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Late Cambrian and Early Ordovician Trilobites from the Burke River Structural Belt, Western Queensland, Australia

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BULLETIN: 153 Volume I CORRIGENDA

p. 40, line 3, for all species read most species

p. 74, para 3, line 7, for nodular read notular

p. 88, para 1, line 1, for George Formation read Gorge Formation

p. 106, Synonymy omitted:

cf. 1905 *Ptychoparia dryope* Walcott, p. 78.
cf. 1913 *Conocephalina dryope* (Walcott), Walcott, pp. 138-9, pl. 13, figs 11, 11a-b.
cf. 1933a *Wuhuia dryope* (Walcott), Kobayashi, p. 145.

pp. 105, 200, 206. Delete *nom. nud.* following references to Walcott, 1905.

p. 126, para 2, line 3, read the for their.

p. 143, para 1, line 2, for *ni* read *in*
line 4, delete second h from *chinhsiensis* or else delete (*sic*).

NOTE:
Figure 4 appears at the rear of this volume.

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CONTENTS

SUMMARY

Trilobite faunas are described from sections at Black Mountain, Mount Ninmaroo, Mount Datson, and Dribbling Bore, in the southern part of the Burke River Structural Belt on the eastern margin of the Georgina Basin, western Queensland: 96 species and subspecies are assigned to 51 genera and subgenera classified into 22 families and subfamilies. Seven genera, 5 subgenera, 46 species, and 3 subspecies are new: 28 species are left under open nomenclature. Eight taxa are of early Ordovician age, Datsonian to early Warendian. The remainder are late Upper Cambrian, ranging in age from the informally designated pre-Payntonian B interval to Payntonian. The Cambrian faunas are late Changshanian to early Wanwanian in terms of Asian stage nomenclature; latest Franconian and Trempealeauan with reference to North American stages; and range upwards from approximately Zone 5b (of Westergaard) when compared with the Atlantic-Baltic biostratigraphical scale.

The most complete stratigraphical section is described at Black Mountain, where trilobite faunas are grouped into six successive assemblage-zones on the basis of specific range and association. In ascending order these zones are: *Pseudagnostus clarki patulus* with *Caznaia squamosa, Pseudagnostus clarki prolatus* with *Caznaia sectatrix, Pseudagnostus bifax* with *Pseudagnostus denticulatus, Pseudagnostus clarki maximus* with *Pseudagnostus papilio, Sinosaukia impages, Pseudagnostus quasibilobus* with *Tsinania (Tsinania) nomas.* A seventh zone, that of *Mictosaukia perplexa,* succeeds the *quasibilobus-nomas* Assemblage-Zone at Mount Datson and Dribbling Bore. Biostratigraphical subdivision has been facilitated by use of the Dice Similarity Coefficient and cluster analysis techniques. The faunal passage from latest Cambrian to earliest Ordovician, which is obscured by dolomitic intervals at Black Mountain, Mount Ninmaroo, and Mount Datson, is documented at Dribbling Bore, where the Payntonian-Datsonian boundary, corresponding to the Cambrian-Ordovician boundary, is recognized by the incoming of the conodont assemblage-zone based on *Cordylodus proavus.*

In the early parts of the sequences studied, pre-Payntonian B and early pre-Payntonian A intervals, trilobite assemblages have a high component (often more than half) of cosmopolitan elements, particularly Agnostina, Remopleuridacea, and Asaphacea. In the late pre-Payntonian A and Payntonian, endemic Asian shelf elements or their close relatives, particularly Saukiidae and Leiostegiacea, dominate the assemblages, often in excess of 80 percent of the faunas. Consequently, Asian taxa occurring in western Queensland are revised. Among the Agnostina, late Cambrian representatives of the genus *Pseudagnostus* occurring in Australia are divided into four species groups based on *Pseudagnostus clarki* Kobayashi, *P. convergens* Palmer, *P. clavus* Shergold, and *P. bilobus* Shaw. The morphology of these species is discussed in detail, and descriptions of both external testaceous and parietal surfaces are given wherever possible.

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INTRODUCTION

Ninety six species and subspecies are described from the 'Chatsworth Limestone' and lower Ninmaroo Formation exposed in sections at Black Mountain, Mount Ninmaroo, Mount Datson, and Dribbling Bore on the eastern margin of the Georgina Basin (western Queensland). They are assigned to 51 genera and subgenera, themselves distributed among 22 families and subfamilies. The described faunas span the time interval pre-Payntonian B to early Warendian (Jones, Shergold, & Druce, 1971), i.e. they are of latest Cambrian and earliest Ordovician ages.

The eight taxa described from the Datsonian and earliest Warendian (early Ordovician) are represented by fragmental remains and in the present context are of little value biostratigraphically. Trilobites from this interval occur more commonly, however, in arenaceous successions elsewhere in the Georgina Basin, and in northwestern New South Wales. In the absence of trilobites, fine dating and correlation of the carbonate rocks of this stratigraphical interval are facilitated by conodonts, which begin to show marked morphological diversity at this time (Druce & Jones, 1971).

The 88 Cambrian taxa are described mainly from the 'Chatsworth Limestone' of the Black Mountain section. In this section a single Cambrian species occurs in the lowest Ninmaroo Formation (at horizon K145). Trilobite faunas collected from the 'Chatsworth Limestone' at Dribbling Bore, Mount Datson, and Mount Ninmaroo may be equated with those of the highest 'Chatsworth Limestone' and lowest Ninmaroo Formation at Black Mountain.

This study is the second part of a continuing monograph on late Cambrian and early Ordovician trilobites from northern Australia; an earlier account described the trilobite fauna of the Gola Beds, which occur as an isolated outcrop at Momedah Creek, 20 km east-northeast of Black Mountain (Shergold, 1972). Additional information on that fauna is presented here, and some of the earlier conclusions are reconsidered.

The first collections of the material described here were made by A. A. Öpik and members of the Georgina Basin Party (BMR) during the mapping of the Boulia 1:250 000 Geological Sheet in 1957, and by M. A. Reynolds, who made a small collection in July 1962. These older collections are prefixed with the letter B. I first visited the area in 1967, when the Bureau of Mineral Resources was trough sampling Cambrian and Ordovician carbonate successions for conodont faunas. At this time trilobites were collected at sections from Black Mountain and Momedah Creek. During a second visit in 1969, sections at Black Mountain, Mount Ninmaroo, Mount Datson, and Dribbling Bore were collected in detail along the lines of section from which Druce & Jones (1971) had previously sampled conodonts. These sections, originally measured by G. A. Brown (1961) during the course of an M.Sc. study on carbonate petrography, were remeasured for the accurate location of the trilobite samples described here. Collections made by the author are prefixed K.

During the course of the preparatory work a considerable number of taxa were found that have apparently strong affinities with Asian species previously described by Walcott, Sun, Kobayashi, Endo, and Endo & Resser from 1905 onwards. As some of the older accounts, and many of the earlier illustrations, of these taxa were found difficult to interpret, and because such species appear to occur commonly in Australian Upper Cambrian sequences over very wide areas of outcrop, I visited the U.S. National Museum, Washington, D.C., U.S.A., and the Institute of Palaeontology, University of Tokyo, Japan, during 1971-72, to examine Asian type collections. Brief visits were also made to the British Museum (Natural History) (London), the Institute of Geological Sciences (London), the Sedgwick Museum (Cambridge), the Geological Survey of Canada (Ottawa), the American Museum of Natural History (New York), and the Department of Earth and Space Sciences, State University of New York at Stony Brook (Long Island). Notes on Asian trilobites described by previous writers and included in the systematic palaeontology of this paper are based on personal observations resulting from these visits.

All the specimens mentioned, described, or tabulated in the text, and illustrated on the accompanying plates, are deposited in the Commonwealth Palaeontological Collection, Bureau of Mineral Resources, Canberra, and are prefixed CPC. Specimens in the collections of other institutions are prefixed as follows: USNM, United States National Museum, Washington, D.C., U.S.A.; AMN, American Museum of Natural History, New York; GSC, Geological Survey of Canada, Ottawa. The abbreviation USGS is used in the text for United States Geological Survey.

ACKNOWLEDGMENTS

I gratefully acknowledge the following persons for providing facilities to examine and often replicate materials in their care or possession: Mr F. J. Collier (U.S. National Museum); Dr M. E. Taylor (U.S. Geological Survey); Dr N. Eldredge (American Museum of Natural History); Drs T. E. Bolton and W. H. Fritz (Geological Survey of Canada); Professor A. R. Palmer (State University of New York at Stony Brook); Professor H. B. Whittington (Sedgwick Museum); Dr A. W. A. Rushton (Institute of Geological Sciences); Dr R. A. Fortey (British Museum); and Professors T. Kobayashi and T. Hanai (University of Tokyo). I thank Dr J. E. Hazel (U.S. Geological Survey) for the use of his computer program for the biostratigraphical analyses presented below, and for running these analyses. Dr E. C. Druce (BMR) has given revised conodont information. The rock determinations quoted in Appendix A were made by Mr B. Radke (BMR). Mr H. M. Doyle (BMR) was largely responsible for preparing the accompanying plates. For his constant encouragement of this project, and his critical comments during the years over which the present report was compiled, my thanks are due to Dr A. A. Öpik.

LOCATION AND DESCRIPTION OF THE AREA

The trilobites described below were collected from localities on the Boulia 1:250 000 Geological Series Sheet, SF/54-10 (Fig. 1), on the western flanks of a tectonic feature defined by Öpik (1960, p. 91-3) as the Burke River Structural Belt. Basically this structure is a graben, approximately 32 km in width and extending roughly north-south for nearly 290 km on the Duchess, Boulia, and Springvale 1:250 000 Sheets.

The northern position of the Belt is a fault-bound trough within Precambrian rocks, and lies between Malbon, 70 km south-southwest of Cloncurry, and Chatsworth homestead, 95 km farther south, in the Duchess Sheet area. It contains

Middle and early Upper Cambrian sediments, partly concealed under Cainozoic cover, which have been described, and their faunas documented, in a series of papers by Öpik (1956, 1960, 1961a, b, 1963, 1967a, b, 1970, 1971).

In the central portion of the structural belt, on the Boulia Sheet, late Cambrian and early Ordovician carbonates lie in the floor of the graben and along its faulted flanks, but to the south and southeast they are concealed below Cretaceous and Tertiary sediments. The locations of sections measured in this area are shown in Figure 2. The relationships of the Lower Palaeozoic formations have been described by Casey (1968); Druce & Jones (1971) have described conodont faunas; and Shergold (1972) has begun to investigate the trilobite faunas. Biostratigraphical information, as known to date, has been summarized by Jones, Shergold, & Druce (1971) and Shergold (1971).

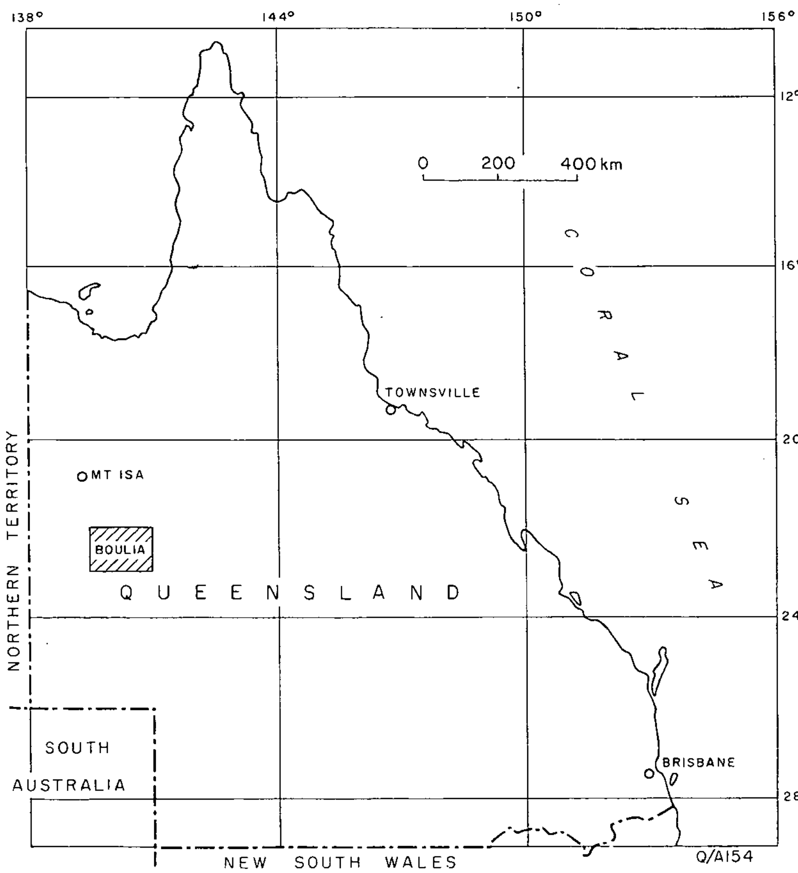

Fig. 1. Location of the Boulia 1:250 000 Geological Series Sheet, western Queensland.

Southwards, on the Springvale Sheet, the graben is concealed below Cretaceous sediments. Two boreholes drilled by Phillips-Sunray, Canary No. 1 and Elizabeth Springs No. 1, penetrated thick un-named shale sequences below Cretaceous strata, which were tentatively assigned on lithological characteristics to the Upper Proterozoic (Green et al., 1963). The western boundary fault of the Burke

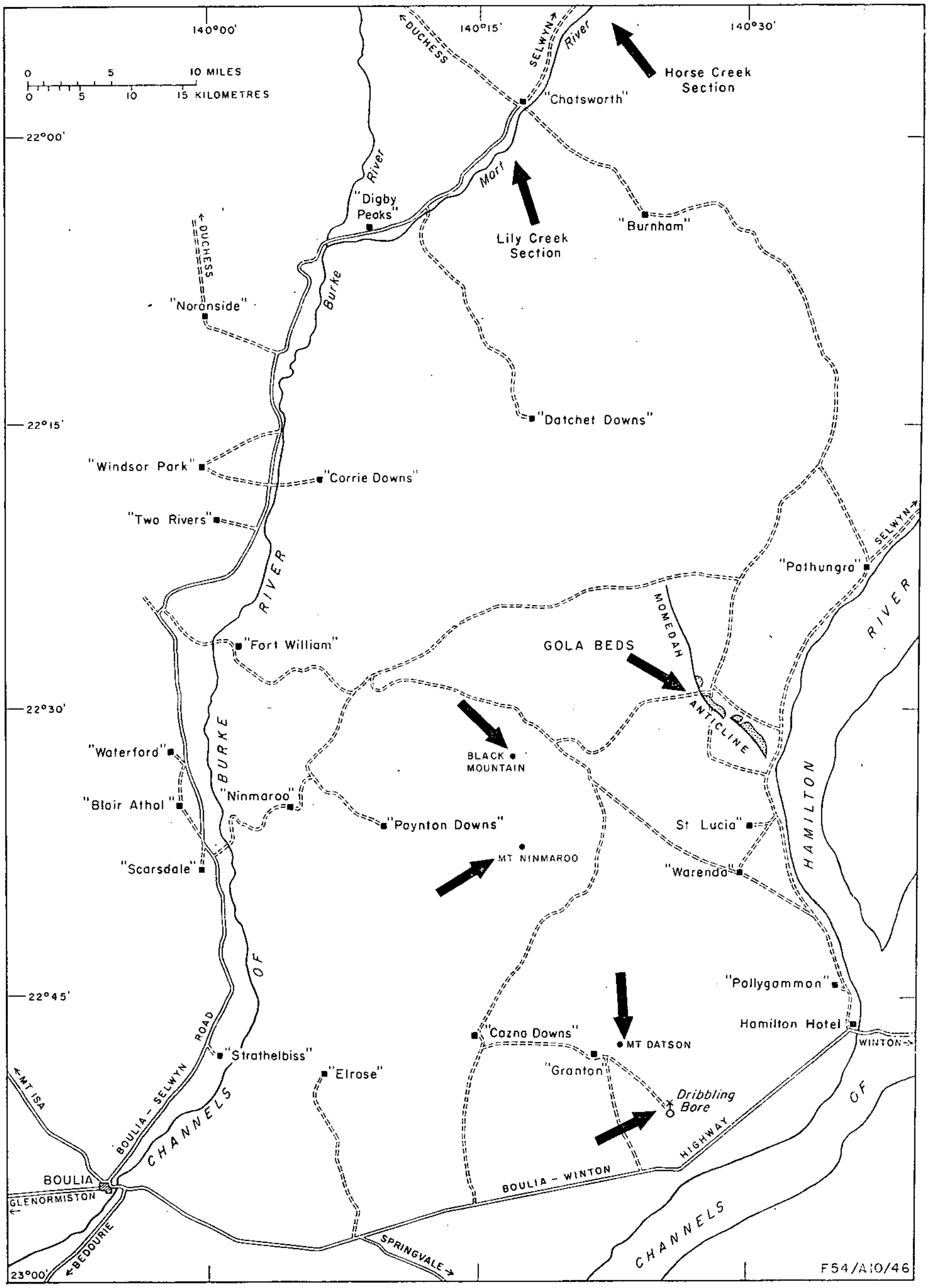

Fig. 2. Location of Late Cambrian and Early Ordovician sections in the Boulia district and Late Cambrian sections in the vicinity of Chatsworth.

River Structural Belt continues from Dribbling Bore south and south-southeast towards Springvale; its course is marked by lines of mud springs.

Cambrian and early Ordovician sediments spread far beyond the present outcrop and probably covered at one time the whole of the Georgina Basin. Post-Ordovician, pre-Mesozoic movements caused the fragmentation of the outcrop revealed by present-day denudation of Cretaceous and Tertiary sediments (Casey et al., 1960). The area has also been disturbed by late Cretaceous and Tertiary movements. A more detailed account of the geological history of the area is given by Casey (1968) and Smith (1972).

DESCRIPTION OF SECTIONS

The four lithological units discussed are the Chatsworth Limestone (*sensu stricto*), 'Chatsworth Limestone', Ninmaroo Formation, and Gola Beds. The concepts of these units in the Burke River area have been discussed by Jones, Shergold, & Druce (1971). Following these authors the Ninmaroo Formation is subdivided into four informally designated members: from the base upwards, the variegated limestone/dolomite member, the breccia member, the encrinite member, and the laminated dolomite member. Until the exact age of the Chatsworth Limestone (*s.s.*) in its type area around Chatsworth homestead is known, and its rock types described, it is necessary to distinguish it from limestones, previously classified as Chatsworth, that occur in the sections under consideration. Limestones in these sections are therefore referred to as 'Chatsworth Limestone'.

In describing the conodont assemblages of sections in the Burke River area, Druce & Jones (1971) have given a brief account of the lithological successions, and the Black Mountain section has been discussed in further detail by Jones et al. (1971). A generalized account of the lower Ninmaroo Formation is given below with some additional information from the measured sections. 'Chatsworth Limestone' is discussed in detail as it contains the bulk of the trilobites described in this paper. Brief petrological descriptions of some of its rocks are given in Appendix A. The descriptive terminology is largely that of Folk (1959), except on the text-figures, where generalized terms such as calcarenite are used. The previously published maps of Jones et al. (1971) are reprinted as Figures 3 and 6.

BLACK MOUNTAIN (Lat. 22°32′S, Long. 140°16′48″E)

Black Mountain, which is shown on some earlier maps as Unbunmaroo, lies 58 km northeast of the township of Boulia on the pastoral holding known as Old Goodwood. Access is gained from the Boulia-Winton Highway, by station tracks to Cazna Downs homestead, and from there northwards on a track cut by Phillips Petroleum Co. in 1962. It can also be reached from the Boulia-Selwyn Road through the properties of Fort William or Corrie Downs.

Black Mountain is a prominent topographical feature, rising to 388 m O.D., about 180 m above the surrounding plain. It is basically a pericline with structural complication at its northern end, which has been axially bisected by the Black Mountain Fault system. This fault has a throw of 450 m to the east, bringing Ninmaroo Formation against 'Chatsworth Limestone'.

Fig. 3. Geology of the Black Mountain and Mount Ninmaroo inliers, showing lines of section sampled.

'Chatsworth Limestone'

'Chatsworth Limestone', 435 m thick, is preserved in the core of the periclinal structure, forming two large east-facing escarpments. Previous accounts of the lithological sequence are summarized on the accompanying section (Fig. 4). Five lithological divisions can be recognized, of which only the uppermost occurs on other sections.

The lowest 129 m of section (Fig. 4, unit 1) is composed of 'marl', micrite, and sparite in thin alternating layers averaging 15-25 cm in thickness. The sparite layers (skeletal calcarenite) lack mud, but contain a preponderance of fossil debris, concentrations of peloid material, and, occasionally, fine quartz sand. Bioclasts, though fragmented, show few signs of abrasion and seem unlikely to have travelled far. The micrite layers (lime mud), many of which are very shelly, may also contain quantities of peloids and quartz sand, and sometimes mud clasts. The bioclasts may be strongly oriented. The biosparites have yielded the bulk of the trilobite material collected from this unit: in all 30 taxa are described.

Unit 2 (Fig. 4), 42 m thick, is composed of similar rocks, sparite predominating, particularly at the top of the unit. Unit 2, however, is distinguished by the occurrence of chert, replacing spar matrices, or within 'marly' intervals as nodules or platy layers; a little pyrite also occurs. The layers alternate as in unit 1. The sparites in particular are highly fossiliferous: 25 trilobite taxa are recorded in unit 2, among which are 7 species of pelagic Agnostina.

Unit 3, occupying the interval of section between 173 and 238.5 m, is characterized by the preponderance of micritic sediment over sparite. Thin, or flaggy-bedded, cross-laminated micaceous and silty limestone (0.6-5.00 cm thick) alternates with equally thin shale or silt partings, in the approximate proportion of 3:2. Layers of mottled limestone occur occasionally in the upper beds. The micrites are frequently of silt-grade carbonate, often with thin laminae of sparite, and containing up to 30 percent of silt-sized quartz. Some layers contain mud clasts and peloids; others are partly silicified, but silicification is not prevalent. Compared with the underlying unit, the trilobite fauna is impoverished, both in numbers of taxa recognized (10) and individuals recovered.

Unit 3 grades upwards into unit 4 (Fig. 4), 34 m thick, a sequence of micrite and sparite which forms the capping of the innermost escarpment feature of the Black Mountain structure. The rocks are cliff-forming; and compared with the previous unit are thickly bedded. Only 3 trilobite taxa were recovered from this division.

Overlying limestone, between 272.5 and 435 m, is predominantly sparite, often richly fossiliferous, sandy, sometimes laminated, and containing peloids and elongated, current-aligned mud intraclasts. Cross-lamination, ripple marks, and scour-and-fill structures have been noted on the line of section. Accumulations of fossil debris form characteristic coquinas. Micrites contain many angular mud laths, as well as elongated rounded clasts. All samples from the uppermost 76 m of unit 5 contain some dolomite, the proportion increasing upwards to culminate in the calcareous dolomite unit (6a, Fig. 4) which lies at the base of the Ninmaroo Formation. All these rocks occur as thin layers (15-30 cm thick), which are grouped into beds (up to 9 m thick) separated by rather thinner predominantly 'marl' units.

In 1962 Phillips-Sunray drilled Black Mountain No. 1 well, commencing in Chatsworth Limestone (*sensu lato*). Scme 177.5 m of this unit was drilled, most of which lies below the exposed sequence in the Black Mountain pericline. The Chatsworth Limestone (*s.l.*) was described as 'light grey, grey to buff, crypto- to microcrystalline, argillaceous, silty in part, glauconitic in part; with interbedded grey to dark grey micaceous, calcareous shale' (Green et al., 1963). No diagnostic trilobites were recovered from the Chatsworth Limestone part of the core (Gilbert-Tomlinson, 1963). Below the Chatsworth Limestone in the borehole a 'dark grey, very micaceous, silty, slightly calcareous [shale] with fine laminations of brownish grey calcareous siltstone' (Green et al., 1963), 48.7 m thick, was drilled. This was correlated with the O'Hara Shale, which occurs below the Chatsworth Limestone (*sensu stricto*) in its type area near Chatsworth homestead. Below this shale came 246 m of limestone, referred to the Pomegranate Limestone. Gilbert-Tomlinson (1963) recovered a species of *Proceratopyge* from this unit, which provides the only tentative date (early Upper Cambrian, Idamean) for the initial 312 m of core.

Ninmaroo Formation

The thickness of the Ninmaroo Formation is assessed at 958 m, of which only the basal part, of Cambrian age, is shown in Figure 4. As mapped originally in 1957, the lower boundary of the Ninmaroo Formation was drawn at the base of a prominent dolomitic unit (6a in Fig. 4), 13.5 m thick, which forms the summit of Black Mountain. This unit also forms the base of the variegated limestone/dolomite member described by Jones, Shergold, & Druce (1971), and forms *in toto* member 1 of Brown (1961) and Druce & Jones (1971), and unit 1 of Casey (1968).

A wide variety of carbonate sediments occurs in the variegated limestone/dolomite member. They range from dolomite, through laminated micrite and fine biosparite with micrite clasts, to pelleted biosparite, oosparite with grapestone clasts and evidence of algal binding, and pebble conglomerate. Ellipsoidal chert stringers and nodules occur at various levels. The dominant lithology in the lower part of the member is, however, dolomite and dolomitized mottled micrite. The trilobite fauna is extremely sparse; brachiopods, ribeirioids, cephalopods, benthonic molluscs, and conodonts are the dominant elements of the biota.

No trilobites were obtained from the overlying breccia member, which occupies the Black Mountain section between 823 and 959 m from its base (not shown in Fig. 4). Fragments of ?*Asaphellus* sp. were, however, collected from two horizons in the succeeding encrinite member, in flaggy cross-laminated biosparites in the interval 971-1001 m from the base of the measured section. Trilobites were also collected from the overlying laminated dolomite member 1137 m from the base of the section, and in subsequent horizons between 1145 and 1173 m. These trilobites, of Warendian age, are presently under study by Miss Joyce Gilbert-Tomlinson (BMR).

MOUNT NINMAROO (Lat. 22°37′24″S, Long. 140°17′30″E)

Mount Ninmaroo is a topographical feature lying on Old Goodwood pastoral holding, 10 km at 165° from Black Mountain (Fig. 3), and 51 km at 50° from Boulia (Fig. 2). The section can be reached by the same routes as those taken for Black Mountain.

The outcrops of Mount Ninmaroo are continuous to the north of the inlier with those of Black Mountain. The structure of Mount Ninmaroo is also periclinal, and the faulting is a southerly continuation of that at Black Mountain (Fig. 3). Dip-slopes extend westwards for up to 5.6 km, and 780 m of carbonates crops out before they are concealed below post-Warendian Swift Beds and Cretaceous strata.

A thickness of 82 m of 'Chatsworth Limestone' was measured in the core of the Mount Ninmaroo structure along the line of section shown in Figure 3. As at Black Mountain, the formation forms the main escarpment face of the structure. The limestones constituting the formation are dominantly sparites, characteristically containing abundant peloids. These pelsparites are often sandy, and may contain micrite clasts. Dolomitization occurs in most of the samples examined, but is often confined to the sandier laminae. These rocks, whose individual layers are no thicker than 30 cm, commonly form groups of beds 6-9 m thick, which alternate with 'marly' intervals. The lithological succession is generalized in Figure 5. All the trilobites described in this Bulletin from Mount Ninmaroo are from the 'Chatsworth Limestone'.

The base of the Ninmaroo Formation, as elsewhere in the area, is marked by the occurrence of dolomite (unit 6a, Fig. 5). At Mount Ninmaroo, however, only 10 km from Black Mountain, the dolomitic interval has thickened to 76 m.

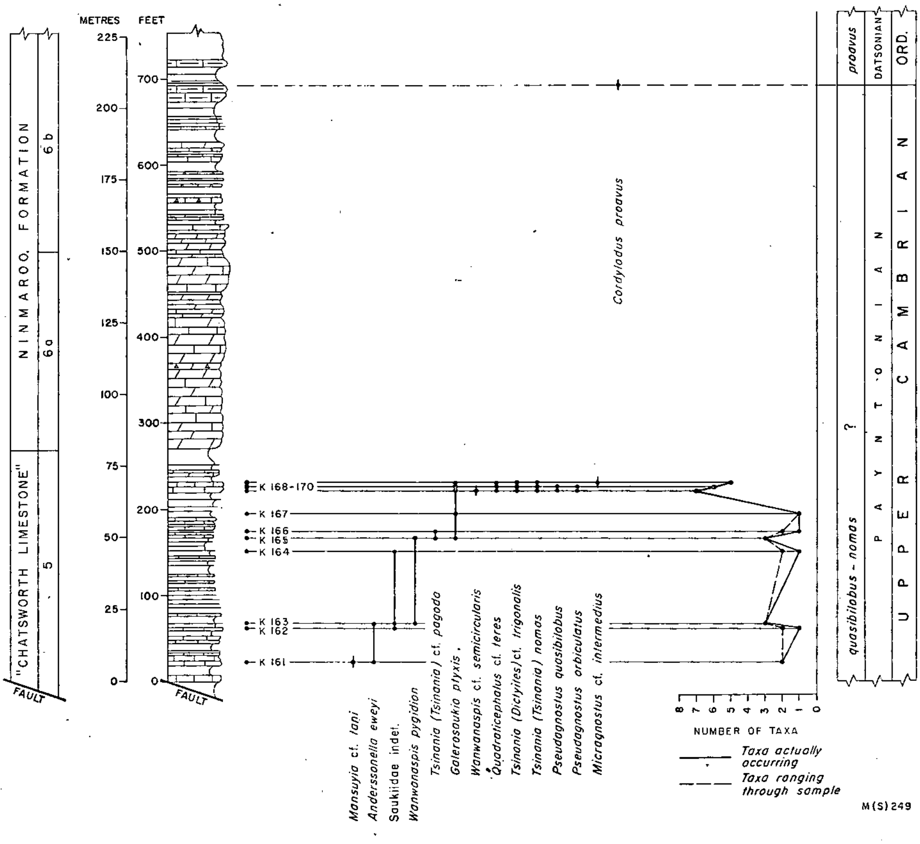

Fig. 5. Stratigraphical analysis of the Mount Ninmaroo section. The lithological key is the same as that for Fig. 4.

Its basal division consists of 6 m of cross-laminated dolomite. Brecciation has been observed 27 m from its base, and the remainder of the unit is flaggy-bedded between 45 and 54 m and 66 and 76 m from the base of the member. This dolomite is succeeded by mottled aphanitic micrite and breccia, which constitutes the remainder of the variegated limestone/dolomite member, whose total thickness is 339 m at Mount Ninmaroo (unit 6b, Fig. 5). No trilobites were collected from unit 6b, or from either of the overlying members, the breccia member 163 m thick on Mount Ninmaroo or the encrinite member 171 m thick. They recur at the base of the laminated dolomite member, however, within the interval 708-725 m from the base of the measured section, and about 12 m above a prominent 'birds-eye' limestone at the top of the encrinite member.

MOUNT DATSON (Lat. 22°47′26″S, Long. 140°22′50″E)

Mount Datson (Fig. 6) is an isolated hill whose summit lies 2.8 km east-northeast of Granton homestead, on the pastoral holding of Granton. It is 51 km at 075° from Boulia, and 29.5 km at 159° from Black Mountain. Access is gained via Granton homestead from the Boulia-Winton Highway.

Mount Datson is the northwest quadrant of a pericline axially bisected by a north-northwest fault system which apparently continues to the south-southeast through Dribbling Bore. The extensive dip-slope topography seen at Black Mountain and Mount Ninmaroo has much lower relief at Mount Datson, and the Lower Palaeozoic succession has more limited areal extent, being partly obscured by Tertiary cover. Nevertheless, a total sequence approaching 840 m is measurable at the northern end of the structure.

