furrow, and relatively narrow (sag.) cranidial border turned slightly addorsally in lateral profile. Ocular ridges are transverse or very slightly sloping posteriorly. The glabella tapers markedly towards the anterior, and has three faint pairs of backwardly directed glabellar furrows; the preoccipital pair is sigmoidal. Only anterolaterally is the occipital ring as wide (tr.) as the preoccipital glabellar lobes. Although the specimen is fairly deeply weathered, Aphelaspid sp. 3 appears to have a granulose prosopon.

Discussion. This species is again difficult to classify because of incompleteness and lack of supporting material. Although probably an aphelaspidinid, its preocular facial sutures are too divergent and its anterior cranidial marginal furrow too sharply incised for inclusion within *Aphelaspis* Resser.

EXPLANATION OF PLATE 42

Figs. 1–2. *Olentella* cf. *olentensis* Ivshin, 1956. 1, AR 605, testaceous cranidium, dorsal view, × 12. 2, AR 605, as above, lateral profile, × 12.

Fig. 3. ?*Olentella* cf. *olentensis* Ivshin, 1956. AR 609, librigena showing caecal network, dorsal view, × 12.

Fig. 4. Trilobita genus et species incertae sedis, sp. 1. AR 623, cranidial fragment, × 8.

Fig. 5. Trilobita genus et species incertae sedis, sp. 2. AR 624, partially exfoliated cranidial fragment, dorsal view, × 4.

Fig. 6. Aphelaspid sp. 3. AR 614, exfoliated mould of incomplete cranidium, dorsal view, × 8.

Fig. 7. ?*Olentella* cf. *olentensis* Ivshin, 1956. AR 606, fragment of thoracic segment which may belong to this species, dorsal view, × 8.

Fig. 8. Trilobita genus et species incertae sedis, sp. 3. AR 625, partially exfoliated librigena, dorsal view, × 8.

Figs. 9–10. *Olentella* cf. *olentensis* Ivshin, 1956. 9, AR 607, exfoliated pygidium, dorsal view, × 12. 10, AR 608, latex cast from external mould of exfoliated pygidial fragment, × 6.

Fig. 11. *Talbotinella*? sp. undet. AR 615, mainly testaceous cranidial fragment, dorsal view, × 8.

Fig. 12. Trilobita genus et species incertae sedis, sp. 5. AR 627, indeterminate early meraspid cephalon, dorsal view, × 28.

PLATE 42


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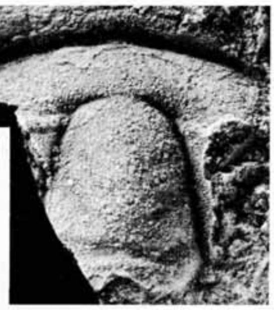
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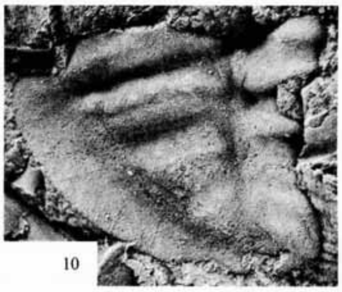
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Aphelaspid sp. 3 most closely resembles two species which have been previously assigned to *Aphelaspis* but which may not belong with this genus. The Antarctic species is considered to have closest affinity with a Chinese species, *A. granulata* Kuo (1963, p. 59, pl. 14, figs. 7–11; *in* Lu *et al.* 1965, p. 177, pl. 30, figs. 1–4), which has similar glabellar shape and furrowing, and apparently a similar preglabellar area. *A. nobilis* Ivshin (1956, pp. 33–36, pl. III, figs. 1–13, 27; pl. IV, figs. 16–17), from central Kazakhstan, also has a similar preglabellar area, but is distinguished by an anteriorly more truncate glabella, and more steeply inclined ocular ridges. *A. granulata* and *A. nobilis* appear to differ from North American species of *Aphelaspis* by the same characteristics which distinguish Aphelaspid sp. 3.

Superfamily OLENACEA Burmeister, 1843
Family TALBOTINELLIDAE Öpik, 1963
Genus TALBOTINELLA Poulsen, 1960 *sensu* Öpik, 1963

Type species. By original designation, *Talbotinella communis* Poulsen (1960, pp. 24–25, pl. 2, figs. 2–8; pl. 3, fig. 2), from the *Bolaspidella* Zone, Cerillo El Solitario, Canota region, Mendoza, Argentina.

Other species. T. leanzai Poulsen (1960, pp. 25–26, pl. 2, figs. 9–12) locality as for type species. *T. rusconii* Poulsen (1960, p. 27, pl. 2, figs. 13–15), locality as above. *T. notulata* Öpik (1963, pp. 73–75, pl. 6, fig. 9), *Glyptagnostus stolidotus* Zone, Georgina Limestone, western Queensland, Australia.

