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LATE CAMBRIAN FOSSILS (BRACHIOPODA, MOLLUSCA, TRILOBITA) FROM NORTHERN VICTORIA LAND, ANTARCTICA

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ABSTRACT. The discovery of Late Cambrian fossils in basement rocks (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 overall 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 reticulata* sp. nov., *Billingsella antarctica* sp. nov., *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.

INTRODUCTION

The Antarctic continent has yielded very few fossils from its pre-Devonian rocks. Early and Mid Cambrian trilobite faunas, described by Palmer & 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 recognised in morainic boulders, ranging in age from late in the Early Cambrian (Late Aldanian to Botoman 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, Gasteropoda, Brachiopoda, and other forms (Webers 1970, 1972; Yochelson, Flower & Webers 1973). Early Cambrian Archaeocyatha are known from several localities in or near the Transantarctic Mountains, including Southern Victoria Land (Laird 1962, 1963; Hill 1964a, 1964b, 1965).

All previously known Cambrian fossils thus come from that sector of Antarctica containing the Ellsworth Mountains and the Transantarctic Mountains, from the southwest 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 Late Cambrian age also limits the possible age range of the Ross Orogeny (Laird _et al._, 1972), which deformed the basement before the basal, Devonian, beds of the platform cover sequence were deposited.

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

Stratigraphy

The fossils described here represent the entire recognisable fauna collected by Dr M.G. Laird, New Zealand Geological Survey, and his field party during the southern summer of 1971/72. 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.; 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. as probably equivalent to part of the Sledgers Formation of Crowder (1968), mapped 150 km to the northeast. 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 & Leitch 1964). Sedimentology and general geology of the Bowers Group rocks in the region are described by Andrews and Laird (in press) and Laird, Andrews and Kyle (in press).

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 mm 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, f271 and f272, at the 400 m, 900 m and 1100 m levels respectively in the stratigraphic column of Laird *et al.* 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 three new species are erected, *Billingsella antarctica* MacKinnon, *Schizambon reticulata* 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 1-5, 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 organised by Cooper, who compiled the final manuscript from individual authors' contributions. Shergold publishes by permission of the Director, Bureau of Mineral Resources, Canberra.

FAUNAL COMPOSITION. AFFINITIES AND AGE

Composition of the fauna is:

Brachiopoda: *Schizambon reticulata* MacKinnon sp. nov., *Prototreta* sp., *Billingsella antarctica* MacKinnon sp. nov.

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, *Aphelaspidinid* sp. 1, *Aphelaspidinid* sp. 2, *Aphelaspidinid* 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.

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 "*A. 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.

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 Northeast Asia.

Interestingly, the trilobite affinities are similar to those of Early and Middle Cambrian Antarctic faunules (Palmer, 1970; 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' 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 Shidertinian 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 Shidertinian: the lower boundaries of both stages are marked by the first appearance of Irvingella. In Australia, Irvingella first appears in the youngest zone (Irvingella 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, Erixanium sentum Zone, age, equivalent to latest Dresbachian (Dunderbergia Zone) and latest Tuorian.

Acknowledgements.

We are grateful to Dr M.G. Laird and his colleagues for making his collections available for our study, and to Dr G. Webers for generously

forwarding photographs and latex moulds of his Late Cambrian trilobite-brachiopod-mollusc fauna from the Ellsworth Mountains for comparison. This work is published with the permission of the Directors of the Bureau of Mineral Resources, Canberra, and United States Geological Survey.

SYSTEMATIC DESCRIPTIONS

Phylum BRACHIOPODA (By D.I. MacKinnon)

Class INARTICULATA Huxley 1896

Order ACROTRETIDA Kuhn 1949

Superfamily SIPHONOTRETACEA Kutorga 1848

Genus SCHIZAMBON Walcott 1884.

Schizambon reticulata sp. nov.

Plate 5, figs. 22, 23.

Material, type specimens. Seven pedicle valve exteriors of which the following are figured:

Holotype : BR 1902

Paratype : BR 1903 (subsequently damaged)

Dimensions.

		Length	Width (mm)
	Holotype : BR 1902	47	45
	Paratype : BR 1903	45	40
Additional complete specimen,	BR 1904	38	35

Other specimens are fragmentary.

Description. The pedicle valve is gently convex and roughly sub-circular 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. The Antarctic specimens of *Schizambon* bear some resemblance to the Argentinian species *S. australis*, figured by Ulrich and Cooper (1938, p.60), but differ principally in the nature of the ornamentation and their slightly smaller size. Whereas the exterior of *S. australis* is dominated by fine, radiating costellae with minor concentric threads, the surface of *S. reticulata* is characterised by a much more even development of costellae and fine concentric growth lines which produce a reticulate pattern. An undescribed species of *Schizambon* from the Gola Beds (Late Cambrian) of Queensland, Australia, has been figured by Hill, Playford and Woods (1971, Plate 1, figs 28, 29) but this species does not resemble *S. antarctica* closely.

Age. According to Rowell (1965, p.288), the genus *Schizambon* occurs in rocks from Late Cambrian to Early Ordovician in age.

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

Prototreta sp. indet.
Plate 5, figs. 14-21.

Material. Five pedicle valves and three brachial valves.

Dimensions.		Length	Width	Height (mm)
Pedicle valves	BR 1911	15	17	9
	BR 1912	20	21	14
	BR 1913	18	20	8
	BR 1914	10	15	7
Brachial valves	BR 1916	17	18	-
	BR 1546	11	13	-

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 inter-trough which widens gradually from apex to commissure. Valve ornamentation consists of numerous distinct fila (approximately 40 fila per mm). Fila are absent on and 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 diverges 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 bladelike and sub-triangular 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, bladelike, subtriangular median septum, this Antarctic acrotretid closely resembles the genus *Homotreta* erected by Bell (1941, p. 230). Rowell (1965, p.276), however, placed *Homotreta* in junior synonomy with the genus Prototreta Bell 1938, a reassignment which is here accepted.

Class ARTICULATA Huxley 1869

Order ORTHIDA Schuchert and Cooper 1932

Superfamily BILLINGSELLACEA Schuchert and Cooper 1932

Genus BILLINGSELLA Hall and Clark 1892

Billingsella antarctica sp. nov.

Pl. 5, Figs. 1-13.

Material, type specimens. 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).

Holotype :	BR 1549	pedicle valve internal mould
Paratypes :	BR 1552	pedicle valve exterior
	BR 1555	pedicle valve internal mould
	BR 1553	brachial valve internal mould

Dimensions of specimens.

		Length	Width (cm)
Holotype :	BR 1549	1.30	1.10
Paratypes :	BR 1552	-	0.95
	BR 1555	0.92	0.95
	BR 1553	0.80	1.10

A graph (Text-fig. 2) displays the length/width relationships of a number of brachial valves.

Description. The outline of the pedicle valve is subquadrate or elongate subrectangular, with the width of the hinge line 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 to 30 degrees, 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 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 farther than the anterolateral edges of the cup-like sockets; in no sense can such blades be regarded as brachiophores. 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 could not be defined.

Discussion. Although the smallness of the sample and the state of preservation of the Antarctic species renders comparison difficult, it is apparent that *Billingsella antarctica* closely resembles several North American species described by Ulrich and Cooper (1938), Bell (1941), and Bell and Ellinwood (1962). Basically, the resemblance lies in the nature of valve profiles and, in part, external ornament. Both *B. perfecta* Ulrich and Cooper and *B. coloradoensis* Walcott exhibit a gross morphology much akin to that of *B. antarctica.* A high interarea imparts to the holotype of *B. antarctica* an outline reminiscent of *B. perfecta pyriformis*, described by Bell (1941, p.247) from the Late Cambrian of Montana. *B. texana*, a rather elongate form described by Bell and Ellinwood (1962, p.413) 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 is deemed inappropriate. 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. Therefore, although morphologic characteristics of the Antarctic species are reflected in several North American species of *Billingsella*, particularly *B. perfecta* Ulrich and Cooper, it is considered that *B. antarctica* was isolated both geographically and genetically from all other stocks so far described and merits recognition as a new species. The apparent lack of affinity between the Antarctic trilobite faunule and any from North America would tend to support this conclusion.

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 neanic forms 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.

Age. The genus Billingsella has a world-wide distribution, occurring in Middle and Upper Cambrian rocks in North America and Europe (Schuchert and Cooper 1932, p.49), Eastern Asia (Kobayashi 1956, p.352), Australia (Öpik 1956, p.47,53; Casey and Gilbert-Tomlinson 1956, p.64; and Traves 1956, p.83,84) and Antarctica (Webers 1972, p.237).

Phylum MOLLUSCA (by E. Yochelson)

Class HYOLITHA Marek 1963

Order HYOLITHIDA Matthew 1899

Family HYOLITHIDAE Nicholson 1872

Genus HYOLITHES Eichwald 1840

Hyolithes sp. indet.

Plate 4, 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 and discussion. 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. 4, 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 an asymmetric angle (Pl. 4, 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 not obvious. 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. 4, 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.

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. 4 fig. 12).

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 hyolithids (Sinclair, 1946). Many species are poorly understood and likely to be conspecific; it therefore seems inadvisable to add further names to the literature until the systematics of the group is better known.

Order ORTHOTHECIDA Marek 1966

Family ORTHOTHECIDAE Syssoiev 1957

Genus CONTITHECA Syssoiev 1972

Contitheca webersi sp. nov.