'Chatsworth Limestone' (Fig. 7), 211 m thick, preserved in the core of the Mount Datson structure, consists dominantly of sandy sparite. As at Mount Ninmaroo, most samples examined from the lower part of the sequence are characterized by an abundance of peloid material. Some biopelsparites contain micrite clasts, or clasts of previously formed biopelsparite. Towards the top of the sequence, in the uppermost 45 m, biosparites become dolomitized, the dolomite being mainly disseminated through the sandier laminae. Although individual layers may be no thicker than 30 cm, they are generally grouped into beds up to 11 m thick on the Mount Datson section.

A cross-laminated calcareous dolomite unit 6 m thick (6a, Fig. 7) marks the base of the Ninmaroo Formation and the variegated limestone/dolomite member, at 211 m from the base of the section. It is succeeded by alternating calcareous dolomite and dolomitic calcarenite for 60 m, and by massive dolomite for a further 41.5 m. In all, the dolomitic interval covers 101.5 m at Mount Datson, compared with 76 m at Mount Ninmaroo and 13.5 m at Black Mountain. The variegated limestone/dolomite member to which it belongs occupies 260 m and is thinner than in the other two sections. Trilobites occur mainly in the upper levels of the 'Chatsworth Limestone' and, rarely, in sparite interbeds within the dolomitic unit (6a) which marks the base of the Ninmaroo Formation.

The succeeding breccia member, 72 m thick, forms the summit of Mount Datson; it consists of dark grey micrite, fine-grained bituminous and cherty sparite, pebble conglomerate, and breccia. A slumped bed occurs 371 m from the base of the section. No trilobites were recovered from this member, or from the over-lying encrinite member, 100 m thick, whose uppermost 43 m is dolomitized at

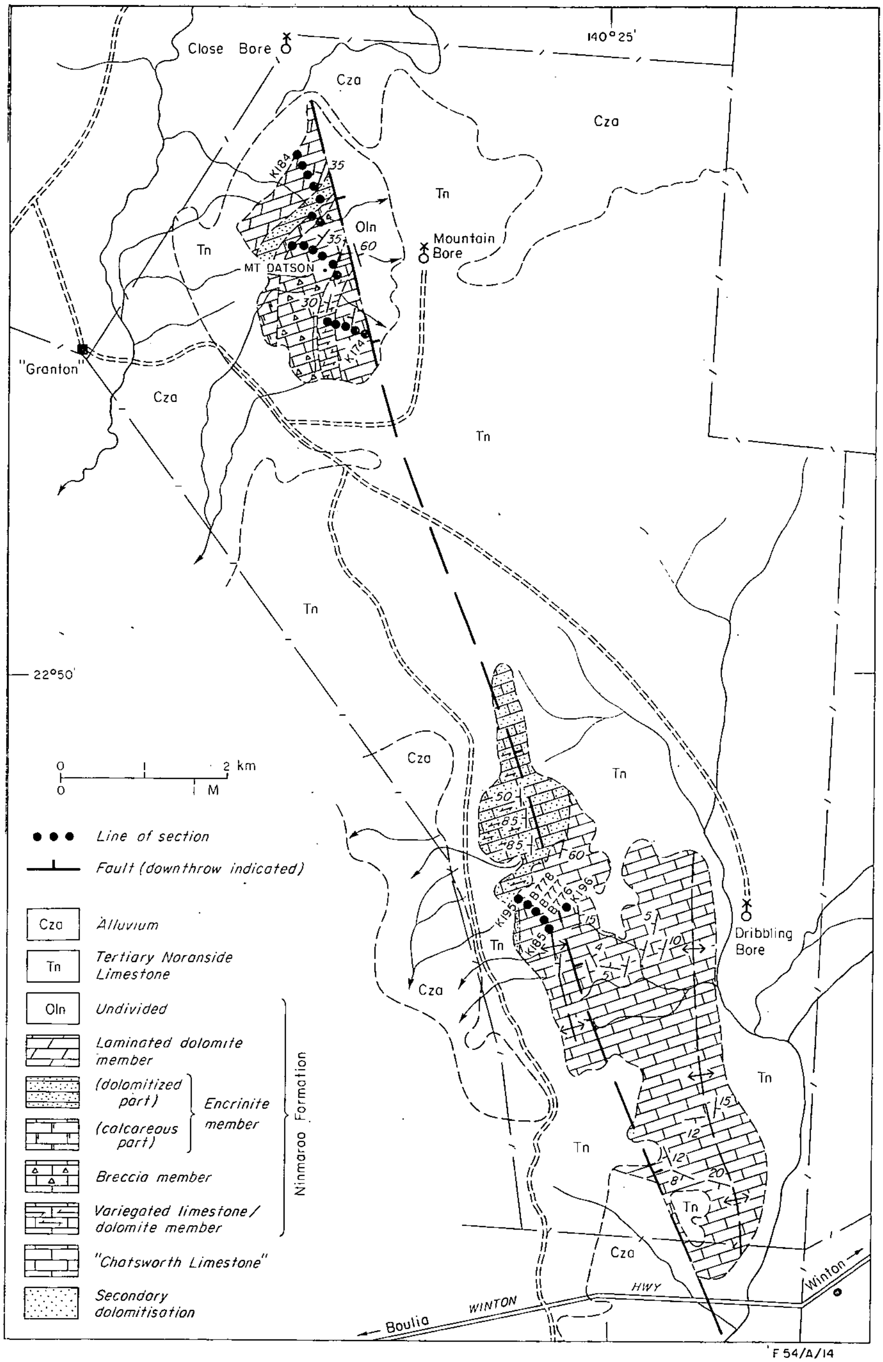

Fig. 6. Geology of the Mount Datson and Dribbling Bore inliers, showing lines of section sampled.

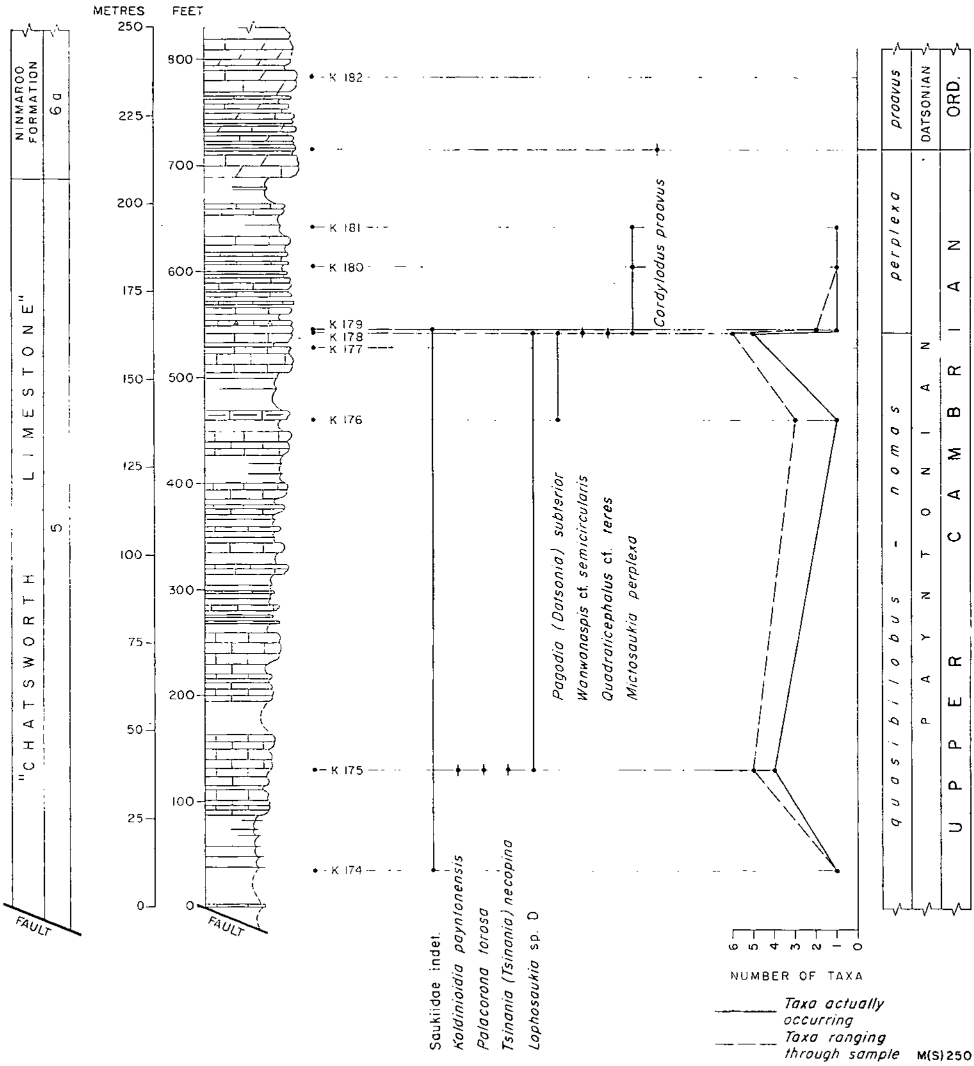

Fig. 7. Stratigraphical analysis of the Mount Datson section. The lithological key is the same as that for Fig. 4.

Mount Datson. Trilobites recur in the succeeding laminated dolomite member, from slumped and brecciated beds 653 and 695 m from the base of the measured section. These trilobites, of Warendian age, are not described in this Bulletin.

DRIBBLING BORE (Lat. 22°52′S, Long. 140°26′30″E)

Outcrops near Dribbling Bore form a low compound north-south ridge about 7 km southeast of Granton homestead, on the property of Granton. The ridge is flanked to the east by a broad limestone pediment which extends to Dribbling Bore. The bore, lying on a line of mud springs, lies at the eastern edge of the outcrop area, and is the only geographical reference point. It lies 54 km at 080° from

Boulia, 37 km at 159° from Black Mountain, and 4 km north of the Boulia-Winton Highway, which provides the access route.

The Dribbling Bore inlier (Fig. 6) has low relief and is encircled by Tertiary sediment and alluvium. The rocks forming the low ridges on its western flank are anticlinal and are separated by north-northwest faulting from a pediment of synclinal strata to the east. Outcrops to the east of the fault line consist solely of 'Chatsworth Limestone', whereas those to the west probably include the basal beds of the Ninmaroo Formation.

'Chatsworth Limestone' at Dribbling Bore (Fig. 8) has an estimated thickness of 200 m. Two lithological divisions can be recognized. At the base of the section, unit 5a, 45 m thick, is dominantly micritic, comprising poorly sorted biomicrites, possibly of algal origin, in the lower 30 m, and biopelsparites with biopelmicrite intraclasts in the upper layers. As at Mount Datson, these rocks are generally grouped into massive beds 6-9 m thick. Unit 5a has provided by far the largest trilobite fauna of the Dribbling Bore section.

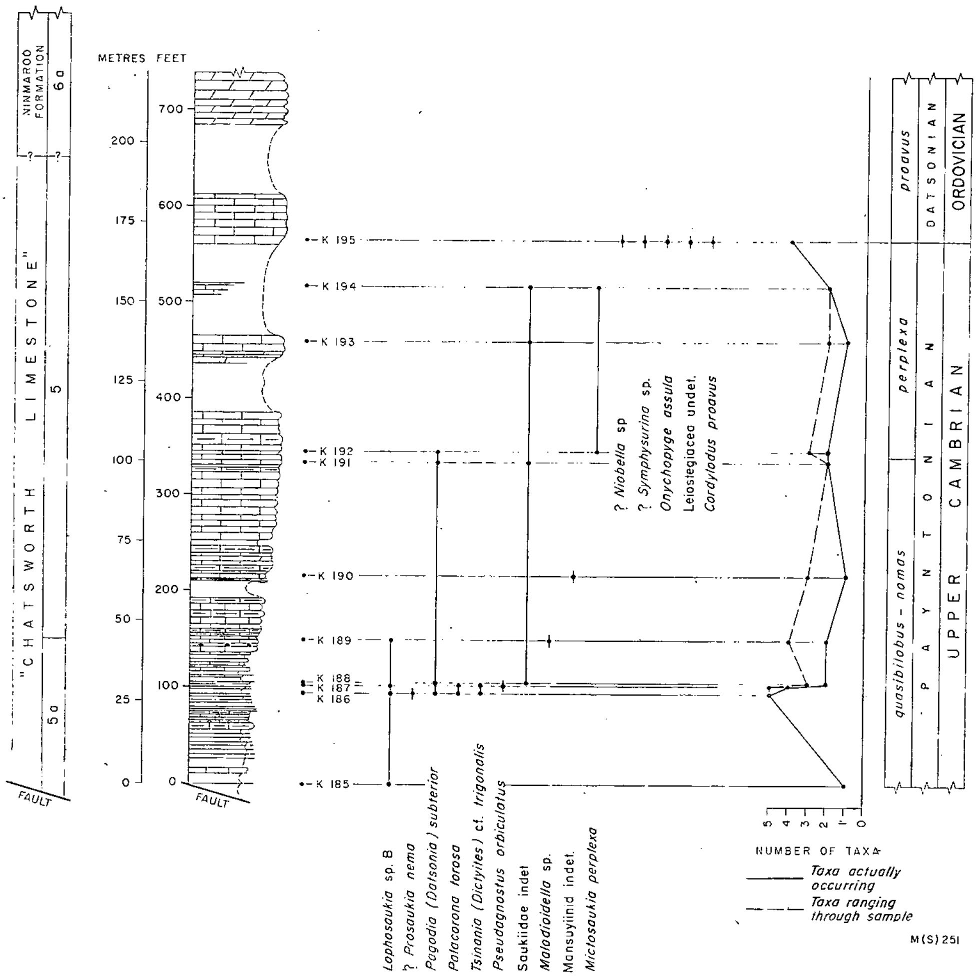

Fig. 8. Stratigraphical analysis of the Dribbling Bore section. The lithological key is the same as that for Fig. 4.

The overlying unit 5 has an estimated thickness of 150 m and is composed predominantly of sparite, characteristically pelleted. Much of the pelsparite is sandy, with dolomitized laminae, and generally contains few bioclasts. Intraclastic biosparite and biopelsparite occur at the top of the succession, the clasts consisting of laminated pelsparite, pelmicrite, and micrite. These rocks may also be dolomitized. In one place (horizon K193) a biolithite occurs, in which bioclasts are bound by micrite of presumed algal origin. Trilobites are found rarely in unit 5, whose faunas occur in intraclastic biosparite and biopelsparite.

The passage into the dolomites of the Ninmaroo Formation, unit 6a (Fig. 8), is obscured by intervals of no outcrop, and secondary dolomitization which affects various horizons at the top of the 'Chatsworth Limestone' at the northern end of the inlier.

Momedah Creek

Momedah Creek is the nearest geographical reference point to two small discontinuous outcrops of late Cambrian limestone straddling the pastoral properties of St Lucia and Pathungra, 77 km northeast of Boulia, and 19 km east-northeast of Black Mountain (Boulia 1:250 000 Geological Series Sheet SF/54-10). Cambrian rocks in the vicinity of Momedah Creek have been informally designated as Gola Beds (Casey, 1959, p. 32; Öpik, 1960, p. 100), and have been described in detail by Shergold (1972).

The dominant rock type is a blue or brownish grey silty pelsparite (calcisiltite) which contains a predominantly agnostid-asaphacean-remopleuridacean faunal assemblage. At intervals, thin layers of pale or greenish grey coarse-grained glauconitic biosparite (calcarenite) are interbedded, which are composed entirely of chaotically oriented fossil debris, peloids, ooliths, sand, and frequently intraclasts composed of laths of laminated recrystallized micrite. This rock, which contains a similar faunal assemblage to that preceding, has also yielded the bulk of the Kaolishaniidae known from the Momedah Creek section. Initially these faunal distinctions were considered to represent two overlapping faunal assemblages, but it is now thought that the agnostid-asaphacean-remopleuridacean one probably represents an autochthonous assemblage deposited in a deep subtidal environment, and that the predominantly kaolishaniid assemblage is allochthonous, having been flushed from shallow subtidal or intertidal environments on neighbouring carbonate banks by periodic turbulent currents.

BIOSTRATIGRAPHY

Zones

In the interval of latest Cambrian to earliest Ordovician time represented by the sections studied, the oldest faunas are observed at Black Mountain and the youngest ones, to the datum of the Cambrian-Ordovician boundary, at Mount Datson and Dribbling Bore. Fortunately, lower and upper parts of the available sequences can be linked together through measured sections at Mount Ninmaroo. Faunas from the Gola Beds (Shergold, 1972) are now thought to be contemporaneous with those occupying the shallower-water environment on the Black Mountain section, 180-240 m from its base.

The biostratigraphical zones proposed below are categorized as assemblage-zones based on the temporal ranges of trilobite taxa, that is, they are associations of species delineated by the overlapping ranges of the taxa shown on the charts Figures 4, 5, 7, and 8. The recognized assemblage-zones are thus formed by the concurrent ranges of selected taxa, and may also include the local range-zone or even biozone of others, as is evident from Figure 4. To confirm the initial subjective division of the biostratigraphical sequence at Black Mountain the occurrence of trilobite taxa throughout the collected samples was analysed for degree of association, utilizing cluster techniques. As a result seven successive biostratigraphical assemblage-zones are recognized and named below. In descending order they are:

7. *Mictosaukia perplexa* A.-Z.
6. *Pseudagnostus quasibilobus-Tsinania nomas* A.-Z.
5. *Sinosaukia impages* A.-Z.
4. *Pseudagnostus clarki maximus-Pseudagnostus papilio* A.-Z.
3. *Pseudagnostus bifax-Pseudagnostus denticulatus* A.-Z.
2. *Pseudagnostus clarki prolatus-Caznaia sectatrix* A.-Z.
1. *Pseudagnostus clarki patulus-Caznaia squamosa* A.-Z.

The name-giving taxa have been chosen to combine, as far as possible, trilobites of families representative mainly of carbonate belt and outer detrital belt environments (Palmer, 1960b, 1968, 1971a, 1971b, for terminology) on the one hand (Pseudagnostinae) and carbonate belt and inner detrital belt environments on the other (Saukiidae, Tsinaniidae) in the hope that associations from any of these environments elsewhere in Australia may be classified within the scheme.

Cluster analysis techniques

Binary coefficients, based on presence or absence of species in samples, and clustering techniques are becoming widely used in biostratigraphical palaeozoogeographical investigations. The techniques and background data for the dendrograms produced in this Bulletin are explained in recent papers by Melo & Buzas (1968), Cheetham & Hazel (1969), and Hazel (1970, 1971), and have been applied to the distribution and content of selected Upper Cambrian trilobite zones by Rowell & McBride (1972a,b).

The analysis of the relationships of taxa to samples on the Black Mountain section was undertaken at the instigation of J. E. Hazel (USGS). Both Q- and R-mode techniques were employed and the resulting cluster dendrograms are illustrated below. The Q-mode dendrogram (Fig. 9) is a pictorial representation of samples related to each other on the basis of the species they contain, and is the result of calculation of the Dice Similarity Coefficient, $\frac{2C}{N_1 + N_2}$, where C is the number of species in common between two samples, and N_1 and N_2 are the number of species in the two samples. The Dice Similarity Coefficient was preferred because of its intermediate characteristics, other available coefficients, e.g. Jaccard, tending to emphasize differences, and the Simpson emphasizing similarities. The chosen coefficient is a modification of the Jaccard Coefficient giving matches among compared samples twice the weight of mismatches (see Hall, 1969, p. 322; Hazel, 1970, p. 3239). In this example 79 taxa from 42 sampled horizons (K103-K144) were related. The dendrogram shows three clusters of low degree of association (A-C) related above the 0.03 phenon line, and five clusters basically of high degree of association (1-5) related above the 0.45 phenon line. These clusters form the basis for the distribution of the assemblage-zones proposed in this paper. As discussed below, however, the limits of the proposed zones and clusters may not always correspond, as non-quantifiable information has also been considered in the zonal delineation. The three low-degree clusters (A-C) are interpreted under the section on stages.

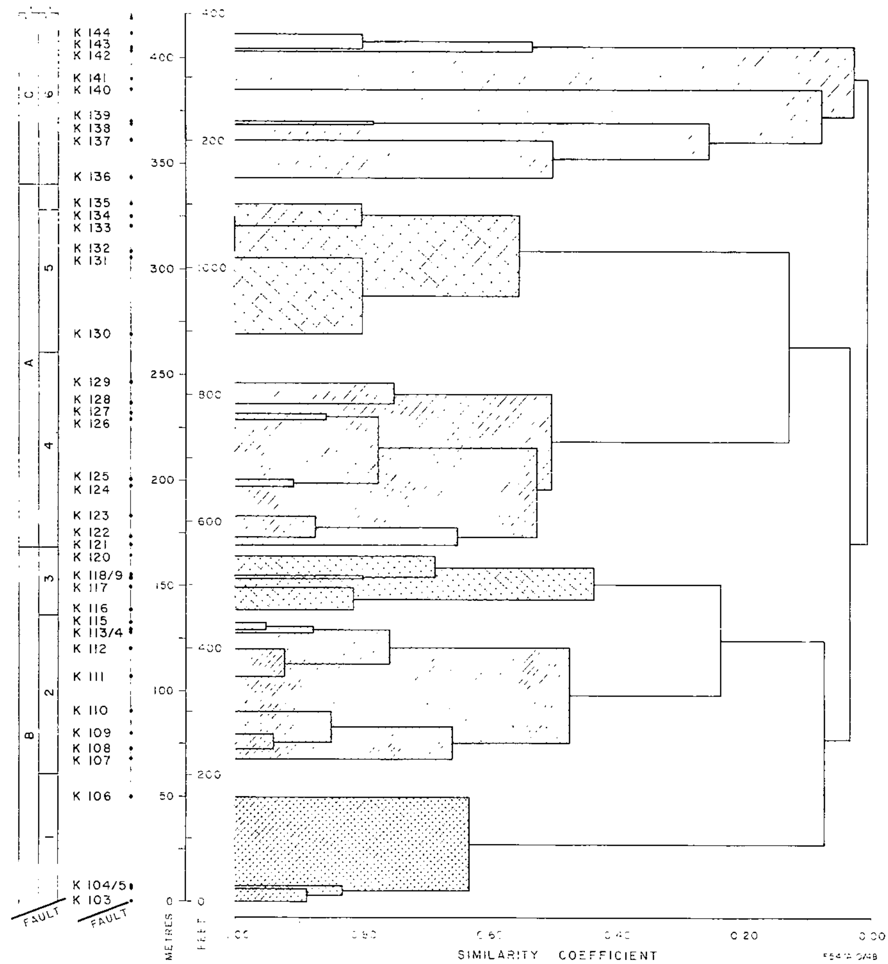

Fig. 9. Q-mode analysis of Black Mountain biostratigraphy, 79 species X 42 horizons, Dice Similarity Coefficient (unweighted pair-groups).

The R-mode dendogram (Fig. 10) is the result of relating species to each other on the basis of samples in which they occur. Samples containing a single taxon, and taxa occurring in only one sample, were discarded, so that the dendrogram is based on 54 species from 40 horizons. The technique clusters those species which are responsible for the Q-mode dendrogram. Six trilobite faunas are clearly distinguished, and these are the associations which characterize the assemblage-zones recognized.

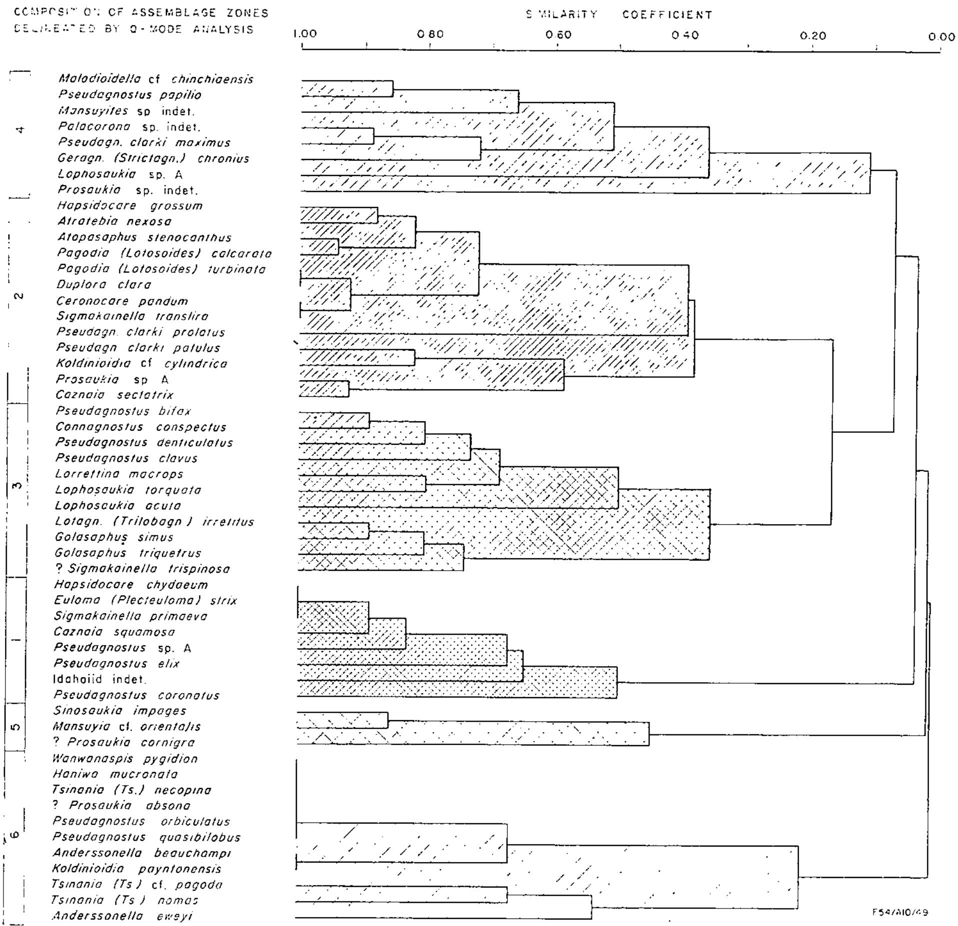

Fig. 10. R-mode analysis of Black Mountain biostratigraphy, 54 species X 40 horizons, Dice Similarity Coefficient (unweighted pair-groups).

In one instance the limits of the Q-mode clusters and the proposed zones differ. This is because the analysis techniques are rigorously objective: samples or species are forced into clusters on the basis of information supplied. The R-mode analysis compares the association of species over their established ranges on a single section and cannot take into consideration knowledge of extended ranges elsewhere, nor can it satisfactorily cluster taxa occurring in a single sample as there is no basis for comparison. Too much weight is possibly placed on presence and insufficient on absence.

The fauna of sample K135 is critical in the scale of biostratigraphical events on the Black Mountain section. It contains three taxa, one ranging upwards from below and terminating, one ranging through, and one confined to the sample, which, under the conditions of the technique utilized, was discarded for the R-mode analysis. Thus two-thirds of the sample have affinity with the faunas of earlier horizons and one-third with later ones, and accordingly the Q-mode analysis clusters the sample with those preceding rather than those following. A subjective division of the biostratigraphical succession would classify sample K135 with later faunas because one of its three species is the first representative of the Family Tsinaniidae, whose acme occurs in supradjacent beds. The species was accorded importance by Jones, Shergold, & Druce (1971) in defining the base of the Payntonian Stage, whose main criterion for recognition is the incoming and diversification of the tsinaniid faunas. Species representative of the family as defined below are confined on present knowledge to this stage. Unfortunately, being of solitary occurrence in K135, the tsinaniid species was discarded for R-mode analysis. The technique can place no weight at all on this occurrence, which is known nonetheless to be of considerable importance. While the cluster techniques would place a division (corresponding in this case to a stage boundary) between K135 and K136 because of the limited data supplied, the boundary is actually placed below K135 on non-quantifiable subjective information. The interpretation of the clusters drawn in Figures 9 and 10 is considered further below.

Definition of the Assemblage-Zones

Assemblage-Zones 1-3, *Pseudagnostus clarki patulus* with *Caznaia squamosa* to *Pseudagnostus bifax* with *P. denticulatus,* are known at the present time only from the Black Mountain section, although it is possible that one or more are represented by the higher faunal horizons of the Chatsworth Limestone (*s.s.*) in its reference area. Assemblage-Zone 4, *Pseudagnostus clarki maximus* with *P. papilio,* is known both from Black Mountain and from the sections at Momedah Creek. Assemblage-Zone 5, *Sinosaukia impages,* again is known only from Black Mountain, but Zone 6, *Pseudagnostus quasibilobus* with *Tsinania nomas,* occurs on all sections except Momedah Creek. Assemblage-Zone 7, *Mictosaukia perplexa,* is mainly known from sections at Mount Datson and Dribbling Bore, but there is also some evidence for its presence at Black Mountain. The lines separating Assemblage-Zones 6 and 7 in Figures 4 and 5, 7 and 8, are somewhat arbitrary owing to poor recovery of trilobite faunas in the latest Cambrian of western Queensland. Lines placed between other biostratigraphical divisions are drawn at the incoming of characteristic faunal assemblages. Intervals of rock without recorded fauna and falling between designated assemblages, interzones, are tabulated on Figure 11.

Assemblage-Zone of *Pseudagnostus clarki patulus* with *Caznaia squamosa,* the *patulus-squamosa* A.-Z.

The base of this assemblage-zone is not seen on the Black Mountain section because of faulting. It may occur, however, in the Chatsworth Limestone (*sensu stricto*) at Lily Creek, 61 km to the north.

Fifteen species occur in the assemblage-zone:

Pseudagnostus clarki patulus
Pseudagnostus coronatus
Pseudagnostus elix
Pseudagnostus sp. A
Pseudagnostus sp. B
Caznaia squamosa
Ceronocare sp.
Euloma (*Plecteuloma*) *strix*
Hapsidocare chydaeum
Koldinioidia cf. *cylindrica*
Mendosina sp.
Pagodia (*Pagodia*) sp.
Sigmakainella primaeva
Wuhuia cf. *W. dryope*
Indeterminate idahoiid

ASSEMBLAGE-ZONE	BLACK MOUNTAIN	MOUNT NINMAROO	MOUNT DATSON	DRIBBLING BORE
proavus				K 195
	Faunal passage unseen		[18 m (60')]	[14 m (45')]
perplexa	K 145 109 m (358') ?		K 181 30 m (100') K 178	K 194 56 m (185') K 192
	Faunal passage unseen	Faunal passage unseen	[5 m (15')]	[3 m (10')]
quasibilobus - nomas	K 144 82 m (268') ? K 135	K 170 63 m (208') K 161	K 177 151 m (495') K 174	K 191 102 m (335') K 185
	[6 m (20')]	Faulting	Faulting	Faulting
impages	K 134 57 m (187') K 130			
	[25 m (71')]			
maximus - papilio	K 129 78 m (255') K 121			
	[7 m (23')]			
bifax - denticulatus	K 120 24 m (80') K 116			
	[6 m (20')]			
prolatus - sectatrix	K 115 66 m (216') K 107			
	[18 m (58')]			
patulus - squamosa	K 106 51 m (166') K 103			
	Faulting			

F54/A10/50

Fig. 11. Intervals of rock assigned to proposed Assemblage-Zones, and thicknesses of Interzones (bracketed).