Age and distribution. South America, Argentina, late middle Cambrian, *Bolaspidella* Zone; Australia, late Cambrian, *G. stolidotus* Zone; Antarctica, Northern Victoria Land, late Cambrian, late Idamean/early Franconian.

Talbotinella? sp. undet.

Plate 42, fig. 11

Material. A single imperfectly preserved and partially exfoliated cranidium, AR 615. The specimen lacks most of its preglabellar area and occipital ring, and the whole of the right pleural portion of the cranidium.

Description. The portion preserved is characterized by a conical glabella, rounded anteriorly, bearing three pairs of furrows; it has short sloping ocular ridges, small palpebral lobes situated mostly in advance of the mid-point of the glabella, broad triangular posterolateral limbs, and anteriorly diverging preocular facial sutures. The over-all prosopon is finely and densely granulose; the granules coalesce to form a dense rugosity.

Discussion. Although the general morphology is somewhat similar to that of *T. notulata* Öpik, there are several points of difference. The glabella of the Antarctic species is less conical than that of *T. notulata*, its palpebral lobes are longer (exsag.), its preoccipital glabellar furrows are non-bifurcated, and its anterior lateral furrows, although very faint, are in fact furrows and not pits. No comparison of preglabellar areas can be offered. The test of the Australian species is smooth.

The material illustrated appears to be classified in Talbotinellidae as envisaged by Öpik, but is inadequate to critically evaluate the determined genus, reference to which is therefore queried.

Several other species have similar morphology to the fragment from Victoria Land. In particular, attention may be drawn to the cranidium that Palmer (1954, p. 745, pl. 84, fig. 11) assigned to *Aphelaspis constricta*, a species from the *Aphelaspis* Zone of Texas; and one of the paratype cranidia of *Crepicephalus orientalis* described by Endo (*in* Endo and Resser 1937, p. 344, pl. 66, fig. 12) from the Paishan Formation of Fengtien Province, Manchuria.

Family OLENIDAE Burmeister, 1843
Subfamilia et genus INCERTAE SEDIS
Olenid sp. undet.

Plate 41, fig. 6

Material. A single incomplete, partially exfoliated cranidium, AR 616, preserved as an external mould, with estimated cranidial length (sag.) of 4 mm.

Description. This species is characterized by divergent preocular facial sutures, convex (sag.) preglabellar field, and well-defined anterior cranidial border and marginal furrow. The glabella is parallel-sided, anteriorly rounded, and its furrowing is effaced. The occipital furrow does not reach the axial furrows laterally, and the occipital ring possesses an occipital node. Posterolateral limbs are narrow (exsag.), long (tr.), and triangular. The preserved palpebral lobe is arcuate, equidistant from the axial furrows anteriorly and posteriorly, anteriorly sited, and about one-half the glabellar length (exsag.). Ocular ridges may be curved.

Discussion. If the ocular ridges are curved the species is differentiated from Aphelaspidinae (Pterocephaliidae) and related to Olenidae. Characteristics of the glabella and preglabellar area are also not inconsistent with classification among Olenidae. Insufficient material, however, prevents a qualified determination.

Comparison can be made with few other described species. *Hancrania brevilimbata* Kobayashi (1962, p. 55, pl. IX, figs. 2–6) from the Machari fauna of South Korea, is most similar, but its glabella has a slight anterior taper and considerably stronger furrowing, and its ocular ridges are perhaps sloping rather than curved. Several species of *Olenus* have curved ocular ridges and similarly shaped glabellae, but their glabellar furrowing is invariably stronger, e.g. *O. ogilviei* Öpik (1963, pp. 59–62, pl. 1, figs. 1–9; pl. 2, figs. 2–4). Effacement of the glabellar furrows is, however, no barrier to classification within Olenidae. Well-established genera such as *Peltura* and *Peltocare*, as well as the recently proposed *Leurostega* Robison and Pantoja-Alor, 1968, *Psilocara* Fortey, 1974, and *Svalbardites* Fortey, 1974, all have effaced glabellae. Partial effacement characterizes several others, e.g. *Leptoplastus*.

Superfamily LEIOSTEGIACEA Bradley, 1925
Family LEIOSTEGIIDAE Bradley, 1925
Subfamily PAGODIINAE Kobayashi, 1935
Genus PROCHUANGIA Kobayashi, 1935

Type species. By original designation, *Prochuangia mansuyi* Kobayashi (1935, pp. 186–187, pl. VIII, fig. 8; pl. X, figs. 1–7), from Saisho-ri, South Korea.