Plate 4, figs. 1-9, 22.

Material, type specimens. Twelve specimens.

Holotype : TM 5411

Paratypes : TM 5410, 5412, 5413, 5423, 5424

Description. Orthothecoids with a concavo-convex profile, ornamented by numerous fine lirae. Nucleus and earliest part of shell are unknown; the principal part 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. The ventral surface near the anterior margin expands slightly, though the dorsum is straight throughout growth, so that in side view the mature shell is dorsally convex. 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. Growth lines are unknown on the dorsum and the rounded ventral margins; 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. This species shows several interesting features. Presumably the unusual cross-section (Pl. 4, 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. 4, fig. 2) 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. 4, figs. 1, 4) is a development of maturity to compensate for the increased weight of the growing animal. The well-rounded dorsum (Pl. 4, fig. 8) covered by fine ornament (Pl. 4, fig. 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 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, O. 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 World War II (Sinclair, 1946) and more have been named since.

Contitheca webersi is closest to C. lineatalus (Holm) from the Paradoxides forchhammeri Zone of southern Sweden. The cross-section of that species is unknown, but the concave ventor is more gently curved than in this species 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 Syssoiev (1972) provides an excellent model.

Class GASTROPODA Cuvier 1797

Order ARCHAEOGASTROPODA Thiele 1925

Family ONYCHOCHILIDAE Koken 1925

Genus SCAEVOGYRA Whitfield 1878

Scaevogyra sp. indet.

Plate 4, figs. 23, 24.

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

Description and discussion. The specimens are subglobose in outline, possessing few whorls, which expand at a rapid rate (Pl. 4, 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. 4, 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.

Scaevogyra is a characteristic Late Cambrian genus in North America and northeastern Asia. Although some of the described species are lower-spired than this new form, a few specimens attributed to the type species S. sweezei (Whitfield) and others attributed to S. elevata (Whitfield) 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, 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, 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

"Pelagiella" sp. indet

Plate 4, 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 surface is flattened, the overall form lenticular in outline. 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 unbilicus. 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*, *Cyrtolithes atlantoides* Matthew, is an Early Cambrian species with a strongly inflated lower profile, whereas the Antarctic form is quite lenticular (Pl. 4, fig. 16). Because the specimens cannot be freed from the matrix (Pl. 4 figs. 17, 20) it is difficult to convey their relative compression. They are listed here as "*Pelagiella*".

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. 4, 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. 4, fig. 18) onto the largest (Pl. 4, 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. 4, figs. 13, 14, 20) retain patches of the shell. The apparent difference between the Antarctic steinkerns (Pl. 4, 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. 4, 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: 27, pl. 2, figs 15a-c) designated Jaekel (1909 : 400), from the late *Olenus* and *Parabolina spinulosa* with *Orusia lenticularis* Zones, Andrarum, Skaane, Sweden (*fide* Westergaard 1922: 116-7).

Other species. Other species of *Pseudagnostus* are too numerous to list here: at the present time no fewer than 74 specific taxa can be incorporated in *Pseudagnostus sensu lato*.

Age & Distribution. Cosmopolitan, occurring in Alaska, Canada, USA, South America, Europe, USSR, China, Manchuria, Korea, Vietnam, Australia, and now recorded from Antarctica, during the time span of earliest Late Cambrian to Early Ordovician.

Pseudagnostus sp. undet.

(Pl. 2, figs 9-10)

Material. Two cephala and fragments of three pygidia; specimens are preserved with shell, are exfoliated, or preserved as moulds. Figured specimens AR 601-3.

Dimensions. The two complete cephala have lengths (sag.) of 3.20 and 3.60 mm. Pygidial lengths (sag.), exclusive of the articulating half-ring, range between

3.20 and 3.40 mm.

Description. The cephalon is subovate, en grande tenue, with deeply grooved marginal furrows. The cephalic acrolobe has appreciable convexity (tr., sag.), is unconstricted laterally, and is divided antero-sagitally 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 curvilinear anterior furrow, 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 meshed or finely araneavelate prosopon.

The pygidium, like the cephalon, is subovate, en grande tenue, with deeply grooved marginal furrows. Unlike the cephalon, the acrolobe may be strongly 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, the species exhibiting a plethoid and deuterolobate condition. Although the deuterolobe is relatively narrow (tr.) on some specimens, the pleural areas are notably restricted in extent. 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, *Pseudagnostus cyclopyge* (Tullberg), and its immediate allies, e.g. *P. communis* (Hall & Whitfield) *sensu* Lu *et al.*, (1965: 41-2, pl. 4, figs. 6-8) from China: *P. idalis* Öpik (1967: 153, pl. 63, figs. 1, 3; pl. 62 figs. 8-9) and *P. ampullatus* Öpik (1967: 150, pl. 61, figs. 7-11) from Australia; *P. leptoplastorum* Westergaard (1944: 39, pl. 1, fig. 1) from Sweden; and *P. pseudocyclopyge* Ivshin (1956: 17-9, pl. 1, figs. 1-8, 10, 16-17; 1962: 18, pl. 1, figs. 19-22) from Kazakhstan. The pygidium of the North American species *P. gyps* Clark (1923: 124, pl. 1, fig. 9; 1924: 16, pl. 3, fig. 2; Rasetti 1944: 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 *Pseudagnostus communis* (Hall & 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 *Pseudagnostus cyclopyge* (Tullberg) in cephalic shape; their axial glabellar nodes are situated farther 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 farther 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: 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: 89-90, pl. 4, fig. 2), from the Erixanium sentum Zone, Georgina and Pomegranate Limestones, western Queensland, Australia.

Other species. Stigmatoa silex Öpik (1963: 90-91, pl. 4, fig. 4), Erixanium sentum Zone, O'Hara Shale, Pomegranate Limestone, western Queensland, Australia. Stigmatoa sidonia Öpik (1963: 91-2, pl. 4, fig. 1), Irvingella tropica with Agnostotes inconstans Zone, Pomegranate Limestone, western Queensland, Australia. Stigmatoa tysoni Öpik (1963: 92-3, pl. 4, fig. 3), Erixanium sentum Zone, Georgina Limestone, western Queensland, Australia. Stigmatoa sp. is described below from Northern Victoria Land, Antarctica.

Age & Distribution. All previously known species occur in Australia, mainly in the carbonate sequences of western Queensland, where their age is early Late Cambrian, Late Idamean, Zones of Erixanium sentum and Irvingella tropica with Agnostotes inconstans.

Stigmatoa sp. undet.

(Pl. 2, figs. 1-2)

Material. A single cranidial fragment which has a glabellar length (sag.) of 3.70 mm, AR 604.

Comments. Stigmatoa sp. is characterised by a stout nuchal spine (Pl. 2, fig. 2), sigmoidal preoccipital glabellar furrows, large palpebral lobes situated close to the glabella, and a finely granulose prosopon. Other morphologic features conform with those of species previously assigned to the genus.

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 nuchal spine, but wider (tr.) palpebral areas, and hence longer ocular ridges. *S. silex* has similarly sited palpebral lobes and similarly stout nuchal spine, but appears to have a punctate test. *S. sidonia* has only a short nuchal spine and a minutely punctate test. *S. tysoni*, perhaps the closest species to *Stigmatoa* sp. in terms of gross morphology, has similar relationship of palpebral lobes to glabella, but possesses a shorter nuchal spine and apparently a cambric prosopon, 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: 66-7, pl. V, figs. 1-11, pl. VI figs. ?6, ?10; *in* Nikitin 1956: pl. XI, fig. 7), from the late Tuorian (Ivshin & Pokrovskaya 1968: 101), *Aphelaspis-Kujandaspis* Zone, Tortkuduk Suite, central Kazakhstan, USSR.

Other species. *Olentella shidertensis* Ivshin (1956: 68-9, pl. VI, figs. 1-11, pl. VII, figs. 1-8), locality and horizon as for the type species. *Olentella illustris* Lazarenko (1966: 64-65, pl. VIII, figs. 4-8), Kyutyungd depression, R. Olenek, N. Siberian Platform, Zone of *Irvingella/Cedarellus felix*. *Olentella* cf. *olentensis* Ivshin is described from Northern Victoria Land, Antarctica.

Age & Distribution. USSR, Kazakhstan, late Tuorian, *Aphelaspis-Kujandaspis* Zone; Antarctica, Northern Victoria Land, probably late Idamean/early Franconian.

Comments. As far as cranidial characteristics are concerned, *Olentella* Ivshin 1956, together with *Kujandaspis* Ivshin, *Pedinocephalus* Ivshin 1956, *Pedinaspis* Ivshin 1962, and possibly *Apheloides* Ivshin 1962 appear to form a morphologically related group. Their closest affinites seem to lie with Elviniinae of the *Dunderbergia*-*Elburgia*-*Elvinia* generic group, and the 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 shape and segmentation and similarly organised preglabellar areas, and 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, conversely, a thicker (sag.) anterior cranidial border. The palpebral lobes of *Dunderbergia* are spaced farther 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*, the two differing primarily on glabellar characteristics.

Olentella cf. *olentensis* Ivshin 1956

(Pl. 3, figs. 1-2, 7, 9-10)

cf. 1956 *Olentella olentensis* gen. et sp. nov., Ivshin 1956: 66-7, pl. V, figs. 1-11, pl. VI, figs ?6, ?10.