From the R-mode analysis eight taxa are considered to characterize the assemblage. These species, having a high degree of association, are:

Pseudagnostus coronatus	*Euloma (Plecteuloma) strix*
Pseudagnostus elix	*Hapsidocare chydaeum*
Pseudagnostus sp. A	*Sigmakainella primaeva*
Caznaia squamosa	Indeterminate idahoiid

Conodont trough samples 0-9 of Druce & Jones (1971) fall within the limits of the *patulus-squamosa* A.-Z., and yielded the following species:

Furnishina furnishi	*Oneotodus tenuis*
Furnishina primitiva	*Westergaardodina bicuspidata*
Furnishina rotundata	

The *patulus-squamosa* A.-Z. embraces faunas collected from horizons K103-K106, occurring in an interval of rock 51 m thick.

Assemblage-Zone of *Pseudagnostus clarki prolatus* with *Caznaia sectatrix,* the *prolatus-sectatrix* A.-Z.

In the Black Mountain section the *prolatus-sectatrix* A.-Z. contains twenty taxa:

Pseudagnostus bifax	*Hapsidocare grossum*
Pseudagnostus clarki patulus	*Koldinioidia* cf. *cylindrica*
Pseudagnostus clarki prolatus	*Lophosaukia torquata*
Pseudagnostus sp. C	*Lorrettina macrops*
Atopasaphus stenocanthus	*Pagodia (Lotosoides) calcarata*
Atratebia nexosa	*Pagodia (Lotosoides) turbinata*
Caznaia sectatrix	*Pagodia (Oreadella)* cf. *buda*
Caznaia squamosa	*Prosaukia* sp. A
Ceronocare pandum	*?Richardsonella* sp.
Duplora clara	*Sigmakainella translira*

Ranging upwards from below are the species *Pseudagnostus clarki patulus, Caznaia squamosa,* and *Koldinioidia* cf. *cylindrica,* which in association with *Atopasaphus stenocanthus, Atratebia nexosa, Caznaia sectatrix, Ceronocare pandum, Duplora clara, Hapsidocare grossum, Pagodia (Lotosoides) calcarata, P. (L.) turbinata, Prosaukia* sp. A, and *Sigmakainella translira* are indicated by R-mode analysis to form a significant assemblage.

The assemblage-zone is readily recognized in the Black Mountain section by the association of *Caznaia squamosa* with *C. sectatrix* in its earliest horizon (K107), at which level *Pseudagnostus clarki patulus* is also associated.

The *prolatus-sectatrix* A.-Z. contains the following eight species of conodonts from Druce & Jones' (1971) trough samples 10-21 at Black Mountain:

Furnishina furnishi	*Oneotodus nakamurai*
Proconodontus muelleri	*Oneotodus tenuis*
Furnishina primitiva	*Westergaardodina bicuspidata*
Furnishina rotundata	Gen. et sp. indet. A

The *prolatus-sectatrix* A.-Z. is only known to occur on the Black Mountain section, where its constituents have been recognized in the faunas of horizons K107-K115 inclusive, that is, within an interval 72 m thick. The interval between the last record of the *patulus-squamosa* A.-Z. and the first record of the *prolatus-sectatrix* A.-Z. is 17.4 m.

Assemblage-Zone of *Pseudagnostus bifax* with *Pseudagnostus denticulatus*, the *bifax-denticulatus* A.-Z.

Twenty-two species occur in this zone:

Connagnostus conspectus
Lotagnostus (Trilobagnostus) irretitus
Geragnostus (Micragnostus) cf. *acrolebes*
Geragnostus (Strictagnostus) chronius
Pseudagnostus bifax
Pseudagnostus clavus
Pseudagnostus denticulatus
Atopasaphus stenocanthus
Atratebia nexosa
Ceronocare pandum
Duplora clara
Golasaphus simus
Golasaphus triquetrus
Hapsidocare grossum
Lophosaukia acuta
Lophosaukia torquata
Lorrettina macrops
Pagodia (Lotosoides) calcarata
Pagodia (Lotosoides) turbinata
Parakoldinioidia bigranulosa
Sigmakainella translira
?Sigmakainella trispinosa

About half the fauna ranges upwards from the *prolatus-sectatrix* A.-Z., including *Pseudagnostus bifax, Atopasaphus stenocanthus, Atratebia nexosa, Ceronocare pandum, Duplora clara, Hapsidocare grossum, Lophosaukia torquata, Lorrettina macrops, Pagodia (Lotosoides) calcarata, P. (L.) turbinata,* and *Sigmakainella translira.*

R-mode analysis shows that *Pseudagnostus bifax, P. clavus, P. denticulatus, Connagnostus conspectus, Lotagnostus (Trilobagnostus) irretitus, Golasaphus simus, G. triquetrus, Lophosaukia acuta, L. torquata, Lorrettina macrops,* and *?Sigmakainella trispinosa* have a high level of association and are therefore thought to characterize the assemblage-zone, which is readily recognizable from the five species of Agnostina in association.

The *bifax-denticulatus* A.-Z. includes the following ten conodont species from Druce & Jones' (1971) trough samples 22-28:

Furnishina furnishi
Furnishina primitiva
Furnishina rotundata
Furnishina tricarinata
Oneotodus nakamurai
Oneotodus tenuis
Problematoconites perforata
Proconodontus muelleri
Westergaardodina amplicava
Westergaardodina bicuspidata

The *bifax-denticulatus* A.-Z. occupies a narrow interval in the measured section at Black Mountain. Its faunas are found in sampled horizons K116-K120 inclusive, an interval of 26.5 m. A sampling interval of 6 m intervenes between the *prolatus-sectatrix* and *bifax-denticulatus* Assemblage-Zones.

The zone is known only from the Black Mountain section. Although several of its component species, *Lorrettina macrops, Lophosaukia torquata, Duplora clara, Sigmakainella translira,* and related species of *Golasaphus, Trilobagnostus, Geragnostus,* and *Atopasaphus* occur in the faunas of the Gola Beds at Momedah Creek, these latter are associated with a different suite of Agnostina and are considered younger than the *bifax-denticulatus* A.-Z.

Assemblage-Zone of *Pseudagnostus clarki maximus* with *Pseudagnostus papilio*, the *maximus-papilio* A.-Z.

The seventeen species occurring in this assemblage-zone at Black Mountain are:

Lotagnostus (*Trilobagnostus*) *irretitus*
Geragnostus (*Strictagnostus*) *chronius*
Pseudagnostus clarki maximus
Pseudagnostus clavus
Pseudagnostus papilio
Atratebia nexosa
Golasaphus simus
Golasaphus triquetrus
Lophosaukia sp. A
Maladioidella cf. *chinchiaensis*
Mansuyites spp. indet.
Palacorona sp.
Prosaukia sp. indet.
?*Protopeltura* sp.
Sigmakainella longilira
?*Sigmakainella trispinosa*
Sinosaukia impages

Of these species seven are recorded from the underlying *bifax-denticulatus* A.-Z., namely *Pseudagnostus clavus, Lotagnostus* (*Trilobagnostus*) *irretitus, Geragnostus* (*Strictagnostus*) *chronius, Atratebia nexosa, Golasaphus simus, G. triquetrus,* and ?*Sigmakainella trispinosa.*

Having a high degree of association and thus characteristic of the assemblage are: *Geragnostus* (*Strictagnostus*) *chronius, Pseudagnostus clarki maximus, P. papilio, Lophosaukia* sp. A, *Maladioidella* cf. *chinchiaensis,* and the indeterminate species of *Mansuyites, Palacorona,* and *Prosaukia.* The incidence of the two name-giving pseudagnosti in association with *Pseudagnostus clavus* characterizes the earlier part of the assemblage-zone.

The *maximus-papilio* A.-Z. contains conodonts from Druce & Jones' (1971) Black Mountain trough samples 29-42. They recorded fourteen species:

Furnishina dahlmanni
Furnishina furnishi
Furnishina primitiva
Furnishina rotundata
Furnishina tricarinata
Oneotodus gallatini
Oneotodus nakamurai
Oneotodus terashimai
Oneotodus tenuis
Problematoconites perforata
Proconodontus muelleri
Westergaardodina amplicava
Westergaardodina bicuspidata
Westergaardodina mosseburgensis

Taxa assigned to the *maximus-papilio* A-Z. are from horizons K121-K129 in the Black Mountain section, an interval of 78 m. An interzone of 7 m separates it from the preceding zone.

The *maximus-papilio* A.-Z. is also recognized in the sections at Momedah Creek. If *Pseudagnostus* spp. II and III from the Gola Beds are synonymous with *Pseudagnostus clarki maximus,* then all three of the pseudagnosti defining the earlier part of the *maximus-papilio* A.-Z. are also present at Momedah Creek. The Gola Beds also contain species of *Lotagnostus* (*Trilobagnostus*) and *Golasaphus* differing only in degree from those at Black Mountain, while *Palacorona* sp. and *Mansuyites* spp. indet. from the latter may, when better material is obtained, be referred to the Gola Beds species *Palacorona bacculata* and *Mansuyites futiliformis. Koldinioidia* cf. *cylindrica* may prove to be synonymous with *K. cylindrica, Geragnostus* (*Micragnostus*) cf. *acrolebes* with *G.* (*M.*) *acrolebes,* and *Lophosaukia* sp. A with *L. torquata.* These species, together with *Lorrettina macrops, Duplora clara,* and *Sigmakainella translira,* appear to have extended ranges in the Gola Beds. All are present in the *bifax-denticulatus* A.-Z. of the Black Mountain section. *Sigmakainella longilira* occurs in both sections during *maximus-papilio* time. Confined to the Gola Beds are species of *'Tostonia', Richardsonella, Crucicephalus,* and *Kaolishania,* and these beds are further characterized by the common occurrence of *Mendosina.* The Gola Beds also contain nine species of conodonts, eight of which, including *Proconodontus muelleri, Oneotodus gallatini,* and *Furnishina dahlmanni,* are recorded from the interval of the *maximus-papilio* A.-Z. in the Black Mountain section, where they have reasonably limited ranges. *Sagittodontus eureka* is confined to the Momedah section.

Assemblage-Zone of *Sinosaukia impages,* the *impages* A.-Z.

Only six species occur in the *impages* A.-Z.: *Sinosaukia impages* and *Mansuyia* cf. *orientalis* ranging through it; *Pseudagnostus clarki maximus* and *Geragnostus* (*Strictagnostus*) *chronius* ranging into it from below; and *?Prosaukia cornigra* and *?Wanwanaspis* sp. indet. confined to it.

R-mode analysis suggests that *Sinosaukia impages, Mansuyia* cf. *orientalis,* and *?Prosaukia cornigra* have the highest degree of association and characterize the assemblage.

Conodont trough samples 43-53 from Druce & Jones' (1971) Black Mountain section were taken within the range of the *impages* A.-Z. All proved barren, although three conodont species from the preceding *maximus-papilio* A.-Z. recur in the succeeding zone of *quasibilobus-nomas.*

Taxa from horizons K130-K134 form the assemblage-zone, which therefore occurs through 57 m of strata. An interval of 13 m separates the *impages* A.-Z. from that of *maximus-papilio.* The *Sinosaukia impages* A.-Z. is confined on present knowledge to the Black Mountain section.

Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania* (*Tsinania*) *nomas,* the *quasibilobus-nomas* A.-Z.

Twenty-four species occur in the *quasibilobus-nomas* A.-Z. in the Black Mountain section. The zone is also recognized at Mount Ninmaroo, Mount Datson, and Dribbling Bore, where a further eight species occur. In the list below provenance of the taxa is recorded as follows: 1. Black Mountain section, 2. Mount Ninmaroo section, 3. Mount Datson section, and 4. Dribbling Bore section.

Only two species, *Sinosaukia impages* (1) and *Mansuyia* cf. *orientalis* (1), forming a mere 6 percent of the total assemblage, range upwards from the *impages* A.-Z. The remaining species are:

Geragnostus (*Micragnostus*) cf. *intermedius* (1, 2)
Pseudagnostus orbiculatus (1, 2, 4)
Pseudagnostus quasibilobus (1, 2)
Anderssonella beauchampi (1)
Anderssonella eweyi (1, 2)
Galerosaukia galerita (1)
Galerosaukia ptyxis (2)
Galerosaukia sp. (1)
Haniwa mucronata (1)
Koldinioidia payntonensis (1, 3)
Lophosaukia sp. B (4)
Lophosaukia sp. C (1)
Lophosaukia sp. D (3)
Maladioidella sp. (4)
Mansuyia cf. *tani* (1, 2)
Pagodia (*Datsonia*) *subterior* (3, 4)
Palacorona torosa (3, 4)
?Prosaukia absona (1)
?Prosaukia nema (4)
Ptychaspis (*Asioptychaspis*) *delta* (1)
Quadraticephalus cf. *teres* (2, 3)
Sinosaukia sp. indet. (1)
Tsinania (*Tsinania*) *necopina* (1, 3)
Tsinania (*Tsinania*) *nomas* (1, 2)
Tsinania (*Tsinania*) cf. *pagodia* (1, 2)
Tsinania (*Dictyites*) *antidictys* (1)
Tsinania (*Dictyites*) cf. *trigonalis* (1, 2, 4)
Wanwanaspis pygidion (1, 2)
Wanwanaspis cf. *semicircularis* (1, 2, 3)
Wanwanaspis sp. indet. (1)

Eleven species have a high degree of association on the Black Mountain section and characterize the early part of the assemblage-zone:

Pseudagnostus orbiculatus
Pseudagnostus quasibilobus
Anderssonella beauchampi
Anderssonella eweyi
Haniwa mucronata
Koldinioidia payntonensis
?Prosaukia absona
Tsinania (T.) necopina
Tsinania (T.) nomas
Tsinania (T.) cf. *pagoda*
Wanwanaspis pygidion

The *quasibilobus-nomas* A.-Z. is readily recognized by its Asian Tsinaniidae, Shumardiidae, Kingstoniidae, Pagodiinae, Mansuyiinae, and Tingocephalinae, and its Remopleuridacea. The assemblage-zone contains the acme of the tsinaniids in Australia. Of the pseudagnosti, *P. quasibilobus* seems to be the more important, belonging to a group having cosmopolitan distribution and limited time span.

Conodonts are not common in the *quasibilobus-nomas* A.-Z. Seven species occur, all of which are also present in earlier trilobite assemblage-zones. At Black Mountain only three species have been recorded by Druce & Jones (1971), in trough samples 62, 64, 71, and 74: *Proconodontus muelleri, Furnishina tricarinata,* and *Oneotodus nakamurai.* Five conodont species occur in contemporaneous rocks at Mount Ninmaroo: *Proconodontus muelleri, Furnishina furnishi, F. rotundata, Oneotodus nakamurai,* and *O. tenuis.* A single species, *Furnishina primitiva,* is present in the *quasibilobus-nomas* interval on the Mount Datson section.

The early part of the *quasibilobus-nomas* A.-Z. is well documented in the Black Mountain section over the interval 335-410 m, where representative faunas occur in sampled horizons K135-K144 inclusive. An interval of 6 m separates the assemblage-zone from that preceding. Its relationship to the succeeding *perplexa* A.-Z. is obscure because of the occurrence of dolomite from which no trilobites have been recovered. At Mount Ninmaroo only the mid-part of the assemblage-zone is fossiliferous, dolomitic sediments without trilobites again interrupting the faunal sequence. Conversely, the early part of the *quasibilobus-nomas* A.-Z. is not represented at Mount Datson or Dribbling Bore. At both these localities the passage into the *Mictosaukia perplexa* A.-.Z is observable. In general, the tsinaniid faunas characterizing the *quasibilobus-nomas* A.-Z. are gradually phased out and a more or less barren interval, 45-90 m thick, intervenes before the incoming of *Mictosaukia perplexa* indicates the assemblage-zone bearing that name. At Mount Ninmaroo, the *quasibilobus-nomas* A.-Z. includes the faunas of horizons K161-170, which occur over the initial 70 m of section; at Mount Datson representatives of the assemblage-zone are present between horizons K174 and K177 within the initial 160 m of section; and at Dribbling Bore they occur in the sampled horizons K185-191 over the initial 101 m of section.

Assemblage-Zone of *Mictosaukia perplexa,* the *perplexa* A.-Z.

Only five trilobite species occur in the *perplexa* A.-Z. Three range upwards from the underlying *quasibilobus-nomas* A.-Z.: *Pagodia (Datsonia) subterior, Quadraticephalus* cf. *teres,* and *Wanwanaspis* cf. *semicircularis.* The two remaining species, *Mictosaukia perplexa* and *?Calvinella solitaria,* are confined to the zone, and *?C. solitaria* appears only in the Black Mountain section.

Conodonts are also sparse in the *perplexa* A.-Z. Trough samples from the interval of the trilobite assemblage-zone at Black Mountain (Druce & Jones 1971, sample 83) and Mount Datson (op. cit., samples 17, 19, 25, 27, 29, 31) yielded only two species, *Proconodontus muelleri* and *Oneotodus nakamurai.*

Trilobites indicative of the *perplexa* A.-Z. are known from the Black Mountain, Mount Datson, and Dribbling Bore sections. Dolomitization obscures its relationships with the *quasibilobus-nomas* A.-Z. on Black Mountain, and the presence of dolomitic sediments throughout the interval is responsible for the lack of faunal evidence from Mount Ninmaroo. At Mount Datson and Dribbling Bore the passage from the *quasibilobus-nomas* A.-Z. is sparsely fossiliferous, and the recognition of the *perplexa* A.-Z. rests on the first occurrence of the index species. By indirect correlation, using the base of the overlying *Cordylodus proavus* conodont assemblage-zone as a datum, the base of the *perplexa* A.-Z. is inferred to lie below horizon K145 in the Black Mountain section, where the zonal indicator is not yet recorded. *Perplexa* A.-Z. trilobites are limited to this single sample on Black Mountain, and are entirely unrecorded at Mount Ninmaroo. At Mount Datson, however, *perplexa* A.-Z. faunas are present in samples K178-181, occurring over an interval equivalent to 30 m, and at Dribbling Bore are present in samples K192-194 (53 m).

STAGES

In an earlier paper (Jones, Shergold, & Druce, 1971) three stages were defined in the southern part of the Burke River Structural Belt for the classification of late Cambrian and early Ordovician faunas. The oldest of these stages, Payntonian, was erected for the latest Cambrian faunas in the area and was defined on the basis of trilobites. Datsonian and Warendian Stages were designed for early Ordovician faunas and controlled by conodont sequences. These two stages were defined on the basis of already existing conodont assemblage-zones, but the zonation of the Payntonian was only loosely referred to. Early Payntonian was stated to be characterized by the acme of the trilobite family Tsinaniidae, and late Payntonian by an acme of Saukiidae. These Payntonian divisions are now more rigorously defined. The faunas of the *quasibilobus-nomas* A.-Z. constitute the early Payntonian. In the Black Mountain section early Payntonian faunas occur for the first time in sample K135, so that the base of the *quasibilobus-nomas* A.-Z. and the Payntonian Stage can be recognized within the interval of section 329-335 m from its base. Together these biostratigraphical divisions are represented by cluster C (= 6) on the Q-mode analysis dendrogram (Fig. 9; see discussion above on the clustering of K135). The low degree of association of the faunal content of samples in this part of the dendrogram is the result of a relatively slow filtering into the area of an assemblage of trilobites previously unknown to it, the association of the *quasibilobus-nomas* A.-Z. having marked Asian affinities. Once established, however, early Payntonian faunas became rapidly diversified; they were dominated by smooth-shelled taxa such as Tsinaniidae and Kingstoniidae. The diversification of the trilobites is in marked contrast to that of the rare conodonts. The *Mictosaukia perplexa* A.-Z. comprises the late Payntonian fauna. It appears to have occupied a similar environment to that preceding, and to be coeval with an acme of Saukiidae noted by Sun (1935, p. 9-11) in northern China, where *Mictosaukia* species occur in the *Quadraticephalus walcotti-Saukia acamus* Zone (of Sun, op. cit.).

Two further large groupings of assemblage-zones occurring below the Payntonian are indicated on the Q-mode dendrogram by clusters A and B. As the status of these in the biostratigraphical hierarchy cannot be assessed until the faunas of the Chatsworth Limestone (*s.s.*) at Chatsworth are described, they are designated here as units pre-Payntonian A and B. The distribution of assemblage-zones within these units is summarized below (Fig. 12). The pre-Payntonian A faunas, including those of the Gola Beds, are characterized by:

(1) The long range of *Pseudagnostus clarki maximus* initially associated with *P. papilio* and *P. clavus*.

(2) The morphological gradation from *Mansuyites* to *Mansuyia* (the *Mansuyites-Mansuyia* species lineage) among Mansuyiinae (Kaolishaniidae).

(3) The beginning of a *Sinosaukia* species lineage among Saukiidae.

ZONE	STAGE	
Cordylodus oklahomensis with *C. lindstromi* A.-Z.	DATSONIAN	ORDOVICIAN
Oneotodus bicuspatus with *Drepanodus simplex* A.-Z.		
Cordylodus proavus A.-Z.		
Mictosaukia perplexa A.-Z.	PAYNTONIAN	CAMBRIAN
Pseudagnostus quasibilobus with *Tsinania nomas* A.-Z.		
Sinosaukia impages A.-Z.	pre-PAYNTONIAN A	
Pseudagnostus clarki maximus with *Pseudagnostus papilio* A.-Z.		
Pseudagnostus bifax with *Pseudagnostus denticulatus* A.-Z.	pre-PAYNTONIAN B	
Pseudagnostus clarki prolatus with *Caznaia sectatrix* A.-Z.		
Pseudagnostus clarki patulus with *Caznaia squamosa* A.-Z.		
No Zones designated	post-IDAMEAN	
Irvingella tropica with *Agnostotes inconstans* Z.	IDAMEAN	
Erixanium sentum Z.		
Corynexochus plumula Z.		
Glyptagnostus reticulatus with *Proceratopyge nectans* Z.		
Glyptagnostus reticulatus with *Olenus ogilviei* Z.		

M(P)475

Fig. 12. Distribution and age of Late Cambrian and Early Ordovician Assemblage-Zones in the Burke River Structural Belt.

The pre-Payntonian A may be correlated with the greater part of the *Kaolishania* Zone (late Changshanian: Kobayashi, 1933a) of northern China. Pre-Payntonian B faunas are characterized by:

(1) The ranges of *Pseudagnostus clarki patulus* and *prolatus*.

(2) The occurrence of a *Hapsidocare* lineage among Mansuyiinae (Kaolishaniidae), and a *Ceronocare* lineage among Tingocephalinae (Kaolishaniidae).

(3) The presence of Pagodiinae of the subgenus *Lotosoides*, prosaukioids of the *Prosaukia misa* type, and the beginnings of the saukiid lineages characterized by *Lophosaukia*.

This unit may also correlate in part with the *Kaolishania* Zone of northern China. It may also be equivalent to the Daizanian of Manchuria, an observation based on the morphological similarities between the *Paramansuyella* faunas there and the *Hapsidocare* species of northern Australia.

CAMBRIAN-ORDOVICIAN BOUNDARY

The Cambrian-Ordovician boundary has been drawn by Jones et al. (1971) between their Payntonian and Datsonian Stages, at the base of the conodont assemblage-zone of *Cordylodus proavus* (Druce & Jones, 1971, p. 35). The characteristic species of this assemblage-zone, as listed by Druce & Jones, are *Cordylodus proavus, C.* cf. *C. proavus, Oneotodus gracilis,* and *O. nakamurai,* and the base of the zone is regarded as corresponding with the incoming of *C. proavus* and *C.* cf. *C. proavus* above the last occurrence of *Proconodontus muelleri.* At the top of the 'Chatsworth Limestone' at Dribbling Bore, *Cordylodus proavus* and *'Proconodontus' notchpeakensis* occur at horizon K195, 171 m from the base of the measured section, after an interval of 13 m above the last occurrence of fragments of *Mictosaukia perplexa.* The conodonts are associated with a much fragmented trilobite fauna from which have been identified *Onychopyge assula, ?Niobella* sp., *?Symphysurina* sp., and indeterminate leiostegiaceans. These trilobites are regarded as belonging to the earliest Ordovician trilobite zone in western Queensland, which cannot yet be named for lack of material.

In the other sections the *Cordylodus proavus* A.-Z. enters the sequences at approximately the same time with relation to the occurrence of trilobite faunas. At Mount Datson the zone is first recognized 218 m from the base of the section, and 21 m above the last incidence of *Mictosaukia perplexa.* At Mount Ninmaroo it occurs 210 m from the base of the section, 128 m above the last Upper Cambrian trilobite occurences, which belong to the *quasibilobus-nomas* A.-Z. At Black Mountain, the *C. proavus* A.-Z. occurs first with certainty 569 m from the base of the section, and 108 m higher than the single incidence of the *perplexa* A.-Z. at horizon K145.

The correlation of the measured sections in the south of the Burke River Structural Belt based on the occurrence of the *C. proavus* A.-Z. is shown in Figure 13.

ANALYSIS OF COMPOSITION AND AGE OF FAUNAS

An attempt is made here to isolate those elements of the assemblages that may have some potential for international correlation. The stratigraphical and morphological significance of such elements is discussed in some detail, and placed in global perspective.

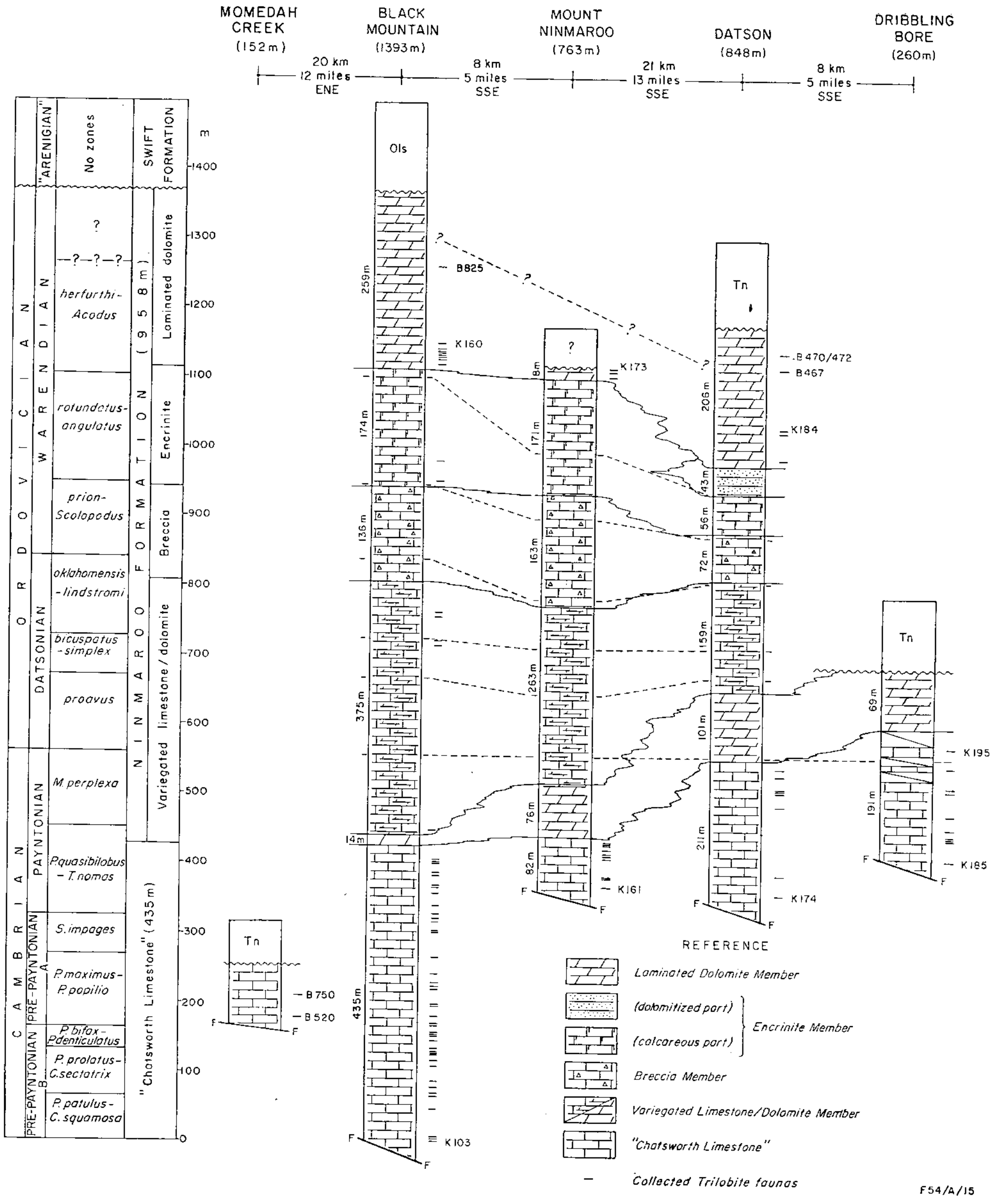

Fig. 13. Correlation of measured sections in the southern part of the Burke River Structural Belt. That shown for Momedah Creek is composite.

Agnostina

The earliest part of the 'Chatsworth Limestone', of pre-Payntonian age, between 0 and 271 m from the base of the Black Mountain section, is characterized by the common occurrence of Pseudagnostinae, whose subtle changes with time offer considerable potential for subdivision of the faunal succession. The initial four assemblages recognized in the Black Mountain sequence are characterized by species of *Pseudagnostus,* and three are defined in particular by the ranges of subspecies of *P. clarki* Kobayashi. These, *P. clarki patulus, P. c. prolatus,* and *P. c. maximus,* succeed each other in time, and are differentiated by the proportions of their shields and the shapes of their borders. Previously described subspecies of *P. clarki* are known from strata of Trempealeauan age in Nevada (Palmer, 1955) and Alaska (Kobayashi, 1935a; Palmer, 1968) and are probably a little younger than the Australian subspecies. *Pseudagnostus orbiculatus,* occurring in the Payntonian, is morphologically closely related to a species of *Pseudagnostus* from the Tiñu Formation of the Nochixtlán region of Mexico (Robison & Pantoja-Alor, 1968). It is contemporaneous with North American subspecies of *Pseudagnostus clarki,* and by virtue of its association with Tsinaniidae, also with pseudagnosti described from both North and South Korea (Kobayashi, 1933a, 1935c) under the name *Pseudagnostus cyclopygeformis* (Sun).

Other papilionate pseudagnosti occurring in the 'Chatsworth Limestone' are referred below to the *Pseudagnostus convergens* group. *Pseudagnostus bifax,* occurring late in the *prolatus-sectatrix* A.-Z. and attaining its acme in the *bifax-denticulatus* A.-Z., is of interest, being most closely related to *P. obsoletus,* described by Lermontova (1951) from the late Cambrian of Boshche-Kul, Kazakhstan. Unfortunately the stratigraphical position of this species is not known to me. *Pseudagnostus papilio,* which succeeds in the *maximus-papilio* A.-Z., occurs also in the faunas of the Gola Beds, and has as its nearest relative *P. convergens* Palmer (1955) from Nevada, of latest Franconian age. *P. cyclopygeformis* Sun, 1924 (*sensu stricto*) from the late Changshanian, *Kaolishania* Zone, of Shantung, appears to be approximately coeval with these two species. Together they may provide a basis for the circum-Pacific correlation of the pre-Payntonian A faunas of Queensland.