Other species. Conocephalites quadriceps Dames (1883, p. 9, pl. 1, figs. 13–18; Lorenz 1906, p. 94, text-fig., referred to *Schantungia* Lorenz; Kobayashi 1937*b*, pp. 75–76, pl. 17, fig. 2*a–c*, referred to *Prochuangia* Kobayashi; Lu *et al.* 1965, p. 416, pl. 79, figs. 2–4), from Saimaki, Liaotung, Manchuria. *P. angusta*

Kobayashi (1935, pp. 188–189, pl. IX, fig. 12), from Saisho-ri, South Korea. *P. posterospina* Kobayashi (1935, pp. 187–188, pl. X, fig. 8), from Saisho-ri, South Korea. *P. imamurai* Endo (1944, pp. 69–70, pl. 10, fig. 12; refigured *in* Lu *et al.* 1965, p. 415, pl. 79, fig. 1), from the Paishan Formation, near Tungchinglien, Liaoyanghsien, Fengtien Province, Manchuria. *P. granulosa* Lu (1956, pp. 376–377, pl. 1, fig. 5; refigured with additional material *in* Lu *et al.* 1965, p. 414, pl. 78, figs. 22–23), from Lungtienchung, Yüping district, eastern Kweichow, China. *P.? berryi* Lochman (1940, pp. 39–40, pl. 4, figs. 17–20), from the *Cedaria* Zone, Bonneterre Dolomite, Missouri, is not referable to *Prochuangia*.

Age and distribution. Before 1967 *Prochuangia* was known only from Asia: Vietnam, China, Manchuria, and South Korea. Since that time, however, Colchen (1967) has recorded its association with *Chuangia* at the eastern end of the Sierra de la Demanda in Logrono Province, northern Spain, and *Prochuangia* is now recorded from Antarctica.

Throughout its range in Asia, *Prochuangia* has a Paishanian (late Dresbachian/Idamean) age, and its occurrence has been thought by Kobayashi (1935, 1960, 1966*a*, 1966*b*, 1967, 1971) to represent a distinct biostratigraphical zone resting with pronounced faunal discontinuity on the *Drepanura* Zone below and directly subjacent to the *Chuangia* faunas. In South Korea, however, a species of *Prochuangia* is found in association with the *Chuangia* faunas (Kobayashi 1966*a*, p. 34, listed), and some doubt must now be expressed on the limited range of the genus. The Antarctic occurrence seems to indicate that the genus existed at least until early Franconian (*Elvinia*) time, i.e. latest *Chuangia* Zone.

Discussion. Concerning the type species, Kobayashi (1935, p. 186) synonymizes specimens from the Tonkin–Yunnan border region of Vietnam and southern China, which were referred by Mansuy (1915, pp. 20–22, pl. II, fig. 14*a–g*) to *C. nais* Walcott. Mansuy (op. cit., explanation to pl. II) indicates, however, that his material was obtained from two distinct horizons; in particular, one pygidium is from his zone of *Ptychaspis angulata* (latest Cambrian) and is very probably not conspecific with the remainder of the figured specimens. Concepts of *Prochuangia* derived from the type species should therefore be based on the Korean material described by Kobayashi.

According to Kobayashi (1935, p. 185) *Prochuangia* is differentiated from *Chuangia* Walcott, 1911 in possessing a pair of pygidial spines, and less 'acutely edged' anterior cranidial border. The absence of a posterior marginal furrow in the pygidium distinguishes it from *Kaolishania*, which also possesses spines. Kobayashi (1935) has noted that the external shell of the glabella is basically unfurrowed, but that the parietal surface possesses three pairs of glabellar furrows, a situation also observed in *Chuangia*.

The most reliable characteristics for the determination of *Prochuangia* appear to be those of the pygidium, as cranidia of the species listed above are not readily distinguished from those of *Chuangia* or *Pagodia*, especially species of the *C. nitida* group (Walcott 1911, pp. 85–86, pl. 15, fig. 6), and of *P.* (*Idamea*) Whitehouse, 1939, *sensu* Öpik, 1967 (see below).

Prochuangia sp., aff. *P. granulosa* Lu, 1956

Plate 40, figs. 1–6

aff. 1956 *Prochuangia granulosa* Lu (sp. nov.), Lu 1956, pp. 376–377, pl. 1, fig. 5.
aff. 1965 *Prochuangia granulosa* Lu, *in* Lu *et al.* 1965, p. 414, pl. 78, figs. 22–23.

Material. This species is known from fragments of thirteen cranidia, eight pygidia, and three librigenae, which make this the most abundantly represented taxon in the collection studied. The illustrated specimens are numbered AR 617–621. Measurable cranidial lengths (sag.) vary between 5·50 and 6·30 mm; pygidial lengths (sag.), excluding the articulating half-ring, measure between 2·00 and 4·20 mm.

Description. The cranidium and librigena illustrated on Plate 40 are well matched and are probably correctly associated with the pygidium, which certainly represents *Prochuangia*. No other combination is possible among the available specimens.

The anterior cranidial margin is gently curved (tr.), passing into a narrow (sag.) upturned anterior cranidial border which bears terrace lines on its adventral and anterior-facing surface. The border is separated from the frontal lobe of the glabella by a deep, narrow (sag.) preglabellar furrow. No preglabellar field intervenes between glabella and border.