Material. Four cranidial fragments, a possible librigena, a thoracic fragment, and six pygidial fragments. Figured specimens, AR 605-9.

Dimensions. Measured cranidia vary in length (sag.) between an estimated 3.40 and 5.60 mm, whereas the lengths (sag.) of the pygidia, excluding the articulating half-ring, vary between 2.20 and 7.40 mm.

Description. The cranidium is sagittally very convex (Pl. 3, fig. 2) in profile. Its glabella is conical, with anteriorly converging flanks, and acutely rounded frontal lobe. 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 thickened (sag.) anterior cranidial border and shorter (sag.), 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 bridged, 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. 3, fig. 3), which is tentatively placed in the species, is aphelaspidinid in aspect, possessing prominent lateral and posterior borders defined by 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. 3, 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 basically subtriangular 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 Aphelaspis nobilis (loc. cit., fig. 13). The librigena illustrated here resembles that of Aphelaspis 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 & Resser 1924

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

Other species. Palmer (1965: 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: *Irvingella* (*Irvingellina*)? sp. undet., Kobayashi (1938: 176, pl. XV, fig. 3a), *Elvinia* Limestone, Mount Hunter, B.C., Canada. *Irvingella media* Resser (1942, *sensu* Wilson 1949: 39, pl. 11, figs. 16-17, 19-20), *Elvinia* Zone, Wilberns Formation, central Texas, USA. *Irvingella obliquoensis* Rusconi (1953, *sensu* Rusconi 1954: 31, text-figs. 17-18, pl. 2, figs. 8-9), Quebradita Oblicua, Argentina. *Irvingella tropica* Öpik (1963: 96-7, pl. 4, figs. 5-8), Zone of *Irvingella tropica* with *Agnostotes inconstans*, Pomegranate Limestone, western Queensland, Australia. *Irvingella flohri* Resser (1942, *sensu* Palmer 1965: 47-8, pl. 6, figs. 16, 19-20, 24), *Elvinia* Zone, Nevada and Utah, USA. *Irvingella major* Ulrich & Resser (1924, *sensu* Palmer 1965: 48, pl. 6, figs. 9-15), *Elvinia* Zone, Nevada, USA. *Irvingella nuneatonensis* (Sharman 1886, *sensu* Rushton 1967: 339-348, pl. 52, figs. 1-12), *Olenus* Zone (younger than *O. dentatus*), Outwood Shales, Warwickshire, UK. *Irvingella perfecta* Tchernysheva (1968: 207-210, pl. 22, figs. 1-8), Chopkin Suite, Norilsk region, N.W. Siberian Platform.

Age & Distribution. *Irvingella* is a cosmopolitan genus occurring in or about the *Elvinia* Zone and its time equivalents in Europe, Siberia, China, Australia, South America, USA, and Canada.

?*Irvingella* sp. undet.

(Pl. 2, fig. 8).

Material. A single incomplete exfoliated pygidium, AR 610.

Dimensions. Estimated sagittal length is 2.00 mm.

Description. The pygidial outline is trapezoidal, with a slightly indented posterior margin. Borders are not preserved laterally. The pleurae are appreciably convex (tr.), and paucifurrowed, only the first pleural segment bearing 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). *Irvingella nuneatonensis* (Sharman) has, according to Rushton (1967: 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 overall appearance of ?*Irvingella* sp. is somewhat similar to that of species of *Dunderbergia* described by Palmer (1960). Although pygidia of *Dunderbergia variagranula* Palmer (1954: 761, pl. 88, fig. 7; 1960: 68, pl. 4, figs. 22, 25-26, 29), *D. polybothra* Palmer (1960: 67-8, pl. 5, figs. 1-4, 6-7, 9, 14), and *D. bigranulosa* Palmer (1960: 66-7, 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: 58-60, pl. II, figs. 1-8), late Tuorian, *Aphelaspis-Kujandaspis* Zone, Tortkuduk Suite, central Kazakhstan, USSR.

Other species. *Pedinocephalus kasachstanensis* Ivshin (1956: 60-62, pl. II, figs. 9-10, ?11, 12), horizon and locality as for type species. *Pedinocephalus bykovae* Ivshin (1956: 62-64, pl. I, figs. 24-26, 28-29), locality as for type species. *Taenicephalus? peregrinus* Henningsmoen (1957: 167-169, pl. 1, figs. 1-6), Subzone of *Olenus gibbosus* with *O. transversus*, Västergötland, Sweden. *Pedinocephalus simplex* Ivshin (1962: 96-8, pl. VI, fig. 2), horizon as for type species. *Pedinocephalus* cf. *bublichenkoi* is described below from

Northern Victoria Land, Antarctica.

Age & Distribution. USSR, central Kazakhstan, late Tuorian, Aphelaspis-Kujandaspis Zone; Sweden, Västergotland, Olenus Series, Olenus gibbosus-O. transversus Subzone; Antarctica, Northern Victoria Land, late Idamean/early Franconian.

Pedinocephalus cf. bublichenkoi Ivshin 1956

(Pl. 2, fig. 3).

cf. 1956 Pedinocephalus bublichenkoi sp. nov., Ivshin 1956: 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.

Dimensions. The specimen is insufficiently complete for measurement; an estimation of length (sag.) would be in the order of 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 to the 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.

Overall, 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*. *Pedinocephalus* 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.

Aphelaspidinid species I.

(Pl. 2, 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 hand posterolateral limb cannot be exposed because the specimen lies adjacent to the *Prochuangia* cranidium figured on Pl. 1, fig. 1.

Description. The illustrated cranidium is characterised by diverging preocular facial sutures, a slightly concavoconvex preglabellar field, short (sag.) anterior cranidial border, and well defined anterior marginal furrow. 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. Aphelaspidinid 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 similarly organised preglabellar area to the holotype of Aphelaspis buttsi (see Proaulocopleura buttsi Kobayashi 1936: 93, pl. 15, fig. 6; Resser 1938: 95, pl. 16, fig. 8) from Alabama, as refigured by Palmer (1962: 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 other 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 Aphelaspidinid 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: 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 Aphelaspis buttsi and the aphelaspidinid at hand, usually having a gentle inclination to the palpebral lobes which lie somewhat more posteriorly on the genae.

A degree of similarity is evident between Aphelaspidinid sp. 1 and Olenus asiaticus Kobayashi 1944, as described from South Korea by Kobayashi (1962: 54-5, pl. IX, figs. 16a-b). Glabellar and ocular characteristics appear to be similar but the Antarctic specimen may be differentiated by the greater angle of divergence of its preocular facial sutures.

Aphelaspidinid species 2

(Pl. 2, fig. 7).

Material. A single, mostly complete, mainly exfoliated pygidium, AR 613.

Dimensions. The pygidial length (sag.), including the articulating half-ring, is 3.80 mm.

Description. The pygidium determined as Aphelaspidinid 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; Aphelaspis buttsi (Kobayashi) as illustrated by Palmer (1962: pl. 4, figs. 26, 31) again offers closest comparison. Aphelaspidinid sp. 2 may in fact represent the pygidium of the cranidium described as Aphelaspidinid sp. 1. With A. buttsi there is comparable degree of segmentation, similar style of pleural furrowing, and narrow borders. Aphelaspidinid sp. 2, however, has a more fully rounded shape, less triangular than that of A. buttsi. Aphelaspis brachyaspis Palmer (1962: 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.

Aphelaspidinid species 3

(Pl. 3, fig. 6).

Material. Mould and counterpart of a single incomplete cranidium (AR 614), the specimen lacking palpebral lobes and posterolateral limbs.

Dimensions. The estimated cranidial length (sag.) is 6 mm.

Description. Aphelaspidinid sp. 3 is characterised 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 end, which is acutely rounded. It 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 Aphelaspidinid sp. 3 appears to have possessed 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.

Aphelaspidinid sp. 3 most closely resembles two species which have been previously assigned to *Aphelaspis* but probably do not belong with this genus. The Antarctic species is believed to have closest affinity with a Chinese species, *Aphelaspis granulata* Kuo (1963: 59, pl. 14, figs 7-11; *in* Lu *et al.*, 1965: 177, pl. 30, figs. 1-4), which has similar glabellar shape and furrowing, and apparently a similarly arranged preglabellar area. A similarly structured preglabellar area is also possessed by *Aphelaspis nobilis* Ivshin (1956: 33-6, pl. III, figs. 1-13, 27, pl. IV, figs. 16-17), from central Kazakhstan, but this species has an anteriorly more truncate glabella, and its ocular ridges are more steeply inclined. *Aphelaspis granulata* and *A. nobilis* appear to differ from North American species of *Aphelaspis* by the same characteristics which distinguish Aphelaspidinid 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: 24-25, pl. 2, figs. 2-8, pl. 3, fig. 2), from the *Bolaspidella* Zone, Cerillo El Solitario, Canota region, Mendoza, Argentina.

Other species. *Talbotinella leanzai* Poulsen (1960: 25-26, pl. 2, figs. 9-12) locality as for type species. *Talbotinella rusconii* Poulsen (1960: 27, pl. 2, figs. 13-15), locality as above. *Talbotinella notulata* Öpik (1963: 73-5, pl. 6, fig. 9), *Glyptagnostus stolidotus* Zone, Georgina Limestone, western Queensland, Australia. ?*Talbotinella* sp. is described herein from Northern Victoria Land, Antarctica.