Concurrent with these groups of pseudagnosti is that designated below as the *Pseudagnostus clavus* species group, which is composed of spectaculate species quite distinct in glabellar characteristics, shield shape, and metamerism from those discussed above. A succession of species of this group occurs in the 'Chatsworth Limestone' of Black Mountain. *Pseudagnostus coronatus* occurs in the *patulus-squamosa* A.-Z., *P. denticulatus* in the *bifax-denticulatus* A.-Z., and *P. clavus* in the *bifax-denticulatus* and *maximus-papilio* A.-Z. They most closely resemble species previously described from the Orlina Mountains, Salair region, Siberia, as *P. subangulatus* (Lermontova, 1940,) *P. punctatus* (Lermontova, 1940), *P. simplex* (Lermontova, 1951), *P. cavernosus* Rozova, 1960, and *P. vulgaris* Rozova, 1960, but until the synonymy among them and their exact stratigraphical positions are known the group cannot be utilized for precise age determination.

A derivative group, that of *Pseudagnostus bilobus,* is perhaps more useful stratigraphically. It is represented in the Payntonian faunas of Black Mountain by *P. quasibilobus,* whose close relatives are distributed world-wide: *P. bilobus* and *P. araneavelatus* Shaw, 1951, in Vermont; *P. canadensis* (Billings, 1860) in the boulder conglomerates of Quebec (Rasetti, 1944) and Newfoundland (C. H. Kindle, pers. comm.); *Neoagnostus aspidoides* and *Hyperagnostus binodosus* Kobayashi, 1955, from British Columbia; *Machairagnostus tmetus* Harrington & Leanza, 1957, from Argentina; *P. longicollis* Kobayashi, 1966, from northern China; *P. cyclopyge* (Tullberg) *sensu* Sun, 1939, from Yunnan; and the undetermined pseudagnostid illustrated from Mexico by Robison & Pantoja-Alor (1968). The group has a limited range on either side of the Cambrian-Ordovician boundary.

Like the Pseudagnostinae, the range of the *Geragnostus* group of species among the Agnostidae also offers potential for biostratigraphical subdivision. The group has a long range, throughout the Late Cambrian and into the early Ordovician, and occurs in many parts of the world. Unfortunately its species are as yet poorly understood and their relationships to each other are unclear. Special mention must, however, be made of the genus *Rudagnostus,* which has a limited range, occurring in Atlantic faunas in Zones 5c-e of Westergaard (1947), and apparently also in the faunas of the Gola Beds at Momedah Creek, where it is of *maximus-papilio* age.

The *Lotagnostus* group, which is better known, and which also occurs in Zones 5c-e of Scandinavia, is also of special interest. An effaced derivative of this genus, *Trilobagnostus* Harrington, 1938, occurs in the *maximus-papilio* and *bifax-denticulatus* A.-Zs in sections at Black Mountain and Momedah Creek. A case is proposed below for the recognition of *Lotagnostus* (*Trilobagnostus*) in Nevada (the *Lotagnostus obscurus* of Palmer, 1955), where it has an early Trempealeauan age, and Vermont, where Shaw (1951) described it as *Homagnostus* sp. from rocks of early Ordovician age (*Missisquoia* Zone). In Nevada, *Lotagnostus* (*Trilobagnostus*) *obscurus* is associated with *Pseudagnostus convergens,* and in Queensland *Lotagnostus* (*Trilobagnostus*) spp. are associated with *Pseudagnostus papilio,* whose closest relative is *P. convergens.*

Asaphacea

The Asaphacea are first noted in the *prolatus-sectatrix* A.-Z. of the 'Chatsworth Limestone' of Black Mountain, with the incidence of *Atopasaphus.* Other Asaphacea are known earlier in western Queensland, however, in the Mindyallan (*Griphasaphus,* Öpik, 1967a), in the Idamean (*Charchaqia,* Whitehouse, 1939), and in the immediate post-Idamean near Chatsworth (author's collections). In the Cambrian, Asaphacea are most diversified in the *bifax-denticulatus* and *maximus-papilio* A.-Zs with the proliferation of species of *Golasaphus,* also known from the latter assemblage-zone at Momedah Creek. Bearing in mind the previous comments on the age and distribution of the agnostid genera *Rudagnostus* and *Lotagnostus,* it is of interest to note that the Swedish Cambrian Asaphidae, represented by *Niobella,* occur in Zones 5d-e (Westergaard, 1939, 1947), which may be evidence for a contemporaneity of Asaphacean radiation. Elsewhere, the presence of *Yuepingia* in the late Franconian faunas of Alaska (Palmer, 1968) may indicate an approximately contemporaneous event. As in Scandinavia, Australian Asaphacea fail in the latest Late Cambrian but reappear in the early Ordovician. The close morphological similarity between *Golasaphus* species, of *maximus-papilio* time in Queensland, and the *Asaphellus* species, of earliest Ordovician age in Mexico (Robison & Pantoja-Alor, 1968), is noted.

Remopleuridacea

A good sequence of Remopleuridaceans occurs in the lower 'Chatsworth Limestone' in the Black Mountain section, indicating earlier origins than hitherto expected. They are assigned either to *Sigmakainella* Shergold, 1972, or *Richardsonella. Sigmakainella primaeva* occurs commonly in the *patulus-squamosa* A.-Z., followed by *S. translira* in the succeeding *prolatus-sectatrix* and *bifax-denticulatus* A.-Zs, and, at Momedah Creek, in the *maximus-papilio* A.-Z. Its associate there, *S. longilira,* appears in the Black Mountain section also in the *maximus-papilio* A.-Z. These species have kainelloid rather than richardsonelloid characteristics. Their closest relationships, however, appear to lie with late Franconian and early Trempealeauan taxa from Alaska (Palmer, 1968) referred to *Richardsonella.* The pygidia referred below to *?Sigmakainella trispinosa,* from the *bifax-denticulatus* and *maximus-papilio* A.-Zs of Black Mountain, are noteworthy for the similarity of their morphology to that of *Hungaia.* The incidence of *'Tostonia'* sp. in the faunas of the Gola Beds, of *maximus-papilio* age, and its similarity with pygidia described from the late Franconian and early Trempealeauan of Nevada (Palmer, 1956) is again noted (Shergold, 1972). In the upper 'Chatworth Limestone' at Black Mountain, the presence of a remopleuridacean of Asian affinity, *Haniwa,* strengthens the correlation of the *Tsinania* faunas of Australia and Korea. In Australia the genus is of Payntonian age. Elsewhere in northern and central Australia, remopleuridaceans are common in earliest Ordovician rocks, as for instance at Mootwingee in western New South Wales, nearly 800 km to the south.

Dikelocephalacea

In discussing the relationships of the Agnostina, Asaphacea, and Remopleuridacea, their widespread distribution has been noted. When the Saukiidae, Tsinaniidae, Shumardiidae, and Kaolishaniidae are considered, however, a more provincial theme is introduced. With the exception of certain prosaukioids, the Saukiidae of the Black Mountain section are of Asian aspect, being similar to taxa previously described from China, Manchuria, Korea, and Vietnam. In the southern part of the Burke River Structural Belt saukiid faunas are present in the lowest part of the 'Chatsworth Limestone' at Black Mountain, where two species of the new genus *Caznaia,* of prosaukioid type, occur in successive assemblages, in the *patulus-squamosa* and *prolatus-sectatrix* A.-Z.s. Older saukiids are known from the yet undescribed Chatsworth Limestone sequences at Chatsworth (author's collections), and Öpik (1967a) has argued for the recognition of still earlier representatives in the Mindyallan faunas. *Caznaia* belongs to a group of Saukiidae which also includes *Prosaukia* (s.s.), *Anderssonella, Galerosaukia* gen. nov., and *Lichengia.* Associated with *Caznaia* spp. is a further prosaukioid with similar morphology to that of the type species *Prosaukia misa;* and a comparable species, known only from fragments too poorly preserved for accurate determination, occurs in the *maximus-papilio* A.-Z. In North America *Prosaukia misa* occurs in rocks of late Franconian age. *?Prosaukia cornigra,* from the *Sinosaukia impages* A.-Z., characterized by a long nuchal spine, has glabellar affinity with *Caznaia,* but is otherwise dissimilar to existing described taxa.

Species of *Anderssonella* occur in the Payntonian faunas of the *quasibilobus-nomas* A.-Z. on the Black Mountain section. They are comparable with Fengshanian species described from northern China (Sun, 1924), where they occur in Sun's (1935) *Quadraticephalus walcotti-Saukia acamus* Zone. In Queensland, *Anderssonella* is associated with the new genus *Galerosaukia,* is related to it, and forms an intermediate morphological link in the possible derivation of *Lichengia* from a *Prosaukia-Anderssonella* evolutionary lineage. Two species of *Galerosaukia* succeed stratigraphically during the time of the *quasibilobus-nomas* A.-Z.

Ranging concurrently with part of the *Prosaukia-Anderssonella-Galerosaukia* generic group is a second, characterized by *Sinosaukia* and *Lophosaukia. Lopho-*

saukia occurs considerably earlier in Queensland, in the late *prolatus-sectatrix* A.-Z., than in Asia, where it does not appear until the Fengshanian. In Australia the genus ranges through the succeeding *bifax-denticulatus* and *maximus-papilio* A.-Zs, is absent from the *impages* A.-Z., but reappears in the Payntonian *quasi-bilobus-nomas* A.-Z. *Sinosaukia* species do not range so widely, occurring in the *impages* A.-Z., and early Payntonian *quasibilobus-nomas* A.-Z. only. *Sinosaukia* is one of the few genera to range across the Payntonian/pre-Payntonian boundary in Queensland. Its species are closely related to those previously described from the Fengshanian *Quadraticephalus walcotti-Saukia acamus* Zone (Sun, 1935) of northern China. In Australia *Sinosaukia,* like *Lophosaukia,* appears earlier than in Asia, in strata correlating with the late Changshanian of northern China.

Leiostegiacea

Throughout the 'Chatsworth Limestone' faunas of the Black Mountain section, the Leiostegiacea present show constant affinity with Asian relatives. Mansuyiinae are represented throughout the faunal sequence, by *Hapsidocare* gen. nov. in the earlier assemblage-zones—two successive species occur in the *patulus-squamosa, prolatus-sectatrix,* and *bifax-denticulatus* A.-Zs; by *Mansuyites* in the *maximus-papilio* A.-Z.; and by *Mansuyia* in the *impages* and *quasibilobus-nomas* A.-Zs. *Hapsidocare* appears to derive from *Paramansuyella,* of Daizanian age in Manchuria (Endo *in* Endo & Resser, 1937), which is also reported from the base of the Chatsworth Limestone (*s.s.*) in the Chatsworth area (Öpik, 1960, p. 105), and from the Clark Sandstone of the Bonaparte Gulf Basin sequence (Öpik *in* Kaulback & Veevers, 1969). Indeterminate species of *Mansuyites* occur in the *maximus-papilio* A.-Z. of the Black Mountain section, but the genus is better represented by specifically determinable material in contemporaneous strata at Momedah Creek. In Asia the range of *Mansuyia,* when its involved synonymy is resolved (Shergold, 1972, p. 52-4), commences in the late Changshanian (*Kaolishania* Zone) of Shantung, and continues into the Fengshanian of Chihli (Sun, 1924). In South Korea the genus is recorded by Kobayashi (1966a) from the *Dictyites* Zones. Australian representatives have similar ranges to their close Chinese relatives, commencing in the *impages* A.-Z., and continuing into the early Payntonian *quasi-bilobus-nomas* A.-Z.

Associated Tingocephalinae have similar ranges. The earliest representative on the Black Mountain section, *Ceronocare* sp., appears in the *patulus-squamosa* A.-Z. A further species, *C. pandum,* characterizes the later part of the *prolatus-sectatrix* A.-Z. and continues into the *bifax-denticulatus* A.-Z. *Ceronocare* is as yet unrecognized outside Queensland. *Palacorona* species succeed *Ceronocare* in the *maximus-papilio* A.-Z., both at Black Mountain and Momedah Creek; the genus reappears in the Payntonian *quasibilobus-nomas* A.-Z. at Dribbling Bore. Kaolishaniinae have a more restricted range in Queensland, being recorded only from the *maximus-papilio* A.-Z. at Momedah Creek. At Black Mountain their expected stratigraphical position is occupied by Pagodiinae, which have a long range in Australia, as in Asia. The Pagodiinae are represented by subgenera of *Pagodia* in several zones: by *Idamea* in the Idamean (Öpik, 1967a), which correlates with the *Chuangia*-bearing rocks of Asia; by *Pagodia* in the late *patulus-squamosa* A.-Z.; by *Lotosoides* and *Oreadella* in the *prolatus-sectatrix* and *bifax-denticulatus* A.-Zs; and, at Mount Datson and Dribbling Bore, but not at Black Mountain, by *Datsonia* in the Payntonian. As there appears to be some confusion between *Chuangia* and *Pagodia* in the Asian literature no fine age can be given by pagodiinid representatives until the ranges and concepts of some of the Asian species are clarified.

The Tsinaniidae, classified here with Leiostegiacea, and confined to the Payntonian *quasibilobus-nomas* A.-Z., provide a firm correlation with the Asian *Ptychaspis subglobosa* Zone (Sun, 1935) of northern China, the *Tsinania* Zone (Kobayashi, 1931, 1933a) of Manchuria, and the *Dictyites* Zone of South Korea (Kobayashi, 1935c). Of the five tsinaniid species occurring at Black Mountain, two are given qualified Asian specific names, and the remainder are very closely related to previously described Asian species.

Other polymerid trilobites

Of the remaining trilobites of the Black Mountain sequence, mention must be made of the occurrence in the *patulus-squamosa* A.-Z. of *Wuhuia* cf. *dryope*, a dokimocephalid of Asian type whose occurrence is earlier than previously recorded. Other Asian Dokimocephalidae occur later in the *Kaolishania* and *Tsinania* faunas, of late Changshanian and Fengshanian age in northern China, Manchuria, and Korea. *Wuhuia* is succeeded by *Lorrettina* in the *prolatus-sectatrix* and *bifax-denticulatus* A.-Zs at Black Mountain, and the *maximus-papilio* A.-Z. at Momedah Creek. As noted previously (Shergold, 1972, p. 68), *Lorrettina* has a strong morphological resemblance to Dokimocephalidae from the Dresbachian of North America, e.g. *Kindbladia*. Other members of the family occur in the Chatsworth Limestone (*s.s.*) at Chatsworth (author's collections).

The presence of *Euloma* (*Plecteuloma*) in the *patulus-squamosa* A.-Z. extends the lower range of known Eulominae. *Duplora*, from the *prolatus-sectatrix, bifax-denticulatus,* and *maximus-papilio* A.-Zs (the last at Momedah only), is so far unique to western Queensland, although some resemblance to Westergaard's (1909, pl. 1, fig. 21) species *Euloma primordiale* is suggested.

Following previous comments on the ranges and distributions of Atlantic Asaphacea and Agnostina, the occurrence of *?Protopeltura* at the base of the *maximus-papilio* A.-Z. on Black Mountain is of some interest. Alone the trilobite perhaps indicates a degree of correlation with Zone 5c (Westergaard, 1947) in Scandinavia. At Black Mountain it is associated with the conodont *Westergaardodina mosseburgensis* which, according to Druce & Jones (1971, p. 43), does not range later than Zone 5d in Scandinavia.

Asian Shumardiidae occur throughout the 'Chatsworth Limestone' of the Black Mountain sequence. They are all placed here in the genus *Koldinioidia,* but when further material becomes available it may prove possible to differentiate further genera. The species that characterizes the Payntonian, *K. payntonensis,* most closely resembles the Mexican *K. sulcata* described by Robison & Pantoja-Alor (1968).

SUMMARY STATEMENT OF CORRELATION

The pre-Payntonian B faunas of the *Pseudagnostus clarki patulus-Caznaia squamosa, P. c. prolatus-C. sectatrix,* and *P. bifax-P. denticulatus* Assemblage-Zones contain few elements by which they can be directly correlated with Asian faunas. In them, however, are seen elements contributing to the late Changshanian

Kaolishania faunas of Asia. There are no common taxa with the Paishanian *Chuangia* faunas of China, Manchuria, Korea, or Vietnam, which underlie the *Kaolishania* faunas in Asia, and occur considerably earlier in the scale of late Cambrian biostratigraphical events. Kobayashi (1933a) has noted the record of *Chuangia* associated with ptychaspidids in Walcott's (1913) sample C64. Examination of Walcott's specimens (see Walcott, 1913, pl. 17, fig. 20 *inter alia*) shows them to be different from the type material of *Chuangia* and probably representative of *Pagodia,* although to which subgenus they belong is disputable owing to incomplete preservation. Cranidial material, not illustrated, in the U.S. National Museum suggests close comparison with *Pagodia* (*Lotosoides*), whose type species is of pre-Payntonian B age. However, *Pagodia* (*Pagodia*) is noted to occur in a Fengshanian assemblage at Walcott's locality C56 (Walcott, 1913, p. 22). The *Chuangia batia* recognized by Sun (1924, p. 58, pl. IV, figs 4a-e) from a *Kaolishania* fauna at Kaolishan, Shantung, is based on cranidia which seem to equate with those figured by Endo (1939, p. 9-10, pl. 2, figs 3-6, 10) as *Paramansuyia chinensis,* now referred to *Mansuyia chinensis* (Endo) (see Shergold, 1972, p. 53).

Endo's Daizanian *Paramansuyella* faunas (*in* Endo & Resser, 1937, p. 305), which are interposed between Fengshanian (= Yenchouan) tsinaniid assemblages and Paishanian *Chuangia* faunas at Paichiashan, in the Wuhutsui Basin, southern Manchuria, are difficult to interpret beyond Asia because of taxonomic problems. Kobayashi (1956, p. 13; 1966b, p. 244) considers that the youngest Daizanian zone, that of *Paramansuyella granulosa,* is equivalent to his (1933a) *Kaolishania* Zone, because the nominal species is a kaolishaniid rather than a mansuyiinid as envisaged by Endo. Kobayashi (1966b, p. 244) further thinks that the nominal species of the older Daizanian zone, *Paramansuyella puteata* Endo, is referable to *Mansuyia,* in which case the entire Daizanian might be accommodated within the time span of the *Kaolishania* Zone as construed by Kobayashi. It is in this context that he has used (1966a, b, 1967) the stage name Daizanian for an interval of time characterized by *Kaolishania* assemblages. The reference of *Paramansuyella puteata* to *Mansuyia* may be queried on morphological grounds, particularly the sagittal extent of the preglabellar area and the very shallow pygidial 'bowl', both of which ally it more closely to the new genus *Hapsidocare* described below, of pre-Payntonian B age. The faunas of the early Daizanian may thus equate with those of pre-Payntonian B or antedate them. Study of the post-Idamean faunas in the Chatsworth Limestone (*s.s.*) at Chatsworth may help resolve this problem.

Correlation of pre-Payntonian B trilobite faunas with contemporaneous North American assemblages is tenuous. The existence of *Prosaukia* sp. A, similar to *P. misa,* the type species of the genus, in the *prolatus-sectatrix* and *bifax-denticulatus* A.-Z.s provides perhaps a slender linkage with faunas from the *Ptychaspis-Prosaukia* Zone of the Upper Mississippi Valley. The subspecies of *Pseudagnostus clarki* occurring in the pre-Payntonian B assemblages appear earlier than those of cordilleran North America.

The pre-Payntonian A faunas, assemblage-zones of *Pseudagnostus clarki maximus* with *P. papilio* and of *Sinosaukia impages,* are more readily correlatable. The presence of Kaolishaniinae, Mansuyiinae, Tingocephalinae, and the saukiid *Lophosaukia* provide a basis for comparison with the *Kaolishania* faunas noted above, which occur over a wide area in Asia. The close relationship of *Pseudagnostus papilio* with *P. cyclopygeformis* (Sun) (*sensu stricto*) provides a further strong linkage. Looking towards cordilleran North America the agnostids *Pseudagnostus clarki maximus, P. papilio,* and *Lotagnostus* (*Trilobagnostus*) spp. and the remopleuridaceans provide a degree of correlation with late Franconian and early Trempealeauan faunas of the Great Basin and Alaska. Correlation with Zones 5d-e of Scandinavia is suggested on the basis of the occurrence of *?Protopeltura, Rudagnostus, Lotagnostus* (*Trilobagnostus*), and a diversification of Asaphacea. In terms of affinity the faunas of the *maximus-papilio* A.-Z. are more cosmopolitan than those of any other assemblage yet recognized in the southern part of the Burke River Structural Belt in post-Idamean times.

A marked impoverishment of fauna is evident during the time of the *Sinosaukia impages* A.-Z., and the elements of the assemblage are provincial, with a strong Asian affinity. This trend is continued during the Payntonian, whose faunas are totally of Asian aspect. Payntonian faunas, of the *quasibilobus-nomas* and *perplexa* A.-Z.s, correlate with those of the Fengshanian (Yenchouan) and early Wanwanian of China, Manchuria, North Korea, South Korea, Vietnam, and Peninsular Thailand, containing similar specific taxa of the families Tsinaniidae, Kingstoniidae, Shumardiidae, Saukiidae, and Ptychaspididae. Only the Agnostina can be utilized in correlation outside the Australo-Sinian region at this time, *Pseudagnostus quasibilobus* having similarity with North American and Mexican species.

PALAEONTOLOGY

MORPHOLOGICAL TERMINOLOGY APPLICABLE TO PSEUDAGNOSTINAE

Although the terminology defined below is primarily used in the description of Pseudagnostinae, it may also be applicable to other Agnostina. Much of this terminology is based on earlier usage by Öpik (1961a, b, 1963, 1967a). In the ensuing descriptions of species of *Pseudagnostus,* specimens preserved with their carapaces are described under the heading of external testaceous morphology, below which are noted observations on the dorsal appearance of the shells, or their imprints which may be preserved as external moulds, and the proportions of their parts. Specimens preserved as moulds of the ventral surface of the shell, showing details of the caecal networks and musculature, are discussed under the heading of parietal morphology.

General Descriptive Terminology (Text-fig. 14)

Accessory furrows: Pygidial furrows extending posterolaterally from the posterior terminations of the axial furrows, encompassing the deuterolobe. As interpreted by Öpik (1963, p. 30; 1967a, p. 52) accessory furrows are 'parietal septa of pygidial alimentary glands'. On specimens preserved en grande tenue the accessory furrows are invariably well defined, continue to the posterior marginal furrow, and encircle the deuterolobe; they are therefore plethoid (Shergold, 1972, p. 15).

Acrolobe: Used in the sense of Öpik (1967a, p. 53), the acrolobe is the convex (sag., tr.) body of either cephalic or pygidial shield which is surrounded by peri-

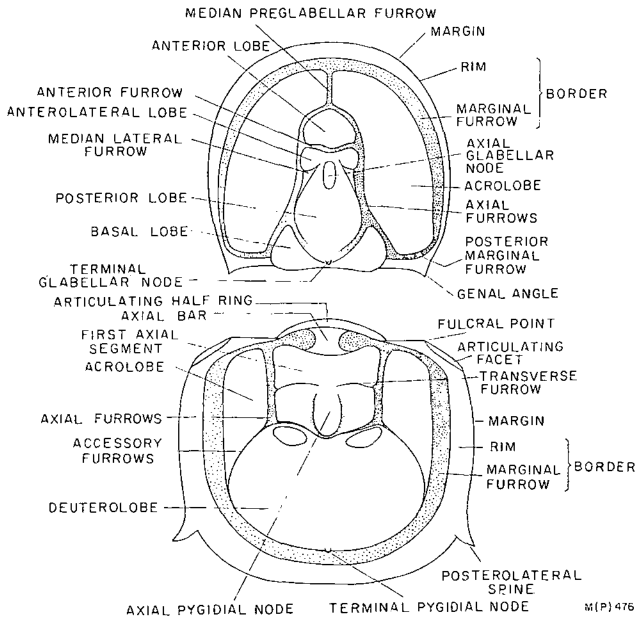

Fig. 14. Descriptive elements of the testaceous morphology of *Pseudagnostus*.

pheral marginal furrows. Frequently the lateral margins of the acrolobe curve slightly inwards, and in this condition they are known as constricted; those that maintain a constant curvature are unconstricted. All species of *Pseudagnostus* have constricted acrolobes in the pygidium, the condition being most readily observed on parietal surfaces. Some species also have constricted cephalic acrolobes.

Anterior furrow: A rectilinear or curvilinear furrow that separates the anterior glabellar lobe from the anterolateral lobes.

Anterolateral furrows: In papilionate species of *Pseudagnostus,* in which the axial glabellar node lies between the anterolateral glabellar lobes, the anterior furrow is often interrupted sagittally and divided into two parts at an obtuse angle to each other. These parts are referred to as anterolateral furrows.

Anterior lobe: The foremost lobe of the glabella, usually separated from the anterolateral lobes by anterior or anterolateral furrows. In some species, where the anterolateral furrows are obliterated, the anterior and anterolateral lobes may appear fused.

Anterolateral lobes: On testaceous specimens low swellings at the anterolateral corners of the posterior glabellar lobe are termed anterolateral lobes. They are separated from the anterior lobe by anterior or anterolateral furrows, and from the remainder of the posterior lobe generally by weak median lateral furrows. On parietal surfaces the anterolateral lobes are seen to be defined by raised rims enclosing areas of muscle attachment. In papilionate species these lobes are divided sagittally by the axial glabellar lobe.

Articulating facets: Abaxially sloping, generally gently concave, surfaces at the anterolateral corners of the pygidium. They may vary from species to species in the degree of inclination to the anterior pygidial margin.

Articulating half-ring: A segment of a sphere, part of the articulating device as described by Öpik (1963, p. 31; 1967a, p. 53), separated from the first axial segment of the pygidium by an axial bar. Various types of articulating devices are listed by Öpik (1967a, p. 53): that applicable to *Pseudagnostus* is the glyptagnostoid condition.

Axial bar: A further component of the articulating device *sensu* Öpik (loc. cit.) which refers to the 'convex floor of the articulating furrow in the form of a median segment of a cylinder between the muscle spots'.

Axial furrows: Used as in previous reports by many authors. For comments see Öpik (1963, p. 31).

Axial glabellar node: An elongate node lying near the mid-length of the glabella, either between or behind the anterolateral glabellar lobes. Frequently it has a posterior cleft and a marked sagittal ridge. Occasionally an axial glabellar carina runs backwards from the rear of the node along the sagittal line to the terminal glabellar node. For further comments see under papilionate and spectaculate axial glabellar nodes.

Axial pygidial node: A convexity on testaceous specimens, lying sagittally on the second axial segment of the pygidium, but sometimes linked by a faint convex ridge to the posterior part of the first segment. Exfoliated specimens show this node to be bilobed and bifid (Text-figs 26, 32), with steeply sloping almost concave flanks and a distinct crest. There are high spots both at the front and rear of the crest.

Axial segments: Metameric divisions of the pygidial axis. Two anterior rings are invariably present, but several other paired swellings occur behind them; they are related to the musculature and give an indication of the number of segments, now effaced or fused, which originally constituted the deuterolobe.

Basal lobes: Triangular or pear-shaped lobes lying at the posterolateral corners of the posterior glabellar lobe and separated from it by curved or sinuous furrows, often effaced anteriorly in testaceous material. They are linked behind, and often below (depending on preservation), the posterior glabellar lobe by a connective band (see Öpik 1963, p. 51, fig. 13, labelled bnd).

Border: As used in this Bulletin the border includes the rim and marginal furrows. It lies within the margin of the shield, peripheral to the acrolobe.

Connective band: A narrow (sag.) band connecting the basal lobes across the back of the posterior glabellar lobe.

Constricted, unconstricted acrolobes: See comments under acrolobe.

Deliquiate, non-deliquiate marginal furrows: See comments under marginal furrows.

Deuterolobe: A tumid convexity lying between that part of the pygidial axis defined by axial furrows and the posterior marginal furrow. Laterally it is defined by accessory furrows. Degree of convexity, and thus definition, varies greatly. The deuterolobe may be encircled by accessory furrows posteriorly where they merge with the posterior marginal furrow to give a plethoid condition. An agnostid in which the deuterolobe is well defined is described as deuterolobate.

Effaced, effacement, partial effacement: An effaced condition is one in which furrows and lobes are obliterated to give a smooth or near-smooth surface. In Pseudagnostinae all conditions of partial effacement exist, from highly effaced to en grande tenue.

En grande tenue: A term introduced by Öpik (1961b, p. 55) and redefined by him (1967a, p. 56) to categorize agnostids having distinct lobes and furrows.

Fulcral points: Forward-directed points formed at the adaxial culmination of the articulating facets.

Genal angle: The rearward-pointing process derived from the posterior cephalic margin at the posterolateral corner of the cephalon is referred to here as the genal angle.

Margin: The outer periphery of the shield, lying between the marginal furrows and the edge of the carapace. Used as a synonym of rim. See simplicimarginate and zonate below.

Marginal furrow: A furrow lying at the break in convexity between the acrolobe and the margin. It may be deeply grooved or channel-like, in which case it is deliquiate. If merely a break in convexity it is termed non-deliquiate.

Median lateral furrows: Generally weakly defined in most Pseudagnostinae, these furrows separate the anterolateral glabellar lobes from the remainder of the posterior lobe. In the *Pseudagnostus bilobus* species group they may be deeply incised. Öpik (1963, p. 51) refers to them as lateral glabellar furrows, but they are here categorized as median lateral furrows to distinguish them from anterolateral ones.

Median preglabellar furrow: This furrow lies on the sagittal line, and runs from the axial furrows encircling the front of the glabella to the anterior cephalic marginal furrow, thus dividing the cephalic acrolobe anteriorly.

Papilionate: Pseudagnostinae in which the axial glabellar node lies between the anterolateral lobes, as in the *Pseudagnostus clarki* species group, are here termed papilionate.

Plethoid: Species of *Pseudagnostus* with accessory furrows defining the deuterolobe clearly and continuing posteriorly to the marginal furrow are called plethoid. Such species are invariably preserved en grande tenue (see Shergold, 1972, p. 15).

Posterior lobe: The main body of the glabella between the connective band of the basal lobes and the anterior or anterolateral glabellar furrow. Anterolaterally convex swellings are divided off as anterolateral lobes, separated from the main part of the posterior lobe by median lateral glabellar furrows. Rearwards the posterior lobe is elevated and generally is appreciably convex. Its rear in pseudagnosti is usually angulate in the diplagnostid fashion.

Posterolateral spines: These are sited on the posterolateral margins of the pygidium, but are varyingly situated with respect to the rear of the deuterolobe. The spines vary in size from mere spinules to stout mucronations. They may be deflected outwards from the lines of the pygidial margins or lie in line with them. They may be straight, curved, or hooked, and are frequently oriented adventrally.

Rhaptoid: Applied to pseudagnosti in which the notular lines are clearly visible (Shergold, 1972, p. 15). The term differs only in minor degree from notulate, which means possessing notulae.

Rim: See margin (above).

Shield: Used as a synonym for carapace.

Simplicimarginate: Agnostina with 'basic, unmodified rim' (see Öpik, 1967a, p. 61).

Spectaculate: A term introduced here for pseudagnosti in which the axial glabellar node lies to the rear of the anterolateral glabellar lobes, and is therefore also to the rear of the anterior glabellar furrow.

Terminal glabellar node: A small node lying at the posterior extremity of the posterior glabellar lobe. Öpik (1967a, p. 61) considers this node 'a homologue of the glabellar spine of eodiscids'.

Terminal pygidial node: A small node, similar to that of the cephalon, lying at the posterior culmination of the deuterolobe and the tip of the intranotular axis (see below: notes on musculature).

Transverse articulating furrows: Transverse furrows separating the segments of the pygidial axis. They are interrupted sagittally by the pygidial axial node, and terminate adaxially in apodemal pits. Often they are partly effaced.

Zonate: Agnostina having a duplicated posterior margin: 'a ridge on the rim or even a fold of the margin of the acrolobe' (Öpik, 1967a, p. 62).