The glabella, abutting against the cranidial border, is obtusely rounded anteriorly, and laterally constricted immediately in front of the point at which the ocular ridges intersect the axial furrows, giving the frontal lobe an anterolaterally expanded appearance. Two pairs of glabellar furrows are faintly indicated on the external test: both are arcuate, curving rearwards and adaxially; the preoccipital furrows possibly bifurcate adaxially (Pl. 40, fig. 3).

The occipital furrow is deeply incised, distinctly widened sagittally to form a platform. The occipital ring is slightly wider (tr.) than the glabella, sagittally extended rearwards (Pl. 40, fig. 2), and bears a faint occipital node.

The palpebral lobes are gently arcuate, mainly lying posterior to the mid-point of the glabella, and the palpebral furrows strongly defined. Faint ocular ridges connect the anterior ends of the palpebral lobes to the axial furrows, constricting the glabella at the point of intersection. The preocular facial sutures run exsagittally forwards, intersecting the cranidial margin at an obtuse angle. The postocular facial sutures run obliquely to the posterior margin, enclosing short (tr.), triangular posterolateral limbs. Posterior marginal furrows are sinuous, clearly defined, and wide, and are characterized by a sigmoidal course distally. They close before the extremity of the posterolateral limbs, where a narrow ridge is formed, and apparently do not continue on to the librigena. The cranidial prosopon is finely granulose.

The associated librigena, very similar to that of *Pagodia* (*Idamea*) *baccata* Öpik, 1967, is characterized by a thickened lateral border which bears, across its marginal convexity, branching terrace lines continuing to the doublure of the genal spine posterolaterally, and on to the anterior cranidial border anterolaterally. The lateral marginal furrow terminates a considerable distance from the genal angle. There is apparently no posterior marginal furrow, and accordingly the genal field has a strong convexity (exsag.). An eye socle is preserved on the illustrated specimens, surmounting a very shallow subocular groove. The granulose prosopon is similar to that of the cranidium.

If its spines are neglected, the pygidium is semicircular. The anterior margin, between the axial furrows and the geniculation, is often a straight sharp edge, which rises anterolaterally to form very prominent fulcral points before passing into obtusely rounded anterolateral corners. The pygidial outline is broken by a pair of long, stout, posterolateral spines which are drawn from the opisthopleuron of the first and propleuron of the second pleural segments. Only two pleural segments are indicated; the first bears a deeply incised pleural furrow which defines the anterior margin of the posterolateral spine base, and extends close to the lateral margin of the shield, curving parallel to this margin over the distal portion of its course. The pleural furrow of the second segment is no more than a shallow depression. Marginal furrows are not evident. The axis, containing four, possibly five, segments and a terminal piece, is connected to the posterior margin by a short postaxial ridge. The articulating half-ring is a simple crescent. The dorsal surface of the test bears a fine low-density granulation. Weak traces of the caecal system of the parietal surface are indicated on specimen AR 621, Plate 40, fig. 5.

Discussion. All species of *Prochuangia* have very similar pygidia: all have similar shape and similar relationship of pleurae to spines. Only two pleural segments are known in all species which are interpretable. *Prochuangia* pygidia are differentiated by the orientation of their spines and degree of segmentation of their axes.

Orientation of the posterolateral spines, straight backwards to give the pygidium an elongate form, distinguishes *P. posterospina* Kobayashi from all other species assigned to the genus.

The pygidium of *Prochuangia* sp. aff. *P. granulosa* is distinguished from the type species, *P. mansuyi* Kobayashi, in having probably one less segment in the axis—unless Kobayashi (1935, p. 186) included the terminal piece in his count of axial rings. *P. granulosa* Lu has at least one additional axial segment, a total of six (Lu 1956, p. 376). In other respects, however, especially the form of the spines and the granulose prosopon, *Prochuangia* sp. and *P. granulosa* are closely comparable. Neither Dames (1883, pp. 9–11) nor Kobayashi (1937*b*, p. 426) give any indication of the axial segmentation for *P. quadriceps* (Dames 1883), but Kobayashi's illustrations of at least one of the type pygidia (1937*b*, pl. 17, fig. 2*b*) look closely comparable to the Antarctic *Prochuangia* sp.

Other genera whose pygidial morphology is similar are *Chuangioides* Chu (based on *C. punctatus* Chu, 1959, p. 123, pl. VII, figs. 1–2), which has similar shape, segmentation, and furrowing, but lacks spines; *Pagodia* (*Idamea*) Whitehouse (based on *I. venusta* Whitehouse, 1939, pp. 232–233, pl. XXIV, figs. 4–6, emended Öpik 1967, p. 258 et seq.), which has similar shape and segmentation, but different furrowing, and also lacks spines; *Chuangia* Walcott (based on *C. batia* Walcott, 1905, figured 1911, p. 85, pl. 15, fig. 3, 3*a*), which lacks spines and has a considerably broader, flatter pygidial shield, but has similar segmentation although partially effaced. *Iranochuangia* Kobayashi (1960, p. 263, based on *C. nais* var. *persicum* King, 1937, p. 15, pl. 4, fig. 4*a*–*d*) has a pygidium similar to that of *P.* (*Idamea*) and *Chuangioides*, lacking spines. *P.* (*Lotosoides*) Shergold, 1975 has a spinose pygidium closely comparable with that of *Prochuangia* sp., but occurs considerably later. *Lotosoides* is closely related to other late Cambrian pagodiids which are non-spinose.