Age & Distribution. South America, Argentina, Late Middle Cambrian, *Bolaspidella* Zone; Australia, Late Cambrian *Glyptagnostus stolidotus* Zone; Antarctica, Northern Victoria Land, Late Cambrian, late Idamean/early Franconian.

?*Talbotinella* sp. undet.

(Pl. 3, 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 left pleural portion of the cranidium.

Description. The portion preserved is characterised by a conical glabella, acutely 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 overall 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 *Talbotinella 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 classifiable 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: 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 & Resser 1937: 344, pl. 66, fig. 12) from the Paishan Formation of Fengtien Province, Manchuria.

Family OLENIDAE Burmeister 1843

Subfamiliae et genera incertae sedis

Olenid species undet.

(Pl. 2, fig. 6).

Material. A single incomplete, partially exfoliated cranidium, AR 616, preserved as an external mould.

Dimensions. The estimated cranidial length (sag.) is 4.00 mm.

Description. This species is characterised 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 a nuchal 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 are anteriorly curved.

Discussion. The orientation of the ocular ridges differentiates this species from Aphelaspidinae (Pterocephaliidae) and relates it 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: 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., *Olenus ogilviei* Öpik (1963: 59-62, pl. 1, figs. 1-9, pl. 2, figs. 2-4).

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: 186-7, pl. VIII, fig. 8, pl. X, figs. 1-7), from Saisho-ri, South Korea.

Other species. *Conocephalites quadriceps* Dames (1883: 9, pl. 1, figs. 13-18; Lorenz 1906: 94, text-fig., referred to *Schantungia* Lorenz; Kobayashi 1937: 75-6, pl. 17, figs. 2a-c, referred to *Prochuangia* Kobayashi; Lu *et al.*, 1965: 416, pl. 79, figs. 2-4), from Saimaki, Liaotung, Manchuria. *Prochuangia angusta* Kobayashi (1935: 188-9, pl. IX, fig. 12), from Saisho-ri, South Korea. *Prochuangia posterospina* Kobayashi (1935: 187-8, pl. X, fig. 8), from Saisho-ri, South Korea. *Prochuangia imamurai* Endo (1944: 69-70, pl. 10, fig. 12; refigured Lu *et al.*, 1965: 415, pl. 79, fig. 1), from the Paishan Formation, near Tungchinglien, Liaoyanghsien, Fengtien Province, Manchuria. *Prochuangia granulosa* Lu (1956: 376-7, pl. 1, fig. 5; refigured with additional material *in* Lu *et al.*, 1965: 414, pl. 78, figs. 22-23), from Lungtienchung, Yuping district, eastern Kweichow, China.

Prochuangia? berryi Lochman (1940: 39-40, pl. 4, figs. 17-20), from the *Cedaria*

Zone, Bonneterre Dolomite, Missouri, is not referable to *Prochuangia*.

Age & 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, 1966A, 1966B, 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 1966A: 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.

Comments. Concerning the type species, Kobayashi (1935: 186) synonymises specimens from the Tonkin-Yunnan border region of Vietnam and southern China, which were referred by Mansuy (1915: 20-22, pl. II, figs. 14a-g) to *Chuangia 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 nonconspecific 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: 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 (*loc. cit.*) 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 Chuangia nitida group (Walcott 1911: 85-6, pl. 15, fig. 6), and of Pagodia (Idamea) Whitehouse 1939, sensu Öpik 1967 (see below).

Prochuangia sp., aff. P. granulosa Lu 1956
(Pl. 1, figs. 1-6)

aff. 1956 Prochuangia granulosa Lu (sp. nov.), Lu 1956: 376-377, pl. 1, fig. 5.

aff. 1965 Prochuangia granulosa Lu, in Lu et al., 1965: 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 617-21.

Dimensions. 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 Pl. 1 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. 1, 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. 1, fig. 2), and bears a faint nuchal 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 anterosagittally to the margin, intersecting at an obtuse angle. The postocular facial sutures run direct to the posterior margin, enclosing short (tr.), triangular posterolateral limbs. Posterior marginal furrows are sinuous, clearly defined, and wide, and are characterised 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 characterised 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 is arrested 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. A granulose prosopon is evident, similar to that of the cranidium.

If its spines are neglected, the pygidium is semi-circular. 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, Pl. 1, 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: 186) included the terminal piece in his count of axial rings. *Prochuangia granulosa* Lu has at least one additional axial segment, a total of six (Lu 1956: 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: 9–11) nor Kobayashi (1937: 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 (*loc. cit.* pl. 17 (6), fig. 2b) look closely comparable to the Antarctic *Prochuangia* sp.

Other genera whose pygidial morphology is similar are *Chuangioides* Chu (based on *C. punctatus* Chu 1959: 123, pl. VII, figs. 1–2), which has similar shape, segmentation and furrowing, but lacks spines; *Pagodia* (*Idamea*) Whitehouse (based on *Idamea venusta* Whitehouse 1939: 232–233, pl. XXIV, figs. 4–6, emended Öpik 1967: 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: 85, pl. 15, figs. 3, 3a), which lacks spines and has a considerably broader, flatter pygidial shield, but has similar segmentation although partially effaced. *Iranochuangia* Kobayashi (1960: 263, based on *Chuangia nais* var. *persicum* King 1937: 15, pl. 4, figs. 4a–d) has a pygidium similar to that of *Pagodia* (*Idamea*) and *Chuangioides*, lacking spines. *Pagodia* (*Lotosoides*) (subgen. nov., Shergold, *in press*) 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: pl. 17 (6), fig. 2a) 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 recognised, 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 Idamea 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: pl. 18, fig. 1) for Pagodia (Idamea) baccata. In both species terrace lines are heavily inscribed 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: 56-7, fig. 6; Westergaard 1948: 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: 98), those with five or fewer axial segments in the pygidium are classified as *Proceratopyge* (*Proceratopyge*); those with more than five are referred to *Proceratopyge* (*Lopnorites*) Troedsson 1937. Listed regardless of synonymy other species include: *Proceratopyge nathorsti* Westergaard (1922: 120, pl. 2, figs 3-5; 1947: 10, pl. 2, figs. 2-7), *Agnostus pisiformis* Zone, Andrarum, Sweden; Möckleby, Öland. *Proceratopyge tullbergi* Westergaard (1922: 121, pl. 2, figs. 6-7; 1947: 11-12, pl. 2, figs 8-10), *Protopeltura aciculata* Subzone, Andrarum, Sweden. *Proceratopyge lata* Whitehouse (1939: 248-9, pl. XXV, figs 12, ?13; Öpik 1963: 98-99, pl. 4, figs. 9-10, pl. 5, figs CC, EF, GF), *Glyptagnostus reticulatus* through *Irvingella tropica* with *Agnostotes inconstans* Zones, western Queensland, Australia. *Proceratopyge nectans* Whitehouse (1939: 249-250, pl. XXV, figs. 8a-b), *Glyptagnostus reticulatus* Zone, western Queensland, Australia. *Proceratopyge similis* Westergaard (1947: 10-11, pl. 2, fig. 1), *Agnostus pisiformis* Zone?, Andrarum?, Sweden. *Proceratopyge magnicauda* Westergaard (1947: 32, pl. 2, fig. 11 (no description); 1948: 6-7, pl. 1, figs. 17-18), *Leiopyge laevigata* Zone, Andrarum, Sweden. *Proceratopyge* (*Proceratopyge*) *liaotungensis* Kobayashi & Ichikawa (1955: 69, pl. 11, figs. 1-9; Lu *et al.*, 1965: 550, pl. 115, figs. 6-11), *Chuangia* Zone, Chinchiachengtzu, Manchuria. *Proceratopyge asiatica* Ivshin 1956: 24-26, pl. VIII, figs 17-23; 1962: 287, pl. XIX, fig. 14), Kuyanda horizon, Tortkuduk Suite, Kazakhstan, USSR. *Proceratopyge chuhsiensis* Lu (1956: 280-282, pl. 1 figs. 1-6; Lu *et al.*, 1965: 547, pl. 114, figs. 3-6), south western Chuhsien, North Anwhei, China. *Proceratopyge triangulata* Ivshin (1962: 288-9, pl. XIX, fig. 15), Soletin horizon, Kuyanda Stage, Tortkuduk Suite, Kazakhstan, USSR. *Proceratopyge* cf. *chuhsiensis* Lu *sensu* Öpik (1963: 99-100, pl. 5, fig. AA), *Irvingella tropica*/

Agnostotes inconstans Zone, western Queensland, Australia. *Proceratopyge tenuita* Lazarenko (1966: 51-2, pl. III, figs 10-16), *Irvingella/Cedarellus felix* Zone, Kyutyungd depression, Karaulakh Mountains, R. Lena below Chekurovka, N. Siberian Platform, USSR. *Proceratopyge portentosa* Lazarenko (1966: 52-54, pl. IV, figs 1-6), horizon and locality as above. *Proceratopyge captiosa* Lazarenko (1966: 54-55, pl. IV, figs. 7-10), horizon and locality as above. *Proceratopyge* cf. *lata* Whitehouse is described from Antarctica.