TERMINOLOGY DESCRIBING MUSCULATURE (Text-fig. 15)

The features of the parietal morphology listed below as muscle scars are in reality the impressions of the points of muscle attachment of the ventral surface of the carapace. On the parietal surface these are normally slight depressions enclosed within raised rims or areas. On the ventral test the opposite situation prevails, the areas of attachment being gently raised platforms surrounded by depressed rims. The shell appears to be thickened above these areas where the lobes of the dorsal test are observed. Text-figure 15, based on *Pseudagnostus clarki patulus* subsp. nov., shows the distribution of elements which appear to characterize the impressions of muscle scars as seen on the parietal surface of *Pseudagnostus*. Similar arrangements are illustrated (Text-figs 26, 30, 32, 35, 37) for *P. clarki prolatus, P. orbiculatus, P. bifax, P. papilio,* and *P. coronatus.*

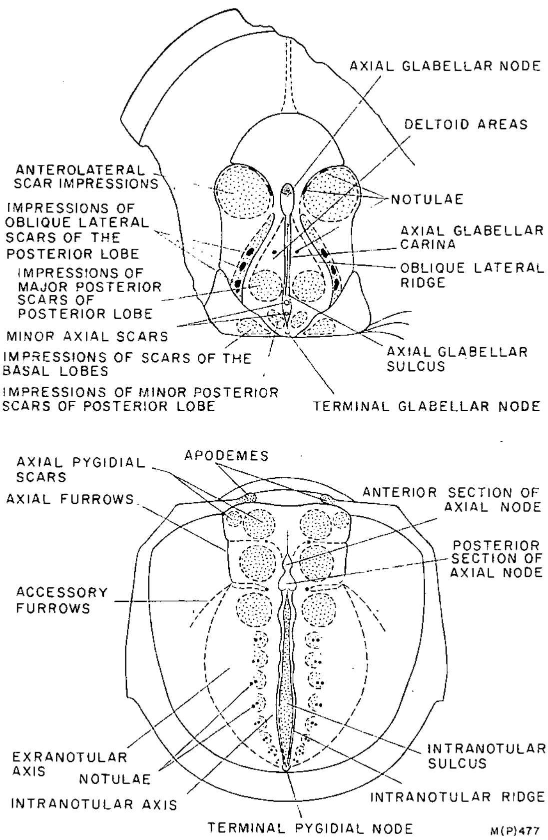

Fig. 15. Terminology of the parietal morphology of *Pseudagnostus.*

Anterolateral scars: These lie on the parietal surface in the position occupied by the anterolateral glabellar lobes of the external testaceous surface. They are the largest muscle scars of the pseudagnostinid cephalon.

Apodemal pits: Apodemal pits are depressions on the dorsal carapace caused by the adventral invagination of the test to produce apodemes. The impression of an apodeme on the parietal surface is called a notula.

Axial glabellar carina: A pair of narrow (tr.) elevated ridges—axial glabellar carinae—flanks the axial glabellar sulcus on the parietal surface. Anteriorly they merge into the axial glabellar node, where they also join the oblique lateral ridges.

The carinae define the adaxial limits of the major and minor posterior scars. The carinae run the length of the glabella between the axial and terminal nodes. They are analogous to the intranotular ridges of the pygidium.

Axial glabellar sulcus: This is a narrow groove which runs along the sagittal line of the parietal cephalic surface from the terminal glabellar node to the axial glabellar node. It runs into the cleft in the rear of the latter. The sulcus is widest (tr.) between the major and minor posterior scars.

Axial pygidial scars: A general term for the paired muscle scars of the pygidial axis. The scars of the first three segments are usually well defined in *Pseudagnostus* species, but in exceptionally well preserved specimens up to seven further pairs of scars are observed behind the third pair. A pair of notulae lies in the middle of the muscle scars of this (the post-third) part of the axis.

Deltoid areas: These are triangular depressions lying between the oblique lateral ridges and the axial carina. They are morphologically distinct from the major posterior muscle scars which enclose them rearwards.

Extranotular axis: The area of deuterolobe lying between the notular lines and the accessory furrows, or their inferred position (see Öpik, 1963, p. 31).

Intranotular axis: The sagittal area enclosed within the notular lines (Öpik, 1963, p. 31).

Intranotular ridge: Narrow (tr.) ridges lying on either side of the intranotular sulcus, and anteriorly merging with the pygidial axial node. These ridges are complex structures, knotted in appearance, and apparently formed by coalescence of small swellings lying between the paired muscle scars and the intranotular sulcus.

Intranotular sulcus: A sagittal groove, widening (tr.) anteriorly and posteriorly, running between the terminal pygidial node and the axial pygidial node. The sulcus runs into the latter node and cleaves it sagittally.

Major posterior scars of the posterior lobe: A pair of large circular depressed areas lying across the rear of the posterior glabellar lobe, on a transverse line across the maximum width of that lobe. The two scars are separated from each other, on either side of the sagittal line, by the axial glabellar carinae and sulcus and from the oblique lateral scars by the oblique lateral ridges. These scars are present in other Agnostina, e.g. *Ammagnostus* (Öpik, 1967a, pl. 66, fig. 5), *Glyptagnostus* (*Lispagnostus*) (Öpik, 1967a, p. 169, text-fig. 50), *Galbagnostus* (Whittington, 1965, p. 306, fig. 2, pl. 3, figs 7, 12), and *Trinodus* (Hunt, 1967, pl. 22, fig. 44).

Minor axial scars: Two small scars lying on the sagittal line of the glabella intermediate between the major and minor posterior scars within the axial glabellar sulcus.

Minor posterior scars of the posterior lobe: A pair of small ovoid impressions lying to the rear of the major posterior scars, but just anterior to the terminal glabellar node, are visible on some specimens of *Pseudagnostus*.

Notulae: Small circular or subcircular pits, most obvious on the parietal surface and lying within areas defined by muscle scars, have been termed notulae by Öpik

(1963, p. 32). Generally a pair of notulae is associated with each muscle scar. Notulae also occur in the cephalon, in some species being present in the floor of the oblique lateral scars of the posterior lobe.

Notular furrows and notular lines: See Öpik (1963, p. 32).

Oblique lateral ridges: A pair of ridges adaxially flanks the oblique lateral muscle scars and also defines the abaxial limits of the major posterior scars. Anteriorly they merge with the axial carinae or become indistinct in the area between the anterolateral scars of the posterior lobe and the axial glabellar node, depending on the position of this node with relation to the anterolateral scars. Posteriorly these oblique lateral ridges merge into an indefinable area which separates the minor and major posterior scars.

Oblique lateral scars of the posterior lobe: Grooves, interpreted as muscle scars, running obliquely and arcuately from the abaxial flanks of the axial glabellar node to the front of the basal lobes. These scars are complex and apparently connected anterosagittally with the anterolateral scars. A series of pits, interpretable as notulae, lies in the floor of these scars in some species. Oblique lateral scars are not confined to *Pseudagnostus:* they are also present in *Xestagnostus* (see Öpik, 1967a, p. 163, fig. 49; pl. 64, figs 4-5; pl. 65, fig. 4b). Possibly, however, they are confined to Pseudagnostinae. Analogous scars, different in shape and orientation, are seen in *Trinodus* (Hunt 1967: pl. 22, fig. 44) and *Galbagnostus* (the second from the rear) (see Whittington, 1965, p. 306, fig. 2, pl. 3, figs 7, 12).

Scars of the basal lobes: Peardrop-shaped scars lie at the adaxial tips of the basal lobes. They are small and not often readily discernible.

MORPHOLOGICAL TERMINOLOGY APPLIED TO POLYMERID TRILOBITES

The greater part of the terminology employed is that defined by Harrington, Moore, & Stubblefield (*in* Moore, 1959). Other terms have been subsequently used by Öpik (principally 1961a, b, 1963, 1967a), and the author. Some of these, where not self-explanatory, are defined or redefined below.

Baccula (-ae): See Öpik (1967a, p. 53). Elevated swellings flanking the preoccipital glabellar lobes, of any shape or size, which may be connected to the glabella, as in Tingocephalinae, or to the adjacent fixigenae (Mansuyiinae), or lie within the axial furrows (Tsinaniidae).

Eye socle: As defined by Shaw & Ormiston (1964, p. 1002), the eye socle is 'that portion of the free cheek directly beneath the visual surface and separated from the genal field by a break in slope and/or a furrow'. Among the trilobites described below, eye socles are well developed in the remopleuridacean genera *Haniwa* and *Sigmakainella,* the ptychopariacean *Euloma* (*Plecteuloma*), and the leiostegiacean *Tsinania*. The eye socle appears to be a manifestation of the caecal system carrying the ocular diverticulum from the ocular ridges around the base of the eye. The principal genal vein (Öpik, 1967a, p. 60, text-fig. 53) branches from the eye socle to strike across the genal field, while the remainder of the diverticulum continues to the rear of the palpebral lobe, where it diverges at the postocular caecal node (Öpik, 1961a, p. 423) to form the caeca of the posterolateral limb.

Genal diverticulum: Part of the caecal network found on the librigena, principally in Saukiidae, the genal diverticulum is a prominent raised line which follows the abaxial margin of the subocular groove as far as the rear of the palpebral lobe, whence it veers abruptly outwards to intersect the genal angle, often as a ridge separating the posterior and lateral marginal furrows. A reticulate caecal network arising from this diverticulum extends to the abaxial portions of the genal field. The genal diverticulum passes adaxially into the preglabellar ridge of the cranidium, which probably carries the anterior ocular diverticulum seen in trilobites with ocular ridges. In the saukiids studied this diverticular system seems to be divorced from the ocular ridges and palpebral lobes. The wide smooth band separating the preglabellar ridge from the ocular ridge is thus probably equivalent to to ocular striga. In some ptychopariaceans, remopleuridaceans, and others, however, an analogous diverticulum circumscribes the front of the glabella as the parafrontal band, passes into the palpebral lobes, continues along the eye socle, and emerges from the latter adjacent to the rear half of the palpebral lobe as the principal genal vein (Öpik, 1967a, p. 60, text-fig. 53, e.g. the anomocaracean *Auritama aurita* Öpik, 1967a, p. 216-8, text-fig. 74). The point at which the principal genal vein issues from the eye socle appears to depend on the width (exsag.) of the posterolateral limbs. It therefore appears that it is homologue of only the posterolateral portion of the genal diverticulum.

Geniculation: The point of adventral bending of the thoracic or pygidial pleurae.

Glabellar keel (or carina): A raised sagittal line bisecting the glabellar and occasionally the preglabellar field on the parietal surfaces of some trilobites, e.g. Tsinaniidae and Asaphidae; associated with the distribution of muscle scars. Harrington (*in* Moore, 1959, p. 0101), following Hupé (1953), regards the 'median cephalic impression' of *Nileus armidillo* Dalman as the impression of the ligament suspensor of the heart.

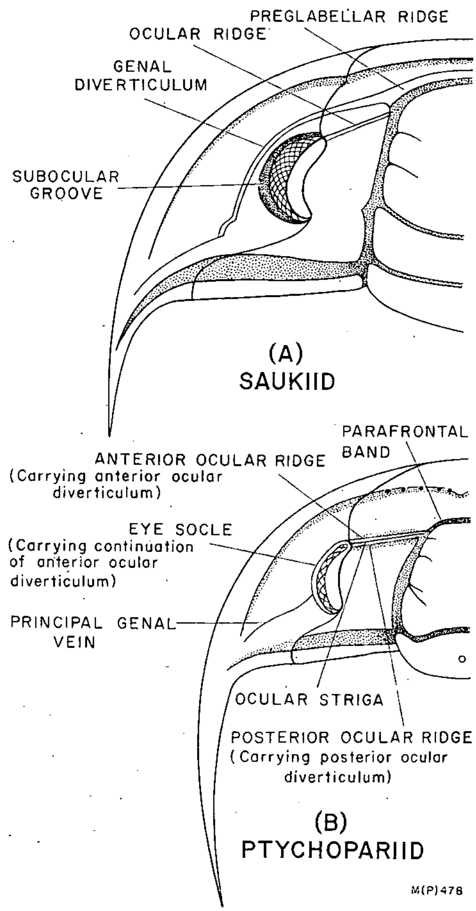

Fig. 16. Genal diverticula in certain saukiids and ptychopariids, based on *Galerosaukia* gen. nov. and *Euloma* (*Plecteuloma*) subgen. nov.

Lira (-ae): Fine raised lines, often anastomosing, generally found on the doublure and borders, but occasionally covering the whole external test (as in Remopleuridacea). This term is preferred to terrace lines.

Paradoublural lines: (see Öpik, 1967a, p. 58). External lines reflecting the edge of the doublure of both cephalon and pygidium.

Parafrontal band: A narrow band following the periphery of the frontal lobe and continuing across the axial furrows into the ocular ridges (Hupé, 1952, p. 105; Harrington, Moore, & Stubblefield, 1959, p. 0123; Shergold, 1972, p. 15).

Plectrum: The rearward projection sagittally of the anterior cranidial border; it may interrupt the course of the marginal furrow, and may extend to the front of the glabella (see Öpik 1967a, p. 59).

Pleural zone: The area occupied by furrowed pleurae of the pygidium, between the axial furrows and pygidial marginal furrow.

Posterolateral limbs: Postocular fixigenal areas distal to the fulcrum or fulcral points. Posterolateral limbs vary in shape depending on the size and extent of the palpebral lobes. Many small-eyed trilobites have broad-based triangular posterolateral limbs, whereas those of large-eyed ones are strap-like or blade-like.

Preglabellar area: The term used for the combined preglabellar field and anterior cranidial border, including the marginal furrow.

Preglabellar boss: A sagittally swollen preglabellar field lying between the anterior cranidial marginal furrow and the preglabellar furrow (this is the frontal boss *sensu* Öpik, 1967a, p. 56).

Preglabellar field: The cranidial area lying between the anterior cranidial marginal furrow and the preglabellar furrow (equals the brim of earlier usage).

Preglabellar ridge: A plicated preglabellar field.

Prosopon: A term introduced by Gill (1949, p. 572) 'for the description of surface appearance' in place of the word ornament, e.g. a cranidium possessing granules has a granulose prosopon. As it is not known whether surface features called ornament were in fact for mere adornment or whether they had a functional significance, as seems to be the case, prosopon is preferred and used here.

Pygidial bowl: The term applies to the posterior pygidial outline between the lateral spine bases of Kaolishaniidae. *Hapsidocare* and *Kaolishania* have very shallow bowls, the margins between the spine bases being nearly transverse or curving only gently. *Mansuyites* and *Mansuyia* have posteriorly extended margins and are thus deep-bowled (see Shergold, 1972, p. 15).

Subocular groove: A depression or furrow, below the visual surface of the eye, which separates it from the genal field.

DEFINITIONS OF MEASURED PARAMETERS

The following symbols have been used for measured parameters in the systematic descriptions:

Miomerid trilobites

Lc_1 Maximum length (sag.) of cephalon
Lc_2 Length (sag.) of cephalic acrolobe
Lb Length (sag.) of border, used for both cephalon and pygidium

Wc_1 Maximum width (tr.) of cephalon
Wc_2 Minimum width (tr.) of cephalon
G Length (sag.) of glabella
N Distance (sag.) from rear of glabella to high spot of axial glabellar node
Lp_1 Maximum length (sag.) of pygidium, including articulating half-ring
Lp_2 Length (sag.) of pygidium, excluding articulating half-ring
La Length (sag.) of pygidial axis
Wa Width (tr.) of pygidial axis
Wp_1 Maximum width (tr.) of pygidium
Wp_2 Minimum width (tr.) of pygidium

Polymerid trilobites

Lc Maximum length (sag.) of cranidium
G Maximum glabellar length (sag.)
Gn Length (sag.) of glabella plus occipital ring
A Maximum length (exsag.) of palpebral lobe
H Length (exsag.) of postocular area between rear of palpebral lobe and posterior cranidial marginal furrow.

A:G and A:Gn are ratios comparing the proportionate lengths of the palpebral lobes to those of the glabella, and glabella plus occipital ring. They give some idea of the increase in the length of the former during morphogenesis.

All the measurements made are chordal, i.e. cranidia were oriented with the occipital ring and preoccipital lobes in the horizontal plane, pygidia with the anterior segments in the same plane. Measurements were taken through binoculars with a micrometer eyepiece.

SYSTEMATIC DESCRIPTIONS

Order MIOMERA Jaekel, 1909
Suborder AGNOSTINA Salter, 1864
Family AGNOSTIDAE M'Coy, 1849
Subfamily AGNOSTINAE M'Coy, 1849
Genus LOTAGNOSTUS Whitehouse, 1936
Subgenus TRILOBAGNOSTUS Harrington, 1938
(= *Distagnostus* Shergold, 1972)

Type species: Agnostus innocens Clark, 1923, p. 122-4, pl. 1, figs 7, 7a; 1924, p. 17-18, pl. 3, figs 3, 3a; from a boulder in limestone conglomerate at Levis, Quebec, Canada; designated by Harrington (1938).

Other species: Agnostus innocens Clark *sensu* Raymond (1924, p. 390, pl. 12, fig. 1), from 'Zone 3 of the Milton Formation', Highgate Falls, Vermont. *Homagnostus* sp. Shaw (1951, p. 110, pl. 24, figs 7-8), from the Highgate Formation, Highgate Falls, Vermont (*Missisquoia* Zone). *Lotagnostus obscurus* Palmer (1955, p. 92, pl. 19, figs 5-7, 10), Bullwhacker Member, Windfall Formation, Eureka district, Nevada (Trempealeauan). *Distagnostus ergodes* Shergold (1972, p. 18-20, pl. 4, figs 1-7), Gola Beds, Momedah Creek, Boulia area, western Queensland

(*Pseudagnostus clarki maximus* with *P. papilio* Assemblage-Zone). Possibly also belonging to the subgenus are: *Lotagnostus subtrisectus* Westergaard (1944, p. 39, pl. 1, fig. 2), Andrarum, Sweden (Zone 5e (Westergaard 1947), *Parabolina longicornis* Zone); and *Agnostus hedini* Troedsson (1937, p. 20-22, pl. 1, figs 6-8), from Quruq-tagh, eastern Tienshan. *Lotagnostus (Trilobagnostus) irretitus* sp. nov. is described below.

Comments: Lotagnostus was proposed by Whitehouse (1936, p. 101) for Agnostina related morphologically to *Agnostus trisectus* Salter (1864b, p. 10, pl. 1, fig. 11). A pygidium figured by Westergaard (1922, pl. 1, fig. 12) from the *Peltura minor* Zone of Andrarum, Sweden, was selected as the type specimen (see Öpik, 1963, p. 53-4 for further discussion). *Trilobagnostus* Harrington (1938, p. 148) was erected for *Agnostus innocens* Clark, 1923, and related trilobites. Following Kobayashi (1939, p. 579), this taxon is considered a sub-genus of *Lotagnostus*, but for different reasons. *Trilobagnostus* is an effaced derivative of *Lotagnostus* occurring at a slightly later time. Species of both taxa have similar parietal morphology, which links them rather closely to *Agnostus* (*sensu stricto*) and *Innitagnostus* Öpik, 1967. All species assigned to *Lotagnostus* have strongly scrobiculate shields and a longitudinal trisection of the pygidial axis. Species assigned to *Trilobagnostus* have effaced external testaceous morphology, and parietal surfaces possess only a low degree of scrobiculation. Within both *Lotagnostus* and *Trilobagnostus* species are differentiated on shield shape, extent of borders, and dimensions and proportions of the pygidial axis.

As a result of examination of replicas of the material from which *Agnostus innocens* was originally described by Clark (1923, 1924), the genus *Distagnostus* Shergold, 1972, must be placed in synonymy with *Trilobagnostus* Harrington, 1938.

Distribution: Canada (Quebec); USA (Vermont, Nevada); Australia (western Queensland); possibly Scandinavia and northwestern China.

Age: In western Queensland *Trilobagnostus* ranges in age from late pre-Payntonian B through pre-Payntonian A (*bifax-denticulatus* and *maximus-papilio* A.-Zs). In Nevada, Palmer (*in* Nolan et al., 1956) has recorded *Lotagnostus obscurus* (= *Trilobagnostus*) from an early Trempealeauan assemblage (*Saukiella pyrene* Subzone, M. E. Taylor, pers. comm.). Species from Vermont assigned to *Homagnostus* by Shaw (1951) are from early Ordovician *Missisquoia* Zone.

LOTAGNOSTUS (TRILOBAGNOSTUS) IRRETITUS sp. nov.

(Pl. 14, figs 1-6; Text-figs 17, 18)

Name: L., *irretitus,* caught in a net, enmeshed, referring to the anastomosing lirations which cover the external surface of the cephalic shield.

Holotype: CPC 11518, a cephalon preserved with shell, illustrated in Pl. 14, fig. 1.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K118, K119, and K121, at 156, 157, and 171 m from the base of the measured section.

Age: Late Upper Cambrian, late pre-Payntonian B to early pre-Payntonian A, *bifax-denticulatus* and *clarki maximus-papilio* Assemblage-Zones.

Material: The species *irretitus* is based on three cephala (CPC 11518-20) and three pygidia (CPC 11521-3), specimens being preserved both as moulds and with shell.

Size: Measured cephala (CPC 11518, 11519) range in sagittal length between 3.45 and 3.60 mm, and the pygidia have lengths (sag.) (Lp_2) between 2.45 and 4.20 mm.

Diagnosis: A species of *Trilobagnostus* Harrington having an araneavelate prosopon.

Differential diagnosis: The araneavelate prosopon of the external cephalic shield readily differentiates *Lotagnostus* (*Trilobagnostus*) *irretitus* from those of the previously described Queensland species, *L.* (*T.*) *ergodes*. Exfoliated shields are indistinguishable. Shergold (1972, p. 17) has previously noted the relationships between species of *Distagnostus* (= *Trilobagnostus*) and those of *Lotagnostus* and *Innitagnostus*. In particular there is a very close resemblance between Australian species of *Lotagnostus* (*Trilobagnostus*) and *Lotagnostus obscurus* Palmer, a Trempealeauan species from Nevada, which can be distinguished only by the proportions of its shields. The cephalon of *Agnostus innocens* Clark has equally strong resemblance, but its pygidium has a more quadrate outline and its pygidial axis appears to be proportionately shorter (sag.). The early Ordovician specimens referred to *Homagnostus* by Shaw (1951) are moulds (USNM 124483) showing parietal morphology very similar to that illustrated here for *Lotagnostus* (*Trilobagnostus*) *irretitus*. Species from Vermont and Australia have shields of different proportions. *Homagnostus* sp. has a longer (sag.) third axial pygidial segment than the Australian species, and the pygidial acrolobe is scrobiculate, a feature not seen on *L.* (*T.*) *irretitus*.

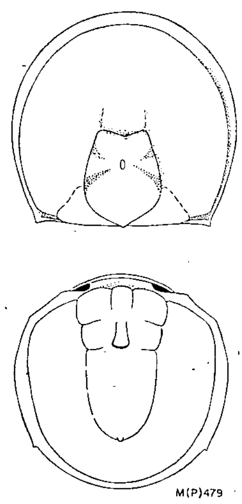

Fig. 17. External testaceous morphology of *Lotagnostus* (*Trilobagnostus*) *irretitus* sp. nov.; cephalic reconstruction based on CPC 11518, x8; pygidium based on CPC 11523, x7 approx.

Description of external testaceous surfaces: The cephalon is ovate, subcircular, generally wider (tr.) than long (sag.), the length varying between 90 and 100% of the width, depending on degree of flattening. The borders are narrow (tr., sag.), about 4% of the total cephalic length (sag.). The cephalic acrolobe is evenly rounded and laterally unconstricted, and when preserved with shell shows no trace of a median preglabellar furrow. The glabella is defined only at the rear on dorsal testaceous surfaces (Pl. 14, figs 1-2), its anterior portions being almost completely effaced, as in *Lotagnostus* (*Trilobagnostus*) *ergodes*. The rear of the glabella is rounded on shelly specimens, but rather more angulate on parietal surfaces. A faint axial glabellar node is present on the external test lying very near the mid-length (sag.) of the glabella, 42-53% of the glabellar length from the rear.

The pygidium is ovate, slightly drawn out posteriorly, its length (Lp_1) being equal to the maximum width (tr.). The borders are as narrow as those of the cephalon. The pygidial acrolobe is gently constricted laterally but, as in *L.* (*T.*) *ergodes,* this is most evident on the larger specimens (Pl. 14, fig. 6). Posterolateral spines, small thorn-like processes, lie on a transverse line across the rear of the third axial segment. The first axial segment is distinctly tripartite, with a narrow (tr.) central portion continuing the convexity of the axial node forwards and separated from lateral lobes by a pair of longitudinal (exsag.) furrows. This tripartition is more obvious in *L.* (*T.*) *irretitus* than in *L.* (*T.*) *ergodes.* Similar longitudinal furrows are present on the second axial segment, enclosing the axial node. The third and posterior segment is elongate, bullet-shaped, occupying approximately 60% of the total axial length (sag.), and about 45% of the total pygidial length (sag., Lp_2).

The external testaceous surface of the cephalon bears a system of anastomosing ridges arranged in a roughly concentric pattern around the outline of the acrolobe. The condition of the external surface of the pygidium is unknown.

Description of parietal surfaces: The parietal morphology of the glabella is well illustrated on the latex cast of specimen CPC 11520 (Pl. 14, fig. 3). The anterior glabellar lobe is seen to be long (sag.) and anteriorly pointed, and to be separated from the posterior lobe by transverse curvilinear furrows, bowed rearwards sagittally. The major posterior muscle scars of the posterior lobe lie in positions analogous to those of *Pseudagnostus.* They are large and circular, and are flanked by similar oblique lateral ridges and deltoid depressions. The oblique lateral ridges merge with the axial glabellar node anteriorly, forming there a distinct sagittal ridge which can be traced through the axial node and across the anterior lobe. A pair of low swellings, which may also represent muscle scars, lie adjacent to the oblique lateral ridges, and these merge anteriorly with a second pair lying in the position of the anterolateral scars of the posterior lobe in *Pseudagnostus.* The arrangement of these features on the parietal surface of *Lotagnostus* (*Trilobagnostus*) *irretitus* is compatible with the arrangement of lobes and furrows seen on species of *Lotagnostus* (*Lotagnostus*), in particular *L.* (*L.*) *trisectus* (Salter) (Westergaard, 1922, p. 117, pl. 1, fig. 11), *L.* (*L.*) *asiaticus* Troedsson (1937, p. 25, pl. 1, figs 10-15), and *L.* (*L.*) *americanus* (Billings) (Rasetti, 1944, p. 233, pl. 36, fig. 1).

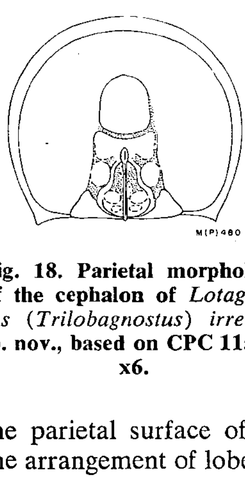

Fig. 18. Parietal morphology of the cephalon of *Lotagnostus* (*Trilobagnostus*) *irretitus* sp. nov., based on CPC 11520, x6.

Evidence for the longitudinal tripartition of the posterior segment of the pygidial axis is almost completely lacking in *L.* (*Trilobagnostus*) *irretitus,* although the notular furrows may be very faintly discerned on CPC 11523 (Pl. 14, fig. 6). This specimen also shows irregular swellings on the flanks of this segment adjacent to the axial furrows, which are presumably a part of the caecal system (cf. Westergaard, 1922, pl. 1, fig. 12). A rather wide, smooth band, slightly V-form, separates the second and posterior axial segments, which in *Lotagnostus* (*Lotagnostus*) may swell into a pair of very narrow (exsag.) lobes.

Genus GERAGNOSTUS Howell, 1935

Subgenus MICRAGNOSTUS Howell, 1935

Type species: Agnostus calvus Lake, 1906, p. 23, pl. 2, fig. 18, from the Tremadocian of Nant rhosddu, Arenig, north Wales; designated by Howell (1935).

GERAGNOSTUS (MICRAGNOSTUS) cf. ACROLEBES Shergold, 1972
(Pl. 13, figs 9-11; Text-fig. 19)

cf. 1972 *Geragnostus (Micragnostus) acrolebes* Shergold, p. 23-4, pl. 5, figs 3-5.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizon K119, 157 m from the base of the measured section, and at B507a and B509 (see Appendix 1).

Age: Late Upper Cambrian, pre-Payntonian B, *Pseudagnostus bifax* with *P. denticulatus* Assemblage-Zone.

Material: The material at hand consists of three pygidia and a single cephalon. Specimens CPC 11724-6 form the illustrated paradigm.

Comment: Geragnostus (Micragnostus) acrolebes was described originally from the Gola Beds of Momedah Creek, western Queensland (Shergold, 1972, p. 23-4). The holotype, a pygidium, was figured by Shergold (op. cit., pl. 5, fig. 4; CPC 9689).

Pygidia from Black Mountain are compatible with the holotype in their shapes and convexities, and the extent of the posterior lobes of the axis. They are, however, less well preserved than the holotype, and the position and orientation of their posterolateral spines is difficult to discern. Conversely, the cephalon is better preserved than that previously illustrated from the Gola Beds. Its more rounded anterior cephalic outline differs slightly from specimens previously figured, although one of these (Shergold, op. cit., pl. 5, fig. 3), in spite of being slightly damaged anterolaterally, is similar. In the shapes of their glabellae and acrolobes, the strengths of their furrows and lobes, and the positions of their axial glabellar nodes, the cephala are quite comparable.

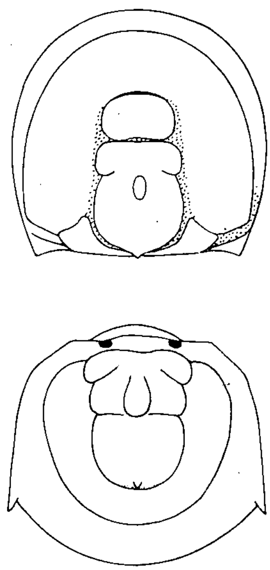

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Fig. 19. External testaceous morphology of *Geragnostus (Micragnostus)* cf. *acrolebes* Shergold, 1972; cephalic reconstruction based on CPC 11724, x16.5; pygidium based on CPC 11725, x17 approx.

GERAGNOSTUS (MICRAGNOSTUS) cf. INTERMEDIUS Palmer, 1968
(Pl. 13, figs 7, 8, 12; Text-fig. 20)

cf. 1968 *Geragnostus intermedius* Palmer, p. B24, pl. 12, figs 1-2.

cf. 1968 *Geragnostus intermedius* Palmer; Robison & Pantoja-Alor, 1968, p. 776, pl. 97, figs 1-10.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizon K139, 375 m from the base of the measured section; Mount Ninmaroo, horizon K170, 70 m from the base of the measured section.

Age: Late Upper Cambrian, Payntonian, *Pseudagnostus quasibilobus* with *Tsinania nomas* Assemblage-Zone.

Material: The Australian material consists of three cephala and a single pygidium. The illustrated cephalon (Pl. 13, fig. 7) has a sagittal length of 2.20 mm, and equal transverse width. Specimens CPC 11727, 11728a-b constitute the figured paradigm.