The cranidium of *Prochuangia* sp. differs from that of *P. mansuyi* in having a narrower (sag.) anterior cranidial border, anterosagittally rather than exsagittally curved preocular facial sutures, and glabella anterolaterally more obviously constricted at the confluence of the ocular ridges and the axial furrows. *P. quadriceps* (Dames) as refigured by Kobayashi (1937*b*, p. 426, pl. 17, fig. 2*a*) has considerably more obvious glabellar furrowing, but the relationship of its cranidial border to the glabella appears similar. *P. angusta* Kobayashi is quite different in glabellar shape, the course of its preocular facial sutures, the shape of its anterior cranidial margin, the relationship of its anterior cranidial border to the glabella, and the position of its palpebral lobes. It more closely resembles some species previously placed in *Chuangia* than other species of *Prochuangia*. The cranidium attributed to *P. granulosa* Lu (*in* Lu *et al.* 1965) is probably the most closely comparable with *Prochuangia* sp., although it has a less obviously constricted glabella and perhaps narrower (tr.) palpebral areas.

With respect to the various groups of *Chuangia* species which can be recognized, *Prochuangia* sp. is closest, by virtue of the nature of the relationship of the anterior cranidial border to the glabella and courses of the preocular facial sutures, to the *nitida–tawenkouensis–kawadai* group. It is primarily differentiated from these species on account of the anterolateral constriction of its glabella. This latter characteristic, however, is one of the main diagnostic features of *Iranochuangia*; but species of this genus apparently have a depressed and flattened anterior cranidial border. *Prochuangia* sp. is related cranidially to species of *Pagodia* (*Idamea*) by the same characteristics that unite it with the *Chuangia* species of the *nitida–tawenkouensis–kawadai* group, and is mainly differentiated by glabellar shape. Whereas the glabella of *Prochuangia* sp. is merely anterolaterally expanded, that of Idamean species is often extended into anterolateral ridges which connect with the preocular areas and block the axial furrows immediately in front of their convergence with the ocular ridges. Species of both *Idamea* and *Prochuangia* have similar prosopon, and similarly structured librigenae, that of *Prochuangia* sp. being nearly identical in morphology with that illustrated by Öpik (1967, p. 262, pl. 18, fig. 1) for *Pagodia* (*Idamea*) *baccata*. In both species terrace lines are strong on the lateral librigenal margin, and continue on to the adventral surface of the narrow upturned anterior cranidial border.

Order ASAPHINA Salter, 1864
Superfamily CERATOPYGACEA Linnarsson, 1869
Family CERATOPYGIDAE Linnarsson, 1869
Subfamily PROCERATOPYGINAE Wallerius, 1895
Genus PROCERATOPYGE Wallerius, 1895
Subgenus PROCERATOPYGE Wallerius, 1895

Type species. By original designation, *Proceratopyge conifrons* Wallerius (1895, pp. 56–57, fig. 6; Westergaard 1948, pp. 5–6, pl. 1, figs. 7–16), middle Cambrian, *Leiopyge laevigata* Zone, Gudhem, Falbygden area, Västergötland, Sweden.

Other species. Numerous other species have been described. Following Öpik (1963, p. 98), those with five or fewer axial segments in the pygidium are classified as *Proceratopyge* (*Proceratopyge*); those with more than five are referred to *P.* (*Lopnorites*) Troedsson, 1937. Listed regardless of synonymy other species of *P.* (*Proceratopyge*) include: *P. asiatica* Ivshin (1956, pp. 24–26, pl. VIII, figs. 17–23; 1962, p. 287, pl. XIX, fig. 14), Kuyanda horizon, Tortkuduk Suite, Kazakhstan, U.S.S.R. *P. captiosa* Lazarenko (1966, pp. 54–55, pl. IV, figs. 7–10), *Irvingella–Cedarellus felix* Zone, Kyutyungd depression, Karaulakh Mountains, River Lena below Chekurovka, Northern Siberian Platform, U.S.S.R. *P. chuhsiensis* Lu (1956, pp. 280–282, pl. 1, figs. 1–6; Lu *et al.* 1965, p. 547, pl. 114, figs. 3–6), south-western Chuhsien, North Anwhei, China. *P.* cf. *chuhsiensis* Lu *sensu* Öpik (1963, pp. 99–100, pl. 5, fig. AA), *I. tropica–Agnostotes inconstans* Zone, western Queensland, Australia. *P. lata* Whitehouse (1939, pp. 248–249, pl. XXV, figs. 12, ?13; Öpik 1963, pp. 98–99, pl. 4, figs. 9–10; pl. 5, figs. CC, EF, GF), *Glyptagnostus reticulatus* through *I. tropica* with *A. inconstans* Zones, western Queensland, Australia. *P.* (*P.*) *liaotungensis* Kobayashi and Ichikawa (1955, p. 69, pl. 11, figs. 1–9; Lu *et al.* 1965, p. 550, pl. 115, figs. 6–11), *Chuangia* Zone, Chinchiachengtzu, Manchuria. *P. magnicauda* Westergaard (1947, p. 32, pl. 2, fig. 11 (no description); 1948, pp. 6–7, pl. 1, figs. 17–18), *Leiopyge laevigata* Zone, Andrarum, Sweden. *P. nathorsti* Westergaard (1922, p. 120, pl. 2, figs. 3–5; 1947, p. 10, pl. 2, figs. 2–7), *A. pisiformis* Zone, Andrarum, Möckleby, Öland, Sweden. *P. nectans*