Age & Distribution: Cosmopolitan. Late Middle Cambrian to Late Cambrian, *Leiopyge Laevigata* to *Protopeltura aciculata* Zones in Europe (Sweden); Late Cambrian, Tuorian, *Agnostus pisiformis* with *Homagnostus fecundus* Zone to early Shidertinian, *Irvingella/Cedarellus felix* Zone, Kazakhstan, Siberian Platform, USSR; Late Cambrian, Paishanian, *Chuangia* Zone, Manchuria, China; Late Cambrian, Idamean, *Glyptagnostus reticulatus* to *Irvingella tropica/Agnostotes inconstans* Zones, Australia; Late Cambrian, late Idamean/early Franconian, Northern Victoria Land, Antarctica.

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

(Pl. 1, figs. 7-9)

cf. 1939 *Proceratopyge lata* sp. nov., Whitehouse 1939:
248-9, pl. XXV, figs. 12, ?13.

cf. 1963 *Proceratopyge lata* Whitehouse, 1939, Öpik 1963:
98-99, pl. 4, figs. 9-10, pl. 5, figs. CC, EF, GF.

Material. A single cranidium, AR 622, and a single pygidial fragment lacking left pleura and axis, AR 623.

Dimensions. The cranidium has a sagittal length of 3.50 mm.

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 acutely 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 sagittally 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 concavo-convex 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. This shows the shield to have been subtriangular, with a conical axis containing perhaps as many as five axial rings, but most probably only three or four, and paucifurrowed pleural zones containing only two well defined segments. The pleural furrows that are preserved are wide (exsag.) and shallow. Interpleural 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. *Proceratopyge* cf. *lata* Whitehouse belongs to a group of species characterised 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 & Ichikawa, and *P. tullbergi* Westergaard.

Proceratopyge cf. *lata* may be compared with what is known of the holotype cranidial fragment of *P. lata sensu* Whitehouse (1939: 248-9, pl. XXV, fig. 12). Both species have similarly faint glabellar furrowing, similarly wide (tr.) preglabellar area, and similarly shaped and extensive posterolateral limbs. Ocular 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 *op. cit.*, p. 249). The specimen which Whitehouse referred either to *P. lata* or to *P. rutellum* probably has similar shape and segmentation to that illustrated here.

Although its palpebral lobes may be somewhat shorter (exsag.) and its ocular ridges less transverse, the cranidium of *P. lata* Whitehouse *sensu* Öpik (1963: 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: 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.

Proceratopyge tullbergi Westergaard (1922: 121, pl. 2, figs. 6-7; 1947: 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.

(Pl. 3, 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 acutely 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: 96-8, pl. VI, fig. 2) and his species *Apheloides striatiferus* (1962: 105-8, 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.). *Apheloides striatiferus* appears to have a convex (tr.) preglabellar field and more steeply inclined ocular ridges. The course of its marginal furrow may also differ. All aspects of the preserved morphology suggest the fragment to be representative of a Pterocephaliid genus.

Specimen 2.

(Pl. 3, fig. 5).

Material. A single partially exfoliated cranidial fragment preserving the complete preglabellar area and a good proportion 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 of the glabella preserved demonstrates an anterior taper and acutely rounded frontal lobe. Traces of the anterior lateral glabellar furrows preserved show them to be short (tr.), faint and transverse linear, 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. verruculapeza* Palmer (1960: 83, pl. 8, figs. 12-13, 15-16, 19-20; 1965: 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, figs. 11) ascribed to *Iddingsia robusta* Walcott (Dokimocephalinae, Elviniidae) from the *Elvinia* Zone of Nevada; and that which Lazarenko (*in* Lazarenko & Nikiforova 1968: 50–51, pl. IX, fig. 12) has referred to *Faciura infida* Lazarenko, from the *Faciura-Garbiella* Zone, Kulyumbe River, northwest Siberian Platform.

Specimen 3

(Pl. 3, fig. 8)

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

Description. This specimen is characterised 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 is superimposed a system of 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

(Pl. 2, fig. 5)

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

Description. Both specimens are characterised 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

(Pl. 3, fig. 12)

Material. A single cephalon, AR 627.

Dimensions. The cephalic length is 0.75 mm.

Comments: The specimen represents an indeterminate meraspid cephalon which presumably could belong to any of the pterocephaliid, elviniid, or olenid 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.

J.H. SHERGOLD
Bureau of Mineral Resources
Canberra
AUSTRALIA.

R.A. COOPER
N.Z. Geological Survey,
Lower Hutt,
NEW ZEALAND.

D.I. MacKINNON
Department of Geology
University of Canterbury
Christchurch
NEW ZEALAND

E.L. YOCHELSON
U.S. Geological Survey
Washington D.C. 20244,
U.S.A.

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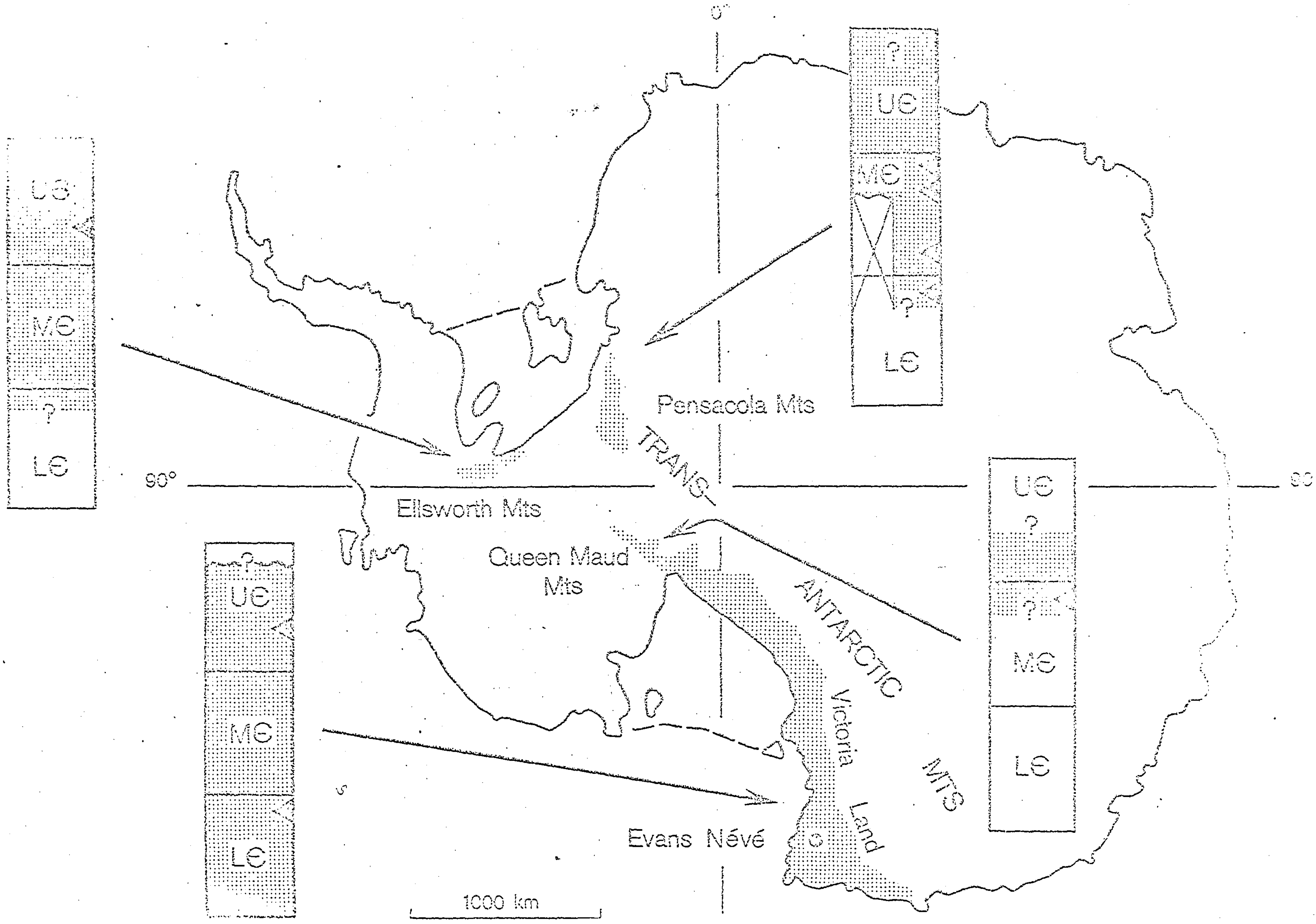
TABLES

TABLE 1. Affinities of Antarctic trilobites.