Comment: The holotype of *Geragnostus* (*Micragnostus*) *intermedius* is the pygidium figured by Palmer (1968, pl. 12, fig. 2), USNM 146842, from the late Franconian of the Hillard Peak area of east-central Alaska. The species has also been identified by Robison & Pantoja-Alor (1968) from the lower, calcareous, part of the Tiñu Formation of Nochixtlán, Mexico. At this latter place *G.* (*M.*) *intermedius* is dated as early Tremadocian (= Datsonian) because it is associated with the conodonts *Cordylodus proavus, C. angulatus,* and *Oneotodus simplex.* As pointed out by Robison & Pantoja-Alor (op. cit.), the pygidium from the *Saukia* Zone of the Williston Basin, Montana, figured by Lochman (1964, p. 52, pl. 14, fig. 5), and referred to *Geragnostus mundus* Raymond, 1924, is probably conspecific with Palmer's species. Lochman's specimens are considered Trempealeauan in age, as is the Australian material, dated as Payntonian (in part Trempealeauan).

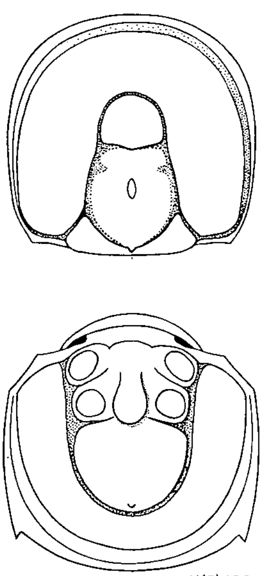

Fig. 20. External testaceous cephalic morphology of *Geragnostus* (*Microagnostus*) **cf.** *intermedius* **Palmer, 1968; based on CPC 11727, x14.5; matched with pygidium, CPC 11728a, x20, showing some parietal morphology.**

Differential diagnosis: Palmer's species *intermedius* is differentiated from others of *Geragnostus* (*Micragnostus*) by a long (sag.) pygidial axis, and the presence on some specimens of a median preglabellar furrow. In these respects the Australian specimens are similar to those from Alaska. There are, however, small differences in the shape of the cephala: the Australian ones are more ovately rounded anteriorly, as are the Mexican specimens. The faint median preglabelar furrow is just visible proximal to the anterior glabellar lobe. Specimens from Alaska, Montana, Mexico, and Queensland have similarly constituted pygidial axes. Pygidial margins are not preserved on the material at hand, and so a definite determination of species must await more complete specimens. The third (posterior) segment of the pygidium is longer (sag.) than in *G.* (*M.*) *acrolebes,* and the cephalon is relatively wider (tr.), more convex (tr.), and anteriorly rounded to a greater degree.

Description: The description is based on limestone moulds showing little detail of the parietal surface morphology. The cephalon has a rounded-quadrate outline, with length (sag.) equal to the maximum width (tr.). The cephalic borders are narrow (tr., sag.), and the marginal furrows shallow. The acrolobe is evenly rounded, unconstricted, and appreciably convex (tr.). A faint median preglabellar furrow is present on some specimens, but is proximally present on all. The glabella, occupying 70% of the cephalic length (sag.), has a small rounded anterior lobe divided from a bulbous and elevated posterior one by a rectilinear transverse anterior furrow. Median lateral lobes are not strongly developed, and the basal lobes are small.

The pygidial acrolobe is also unconstricted and slopes strongly from deep axial furrows both laterally and posteriorly. All segments and furrows of the axis are well developed, the third (posterior) segment being equal in length (sag.) to the two anterior ones combined. The complete pygidial axis occupies 70% of the total pygidial length (Lp_2). The nature of the borders and posterolateral spines is unknown.

Subgenus STRICTAGNOSTUS nov.

Name: L., *strictus,* m., draw together, prefixing the generic nomen *agnostus*. The name refers to the gentle constriction of the pygidial acrolobe and the strongly acutely rounded cephalic acrolobe.

Type species (here designated): *Geragnostus* (*Strictagnostus*) *chronius* sp. nov., from Black Mountain, western Queensland, of pre-Payntonian age.

Other species: Tentatively, the following species might prove to belong to *Geragnostus* (*Strictagnostus*): *Homagnostus reductus* Winston & Nichols (1967, p. 72-3, pl. 13, figs 20, 23), from the *Missisquoia* and *Symphysurina* Zones, Wilberns Formation, central Texas; and *Agnostus a* sp. Kobayashi (1934b, p. 537, pl. 3, figs 2-3), from the *Asaphellus* Zone of Makkol, South Korea.

Distribution: ?North America (Texas), ?South Korea, and Australia (western Queensland).

Diagnosis: A subgenus of *Geragnostus* Howell with gently constricted pygidial acrolobes, and wide deliquiate cephalic marginal furrows.

Comment: Constricted acrolobes are uncommon in Agnostinae as envisaged by Öpik (1967a). The general appearance of both cephala and pygidia assigned to *Geragnostus* (*Strictagnostus*) nevertheless strongly suggests classification within *Geragnostus* and thus within Agnostinae.

Differential diagnosis: The subgenus *Strictagnostus* is differentiated from *Geragnostus* and *Micragnostus* by having a gentle constriction of the pygidial acrolobe. The anteriorly tapering cephalic acrolobe of the type species is known also in *G.* (*G.*) *nesossi* from the Tremadocian of Argentina (Harrington & Leanza, 1957, p. 66, figs 9.1 to 9.5), but in conjunction with the subquadrate outline of the cephalon and the wide marginal furrows, the characteristic has a differentiation value. The anterior glabellar furrow of *Strictagnostus* is transverse, rearwards curvilinear, and the axial node of the glabella appears to lie about the midlength of the posterior glabellar lobe. In these characteristics *G.* (*Strictagnostus*) resembles *G.* (*Micragnostus*) but is distinct from *G.* (*Geragnostus*).

GERAGNOSTUS (STRICTAGNOSTUS) CHRONIUS sp. nov.
(Pl. 13, figs 1-6; Text-fig. 21)

Name: L., *chronius,* enduring, referring to the long range of the species through the pre-Payntonian of the Black Mountain section.

Holotype: CPC 11732, the pygidium illustrated in Plate 13, fig. 5.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K116, K117, K123, and K131, at 138, 149, 185, and 309 m from the base of the measured section.

Age: Late Upper Cambrian, late pre-Payntonian B, Assemblage-Zone of *Pseudagnostus bifax* with *P. denticulatus;* pre-Payntonian A, Assemblage-Zone of *P. clarki maximus* with *P. papilio.*

Material: The species is based on four cephala and two pygidia, all preserved as moulds. The illustrated paradigm comprises the cephala CPC 11729a, b-11731, and pygidia CPC 11732-3.

Size: Measured cephalic lengths (sag.) range between 2.75 and 3.60 mm; and the length (Lp_2) of the single measurable pygidium is 1.50 mm.

Diagnosis: The specific diagnosis is that of the subgenus.

Differential diagnosis: The pygidium of *Geragnostus (Strictagnostus) chronius* is morphologically most similar to that assigned by Winston & Nichols (1967) to *Homagnostus reductus,* differing only in a lesser degree of constriction of the acrolobe. The cephalon of *G. (S.) chronius* is more quadrate than that of *H. reductus,* and although both species possess deliquiate marginal furrows, those of *reductus* are apparently narrower (tr. and sag.). Cephala from Makkol, South Korea, which Kobayashi (1934b) has figured as *Agnostus a* sp., are similar in shape to those figured here, and they also appear to have deliquiate marginal furrows. The last characteristic, however, is by itself not diagnostic of *Strictagnostus,* as such furrows are also present in *Geragnostus nesossi* Harrington & Leanza (see above). The cephalon of *G. (G.) callavei* (Lake, 1906) *mediterraneus* Howell (1935, p. 231-2, pl. 23, fig. 6), from the early Arenigian of Hérault, France, is similar to that of *Strictagnostus chronius* in all respects save that the axial glabellar node lies much farther forwards, reaching the anterior glabellar furrow. Its pygidium may also have a constricted acrolobe, but this cannot be verified from the published illustrations.

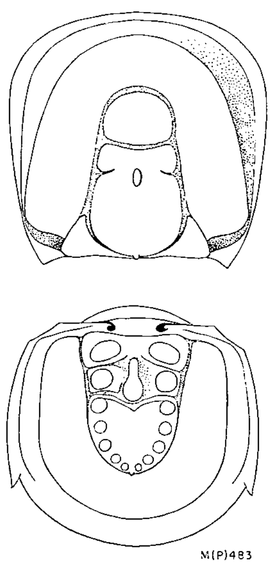

Fig. 21. *Geragnostus (Strictagnostus) chronius* **subgen. et sp. nov.; external testaceous cephalic reconstruction based on CPC 11730, x12; parietal pygidial reconstruction based on CPC 11732, x19.**

Description: The description is based on limestone moulds which show little of the parietal morphology, and is accordingly a composite record of observations.

The cephalon expands forwards and is anteriorly obtusely rounded, its length (sag.) being 92-111% of the width (tr.). The borders are slightly upturned marginally and separated from the acrolobe by shallow, deliquiate, marginal furrows which are widest (tr.) anterolaterally. The cephalic acrolobe, on the other hand, tapers forwards and is acutely rounded. Only the very faintest indication of a median preglabellar furrow is present. The glabella occupies 61-67% of the total cephalic length (sag.). Its anterior lobe is small and rounded, the posterior one elevated and rounded at the rear. Two small lobes are present at the anterolateral corners of the posterior lobe. The anterior glabellar furrow is transverse rectilinear and well defined. The exact position of the axial glabellar node is not known, but it appears to lie well behind the anterior glabellar furrow.

The pygidium has a quadrate outline, obtusely rounded at the rear. The borders are flat and of near equal width around the periphery of the acrolobe. Small posterolateral spines, deflected outwards (abaxially) from the lines of the lateral margins, lie on a transverse line across the middle of the postaxial acrolobe. The acrolobe has low convexity and is laterally slightly constricted. The axis is subconical, tapering rearwards. The first segment is the widest (tr.), separated by curvilinear furrows sloping rearwards abaxially. The second segment is longer (sag.), but less wide (tr.) than the first; it is separated from the posterior segment (the third) by a transverse curved furrow. The third (posterior) segment is parallel-sided, posteriorly rounded, and nearly half the total axial length (sag.). The pygidial axis overall occupies two-thirds of the total pygidial length (Lp_2).

Both pygidia illustrated in Plate 13 (figs 5-6) show traces of muscle scars on their axes. Those of the first segment are situated in comparable positions to those of *Geragnostus tumidosus* Palmer (1955, pl. 20, fig. 15). Those of the second segment, by contrast, are anterolateral in position compared with those of *tumidosus,* in which they lie adjacent to the axial pygidial node. Those of the third (posterior) segment are again anterolaterally sited. A faint crest runs sagittally along the length of this lobe in CPC 11733 (Pl. 13, fig. 6), and low swellings lie at both its anterior and posterior ends. The cephalic acrolobe is scrobiculate and faintly punctate, especially on specimen CPC 11731 (Pl. 13, fig. 4).

Family DIPLAGNOSTIDAE Whitehouse, 1936 emend. Öpik, 1967
Subfamily DIPLAGNOSTINAE Whitehouse, 1936
Genus CONNAGNOSTUS Öpik, 1967

Type species: Connagnostus venerabilis Öpik 1967a, p. 130-2, pl. 54, figs 11-14; pl. 55, figs 1-2; text-figs 36A-C, from the early Upper Cambrian, Mindyallan Stage, Zone of *Glyptagnostus stolidotus,* Georgina Limestone and O'Hara Shale, western Queensland, designated by Öpik (1967a).

Other species: Öpik (op. cit.) included in *Connagnostus* the species *Proagnostus?* sp., Palmer (1962, p. F14, pl. 1, figs 17-19, 23), from the Conosauga Formation, Woodstock, Alabama (see Öpik, 1967a, p. 129 for comment); and tentatively the zonate species *Connagnostus? zonatus* sp. nov., Öpik (1967a, p. 132, pl. 55, fig. 5) from the Mungerebar Limestone, *Cyclagnostus quasivespa* and *Glyptagnostus stolidotus* Zones, western Queensland. A further species, *Connagnostus junior* Shergold (1972, p. 25-6, pl. 5, figs 1-2), was described from the late Upper Cambrian, pre-Payntonian A (*Pseudagnostus clarki maximus* with *P. papilio* Assemblage-Zone), Gola Beds, Momedah Creek, western Queensland. *Connagnostus conspectus* sp. nov. is described below from the pre-Payntonian B interval of Black Mountain.

Distribution: USA (Alabama), Australia (western Queensland).

Age: Early Dresbachian in Alabama; Mindyallan (*Cyclagnostus quasivespa* and *Glyptagnostus stolidotus* Zones) and pre-Payntonian A and B intervals in Australia.

CONNAGNOSTUS CONSPECTUS sp. nov.
(Pl. 13, figs 13-15; Text-fig. 22)

Name: L., *conspectus,* visible, striking, referring to the highly constricted pygidial acrolobe.

Holotype: CPC 11734, the pygidium illustrated in Pl. 13, fig. 13.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K116, K117 and K119, at 138, 149, and 157 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, *Pseudagnostus bifax* with *P. denticulatus* Assemblage-Zone.

Material: The material includes three cephala and four pygidia, all poorly preserved as moulds. The illustrated specimens are the most complete fragments available: CPC 11734-6.

Size: Only one cephalon and one pygidium are sufficiently complete for quantitative assessment. The cephalon CPC 11735, Pl. 13, fig. 13, has a length (sag.) of 2.25 mm, and the holotype pygidium a length (Lp_2) of 2.10 mm. These specimens are slightly larger than those of *C. junior* described previously from the Gola Beds.

Diagnosis: A species of *Connagnostus* based on the following complex of pygidial characteristics: converging lateral flanks, strongly constricted acrolobe, wide, deliquiate marginal furrows, and a wide (sag.) posterior border.

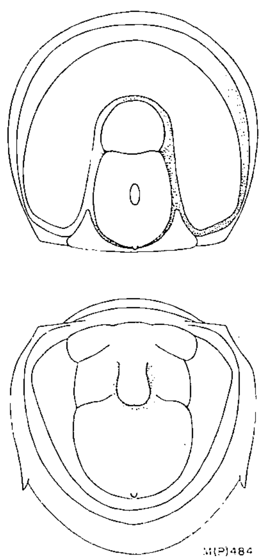

Fig. 22. ***Connagnostus conspectus*** **sp. nov.; reconstruction of external testaceous surfaces based on the cephalon CPC 11735, x14, and pygidium CPC 11734, x15.**

Differential diagnosis: The discussion by Shergold (1972, p. 26) differentiating *Connagnostus junior* Shergold from *C. venerabilis* Öpik, is equally valid for *C. conspectus.* It is notable that the pygidium of *conspectus* has a longer (sag.) third (posterior) axial lobe than that of *C. junior,* which fact is perhaps further evidence for the neotenous derivation of late Cambrian species of the genus from those of Mindyallan age. *Connagnostus conspectus* is differentiated from all other species of the genus on the pygidial characteristics listed in the diagnosis. The cephalic marginal furrows are shallower and narrower (sag.) than in other species, but in other respects cephala of all species are similar.

General description: The cephalon is subcircular, slightly wider (tr.) than long (sag.); $Lc_1:Wc_1$ is 98% for CPC 11735. The borders are wide, 11% sagittally for CPC 11735, but the marginal furrows are shallower than in other species of the genus, especially when vestiges of the shell are retained. The glabella occupies 64% of the cephalic length (sag.). It has a bulbous, rounded anterior lobe, slightly pointed at the front, and an elevated posterior lobe widening (tr.) rearwards. The posterior end of this lobe is rounded rather than angulate, a characteristic considered by Öpik (1967a) more compatible with Agnostinae than Diplagnostinae. The anterolateral lobes are not well developed in

C. conspectus. The position of the axial glabellar node is uncertain, but appears to lie near the middle of the posterior lobe. No median preglabellar furrow is evident on the acrolobes of any of the three cephala available.

The pygidium is elongate, with flanks converging rearwards, acutely rounded posteriorly; $Lp_2:Wp_1$ is near 120%. The marginal furrows are wide (tr., sag.) around the entire periphery of the acrolobe, and the borders occupy 25% of the pygidial length posteriorly. The acrolobe is very conspicuously constricted, as in *C. junior*. The axis is relatively wide (tr.), with a third segment longer (sag.) than the other two segments combined. The axial length is 69% of the total pygidial length. Small, outwardly deflected posterolateral spines lie on a transverse line across the rear of the pygidial acrolobe, but well in advance of the posterior margin of the pygidium.

Nothing is known of the parietal morphology.

Subfamily PSEUDAGNOSTINAE Whitehouse, 1936

The following genera are considered to constitute the subfamily *Pseudagnostinae: Pseudagnostus* Jaekel, 1909, *Pseudagnostina* Palmer, 1962, *Xestagnostus* Öpik, 1967, *Oxyagnostus* Öpik, 1967, and *Litagnostus* Rasetti, 1944.

Pending a detailed revision of *Pseudagnostus* and its allies, the genus is treated *sensu lato,* with its many species grouped around typical representatives. Some of the generic names listed as synonymous with *Pseudagnostus* may eventually be applied to these species groups.

Genus PSEUDAGNOSTUS Jaekel, 1909 *sensu lato*

(*Pseudagnostus* n. g., Jaekel, 1909, p. 400 = *Plethagnostus* Clark, 1923, p. 124 = *Rhaptagnostus* Whitehouse, 1936, p. 97 = *Euplethagnostus* Lermontova, 1940, p. 126 = *Pseudorhaptagnostus* Lermontova, 1940, p. 126 = *Neoagnostus* Kobayashi, 1955, p. 473 = *Hyperagnostus* Kobayashi, 1955, p. 474 = *Machairagnostus* Harrington & Leanza, 1957, p. 63)

Sulcatagnostus Kobayashi, 1937, based on *Agnostus securiger* Lake (1906, p. 20, pl. 2, fig. 11), has a trispinose pygidium and is regarded as a subgenus of *Pseudagnostus* (Rushton *in* Taylor & Rushton, 1971). *Machairagnostus* Harrington & Leanza, 1957, based on *M. tmetus* Harrington & Leanza (1957, p. 63-4, figs 6-7), may be applied to late pseudagnosti considered below as the *bilobus* species group. *Neoagnostus* and *Hyperagnostus,* however, were both proposed (Kobayashi, 1955) for specimens having at least one shield referable to this group. *Neoagnostus aspidoides* Kobayashi (1955, p. 473-4, pl. VII, figs 4-5, pl. IX, fig. 5; GSC 12745-6) has a pseudagnostoid cephalon and a geragnostoid pygidium. *Hyperagnostus binodosus* Kobayashi (1955, p. 475, pl. VII, figs 2-3, pl. IX, fig. 4; GSC 12747) also has a pseudagnostoid cephalon: its pygidium may belong to *Litagnostus.* The pygidium (GSC 12751) which is the holotype of *Trinodus priscus* Kobayashi (1955, p. 476, pl. VII, fig. 6) is a pseudagnostinid of the *bilobus* kind. Should these specimens, all from the McKay Group, be regarded as a single species, united with the pygidium described as *Trinodus priscus,* then the resulting species, which must be placed in *Neoagnostus,* becomes comparable with Shaw's (1951) *Pseudagnostus bilobus. Neoagnostus* then takes priority over *Machairagnostus* should the *bilobus* species group presently placed in *Pseudagnostus s.l.* require a generic name.

Type species: Agnostus cyclopyge Tullberg, 1880, p. 26, pl. 2, figs 15a-c, Zones of *Parabolina spinulosa* with *Orusia lenticularis* and *Olenus,* Andrarum, Skaane (*fide* Westergaard 1922, p. 116-7); designated by Jaekel (1909).

Other species: Including those proposed here, 67 species have been referred to *Pseudagnostus.* Of these, three are *nomina nuda: Pseudagnostus huangluosensis* Kobayashi (1951, p. 75), *Pseudagnostus mirus* Pokrovskaya (*in* Vasilenko 1963, p. 22, chart 3), and *Pseudagnostus solus* Endo (*in* Endo & Resser 1937, p. 304, listed). The remainder are divisible into several species groups, four of which are discussed below, based on *Pseudagnostus clarki* Kobayashi, 1935, *P. convergens* Palmer, 1955, *P. bilobus* Shaw, 1951, and *P. clavus* Shergold, 1972. These groups contain relatively few of the species cited in world literature, the bulk of which may be classified within further species groups based on *Pseudagnostus cyclopyge* (Tullberg, 1880), and *P. communis* (Hall & Whitfield, 1877).

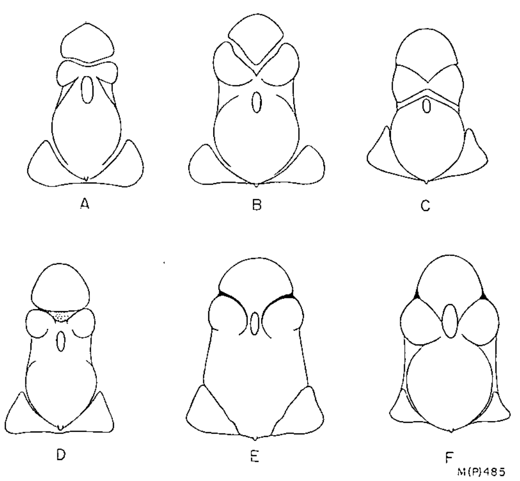

Fig. 23. Arrangements of glabellar lobes and furrows for six species groups of *Pseudagnostus*: (A) *P. cyclopyge* group, based on *P. vastulus* Whitehouse, 1936; (B) *P. clavus* group, based on *P. clavus* Shergold, 1972; (C) *P. bilobus* group, based on *P. quasibilobus* sp. nov.; (D) *P. communis* group, based on *P. communis* (Hall & Whitfield, 1877); (E) *P. clarki* group, based on *P. clarki patulus* subsp. nov.; (F) *P. convergens* group, based on *P. papilio* Shergold, 1972.

Subdivision of *Pseudagnostus* is based firstly on the positioning of the axial glabellar node with respect to the anterolateral lobes; secondly, on the shape and orientation of the anterior, anterolateral, and median lateral glabellar furrows; and thirdly, on the shape of the shields.

The axial node of the glabella is generally sited in one of two positions: it lies either behind the anterolateral lobes and behind the anterior or anterolateral glabellar furrows (here called *spectaculate*), or between the lobes, interrupting the courses of the furrows (*papilionate*). Text-figure 23 compares species belonging to the six groups. Spectaculate pseudagnosti are divisible on the orientations of their median lateral and anterior glabellar furrows. Papilionate species have similar furrowing and are divided mainly on the shapes of their shields. Species grouped on *Pseudagnostus clavus* and *P. bilobus* are spectaculate, whereas those based on *P. clarki* and *P. convergens* are papilionate. Distribution of species among these species groups is indicated under the relevant headings below.

Pseudagnostus clarki species group

Characteristic species: Pseudagnostus (Plethagnostus) clarki Kobayashi, 1935a, p. 47, pl. 9, figs 1-2, *Briscoia* fauna, Alaska; also figured by Palmer (1968, p. 29, pl. 15, figs 10, 13-14) from Jones Ridge, east-central Alaska, from rocks of Trempealeauan age.

Characteristics: Belonging to the papilionate division of pseudagnosti, the *Pseudagnostus clarki* group is related to that based on *Pseudagnostus convergens,* but distinguished from all others by the position of its axial glabellar node, which lies between, rather than behind, the anterolateral glabellar lobes. Anterior and median lateral furrows, which are both faint, are V-form and chevronate respectively. Specimens of this group preserved with shell are invariably effaced, and parietal surfaces show the detail on which the group is based.

Cephala of members of the *clarki* group are relatively wide (tr.), broadly rounded anteriorly, and subcircular. The pygidia are equally wide, but there is a strong tendency for these shields to become elongated rearwards so that the very small posterolateral pygidial spines lie well in front of the rear of the deuterolobe. Borders of both cephalon and pygidium are relatively wide (sag.), but the marginal furrows are non-deliquiate. There is evidence for ten or eleven metameres in the pygidium of species of the *clarki* group.

All morphological features suggest that the *clarki* group of species is derived from a species of the contemporaneous *communis* group through intermediates that have been referred to *Pseudagnostus neon, P. josepha,* or even *P. communis* itself, and that this differentiation took place during the early Franconian (probably within the time span of the *Elvinia* Zone).

Other species: Apart from the nominal species, the following small number of described taxa is referred to the *clarki* group: *Pseudagnostus cyclopygeformis* (Sun) *sensu* Kobayashi (1933a, p. 97-8, pl. 9, figs 19, 23-24; pl. 10, fig. 7; 1935c, p. 111-2, pl. 3, figs 12-14?), *Tsinania* Zone of North Korea, *Eoorthis* Zone of Tomkol, South Korea. *Pseudagnostus laevis* Palmer (1955, p. 97-8, pl. 19, figs 8-9, 11-12), Bullwhacker Member, Windfall Formation, Eureka district, Nevada, USA (Palmer, 1968, p. 29, considers his species a synonym of *Pseudagnostus clarki* Kobayashi, but it is here interpreted as a subspecies). *Pseudagnostus* sp., Robison & Pantoja-Alor (1968, p. 780, pl. 97, figs 17-18), Tiñu Formation, Nochixtlán, Oaxaca district, Mexico. *Pseudagnostus clarki patulus* subsp. nov., *P. clarki prolatus* subsp. nov., *P. clarki maximus* subsp. nov., *P. elix* sp. nov., and *P. orbiculatus* sp. nov. are described below from the 'Chatsworth Limestone' of Black Mountain, western Queensland. *Pseudagnostus* spp. II and III (Shergold, 1972), from the Gola Beds of Momedah Creek, are considered synonymous with *P. clarki maximus* in this paper.

Distribution: The *Pseudagnostus clarki* species group has a wide circum-Pacific distribution, but is not yet recorded from Europe or the USSR. As constituted above, the group is present in North America (Nevada, Alaska), Mexico (Oaxaca), North Korea, South Korea, and Australia (western Queensland).

Age: The oldest species of the *clarki* group occur in Australia (western Queensland), where they occur first in the pre-Payntonian but range into the Payntonian. In Korea representatives of the group are of Fengshanian (= Payntonian) age, and are possibly contemporaneous with the early Trempealeauan occurrences of Nevada. In Mexico the occurrence of the *clarki* group antedates that of the *Cordylodus proavus* conodont fauna at Arroyo Totoyac (Robison & Pantoja-Alor, 1968, p. 772), and may be of latest Cambrian age.

PSEUDAGNOSTUS CLARKI Kobayashi, 1935

Pseudagnostus clarki is a partly effaced species: when the shell is preserved, axial, glabellar, and transverse furrows are either very faint or absent altogether, but when the shell is removed the parietal surface invariably shows faint furrowing.

Pseudagnostus clarki has a subcircular cephalon. The axial node lies between the anterolateral lobes, and this feature differentiates the species from complexes based on *P. communis* (Hall & Whitfield) and *P. prolongus* (Hall & Whitfield). *Pseudagnostus cyclopygeformis* (Sun, 1924), *P. convergens* Palmer, 1955, *P. obsoletus* Lermontova, 1951, and *P. papilio* Shergold, 1972, also have axial nodes lying in this position, but are differentiated on the shape of the shields or degree of effacement. In *P. clarki* the posterior lobe is bluntly rounded, the basal lobes are large, and the cephalic margins relatively wide. The pygidium has near parallel-sided axial furrows, almost effaced transverse furrows, and faintly constricted acrolobe. The articulating half-ring is a simple bar.

Pseudagnostus clarki is divided here into five subspecies, three of which occur in Australia.

PSEUDAGNOSTUS CLARKI CLARKI Kobayashi, 1935

1935 *Pseudagnostus (Plethagnostus) clarki* Kobayashi, 1935a, p. 47, pl. IX, figs 1-2.
1968 *Pseudagnostus clarki* Kobayashi; Palmer, 1968, p. B29, pl. 15, figs 10, 13, 14.

Holotype: USNM 93062, pygidium, Kobayashi 1935a, pl. IX, fig. 2; Palmer 1968, pl. 15, fig. 13; designated by Kobayashi (op. cit., explanation to pl. IX).

Occurrence: Eastern Alaska, *Briscoia* fauna of Hard Luck Creek; Trempealeauan 1 and 2 faunas of Jones Ridge.

Age: Late Upper Cambrian, Trempealeauan.

Diagnosis: A subspecies with subcircular cephalic shield but slightly more elongated pygidium. Both are virtually effaced. The maximum width of the cephalon lies on a transverse line across the front of the axial glabellar node; that of the pygidium lies well to the rear of the third metamer. The pygidium is posteriorly bluntly rounded.

PSEUDAGNOSTUS CLARKI Kobayashi, 1935, LAEVIS Palmer, 1955

1955 *Pseudagnostus laevis* Palmer, p. 97-8, pl. 19, figs 8-9, 11-12.

Holotype: USNM 123559, pygidium, Palmer, 1955, pl. 19, fig. 9; by original designation.

Occurrence: Eureka district, Nevada, Bullwhacker Member of Windfall Formation.

Age: Late Upper Cambrian, Trempealeauan.

Diagnosis: In the cephalon the maximum width lies on a transverse line at the front of the axial glabellar node, as in *P. clarki clarki*. The maximum pygidial width lies well to the rear of the third metamer. Posteriorly the pygidium is drawn out, evenly rounded.

Comment: Although Palmer (1968: B29) now considers his species *laevis* synonymous with *clarki*, the published material shows a difference in the posterior shape of the pygidium. In *clarki* it is gently rounded, in *laevis* more acutely so.

PSEUDAGNOSTUS CLARKI Kobayashi, 1935, PATULUS subsp. nov.
(Pl. 1, figs 1-6; Pl. 2, figs 1-2; Text-figs 15, 24)

Name: L., *patulus*, broad, referring to the width of the cephalon.

Holotype: The cephalon, CPC 11524, illustrated in Plate 1, fig. 1.

Occurrence 'Chatsworth Limestone', Black Mountain, horizons K103, K104, K105, K106, K107, K108, ?K109, at 1.6, 6, 7.3, 59, 68, 73, and probably 80 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zones of *Pseudagnostus clarki patulus* with *Caznaia squamosa* and early *Pseudagnostus clarki prolatus* with *C. sectatrix*.

Material: 16 cephala representing four holaspid instars, and 21 pygidia, also representing four holaspid instars. The illustrated paradigm consists of the cephala CPC 11524-6, 11528, and the pygidia CPC 11527, 11529-31. Material tabulated in the text includes CPC 11543-58.

Size: The range of cephalic length (Lc_1) is 3.50-5.60 mm; pygidial lengths range between 2.80 and 5.70 mm for parameter Lp_2.

Diagnosis: A subspecies of *Pseudagnostus clarki* Kobayashi with strongly effaced cephalon and pygidium. The cephalic shield is subcircular, but that of the pygidium is more elongated. Length to width ratios for head and tail are equivalent, but the maximum length is always appreciably less than the maximum width for each shield. In the cephalon the maximum width lies on a transverse line cutting across the rear of the axial glabellar node, and in the pygidium it lies to the rear of the third metamer, between metameres three and four.

Differential diagnosis: Two characteristics differentiate the cephalon of *Pseudagnostus clarki patulus* from that of *P. clarki*. The cephalon is proportionately wider (tr.), and its maximum width lies behind the rear of the axial glabellar node. The pygidium of *clarki patulus* is a little more acutely rounded posteriorly, but otherwise strictly comparable as far as the previously illustrated material can be interpreted.

Palmer (1968, p. B29) has considered his species *Pseudagnostus laevis* synonymous with *P. clarki sensu* Kobayashi. As noted above the illustrated material from Nevada includes pygidia (Palmer, 1955, pl. 19, figs 11-12) with decidedly acutely rounded posterior margins. The position of the maximum widths of both cephalon and pygidium is similar and in the cephalon lies in front of the axial glabellar node. The last characteristic distinguishes both *P. clarki clarki* and *P. clarki laevis* from *P. clarki patulus*.