Whitehouse (1939, pp. 249–250, pl. XXV, fig. 8*a–b*), *G. reticulatus* Zone, western Queensland, Australia. *P. portentosa* Lazarenko (1966, pp. 52–54, pl. IV, figs. 1–6), horizon and locality as for *captiosa*. *P. similis* Westergaard (1947, pp. 10–11, pl. 2, fig. 1), *A. pisiformis* Zone?, Andrarum?, Sweden. *P. tenuita* Lazarenko (1966, pp. 51–52, pl. III, figs. 10–16), locality and horizon as for *captiosa*. *P. triangulata* Ivshin (1962, pp. 288–289, pl. XIX, fig. 15), Seletin horizon, Kuyanda Stage, Tortkuduk Suite, Kazakhstan, U.S.S.R. *P. tullbergi* Westergaard (1922, p. 121, pl. 2, figs. 6–7; 1947, pp. 11–12, pl. 2, figs. 8–10), *Protopeltura aciculata* Subzone, Andrarum, Sweden. Species formerly referred to *Proceratopyge*, but not listed here under *P.* (*Proceratopyge*), are presently considered to belong to *P.* (*Lopnorites*), to *P.* (*Kogenium*) Kobayashi, 1935, or to genera other than *Proceratopyge*.

Age and distribution. Cosmopolitan. Late middle Cambrian to late Cambrian, *Leiopyge laevigata* to *Protepeltura aciculata* Zones in Europe (England, Sweden, Norway); late Cambrian, Tuorian, *A. pisiformis* with *Homagnostus fecundus* Zone, to early Shidertan, *Irvingella–Cedarellus felix* Zone, Kazakhstan, Siberian Platform, U.S.S.R.; late Cambrian, Paishanian, *Chuangia* Zone, Manchuria, China; late Cambrian, Idamean, *G. reticulatus* to *I. tropica–Agnostotes inconstans* Zones, Australia; late Cambrian, late Idamean–early Franconian, Northern Victoria Land, Antarctica.

Proceratopyge (*Proceratopyge*) cf. *lata* Whitehouse, 1939

Plate 40, figs. 7–9

cf. 1939 *Proceratopyge lata* sp. nov., Whitehouse, 1939, pp. 248–249, pl. XXV, figs. 12, ?13.
cf. 1963 *Proceratopyge lata* Whitehouse, 1939; Öpik 1963, pp. 98–99, pl. 4, figs. 9–10; pl. 5, figs. CC, EF, GF.

Material. A single cranidium, AR 622, with sagittal length of 3·50 mm, and a single pygidial fragment lacking left pleuron and axis, AR 623.

Description. The cranidium assigned to *Proceratopyge* cf. *lata* Whitehouse has low convexity (tr. sag.), and gently arcuate anterior cranidial outline. The glabella is conical, anteriorly rounded, widest (tr.) in the vicinity of the preoccipital furrows. Glabellar furrowing is indistinct: anterior lateral furrows are transverse, slightly curvilinear; median lateral furrows are short, transverse, slightly sloping adaxially and rearwards; preoccipital furrows are complex, bifurcated, and apparently connected to the occipital furrow. A glabellar node is sited medially between the bifurcations of the preoccipital furrows.

The occipital ring is compound, possessing anterolateral lobules connected abaxially with the glabella so that the occipital furrow does not connect with the axial furrows. These anterolateral lobulae are distinguished from the remainder of the occipital ring by faint furrows which merge sagittally into the occipital furrow.

Palpebral lobes are arcuate in plan view, equidistant anteriorly and posteriorly from the axial furrows, extending from opposite the confluence of the anterior lateral glabellar furrows and the axial furrows to the preoccipital furrows. A palpebral furrow is indistinct, the palpebral lobes themselves being narrow (tr.) and rim-like. Anteriorly they pass into short indistinct ocular ridges which are transverse and merge into the preocular areas adjacent to the axial furrows and opposite the anterior lateral glabellar furrows.