Antarctic taxa	Affinities
Pseudagnostus sp.	'*Pseudagnostus communis*' Lu et al., 1965; 'China'
Stigmatoa sp.	*S. tysoni* Öpik 1963; Idamean; *E. sentum* Z.; W. Qld, Australia.
Olentella cf. *olentensis*	*O. olentensis* Ivshin 1956; Tuorian; *G. reticulatus* Z.; *Aphelaspis-Kujandaspis* fauna, Kazakhstan, USSR.
?*Irvingella* sp.	*I. major* Ulrich & Resser 1924; Franconian; *Elvinia* Z.; many localities, USA.
Pedinocephalus cf. *bublichenkoi*	*P. bublichenkoi* Ivshin 1956; Tuorian; *G. reticulatus* Z.; *Aphelaspis-Kujandaspis* fauna; Kazakhstan, USSR.
Aphelaspidinid 1	'*Aphelaspis buttsi* (Kobayashi 1936)'; Dresbachian; *Aphelaspis* Z.; Ala, Nev., USA.
Aphelaspidinid 2	'*Aphelaspis buttsi* (Kobayashi 1936)'; as above.
Aphelaspidinid 3	'*Aphelaspis granulata* Kuo 1963'; 'China'.
?*Talbotinella* sp.	*T. notulata* Öpik 1963; Mindyallan; *G. stolidotus* Z.; W. Qld; Australia.
Olenid 1	*Hancrania brevilimbata* Kobayashi 1962; early U. Cambrian; *Hancrania* Z.; South Korea.
Prochuangia sp.	*P. granulosa* Lu 1956; ?Paishanian; eastern Kueichou, China.
Proceratopyge cf. *lata*	*P. lata* Whitehouse 1939; Idamean; *E. sentum-I. tropica* with *A. inconstans* Zs; W. Qld, Australia.
Specimen 1	??*Pedinocephalus simplex* Ivshin 1962; Tuorian; *G. reticulatus* Z.; Kazakhstan, USSR.
Specimen 2	??*Litocephalus*; late Dresbachian-early Franconian; *Dunderbergia-Elvinia* Zs; Nevada, USA.
Specimen 4	??*Stigmatoa*; late Idamean; *E. sentum-I. tropica*/*A. inconstans*; W. Qld, Australia.


0°
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Ellsworth Mts
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MTS
Queen Maud
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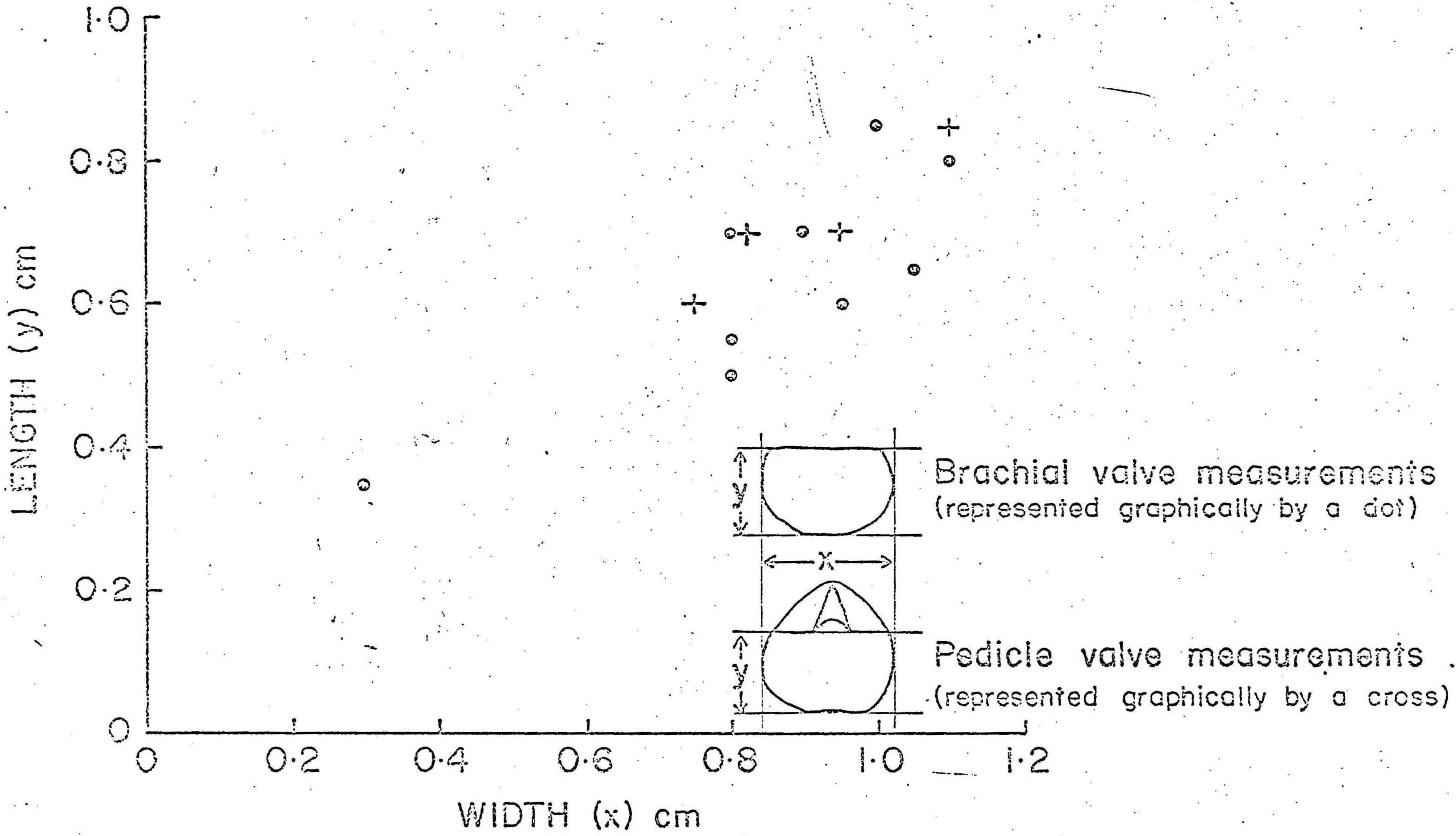
Victoria
Land
Evans Névé
1000 km



1·0
0·8
0·6
0·4
0·2
0
LENGTH (y) cm
0
0·2
0·4
0·6
0·8
1·0
1·2
WIDTH (x) cm
y
x
y
Brachial valve measurements
(represented graphically by a dot)
Pedicle valve measurements
(represented graphically by a cross)

PLATE EXPLANATIONS

PLATE 1

Figs 1-6. *Prochuangia* sp. aff. *P. granulosa* Lu 1956. 1, AR 617, cranidium retaining external test, showing faint granulosity, dorsal view, X8. 2, AR 617, as above, lateral view, X8. 3, AR618, partially exfoliated cranidium with granulose prosopon, dorsal view, X8. 4, AR 620, pygidium retaining external test, granulose, dorsal view, X18. 5, AR 621, latex cast from mould of exfoliated pygidial surface showing traces of caecal network, dorsal view, X6. 6, AR 619, librigena retaining test, oblique dorsal view, X8.

Figs 7-9. *Proceratopyge* (*Proceratopyge*) cf. *lata* Whitehouse 1939. 7, AR 622, early holaspid cranidium with test, dorsal view, X8. 8, AR 622, as above, lateral view, X8. 9, AR 623, pygidial fragment, oblique dorsal view, X12.

PLATE 2

Figs 1-2. *Stigmatoa* sp. undet. 1, AR 604, cranidial fragment retaining test, finely granulose prosopon, dorsal view, X8. 2, AR 604, as above, oblique lateral profile to show nuchal spine, X8.

Fig. 3. *Pedinocephalus* cf. *bublichenkoi* Ivshin 1956. AR 611, testaceous cranidial fragment, dorsal view, X6.

Fig. 4 Aphelaspidinid species 1. AR 612, cranidial fragment, dorsal view, X8.

Fig. 5. Trilobita genus et species incertae sedis, sp. 4. AR 626, partially exfoliated librigena, dorsal view X6.

Fig. 6. Olenid species undet. AR 616, latex cast from external mould of incomplete cranidium, dorsal view, X12.

Fig. 7. Aphelaspidinid species 2. AR 613, mainly exfoliated pygidium, dorsal view, X8.

Fig. 8. ?*Irvingella* sp. undet. AR 610, damaged pygidial fragment, dorsal view, X16.

Figs. 9-11. *Pseudagnostus* sp. undet. 9, AR 601, testaceous cephalon with finely granulose prosopon, dorsal view, X12. 10, AR 603, latex cast from external mould of exfoliated pygidium, dorsal view, X12. 11, AR 602, mainly exfoliated pygidium, dorsal view, X12.

PLATE 3

Figs 1-2. *Olentella* cf. *olentensis* Ivshin 1956. 1, AR 605, testaceous cranidium, dorsal view, X12. 2, AR 605, as above, lateral profile, X12.

Fig. 3. ?*Olentella* cf. *olentensis* Ivshin 1956. AR 609, librigena showing caecal network, tentatively ascribed to this species, dorsal view, X12.

Fig. 4. Trilobita genus et species incertae sedis, sp. 1. AR 623, cranidial fragment, X8.

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

Fig. 6. Aphelaspidinid species 3. AR 614, exfoliated mould of incomplete cranidium, dorsal view, X8.

Fig. 7. ?*Olentella* cf. *olentensis* Ivshin 1956. AR 606, fragment of thoracic segment tentatively ascribed to this species, dorsal view, X8.

Fig. 8. Trilobita genus et species incertae sedis, sp. 3. AR 625, partially exfoliated librigena, dorsal view, X8.

Figs. 9-10. *Olentella* cf. *olentensis* Ivshin 1956. 9, AR 607, exfoliated pygidium, dorsal view, X12. 10, AR 608, latex cast from external mould of exfoliated pygidial fragment, dorsal view, X6.

Fig. 11. ?*Talbotinella* sp. undet. AR 615, mainly testaceous cranidial fragment, dorsal view, X8.