One of the specimens illustrated by Kobayashi (1933a, p. 97-8, pl. IX, fig. 24) as *Pseudagnostus cyclopygeformis* (Sun) is comparable in shape and proportions to cephala of *P. clarki patulus*. It differs in being considerably less effaced.

The *Pseudagnostus* sp. of Robison & Pantoja-Alor (1968: 780, pl. 97, fig. 18), from the Tiñu Formation of Mexico, is similar in shape and degree of effacement to those referred here to *P. clarki patulus*. The accessory furrows of the former are somewhat more obvious, but otherwise the species are comparable on pygidial characteristics. The cephalon of the Mexican species is also similar to those from Australia, but differentiated by its less circular shape.

Description of external testaceous surfaces: The cephalic outline is subcircular, the maximum width being on a transverse line passing to the rear of the axial glabellar node. Expressed as a proportion the length (Lc_1) to width (Wc_1) ratio for seven well preserved cephala varies between 85 and 96% (Table 1). The cephalic borders are relatively wide anteriorly and anterolaterally, on the sagittal line attaining 7-10% of the total cephalic length (sag.), but posterolaterally they are very narrow and pass below the convexity (tr.) of the acrolobe. The lateral marginal furrows are shallow and wide, but the posterior marginal furrows are extremely narrow. There are no cephalic spines. The acrolobe is appreciably convex and bears a very faint median preglabellar furrow; its flanks are unconstricted. The glabella is mostly effaced anteriorly and its extent in that direction is difficult to determine. Against the cephalic length that of the glabella appears to vary between 65 and 77%. The anterior lobe is poorly defined, small, presumably acutely rounded at the front. The anterolateral lobes are large and separated from the anterior lobe by sigmoid furrows terminating on the flanks of the axial node, which lies exactly between them. The node itself is elongate, with an axial carina which may extend rearwards to the posterior terminal glabellar node. Its high spot, however, lies between the anterolateral lobes, 41-45% of the distance from the rear of this cephalon. The posterior lobe is only well defined at the rear, where it is bluntly rounded and bears a poorly defined terminal node. The basal lobes are large and triangular, and are fused with the posterior lobe anteriorly.

The pygidial shield is also subcircular, but slightly more elongate than the cephalon: for ten specimens the length to width ratio varies between 87 and 94% (Table 2). Its borders are wider than those of the cephalon, 8-12% of the total pygidial length (sag.), but its marginal furrows are similarly shallow. Posterolateral spines lie well in front of the rear of the deuterolobe. The articulating devices are not steeply inclined, but nevertheless culminate in small nodes adaxially. The articulating half-ring is not appreciably thickened mesially but is fairly distinct from the floor of the articulating transverse furrow. The axial furrows are generally poorly defined and subparallel, converging slightly rearwards. The first and second pairs of transverse furrows are very nearly effaced, their position being marked on some specimens by faint apodemal pits only. The axial node lies to the rear of the second segment, but there are faint indications of connexions to the midsection of the first segment. Behind the defined axis are faint swellings on some specimens, indicating an effaced third segment. The deuterolobe is ill defined; the acrolobe is only slightly constricted; and a terminal node is always present.

Description of the parietal surfaces: Parietal morphology of the cephalon is illustrated in Text-figure 15 and by specimen CPC 11528 (Pl. 1, fig. 5). Besides a well defined system of muscle spots, carinae, and sulci, specimen CPC 11528 shows a faint scrobiculation. Features of the imprint surface of the pygidium are shown to great advantage and allow the reconstruction drawn as Figure 15. The arrangement of the pygidial muscle scars is similar to that of *Pseudagnostus communis* (see Palmer, 1955, pl. 29, fig. 14). Attention is drawn to several other structures.

Traces of eleven metameres are evident from the disposition of the muscle scars and notulae. An important morphological feature is the wide transverse groove which exists between the second and third axial metameres. In some genera, e.g. *Xestagnostus* and *Lotagnostus,* a pair of thin lobes is wedged in this position, but only a smooth depressed area is present in *Pseudagnostus clarki patulus.* Behind the third pair of muscle scars there are seven or eight pairs of low swellings carrying complementary pairs of notulae. The lines of notulae distinguish the intra- and extranotular areas.

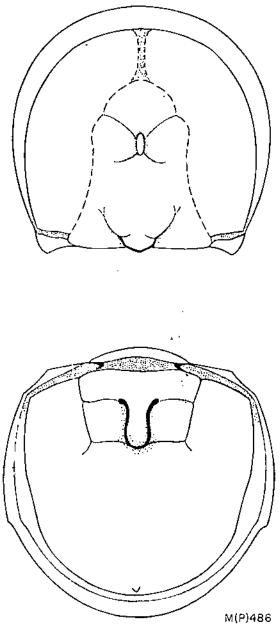

Fig. 24. External testaceous morphology of *Pseudagnostus clarki patulus* subsp. nov.; based on cephalon CPC 11524, x8, and pygidium CPC 11530, x6.5.

The axial node is bilobed and bifid at the rear. It is anteriorly pointed, and some specimens show a slightly elevated ridge extending forwards towards the articulating furrow. Behind the axial node the intranotular axis is composed of two morphological components: a depressed central groove, the intranotular sulcus, and flanking it abaxially two narrow raised ridges, the intranotular ridges. These ridges themselves are complex, being knotted, and formed apparently by the coalescence of small swellings lying between the paired muscle scars on the one hand and the intranotular axis on the other. Where the intranotular sulcus dies out anteriorly the swellings coalesce to form the axial node, its rearwards cleft seemingly representing a continuation of the course of the intranotular sulcus. Possibly the anterior section of the axial node belongs to the first axial metamer. At the rear the intranotular ridges merge into the terminal node, which is also cleft by the intranotular sulcus.

Accessory furrows are very faintly discernible on specimen CPC 11530 (Pl. 2, fig. 2), and the same specimen has evidence of the extent of the extranotular areas, from the distribution of the caecal scrobicules.

PSEUDAGNOSTUS CLARKI Kobayashi, 1935, PROLATUS subsp. nov.

(Pl. 3, figs 1-6; Pl. 4, figs 1-6; Text-figs 25, 26)

Name: L., *prolatus,* extended or elongated, referring to the proportionate length of the cephalon when compared with other subspecies of *P. clarki.*

Holotype: CPC 11532, a cephalon, illustrated in Plate 3, fig. 5.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K111 and K112, 112 and 120 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zone of *Pseudagnostus clarki prolatus* with *Caznaia sectatrix.*

Material: Available material consists of 15 cephala and 24 pygidia. The illustrated paradigm comprises the cephala CPC 11532-6, and the pygidia 11537-42: CPC 11559-80 are tabulated in the text.

Size: Cephalic lengths (sag.) range between 3.10 and 4.70 mm and may represent three holaspid instars; pygidial lengths range between 2.30 and 4.70 mm and are possibly from six instars (Text-fig. 27).

Diagnosis: A partly effaced subspecies of *Pseudagnostus clarki* Kobayashi with similar length-to-width ratios in cephalon and pygidium. Maximum width always slightly, but only slightly, exceeds the maximum length. The maximum width of the cephalon lies on a transverse line cutting the front of the axial glabellar node. In the pygidium it lies across the midlength, at the level of the fourth metamer. The pygidium is posteriorly bluntly rounded.

Differential diagnosis: The cephalon of *Pseudagnostus clarki prolatus* is proportionately less wide and thus proportionately longer than that of *P. clarki patulus.* It is possibly also less wide than that of *P. clarki clarki,* but comparable with that of *P. clarki laevis.* The maximum cephalic width lies in front of the axial glabellar node, as in *clarki clarki* and *clarki laevis,* and this further differentiates the subspecies from *clarki patulus.* The pygidium is morphologically most similar to that of *clarki clarki,* being less acutely rounded posteriorly than that of *clarki laevis.* Pygidial proportions are almost identical with those of *clarki patulus,* differing only in the ratio of axial width to anterior pygidial width, which is greater in *clarki patulus.*

The pygidium of *P. clarki prolatus* strongly resembles that from the Tiñu Formation of Nochixtlán, Mexico, described by Robison & Pantoja-Alor (1968, pl. 97, fig. 18), as *Pseudagnostus* sp. (compare that illustration with Pl. 4, fig. 4).

Proportions of the cephalic and pygidial shields of *Pseudagnostus clarki patulus* and *P. c. prolatus* are compared on Tables 1-2.

Description of external testaceous surfaces: The cephalon is subovoid, the length (sag.) being 92-100% of the maximum width (tr.). The latter lies on a transverse line which passes immediately in front of the axial glabellar node. The ratio of minimum to maximum width varies between 82 and 87%. The borders are proportionately rather narrow, anteriorly being 5-9% of the total cephalic length. The marginal furrows are well impressed as shallow grooves. Both borders and marginal furrows narrow posterolaterally and pass under the convexity (tr.) of the acrolobe. The preglabellar median furrow and the axial furrows are very faint even on the parietal surface and the glabella is well defined only at the rear, adjacent to the basal lobes. Where it can be assessed, the glabella occupies 65-73% of the total cephalic length (sag.). The anterior glabellar lobe is faintly defined and mushroom-shaped; the anterolateral lobes are also faint, and subcircular. The furrows which separate them from the anterior lobe are strongly curvilinear and continue backwards along the flanks of the axial node: they are not transversely continuous. The rear of the posterior lobe is very obtusely rounded, with a small terminal node lying on the sagittal line. The basal lobes are large and triangular. The axial node lies approximately two-thirds of the way along the glabella from the rear and just behind the midlength of the cephalon (N:G 55-68%; N:Lc_1 38-48%).

TABLE 1 Quantitative Comparison of Cephala of Subspecies of *Pseudagnostus clarki*

No.	Lc_1	Lb:Lc_1	G:Lc_1	N:Lc_1	Lc_1:Wc_1	Wc_2:Wc_1	N:G
patulus							
CPC 11553	3.50	—	65.70	42.80	87.50	85.10	68.00
CPC 11554	3.75	9.33	—	41.30	—	—	59.61
CPC 11524	3.95	8.86	75.90	43.10	96.30	86.60	64.80
CPC 11555	4.40	9.09	68.20	36.30	85.30	60.10	58.61
CPC 11525	4.60	10.86	67.40	43.50	90.20	86.00	60.30
CPC 11526	4.80	10.42	69.80	44.80	89.20	84.70	66.67
CPC 11556	4.90	8.20	77.60	43.90	92.50	88.80	63.89
CPC 11557	5.10	6.86	73.50	45.10	86.40	78.80	64.00
CPC 11558	5.60	8.93	69.60	41.10	—	—	58.96
prolatus							
CPC 11559	3.10	6.45	69.30	45.20	92.50	83.60	65.12
CPC 11560	3.20	7.81	64.10	39.10	98.50	—	60.96
CPC 11561	3.20	7.81	73.40	—	—	—	—
CPC 11562	3.30	6.06	69.70	45.50	98.50	86.80	65.20
CPC 11533	3.50	7.14	67.10	41.40	97.20	82.00	61.70
CPC 11535	3.90	6.40	71.80	48.70	93.90	85.80	67.85
CPC 11532	4.15	9.64	66.20	38.60	96.50	83.80	58.19
CPC 11536	4.15	6.02	72.30	43.40	98.80	86.90	60.00
CPC 11563	4.15	4.82	72.30	42.20	99.50	84.70	58.33
CPC 11564	4.30	9.30	68.60	43.00	98.90	85.00	62.72
CPC 11565	4.30	8.14	68.60	39.50	100.00	86.00	57.62
CPC 11566	4.45	6.74	71.90	48.30	94.70	85.00	67.19
CPC 11534	4.60	6.52	69.50	42.80	97.90	84.00	60.94
CPC 11567	4.60	—	65.20	39.20	—	—	60.00
CPC 11568	4.70	5.32	69.10	38.40	—	—	55.39
maximus							
CPC 11581	4.20	9.52	65.48	35.72	—	—	54.55
CPC 11582	4.20	7.14	73.82	45.25	—	—	61.30
CPC 11583	4.25	11.76	70.58	39.99	86.74	89.80	56.66
CPC 11584	4.30	9.30	—	41.76	89.60	91.68	—
CPC 11585	4.55	11.00	70.33	41.77	84.26	87.04	59.39
CPC 11586	4.60	10.86	71.73	44.57	94.86	86.60	62.13
CPC 11587	5.25	9.52	70.47	45.71	87.50	88.33	64.86

TABLE 2 Quantitative Comparison of Pygidia of Subspecies of *Pseudagnostus clarki*

No.	Lp_1	Lp_2	$Lb:Lp_2$	$La:Lp_2$	$Wa:Wp_2$	$Lp_2:Wp_1$	$Wp_2:Wp_1$
patulus							
CPC 11543	2.80	2.65	13.21	86.80	—	84.10	90.80
CPC 11544	4.35	3.95	10.13	89.80	45.93	89.60	86.20
CPC 11530	4.37	4.06	9.11	90.90	43.20	92.90	86.00
CPC 11545	4.85	4.40	9.09	90.90	—	—	—
CPC 11546	4.90	4.50	13.34	86.70	—	91.80	85.90
CPC 11527	—	4.50	11.11	88.90	38.99	91.80	85.60
CPC 11529	4.90	4.55	10.99	89.00	43.95	89.20	89.20
CPC 11547	5.00	4.65	10.75	89.20	—	91.20	—
CPC 11548	—	4.70	10.64	89.40	45.44	87.10	81.90
CPC 11549	5.10	4.80	11.46	88.50	48.89	91.40	85.80
CPC 11550	5.62	5.00	8.80	91.20	48.63	93.10	88.90
CPC 11551	5.70	5.05	10.00	90.00	45.82	94.30	90.80
CPC 11552	—	5.10	7.84	92.20	—	—	84.00
prolatus							
CPC 11569	—	2.30	13.04	86.90	33.30	91.90	86.40
CPC 11537	2.50	2.30	10.86	89.10	45.60	88.40	88.60
CPC 11570	3.20	2.90	12.07	87.90	48.10	90.60	81.20
CPC 11571	3.00	2.70	11.11	88.80	48.10	84.40	84.70
CPC 11541	3.40	3.10	9.68	90.30	52.60	91.20	83.80
CPC 11542	3.50	3.20	7.80	92.20	59.60	91.60	81.30
CPC 11572	3.60	3.30	9.09	90.90	50.80	94.30	87.20
CPC 11573	3.70	3.50	8.57	91.40	49.20	94.60	87.90
CPC 11574	3.90	3.60	9.72	90.30	50.70	89.90	84.00
CPC 11538	—	3.65	8.22	91.70	48.60	86.90	88.00
CPC 11575	4.10	3.75	9.34	89.40	51.50	85.20	79.80
CPC 11576	4.20	3.90	7.69	91.00	—	93.90	—
CPC 11577	4.55	4.25	9.41	90.60	50.00	92.40	86.90
CPC 11578	4.70	4.15	8.61	89.20	51.30	93.20	83.10
CPC 11579	4.50	4.15	8.43	91.60	50.00	91.20	83.80
CPC 11539	—	4.20	9.52	90.50	50.00	95.70	84.00
CPC 11540	4.70	4.25	7.14	93.00	50.70	92.50	83.80
CPC 11580	5.10	4.70	7.45	91.60	—	—	—
maximus							
CPC 11588	4.90	4.50	12.23	87.78	51.28	96.77	83.77
CPC 11589	—	4.50	8.89	91.11	47.62	94.73	88.41
CPC 11590	6.30	5.65	10.62	89.39	50.94	88.96	83.47

The pygidium has the same shape as the cephalon and similar length to width proportions (Lp_2:Wp_1 83-94%; Wp_2:Wp_1 76-88%). The maximum width lies near the level of the fourth pygidial metamer. The borders are broad laterally at this level but are proportionately relatively narrow (sag.) posteriorly, 7-13% of the pygidium length (Lp_2). Marginal posterolateral spinules, mere nicks in the outline of the shield, are very small and set well in front of the rear of the deuterolobe, near its midlength. The articulating half-ring is a simple bar. The articulating facets are concave and culminate at the fulcra in small points. The axial furrows are quite well defined on the mould, less so on the shell. The transverse furrows are not present on the shell, faint only on the parietal surface. Anteriorly the axis occupies 46-56% of the anterior pygidial width. The axial node is bifid at the rear on most moulds. It occupies the whole mid-section of the second axial metamer. The pygidial acrolobe attains 87-93% of the total pygidial length; its flanks are obviously constricted on all except the smallest specimens.

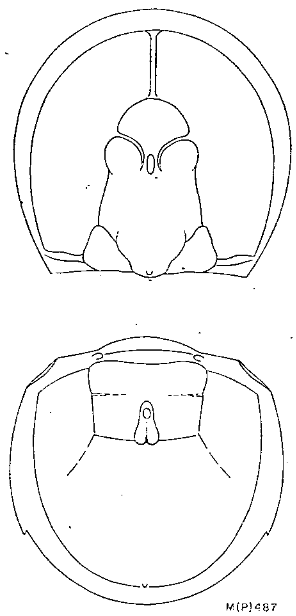

Fig. 25. External testaceous morphology of *Pseudagnostus clarki prolatus* subsp. nov.; based on cephalon CPC 11534, x7.5, and pygidium CPC 11540, x7.5.

Description of the parietal surfaces: The morphology of the parietal surface of *Pseudagnostus clarki prolatus* has been exceptionally well preserved (Pl. 3, figs 1, 3-5; Pl. 4, figs 2, 3, 5, 6). Features of the musculature and caecal system are readily interpretable.

The system of muscle scars in the cephalon is drawn in Figure 26: it is very similar to that of *P. clarki patulus* and need not be described in full. Certain features are less well defined than in *clarki patulus,* notably the structure of the axial glabellar carina. Others are better preserved, for instance the notulae of the oblique lateral scars of the posterior lobe. Specimen CPC 11536 (Pl. 3, fig. 1) shows traces of muscle scars in the shadowy area between the oblique lateral scars and the axial furrows, but these cannot be adequately interpreted from the available material.

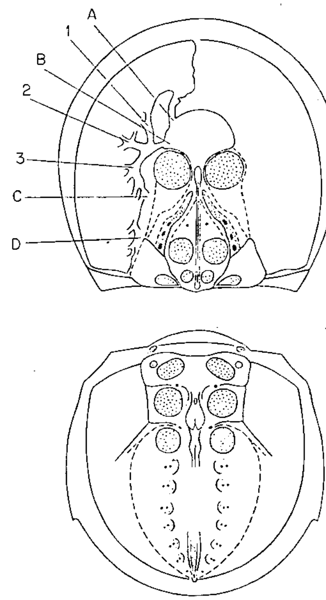

Fig. 26. Parietal morphology of *Pseudagnostus clarki prolatus* subsp. nov.; based on cephalon CPC 11534 and 11536, x8 approx., and pygidium CPC 11539, x7. Letters A-D and numbers 1-3 refer to probable sites of emergence and bifurcation respectively of cephalic caecal diverticula.

In the pygidium the observed muscle-scar pattern is identical with that of *clarki patulus.* There are traces of eleven metameres. A feature not observed on *clarki patulus,* but present on *clarki prolatus,* is low ridges defining the adaxial extremities of the accessory furrows. These seem to arise from the wide furrow between metameres 2 and 3.

CPC 11534 (Pl. 3, fig. 3) shows many features of the caecal system, especially on its left hand side. Of considerable interest is the presence of a pair of diverticula issuing from the anterior glabellar lobe (Fig. 26 A and B). That at the anterolateral corner (A) issues towards the front of the cephalon and branches rapidly into a fused mass of caeca. That arising from the posterolateral margin of the anterior lobe (B) feeds the flank of the acrolobe. It branches into three major caeca which rapidly subdivide abaxially (Fig. 26, 1-3). A third diverticulum (C) may arise from the shadowy area at the back of the anterolateral lobes, but is indistinct and a fourth (D) possibly arises near the anterior tips of the basal lobes (Pl. 3, fig. 5, right hand corner).

The caecal system shown by CPC 11534 is similar to that illustrated by Öpik (1961b, p. 414, text-fig. 4) for *Ptychagnostus,* but the anteriormost diverticulum seen in *Pseudagnostus clarki prolatus* is not present in that genus. The second or posterior diverticulum of *Ptychagnostus* corresponds to the third diverticulum of *Pseudagnostus* (C on Fig. 26).

The caecal system of the flanks of the acrolobe is emphasized by a heavy scrobiculation. The major diverticula seem to be connected with the raised areas which separate the muscle scars, but it is not yet possible to confirm this statement.

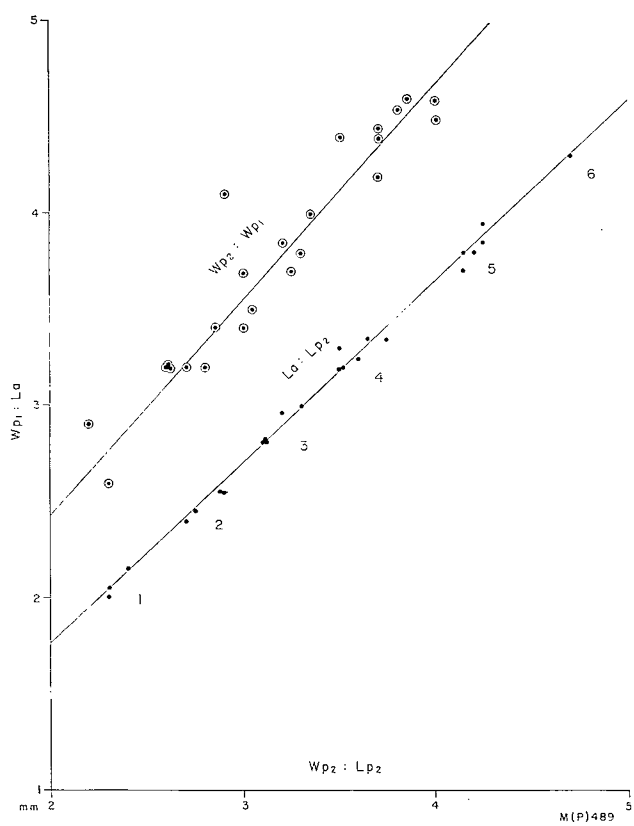

Fig. 27. Pygidial proportions of *Pseudagnostus clarki prolatus* subsp. nov., indicating the possible presence of six instars among the treated materials.

Pseudagnostus clarki Kobayashi, 1935, maximus subsp. nov.
(Pl. 5, figs 1-2; Text-fig. 28)

1972 *Pseudagnostus papilio* Shergold (*pars*); Shergold, 1972, p. 28-31, pl. 1, fig. 2 (CPC 8443).

1972 *Pseudagnostus* sp. II; Shergold, 1972, p. 35, pl. 2, figs 6-7 (CPC 8458, 8459).

?1972 *Pseudagnostus* sp. III; Shergold, 1972, p. 35-36, pl. 2, fig. 8 (CPC 8460).

Name: L., *maximus,* the greatest: this subspecies is the largest of *Pseudagnostus clarki.*

Holotype: CPC 11587, a cephalon preserved with shell, illustrated in Plate 5, fig. 1.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K121, K122, K123, K124, K125, K126, K128, K130, at 171.4, 175, 185, 200, 202.5, 232, 240, and 272.4 m from the base of the measured section. Previously described material indicated in the synonymy is from the Gola Beds of Momedah Creek, from locality B520.

Age: Late Upper Cambrian, pre-Payntonian A, Assemblage-Zones of *Pseudagnostus clarki maximus* with *P. papilio* and of *Sinosaukia impages.*

Material: Material from the Black Mountain sequence consists of 14 cephala and 9 pygidia, preserved both with shell and as limestone moulds. Material from the Gola Beds has been discussed previously (Shergold, 1972). The illustrated paradigm consists of the cephalon CPC 11587 and the pygidium CPC 11590. Specimens CPC 11581-6 and 11588-9 are tabulated in the text.

Size: Cephalic lengths (sag.) range between 4.20 and 5.25 mm, and pygidial lengths between 4.90 and 6.30 mm.

Diagnosis: A subspecies of *Pseudagnostus clarki* with its maximum cephalic width (tr.) lying on a transverse line through the centre of the axial glabellar node, and its maximum pygidial width (tr.) lying to the rear of the third axial metamer.

Differential diagnosis: This subspecies is differentiated from others referred to *Pseudagnostus clarki* on the shape of its shields alone (Tables 1 and 2). In all other characteristics—proportions, positions of nodes, spines, and borders—it is similar to *P. clarki patulus.*

Description of external testaceous surfaces: P. clarki maximus is proportionately very similar to *P. c. patulus,* and the subspecies are effaced to similar degrees. The description of *patulus* thus serves also for *maximus,* except for the shape of the shields. As indicated in the diagnosis the cephalon is widest (tr.) at the level of the axial node, and the pygidium at the rear of the third metamer.

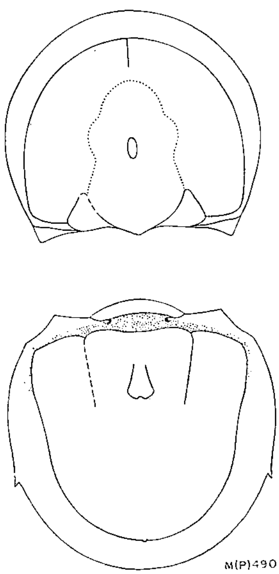

Fig. 28. External testaceous morphology of *Pseudagnostus clarki maximus* subsp. nov.; based on cephalon CPC 11587, x5.5, and pygidium CPC 11590, x6 approx.

Description of the parietal surfaces: The parietal surfaces of *Pseudagnostus clarki maximus* have identical distribution and orientation of muscle scars with those of *P. c. patulus* and *P. c. prolatus*. In the cephalon the axial glabellar sulcus is better defined and wider, showing a situation closely resembling that of the intranotular sulcus of the pygidium. As in *clarki patulus* notular pits are observed within the oblique lateral scars of the posterior glabellar lobe.

The caecal network is not well preserved, but the visible parts are very closely comparable with corresponding parts of the system of *P. c. prolatus*.

In the pygidium the arrangement of the muscle scars and notulae again compares to the situation observed in *clarki patulus*. There are traces of eleven metameres, those to the rear of the defined axis having readily visible duplicated notulae on each segment (Pl. 5, fig. 2). The caecal network of the pygidium is not well preserved.

PSEUDAGNOSTUS ELIX sp. nov.
(Pl. 2, figs 3-7; Text-fig. 29)

Name: L., *elix,* ditch, or channel, noun in apposition, referring to the deliquiate marginal furrows.

Holotype: CPC 11688, pygidium, illustrated in Plate 2, figs 3, 5.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K103 and K104, at 1.6 and 6 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zone of *Pseudagnostus clarki patulus* with *Caznaia squamosa.*

Material: Available material comprises two cephala and four pygidia; the illustrated paradigm consists of specimens CPC 11688-91.
Size: The cephala range in length (sag.) between 3.19 and 3.94 mm; pygidia (Lp_2) between 2.62 and 3.44 mm.

Diagnosis: A semi-effaced species of *Pseudagnostus* with the following complex of characteristics: gently constricted cephalic and pygidial acrolobes; large triangular basal lobes; axial glabellar node situated between small anterolateral lobes; long (sag.), anteriorly ogival anterior lobe; median preglabellar furrow; deliquiate pygidial marginal furrows with spines lying between the rear of the deuterolobe and the constriction of the acrolobe.

Differential diagnosis: Pseudagnostus elix has characteristics of both the *P. communis* and *P. clarki* species groups. It resembles species of the former in the shape of the anterior glabellar lobe, the orientation of the glabellar furrows, and shape and degree of effacement of the shields; and of the latter in the positioning of the axial glabellar node, width of pygidial borders, and degree of constriction of the pygidial acrolobe.

Cephala attributed by Sun (1924, p. 26-28, pl. II, figs 1a-h) to *Pseudagnostus (Rhaptagnostus) cyclopygeformis* have similar shapes to those of *P. elix*. Their glabellae have similarly pointed anterior lobes, and the axial glabellar node lies in an equivalent position, midway between the lateral lobes. *P. cyclopygeformis* is, however, distinguished by its small basal lobes, and the pygidium is quite distinct from that of *P. elix,* the first transverse furrow of the axis being less severely effaced, and being quite obviously rhaptoid.

Cephala attributed to *P. cyclopygeformis* by Kobayashi (1933a, p. 97-98, pl. IX, figs 19, 23-4) have a slightly different shape from those figured by Sun, and moreover have larger basal lobes. In these respects they are closer to *P. elix,* but they differ in having considerably smaller and less prominent anterior glabellar lobes.

As indicated above, cephala of *P. elix* also resemble those of *P. communis* (Hall & Whitfield), and especially that figured by Palmer (1960, p. 61, pl. 4, fig. 3). In *P. communis,* generally, the glabellar node lies to the rear of the anterolateral lobes and is thus readily distinguishable. Pygidia attributed to *P. communis* by Lochman (1964, p. 47, pl. 9, figs 34-36) are superficially similar to those of *P. elix.* They appear to have stronger accessory furrows, but the poor quality of the illustrations prevents close comparison.

Finally, pygidia of *P. elix* resemble those figured by Frederickson (1949, p. 362, pl. 72, fig. 17) as *Pseudagnostus josepha* (Hall). Both species have wide borders and constricted acrolobes. Cephala of *P. josepha,* as interpreted by Frederickson, associated with these pygidia differ from those of *elix* once more in the positioning of the axial glabellar node.

General description: Pseudagnostus elix is based on moulds which give little indication of parietal morphological details, and all morphological information is grouped under the one heading.

The cephalic outline is subcircular: it has a slightly upturned narrow border with rather broad marginal furrows. The acrolobe is gently constricted and cleft mesially by a preglabellar furrow. The glabella occupies 68-74% of the cephalic length (sag.). It has a prominent anterior lobe which is pointed anteriorly; and small compact anterolateral lobes which are divided by an axial glabellar node whose midpoint lies some 40% of the cephalic length from the rear. The posterior lobe is laterally parallel-sided, posteriorly rounded, and flanked posterolaterally by large triangular basal lobes which are well demarcated from it.

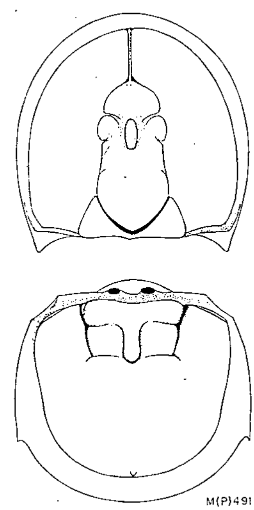

Fig. 29. External testaceous morphology of *Pseudagnostus elix* sp. nov.; based on cephalon CPC 11689, x7.5, and pygidium CPC 11688, x7.5.

The pygidium is similar in shape to the cephalon, with a length to width ratio of 80-90%. Its borders are relatively wide posteriorly, attaining 8-10% of the total length, upturned laterally, downsloping posteriorly. Small spines lie between the rear of the deuterolobe and the constricted acrolobe. The margin behind them is evenly rounded. The marginal furrows are wide and shallow, forming a shallow gutter. Anterior and lateral marginal furrows are confluent. The articulating facets slope strongly, and adaxially culminate in short points. The articulating half-ring is thickened mesially (sag.), the thickening being flanked by deep apodemal pits. The axial furrows are distinct, converging only slightly backwards. The first axial transverse is effaced, the second clearly visible. The axial node occupies the whole width of the second segment. Behind the defined axis muscle scars indicate faintly a third segment. Notular lines are almost, but not quite, effaced. A terminal axial node is always present, as are traces (adaxially) of accessory furrows. The deuterolobe overall remains poorly defined. The axial portion of the pygidium occupies about 90% of the pygidial length (sag.).