The preocular facial sutures diverge appreciably to enclose a preglabellar area slightly less wide (tr.) than the palpebral cranidial width. Gently convex (exsag.) preocular areas pass sagittally into a depressed plectral area, and are defined anteriorly by plectral lines. A shallow marginal furrow is present, and a narrow (sag.) cranidial border is upturned. The preglabellar field bears a caecal network which extends across the marginal furrow on to the cranidial border. A pair of diverticula, crossing the preglabellar furrow, connect the preocular areas with the anterolateral portions of the glabella. The postocular facial sutures diverge very strongly to the posterior cranidial border and enclose narrow (exsag.) but long (tr.), strap-like posterolateral limbs. These bear shallow marginal furrows widening (exsag.) distally.

Apart from the prosopon of the preglabellar area, and the presence of transverse terrace lines along the anterior extremity of the anterior cranidial border, the cranidium lacks surface details.

Only a fragment of a pygidium is available for description. The shield is assumed to have been subtriangular, with an axis containing most probably only three or four axial rings, and pleural zones containing only two well-defined segments. The pleural furrows that are preserved are wide (exsag.) and shallow. Inter-pleural furrows are effaced. A delicate lateral spine is preserved, formed from the opisthopleuron of the first and propleuron of the second pleural segments. The second pleural furrow, extending close to the margin of the pygidium, defines the rear of the spine base. The spine itself bears longitudinal terrace lines. A broad doublure is evident, bearing nine roughly concentric terrace lines.

Discussion. P. cf. *lata* Whitehouse belongs to a group of species characterized by rather widely diverging preocular facial sutures, well-developed plectral lines, long (exsag.) palpebral lobes with strap-like posterolateral limbs, and a paucifurrowed pygidium. Excluded from comparison are all those species possessing a narrow (tr.) preglabellar area, or more than five axial rings in the pygidium. *P.* cf. *lata* can therefore be compared only with *P. lata* Whitehouse, *P. liaotungensis* Kobayashi and Ichikawa, and *P. tullbergi* Westergaard.

P. cf. *lata* may be compared with what is known of the holotype cranidial fragment of *P. lata sensu* Whitehouse (1939, pp. 248–249, pl. XXV, fig. 12). Both species have similarly faint glabellar furrowing, similarly wide (tr.) preglabellar area, and similarly shaped and extensive posterolateral limbs. Palpebral characteristics cannot be adequately compared as the type specimen of *P. lata* lacks palpebral lobes. The faint ocular ridges of *P. lata* appear to be more strongly inclined than those of the Antarctic species and intervening occipital lobulae and furrows are less well developed; the Antarctic species is therefore identified as *P.* cf. *lata*. Pygidial characteristics cannot be compared because of the uncertainty of assignment of the pygidium of *P. lata* (see Whitehouse 1939, p. 249), and the inadequacy of the preservation of the Antarctic specimen.

Although its palpebral lobes may be somewhat shorter (exsag.) and its ocular ridges less transverse, the cranidium of *P. lata* Whitehouse *sensu* Öpik (1963, pp. 98–99, pl. 4, figs. 9–10; pl. 5, figs. CC, EF, GF) is essentially similar to that of *P.* cf. *lata*. Similar characteristics, and especially the more strongly sloping ocular ridges, distinguish *P. liaotungensis* Kobayashi and Ichikawa (1955, p. 69, pl. 11, figs. 1–9) from *P.* cf. *lata*. The Manchurian species appears also to have a slightly wider (tr.) preglabellar area, almost as wide (tr.) as the palpebral cranidial width. From what is known of the pygidium of *P.* cf. *lata*, it is closely comparable with that of *P. liaotungensis*. The second pleural furrow is, however, less deeply incised on the Antarctic material.

P. tullbergi Westergaard (1922, p. 121, pl. 2, figs. 6–7; 1947, pp. 11–12, pl. 2, figs. 8–10), though similar to *P.* cf. *lata* in many respects, has apparently a longer (sag.) preglabellar area, and wider (exsag.) posterolateral limbs. Its pygidium would appear comparable in shape and degree of segmentation with those of both *P.* cf. *lata* and *P. liaotungensis.*

TRILOBITA FAMILIAE, GENERA ET SPECIES INCERTAE SEDIS

Specimen 1

Plate 42, fig. 4

Material. A single cranidial fragment preserving only a portion of the glabella and the preglabellar area, AR 623.

Description. The preglabellar area is fractionally wider (tr.) than long (sag.) and is enclosed apparently by preocular facial sutures running virtually straight forwards from the anterior end of the palpebral lobes (not preserved). It is composed of a flat (sag.) or slightly concave (sag.) preglabellar field and gently convex (sag.) anterior border of equal length (sag.). The anterior marginal furrow is bowed slightly forwards at the sagittal line. Ocular ridges appear to have been straight, inclined slightly abaxially and posteriorly, and the palpebral areas to have been about half the anterior glabellar width (tr.). The fragment of glabella preserved shows it to have been rounded and narrowed anteriorly. The preglabellar furrow is pitted on either side of the sagittal line. The prosopon is very finely granular with occasional larger granules randomly scattered on the preglabellar field and preocular areas.