Fig. 12. Trilobita genus et species incertae sedis, sp. 5 AR 627, indeterminate early meraspid cephalon, dorsal view, X28.

PLATE 4.

All specimens, X5.

Figs. 1-9, 22 *Contitheca webersi* Yochelson, n. sp. 1-5, TM 5411, right side, left side, dorsal, ventral, and apical views of holotype, a steinkern. 6, 7, TM 5413, very slightly oblique natural cross-section of a small paratype, a steinkern and natural cross-section of the larger end. 8, 9, TM 5410, dorsal views of paratype showing fine threadlike transverse lirae when illuminated from side and fine growthlines when illuminated from aperture. 22, slab with two incomplete paratypes (TM 5423, 5424), both showing the curvature of the ventral surface.

Figs. 10, 13-20. "*Pelagiella*" sp. indet. 10, 15, TM 5407, oblique view tilted to show profile and top of a steinkern showing markings which are not growth lines.

13, 14, 20, TM 5406, side view, tilted, oblique basal view and basal view of a specimen retaining patch of shell on basal surface. 16-18, TM 5408, oblique top view, oblique side view reversed in orientation to show lenticular profile and basal view of a steinkern. 19, TM 5409, top view of specimen retaining a patch of shell.

Figs. 11, 12, 21 — *Hyolithes* sp. indet. 11, 12, TM 5414, 5415, side view of two specimens in profile and ventral view, the one in lower center slightly oblique; TM 5415 paratype of *Contitheca webersi* with the base exposed is to the left. 21, TM 5425, ventral view of a broken specimen with steinkern removed and growth lines of dorsal surface visible towards the apex.

Figs. 23, 24 — *Scaevogyra* sp. indt.

23, TM 5417, side view of a steinkern showing two whorls. 24, TM 5416, oblique basal view of a masked and elongated steinkern; the sharp line to left intersecting the specimen is a tool mark.

PLATE 5.

Figs. 1-13. — *Billingsella antarctica* sp. nov. 1, 2, BR 1553 (paratype), internal mould and rubber latex cast of brachial valve, X3. 3, 4, BR 1550, internal mould and rubber latex cast of brachial valve, X3. 5, 6, BR 1554, external mould and rubber latex cast of brachial valve, X3. 7, BR 1555, (paratype), internal mould of pedicle valve, X2.5. 8, BR 1556, internal mould of pedicle valve showing development of mantle canal system, X4. 9, 10, BR 1551, internal mould and rubber latex cast of small brachial valve, X3. 11, BR 1552, (paratype), pedicle valve exterior, X2.5. 12, 13, BR 1549 (holotype), internal mould and rubber latex cast of pedicle valve, X3.

Fig. 14-21. Prototreta sp. indet. All except Fig. 17 are scanning electron micrographs. 14, BR 1911, external view of pedicle valve, X19. 15, BR 1911, oblique posterior view of pedicle valve showing pseudointerarea with intertrough, X19. 16, BR 1911, pedicle valve in lateral profile, X19. 17, BR 1913, external view of partly decorticated pedicle valve, X16. 18, BR 1912, external view of pedicle valve showing, in detail, the protegular region and pedicle foramen, X200. 19, BR 1916, oblique lateral view of brachial valve interior, X18. 20, BR 1546, external view of brachial valve, X17. 21, BR 1916, internal view of brachial valve, X18.

Fig. 22, 23. Schizambon reticulata sp. nov. 22, BR 1903 (paratype), external view of pedicle valve, X7. 23, BR 1902 (holotype), external view of pedicle valve, X8.

TEXT-FIGURE CAPTIONS

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.

TEXT-FIG. 2. Graph showing the relationship of brachial valve length to width in *Billingsella antarctica* MacKinnon sp. nov.

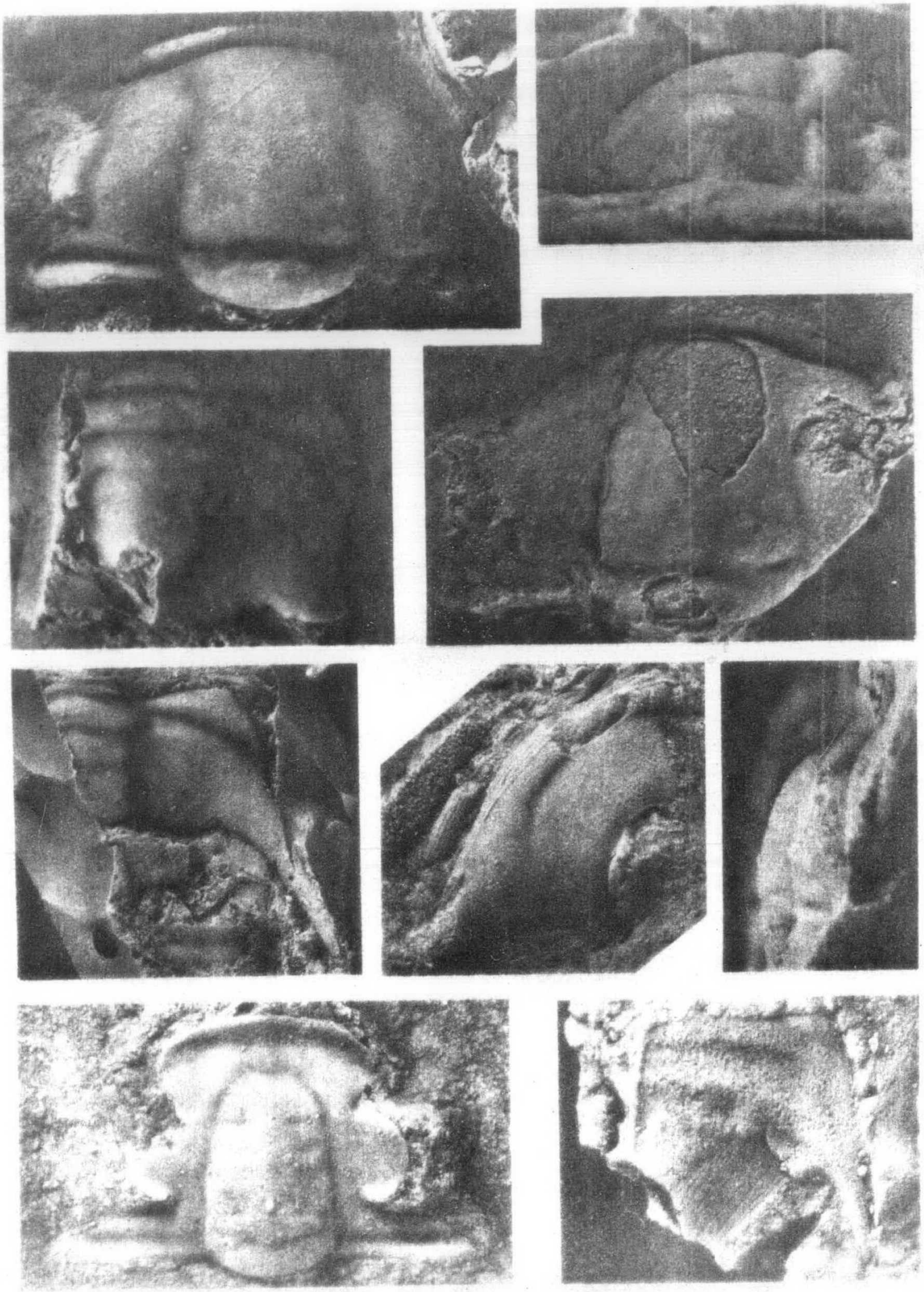
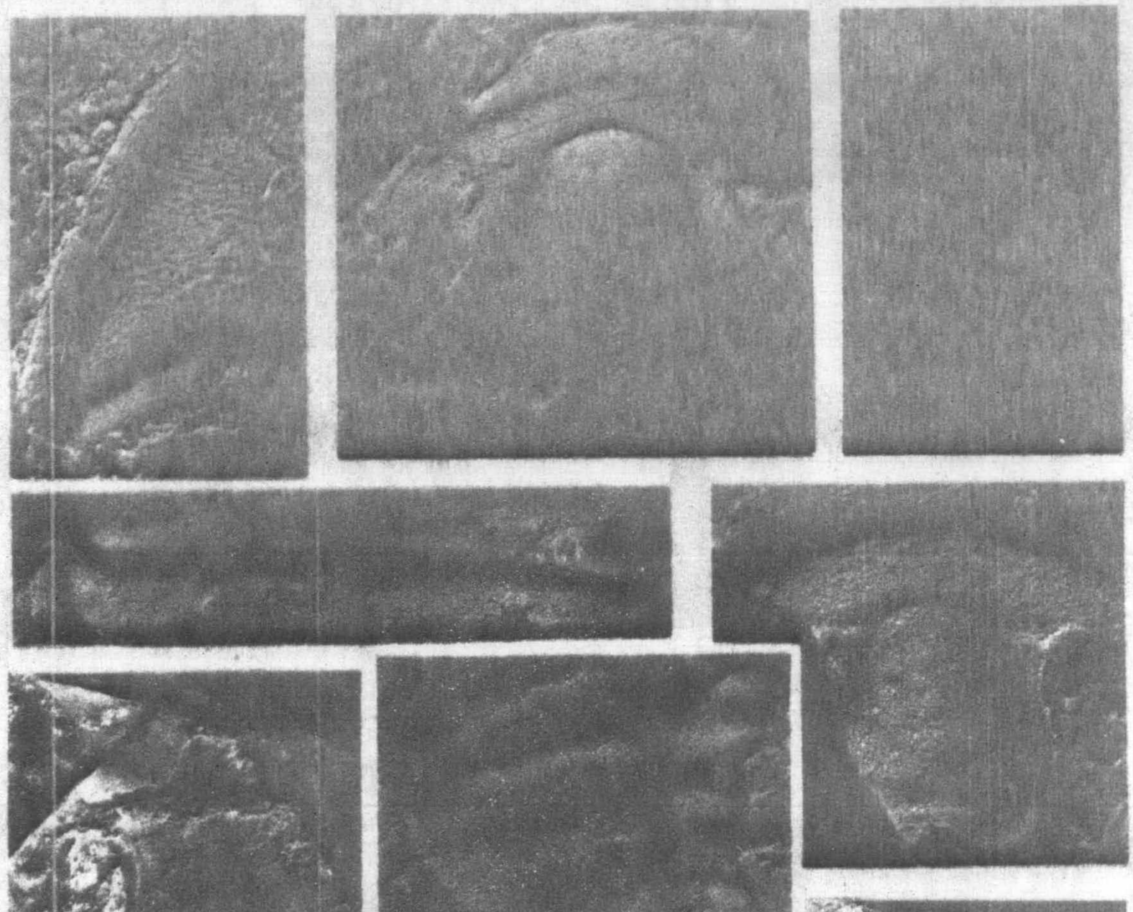