Discussion. The morphology of the fragment is similar to that of species which Ivshin (1962) has named from central Kazakhstan; notably his specimen of *Pedinocephalus simplex* (1962, pp. 96–98, pl. VI, fig. 2) and his species *Apheloides striatiferus* (1962, pp. 105–108, pl. VII, figs. 1–3). The former has similarly wide (sag.) preglabellar field and cranidial border, and marginal furrow sagittally anteriorly curved; its preglabellar area, however, appears to be wider (tr.). *A. striatiferus* appears to have a convex (tr.) preglabellar field and more steeply inclined ocular ridges, and the course of its marginal furrow may also differ.

Specimen 2

Plate 42, fig. 5

Material. A single partially exfoliated cranidial fragment preserving the complete preglabellar area and the anterior portion of the glabella, AR 624.

Description. Anteriorly divergent preocular facial sutures enclose a preglabellar area three times as wide (tr.) as long (sag.), composed of a flat or concave (sag.) preglabellar field and convex (sag.) cranidial border. The latter is thicker (sag.) than the sagittal dimension of the preglabellar field, is sagittally slightly depressed, and rises abruptly from the prominent transverse marginal furrow. The portion preserved indicates an anteriorly tapered glabella. Traces of the anterior lateral glabellar furrows preserved show them to be short (tr.), faint and straight, while the median lateral furrows are similar but inclined slightly rearwards. Ocular ridges are straight, gently inclined abaxially and posteriorly, and are short. A faintly granulose prosopon is observed.

Discussion. Specimen 2 may be representative of Pterocephaliidae (Aphelaspidinae) through resemblance to *Litocephalus*, e.g. *L. verruculopeza* Palmer (1960, p. 83, pl. 8, figs. 12–13, 15–16, 19–20; 1965, p. 63, pl. 11, figs. 7–9), from the *Dunderbergia* Zone of Nevada. The preglabellar area also resembles that of the specimen which Palmer (1965, pl. 2, fig. 11) ascribed to *Iddingsia robusta* Walcott (Dokimocephalinae, Elviniidae) from the *Elvinia* Zone of Nevada; and that which Lazarenko (*in* Lazarenko and Nikiforova 1968, pp. 50–51, pl. IX, fig. 12) has referred to *Faciura infida* Lazarenko, from the *Faciura–Garbiella* Zone, Kulyumbe River, north-west Siberian Platform.

Specimen 3

Plate 42, fig. 8

Material. Three librigenae, one of which is illustrated here, AR 625.

Description. This specimen is characterized by a rather convex (exsag., tr.) genal field sloping to wide (tr.), shallow lateral marginal furrows, and short somewhat deeper posterior ones. The marginal furrows intersect at the genal angle but do not continue into the spine base. The genal spine (broken on the illustrated specimen) appears to have been long and stout. The anterolateral prong is short and pointed. From the configuration of the posterior margin the associating cranidium must have possessed long triangular posterolateral limbs. A finely granulose prosopon is evident on which are superimposed low density randomly distributed larger granules. The lateral and anterolateral borders bear terrace lines, as presumably did the adventral surface of the genal spine.

Discussion. Librigenae represented by Specimen 3 are difficult to classify. Their prosopon is similar to that seen on Specimen 1, and on *Olentella* cf. *olentensis* Ivshin described above, and they are probably attributable to a pterocephaliid trilobite.

Specimen 4

Plate 41, fig. 5

Material. Two librigenae, the illustrated specimen being complete, AR 626.

Description. Both specimens are characterized by the presence of advanced genal spines, long posterior margins, and deeply incised marginal furrows which meet at the genal angle but do not continue into the spine bases. The illustrated specimen indicates that the cranidium to which it was attached possessed long (exsag.) palpebral lobes, and short broadly triangular posterolateral limbs. Both lateral and posterior borders are narrow. The genal field bears a rather sparse and faint caecal system, some caeca crossing the marginal furrows and passing into the borders. An underlying parietal prosopon appears to be finely granulose.

Discussion. The available material defies definite classification. The only cranidium among the collected specimens with palpebral lobes sufficiently long to accommodate this type of librigena is that assigned here to *Stigmatoa*. Librigenae are previously undescribed for this genus, preventing direct comparison.

Specimen 5

Plate 42, fig. 12

Material. A single cephalon, AR 627, with cephalic length of 0·75 mm.

Discussion. The specimen represents an indeterminate meraspid cephalon which presumably could belong to any of the pterocephaliid, or elviniid trilobites described here.

This meraspid appears to represent a cephalon with fused genae. The glabella is anteriorly undifferentiated from the front portion of the cranidium and may have five segments. A strongly differentiated occipital ring is evident. Short faint transverse ocular ridges arise from a position opposite the middle of the frontal lobe and are orientated in olenid fashion. Palpebral lobes are either very short (exsag.) or merge imperceptibly into the general convexity of the specimen.

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