PLATE 1

PLATE 2



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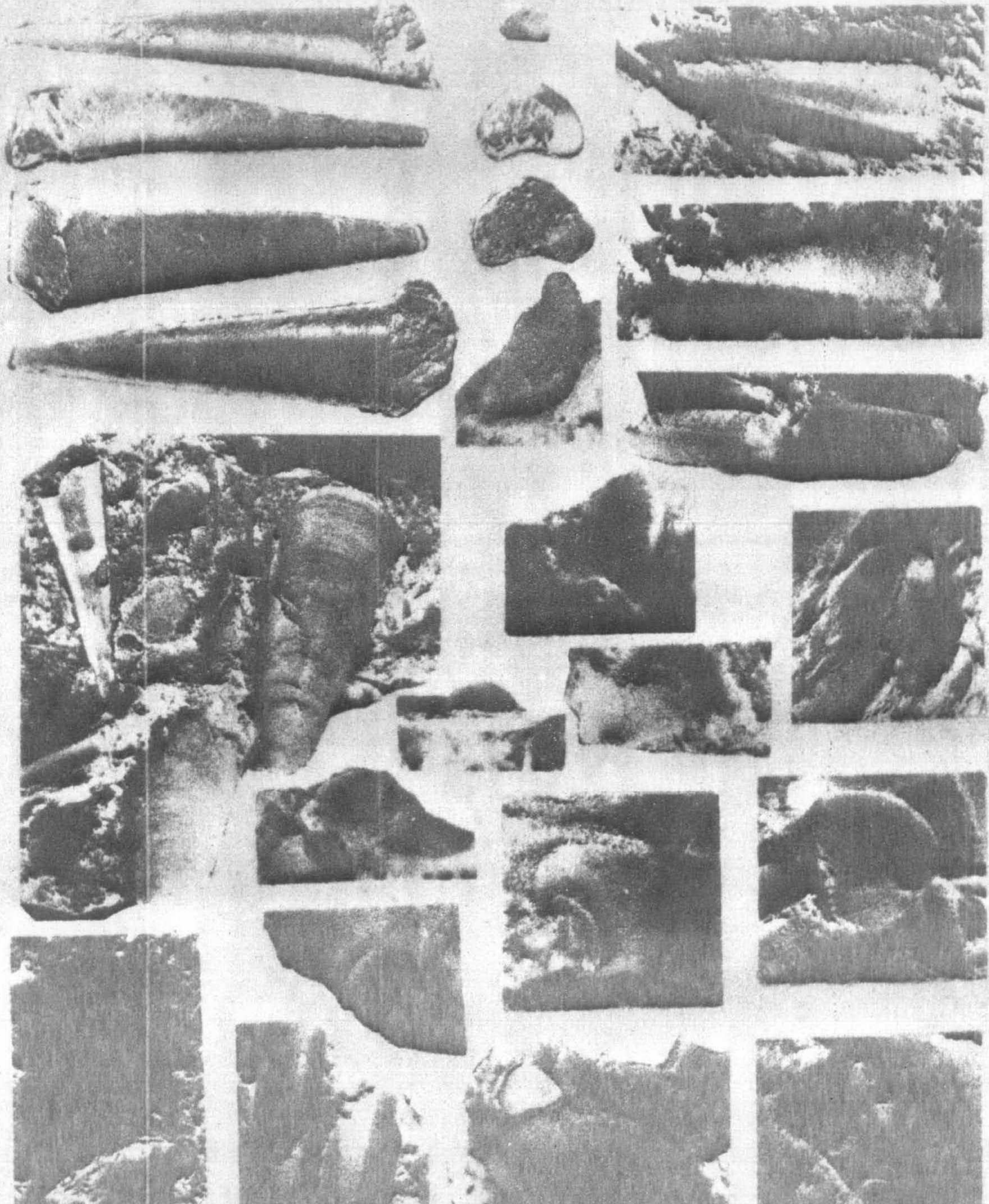

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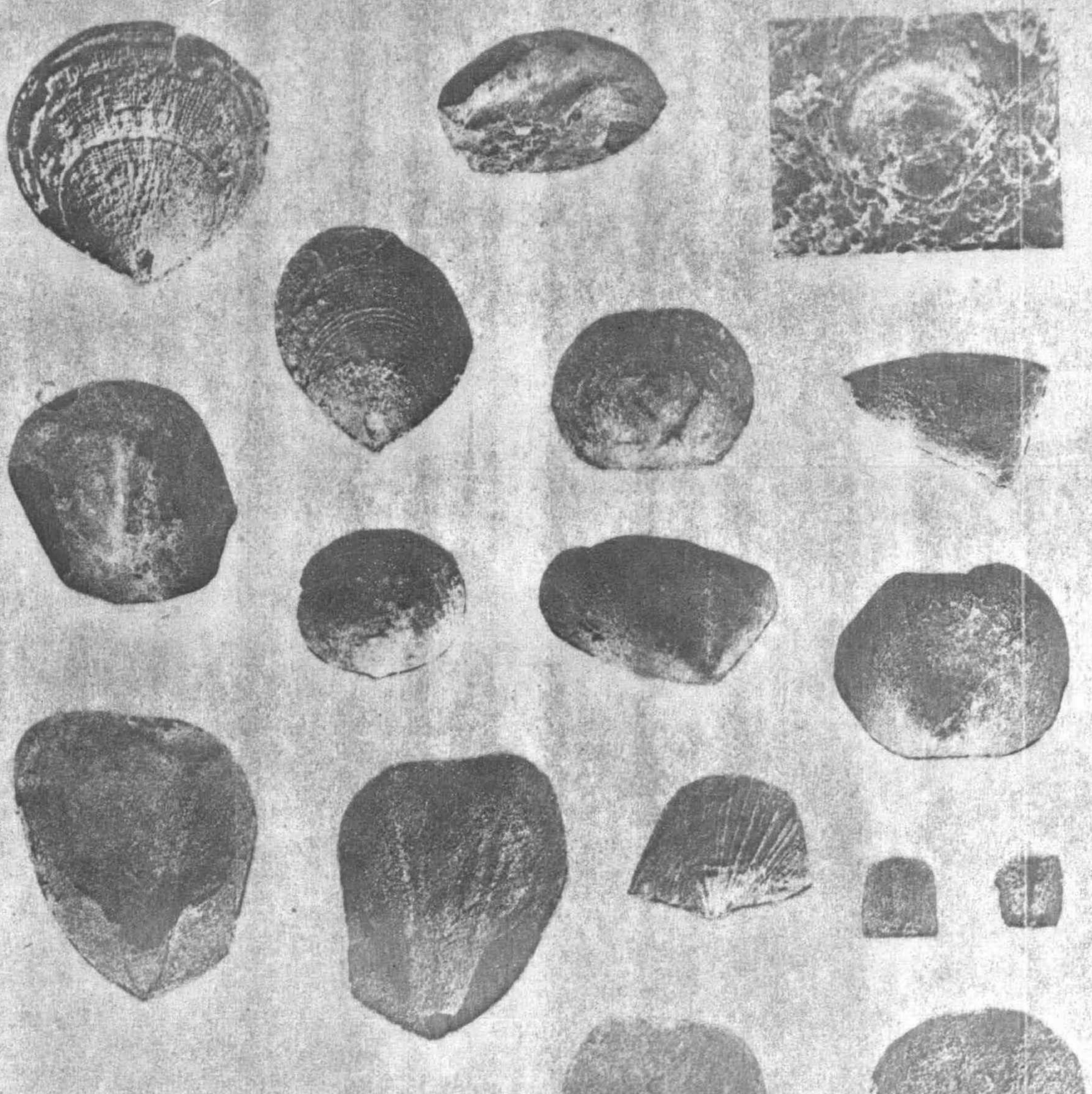

PLATE 5