PSEUDAGNOSTUS ORBICULATUS sp. nov.
(Pl. 12, figs 8-12; Text-fig. 30)

Name: L., *orbiculatus,* circular, referring to the shape of the pygidial acrolobe.

Holotype: CPC 11591, cephalon, illustrated in Plate 12, fig. 9, an exfoliated mould.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K138, K139, at 374 and 375 m from the base of the measured section, and at B510 and B510b, which are previously collected horizons not on the measured section line; Mount Ninmaroo, horizons K168, K169, at 67 and 68 m from the base of the measured section; Dribbling Bore, horizon K187, 31 m from the base of the section.

Age: Late Upper Cambrian, Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas.*

Material: The species is known from 24 cephala and 12 pygidia, none well preserved. The illustrated material comprises CPC 11591-5.
Size: Measured cephala range in length (sag.) from 1.90 to 2.90 mm; pygidia range from 1.60 to 2.60 mm.

Diagnosis: A species of *Pseudagnostus* with the following complex of characteristics: shields subovoid or subcircular; furrows and lobes almost effaced; axial glabellar node lying between the anterolateral glabellar lobes; pygidial acrolobe evenly rounded laterally and posteriorly, unconstricted; spines small, thorn-like, placed on a transverse line slightly in front of the rear of the deuterolobe.

Differential diagnosis: From the shape of the cephalon and the position of the axial glabellar node, *P. orbiculatus* belongs to the *P. clarki* species group. It is not, however, a subspecies of *P. clarki:* its borders are too narrow, its shield proportions differ, and it lacks a drawn-out posterior pygidial margin. Lack of converging pygidial flanks precludes classification with members of the *P. convergens* group. Though the small pygidial spines again point towards the *clarki* group, the rounded pygidial acrolobe sufficiently differentiates *P. orbiculatus* from all species assigned to it. Indeed, this characteristic is more reminiscent of species classified here with *P. communis*. There is, however, no guarantee that the combination of head and tail presented here is correctly matched, as the pygidia do not seem greatly different from those of *P. quasibilobus* occurring in the same deposits. A similar combination to that described here was, however, figured as *Pseudagnostus* sp. by Robison & Pantoja-Alor (1968, p. 780, pl. 97, figs 17-18) from Nochixtlán, Mexico. Australian and Mexican cephala are morphologically very close, but the poorly preserved pygidia cannot be adequately assessed. The Mexican species is slightly younger than *P. orbiculatus,* early Datsonian on the Australian biostratigraphical scale.

General description: The cephalon is semioval, with maximum width (tr.) at the front of the axial glabellar node; $Lc_1 : Wc_1$ is approximately 93% for the holotype. The cephalic borders are moderately wide, up to 10% of the cephalic length (sag.). The glabella, a little over two-thirds of the cephalic length (sag.), has effaced lobes and furrows. A faint median preglabellar furrow is present on internal moulds. The axial glabellar node lies between the anterolateral glabellar lobes, about 60% of the distance from the rear of the glabella. The anterior furrows are faint, shallow, and V-form. Those separating the anterolateral lobes from the remainder of the posterior lobe are posteriorally directed from the sagittal line and the base of the axial node, and are similarly faint. The posterior lobe is angulate and elevated at the rear; and the basal lobes are large and triangular.

The pygidium is also semi-oval, occasionally subquadrate, posteriorly rounded; $Lp_2 : Wp_1$ is 82-88%. The borders are moderately wide, wider than those of the cephalon; $Lb : Lp_2$ ranges to 15%. The lateral margins curve slightly outwards and the small posterolateral spines derive from this curvature. They lie slightly forwards of a transverse line across the rear of the deuterolobe. The acrolobe is virtually effaced, axial furrows being defined only adjacent to the first and second axial segments. Behind these little trace of furrowing is evident. The deuterolobe is rounded posteriorly, and the acrolobe unconstricted laterally.

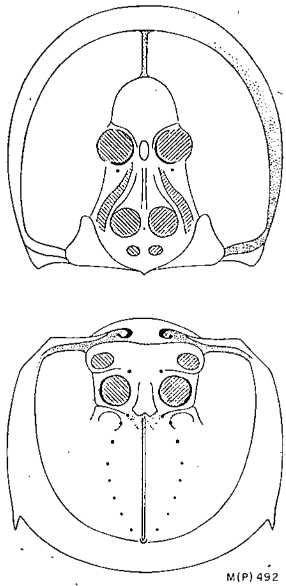

Fig. 30. Parietal morphology of *Pseudagnostus orbiculatus* sp. nov.; based on cephalon CPC 11591, x12, and pygidium CPC 11594, x13.

Morphology of the cephalic parietal surface is shown on the holotype, CPC 11591 (Pl. 12, fig. 9), and is essentially similar to that of the subspecies of *Pseudagnostus clarki* described above. Little can be gained from the available material towards an understanding of the parietal morphology of the pygidium. The nodular lines reproduced in Text-figure 30 are faintly visible on CPC 11594 (Pl. 12, fig. 11), which also possesses traces of only nine metameres. Eleven are normally found on the subspecies of *P. clarki.*

Pseudagnostus convergens species group

Characteristic species: Pseudagnostus convergens Palmer 1955: p. 96-7, pl. 19, figs 14-15, latest Franconian, Catlin Member, Windfall Formation, Eureka district, Nevada.

Characteristics: A small group of mainly effaced papilionate species closely related to the *clarki* group is distinguished by their more acutely rounded ovate shields and narrow (sag.) borders. The posterolateral spines of the pygidium are so small that some species have been considered non-spinose. The pygidial flanks converge strongly rearwards, and the constituent species are deuterolobate but generally non-plethoid. As in the *clarki* group there is evidence for up to eleven pygidial metameres.

Other species: Pseudagnostus obsoletus Lermontova (1951, p. 10-11, pl. 2, figs 8-10), late Cambrian, Boshche-Kul, SE Kazakhstan, USSR. *Pseudagnostus* cf. *obsoletus* Lerm. (MS) (Lermontova, 1940, p. 125, pl. 49, fig. 11), Boshche-Kul, Kazakhstan (this seems to be the same specimen that Lermontova (1951) subsequently figured on pl. 2, fig. 8). *Agnostus cyclopygeformis* Sun (1924, p. 26-8, pl. 2, figs 1a-h), Kaolishan Formation, Shantung, China. *Pseudagnostus cyclopygeformis* (Sun) *sensu* Endo (1939, p. 6, pl. 1, figs 14-15, *non* fig. 13 = geragnostoid), Tawenkou Formation, Shantung, China. *Pseudagnostus cyclopygeformis* (Sun) *sensu* Lu (*in* Lu et al., 1957, p. 259, pl. 137, figs 20-21), Taian, Shantung, China. *Pseudagnostus cyclopygeformis* (Sun) *sensu* Lu (*in* Lu et al., 1965, p. 42, pl. 4, figs 10-12, ?9), locality presumed as above. *Pseudagnostus papilio* Shergold (1972, p. 34, pl. 2, figs 3-5), Gola Beds, Momedah Creek, Boulia area, western Queensland. The following species, which are considerably less effaced than those listed above, may also belong to the *convergens* group: *Plethagnostus gyps* Clark (1923, p. 124, pl. 1, fig. 9; 1924, p. 15, pl. 3, fig. 2), Lévis boulder conglomerates, Lévis, Quebec, Canada; *Pseudagnostus gyps* (Clark) *sensu* Rasetti (1944, p. 234, pl. 36, figs 20-22), locality as above; and *Pseudagnostus* sp. I, Shergold (1972, p. 34, pl. 2, figs 3-5), again from the Gola Beds, Momedah Creek, western Queensland. *Pseudagnostus bifax* sp. nov. is described below.

Distribution: The *convergens* group occurs in North America in the USA (Nevada) and possibly Canada (Quebec), the USSR (Kazakhstan), China (Shantung), and Australia (western Queensland).

Age: In Australia the *Pseudagnostus convergens* species group has a pre-Payntonian age. In North America (Nevada) it is latest Franconian, and in China latest Changshanian. The age and details of the occurrence in Kazakhstan are not known.

PSEUDAGNOSTUS BIFAX sp. nov.
(Pl. 9, figs 1-7; Pl. 10, figs 1-5; Text-figs 31-33)

Name: L., *bifax,* two-faced, alluding to the different appearances of specimens preserved with test or as moulds.

Holotype: CPC 11596, a cephalon preserved with shell, illustrated in Plate 9, fig. 1.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K115, K116, K117, K118 and K119, at 132, 138, 149, 156, and 157 m from the base of the measured section; and at horizons B507a′, B507a″ and B507b (see Appendix 1).

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zone of *Pseudagnostus bifax* with *P. denticulatus*.

Material: The species is described from 47 cephala representing 6 or 7 instars; and 30 pygidia representing the same number of growth stages. Specimens CPC 11596-668 form the collection from which the illustrated and quoted items have been drawn.

Size: Cephala range in length (sag.) between 2.10 and 4.90 mm; pygidial lengths (Lp_2) range between 2.10 and 4.70 mm (Tables 3-4).

Diagnosis: The shell of *Pseudagnostus bifax* is strongly effaced. Even the nodes of the cephalon and pygidium are nearly obliterated, and in the cephalon the marginal furrow is effaced sagittally. In the pygidium the axial furrows are very faintly visible. Both cephalic and pygidial acrolobes are slightly constricted. Although the cephalon is rather bluntly rounded anteriorly, the pygidium is drawn out and pointed at the rear. Its spines lie well back on the shield. On removal of the shell, features of the parietal surface of the pygidium show traces of ten metameres.

Differential diagnosis: The most readily comparable species is *Pseudagnostus obsoletus* Lermontova (1951, pl. 2, figs 8-10) from Kazakhstan. When shell is preserved both species have an equivalent degree of effacement. The spines of the pygidium are similarly situated well to the rear of the shield. Their shields have similar shape, although the cephalon of *P. bifax* is commonly less pointed anteriorly and the pygidium less acutely rounded posteriorly. Such differences also distinguish *P. bifax* from *P. papilio* Shergold (1972, pl. 1, figs 1, 3-8; pl. 2, figs 1-2), and *P. convergens* Palmer (1955, pl. 19, figs 14-15). *P. bifax* is further differentiated from *P. obsoletus, papilio,* and *convergens* by its slightly wider cephalic and pygidial borders; and when preserved with shell, by a nearly obliterated anterior cephalic marginal furrow.

Pseudagnostus bifax is comparable to *Pseudagnostus* (*Rhaptagnostus*) *cyclopygeformis* (Sun) (1924, pl. 2, figs 1a-h) from Shantung and Hopei Provinces of China. The specimens illustrated by Sun are moulds and the nature of the species when preserved with shell is not known. The parietal surfaces of *P. cyclopygeformis* have greater relief than those of *P. bifax,* especially in the cephalon, and the siting of the pygidial spines is not clear. Sun (1924, p. 27) says that they are absent, but they are probably extremely small, and may perhaps have been destroyed during preparation. Sun says further that the pygidium has traces of only nine metameres, whereas in *P. bifax* there are ten, but this number almost certainly changes during morphogenesis.

Pseudagnostus prolongus (Hall & Whitfield, 1877), which is somewhat similar in shape and degree of effacement, has its glabellar axial node situated farther to the rear of the glabella. In *P. bifax* it lies between the anterolateral lobes, whereas in *P. prolongus* it is behind them.

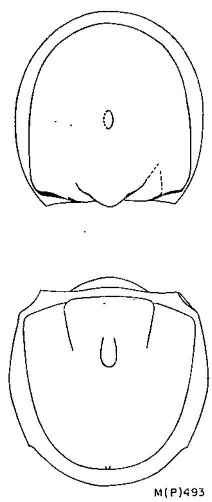

Fig. 31. External testaceous morphology of *Pseudagnostus bifax* **sp. nov.; based on cephalon CPC 11596, x7, and pygidium CPC 11649, x8.**

Description of external testaceous surfaces: Both cephalon and pygidium are strongly effaced when preserved with shell, and only the marginal furrows are well defined, although even these are effaced at the front of the cephalon. Both head and tail are similarly shaped, more or less ovoid, but the pygidium is generally more pointed than the cephalon. Distinct changes in shape occur during morphogenesis (see below).

The cephalon is on average slightly longer than wide; $Lc_1:Wc_1$ is 95-110%. Anteriorly the border occupies 2.5-8.5% of the total cephalic length (sag.), depending on preservation. Posterior cephalic margins are non-spinose and relatively narrow. Cephalic acrolobes are faintly constricted. Owing to effacement the anterior limits of the glabella are indistinct, and the posterior lobe is only slightly elevated. The glabella appears to occupy 66-79% of the cephalic length (sag.). Its axial node lies nearly at the middle of the cephalon ($N:Lc_1$ is 41-50%), and about two-thirds the length of the glabella from the rear (N:G 55-74%). A median preglabellar furrow is faintly indicated on the shell.

Length and width of the pygidium are nearly equal; $Lp_2:Wp_1$ is 88-104%. It is oblong, semi-ovoid, pointed a little at the rear, with converging flanks. The acrolobe occupies 89-95% of the pygidial length (Lp_2) and is markedly constricted. The border occupies the remaining 5-11% of Lp_2. The posterolateral spines are very small, merely small projections breaking the curvature of the flanks. Behind the spine bases the posterior margin curves strongly as in *Pseudagnostus convergens*. This is most evident on late holaspid shells (Pl. 10, figs 1-2). Axial furrows defining the anterior part of the axis are weak on the shell, subparallel-sided or gently converging rearwards. The axial node is almost effaced and extends backwards a good deal farther than the terminations of the axial furrows. Accessory furrows and deuterolobe are not defined on the shell. The articulating half-ring is a simple bar with shallow axial platform. The facets are strongly concave, rising adaxially to distinct fulcral points.

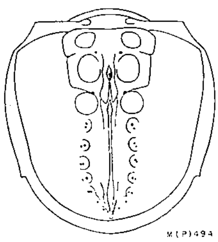

Fig. 32. Parietal morphology of the pygidium of *Pseudagnostus bifax* sp. nov.; based on CPC 11667, x6.

Description of parietal surfaces: As in subspecies of *Pseudagnostus clarki,* the parietal surfaces of *P. bifax* show a surprising wealth of morphological structure, considering the strongly effaced external surface of the shell. The discrepancy between external and parietal surfaces has contributed to the naming of the species.

Illustrated on Plate 9 is a series of cephala showing gradations in morphology dependent on degree of exfoliation of the shell (figs 1, 3, 4, 5). Specimen CPC 11597 (fig. 2) is a latex cast from an external mould. Fully weathered specimens show the complete outlines of the glabella (figs 4-5) and some of the muscle scars. In particular, the anterolateral scars are always prominent. On CPC 11597 the impression bounding these scars anteriorly is pitted, and other pits or notulae are associated with the oblique lateral scars, and perhaps also with the major posterior scars of the posterior lobe. Although depressed deltoid areas are visible on some specimens, the axial glabellar sulcus and axial glabellar carina are poorly defined, as is the caecal system.

Parietal morphology is beautifully preserved in the pygidia (Pl. 10, figs 2, 5). It is entirely comparable in morphology with that described above for *Pseudagnostus clarki patulus,* but shows in addition paired notulae for each metamer, of which there are traces of ten.

On CPC 11667 (Pl. 10, fig. 2) the notulae, muscle scars, and bilobed, bifid axial node are clearly visible. CPC 11668 (fig. 5) shows traces of the intranotular ridges and intranotular sulcus.

Also noted are that the pygidial acrolobe is more strongly constricted on the parietal surface, cf. Plate 10, figures 2 and 4; and that the posterolateral spines are larger on the mould.

Morphogenetic variation: 47 cephala, derived from three stratigraphical horizons, are plotted on Text-figure 33A-B. They range in length (sag.) between 2.10 and 4.90 mm and appear to order themselves into seven groups which may represent instars. The sample is composed of specimens from group 4-6 having a size range between 3.30 and 4.50 mm. Seventeen specimens occupy group 5, which has a size range 3.70-4.00. Thirty pygidia, ranging in length (Lp_2) between 2.10 and 4.70 mm are ordered into six groups (Text-fig. 33C). Of these groups 3-5, size

TABLE 3 Parameters and Proportions of Cephala of *Pseudagnostus bifax*

No.	Lc_1	$Lb:Lc_1$	$G:Lc_1$	$N:Lc_1$	$Lc_1:Wc_1$	$Wc_2:Wc_1$	N:G
CPC 11602	2.10	7.14	71.44	45.24	95.45	86.38	63.34
CPC 11603	2.70	5.55	70.37	46.29	98.19	87.28	65.79
CPC 11604	2.80	5.36	71.40	42.80	107.40	88.80	60.00
CPC 11605	2.90	3.45	75.86	50.00	96.68	86.68	65.92
CPC 11601	2.95	5.08	69.24	47.45	101.00	94.82	73.59
CPC 11606	3.10	—	72.47	48.39	98.42	92.06	65.42
CPC 11607	3.10	4.85	74.18	48.37	101.60	88.52	65.22
CPC 11600	3.30	4.55	75.90	48.50	103.00	89.10	64.00
CPC 11608	3.40	4.41	70.70	44.30	103.00	86.20	62.50
CPC 11609	3.50	7.05	—	43.80	107.90	86.70	—
CPC 11610	3.50	5.72	71.60	44.40	109.50	90.80	62.00
CPC 11611	3.50	4.28	70.00	42.85	100.00	91.41	61.22
CPC 11612	3.55	4.27	70.42	45.07	109.20	92.30	64.00
CPC 11599	3.60	5.55	72.23	44.44	105.80	89.71	70.00
CPC 11613	3.60	6.95	69.50	48.70	104.20	88.50	61.53
CPC 11598	3.60	5.55	70.81	47.22	98.63	90.40	66.67
CPC 11614	3.60	5.55	68.06	44.44	107.00	94.04	65.30
CPC 11615	3.70	6.77	70.40	44.60	—	—	63.46
CPC 11616	3.70	6.77	73.00	46.00	102.70	87.00	62.95
CPC 11617	3.70	4.05	71.61	45.95	104.20	—	64.14
CPC 11597	3.70	4.05	68.92	43.24	—	—	62.75
CPC 11618	3.75	8.00	72.01	42.67	104.00	89.33	59.26
CPC 11596	3.75	4.00	73.33	44.00	100.00	90.31	60.01
CPC 11619	3.80	6.59	76.30	44.70	102.50	85.10	58.61
CPC 11620	3.80	3.94	72.32	44.73	97.34	89.74	61.81
CPC 11621	3.80	2.63	71.06	46.05	102.70	85.13	64.80
CPC 11622	3.85	—	71.50	46.80	110.00	91.41	65.46
CPC 11623	3.90	6.41	71.80	48.72	108.30	94.43	67.85
CPC 11624	3.90	5.13	74.35	47.45	100.00	88.45	63.8[illegible]
CPC 11625	3.90	5.12	—	43.60	101.30	87.00	—
CPC 11626	3.90	5.12	66.67	46.15	104.00	89.33	69.23
CPC 11627	3.90	2.56	71.80	—	108.30	—	—
CPC 11628	3.95	6.32	73.41	48.10	102.60	89.60	65.52
CPC 11629	4.00	5.00	71.22	43.72	100.00	90.80	68.42
CPC 11630	4.10	7.32	67.07	41.46	107.90	86.84	61.81
CPC 11631	4.15	6.02	73.50	48.19	102.40	81.37	65.57
CPC 11632	4.30	6.99	74.50	—	109.00	90.00	—
CPC 11633	4.30	6.97	79.09	47.67	—	—	—
CPC 11634	4.30	5.81	74.40	47.62	105.00	90.24	64.07
CPC 11635	4.40	6.82	74.99	40.91	—	—	—
CPC 11636	4.40	4.54	76.12	47.72	106.00	91.58	62.69
CPC 11637	4.70	8.51	68.08	41.49	106.80	87.50	60.94
CPC 11638	4.90	6.12	71.40	47.00	107.80	88.00	67.23

TABLE 4 Parameters and Proportions of Pygidia of *Pseudagnostus bifax*

No.	Lp_1	Lp_2	$Lb:Lp_2$	$La:Lp_2$	$Wa:Wp_2$	$Lp_2:Wp_1$	$Wp_2:Wp_1$
CPC 11639	2.25	2.10	9.53	90.00	48.60	100.00	88.70
CPC 11640	2.65	2.40	8.33	91.45	46.80	92.30	90.38
CPC 11641	—	2.65	9.43	88.69	47.95	94.62	85.90
CPC 11642	2.95	2.70	11.11	88.88	49.03	93.11	87.92
CPC 11643	3.20	2.85	10.53	89.48	47.18	98.26	91.37
CPC 11644	—	2.90	6.90	93.00	50.00	88.00	84.90
CPC 11645	3.20	2.95	8.49	91.50	52.90	98.10	88.10
CPC 11646	3.30	3.05	9.83	90.16	49.12	95.30	89.06
CPC 11647	3.35	3.00	10.00	90.00	—	96.76	—
CPC 11648	3.40	3.05	8.19	91.81	49.16	88.41	85.51
CPC 11649	3.45	3.20	9.37	90.63	50.91	101.40	87.35
CPC 11650	3.65	3.30	7.57	92.43	49.20	92.96	88.74
CPC 11651	3.65	3.30	6.06	93.96	—	—	—
CPC 11652	3.65	3.35	10.42	89.80	50.00	97.00	87.00
CPC 11668	—	—	—	—	50.86	—	89.39
CPC 11653	3.85	3.45	8.69	91.31	—	88.45	—
CPC 11654	—	3.50	7.18	93.00	53.50	100.00	86.00
CPC 11655	—	3.60	5.57	94.50	—	101.00	90.10
CPC 11656	3.85	3.60	11.11	88.88	50.86	104.30	85.60
CPC 11657	—	3.65	6.85	93.00	50.00	96.00	94.90
CPC 11658	4.20	3.90	6.41	93.90	56.20	93.00	—
CPC 11659	4.30	3.80	7.54	90.78	47.88	100.00	93.42
CPC 11660	4.30	3.90	5.12	94.80	54.30	95.00	85.20
CPC 11661	4.30	3.90	7.70	92.30	52.85	92.87	83.00
CPC 11662	—	4.00	10.00	90.00	50.00	94.12	84.80
CPC 11663	—	4.10	7.31	92.80	50.70	97.80	82.00
CPC 11664	—	4.30	7.06	94.10	56.16	101.20	84.87
CPC 11665	4.90	4.55	8.80	91.20	51.23	98.91	89.13
CPC 11666	5.00	4.60	5.43	94.56	50.60	95.85	86.46
CPC 11667	5.15	4.70	7.44	92.55	50.62	98.95	87.36

3.20-4.30 mm, contain the majority of the specimens, but the maximum number, eight, occurs in group 5, of size range 3.80-4.30 mm. The fact that the groupings of heads and tails do not correspond numerically may mean that the pygidia in each instar are slightly larger than their corresponding cephala.

PSEUDAGNOSTUS PAPILIO Shergold, 1972
(Pl. 11, figs 1-8; Text-figs 34-35)

1972 *Pseudagnostus papilio* Shergold, p. 28-31, pl. 1, figs 3-8, 1, *non* fig. 2 = *Pseudagnostus clarki maximus* subsp. nov.; pl. 2, figs 1-2.

Holotype: The holotype, described by Shergold (op. cit., pl. 1, fig. 3) is CPC 8442, a cephalon from the Gola Beds of Momedah Creek, western Queensland.

Occurrence: Originally described from the Gola Beds, the species is now known additionally from the 'Chatsworth Limestone' of Black Mountain, horizons K121, K123, and K124, at 171.4, 185, and 200 m from the base of the measured section; and at B509 (see Appendix 1).

Age: Late Upper Cambrian, pre-Payntonian A, Assemblage-Zone of *Pseudagnostus clarki maximus* with *P. papilio*.

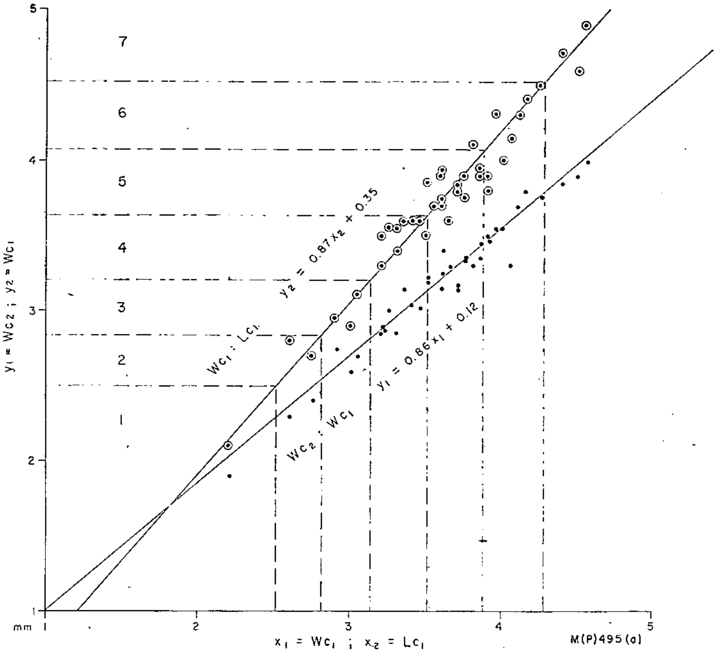

Fig. 33A

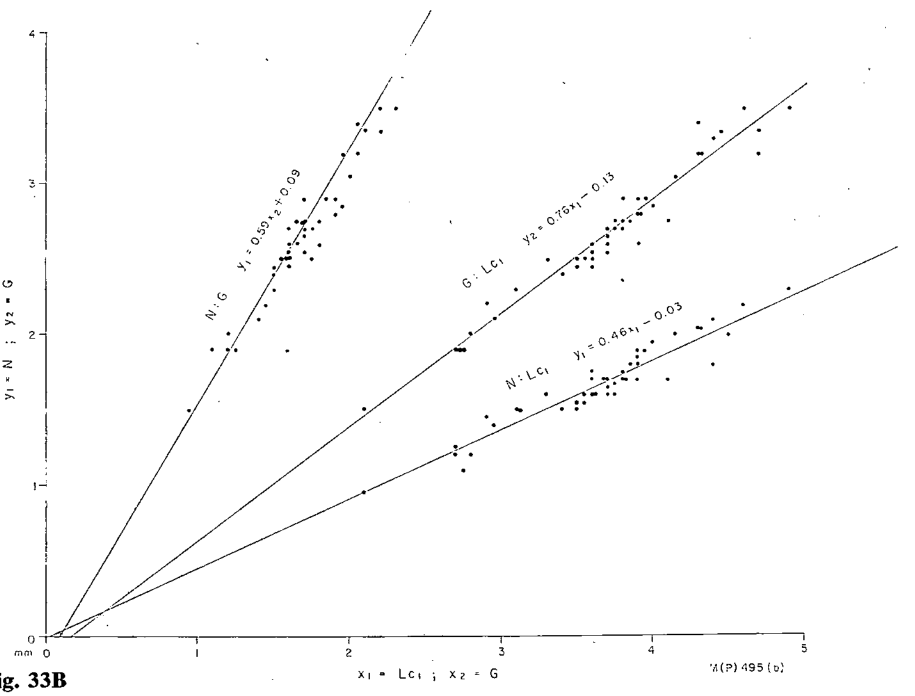

Fig. 33B

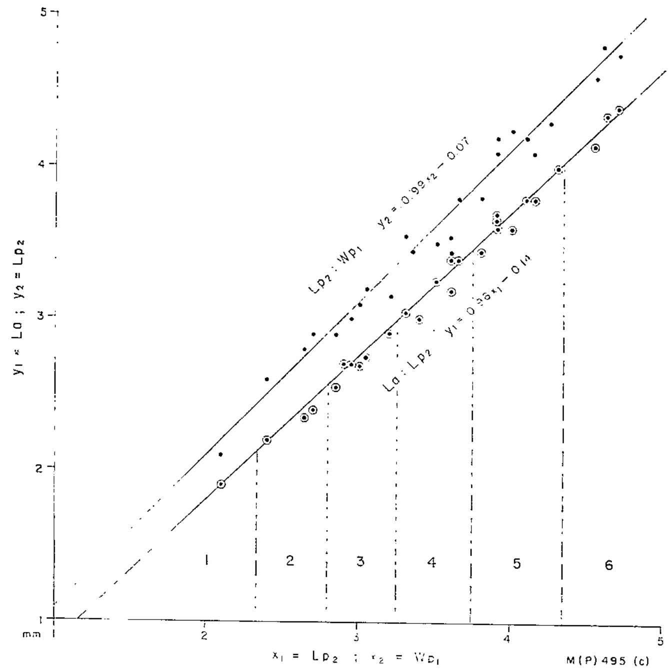

Fig. 33C

Fig. 33. Quantitative definitions of *Pseudagnostus bifax* sp. nov.; (A) and (B) cephalic characteristics, illustrating tentative instar groupings (1-7); (C) pygidial characteristics and possible instars (groups 1-6). For definition of parameters see p. 47.

Material: Ten cephala and five pygidia are referred with certainty to this species from the Black Mountain section. The illustrated material consists of specimens CPC 11669-76, and CPC 11677-87 are mentioned in the text.

Size: Cephala vary in length (sag.) between 1.70 and 5.00 mm, and pygidia (Lp_2) between 2.30 and 3.60 mm. A comparison of the proportions of specimens described here with those from the Gola Beds is given in Table 5.

Comment: As with *Pseudagnostus clavus* (below), the specimens described from the Gola Beds are all parietal surfaces, preserved as limestone moulds. Those from Black Mountain are generally preserved with vestiges of their shells. Thus any discrepancy which appears in the table of comparative proportions is probably related to the degree of exfoliation of the test. In particular, the cephalic borders are wider on moulds than on those specimens preserved with shell. Apart from such points the specimens from the two localities are closely comparable and are regarded here as conspecific.

Two specimens are illustrated in Plate 11 (figs 4-5) which show the cephalic parietal morphology. As can be clearly seen from figure 5, the structures of *Pseudagnostus papilio* are composed of similar elements, similarly distributed, to those of *P. clarki* (Pls 1 and 3), and to *P. bifax* (Pl. 9).

TABLE 5 Comparative Proportions of *Pseudagnostus papilio* from Black Mountain and the Gola Beds

No.	Lc_1	$Lb:Lc_1$	$G:Lc_1$	$N:Lc_1$	$Lc_1:Wc_1$	$Wc_2:Wc_1$	N:G
Cephala: Black Mountain							
CPC 11669	1.70	4.41	76.47	47.07	106.30	90.63	61.55
CPC 11670	1.90	5.36	68.41	42.10	105.50	97.21	61.55
CPC 11671	2.05	4.86	78.03	48.77	100.00	92.68	62.50
CPC 11677	3.50	2.86	71.42	51.42	97.23	88.88	72.01
CPC 11672	3.85	3.89	80.52	51.94	91.93	92.55	64.51
CPC 11673	5.00	4.00	66.00	43.00	98.04	89.21	65.15
Cephala: Gola Beds							
CPC 11680	2.25	6.67	66.67	66.67	102.30	90.90	44.44
CPC 8442	2.30	4.34	78.27	50.00	92.00	88.00	63.89
CPC 8447	2.50	6.00	64.00	46.00	102.10	93.87	71.88
CPC 11681	2.55	5.81	68.22	35.30	98.06	90.38	52.94
CPC 11682	2.65	3.85	71.71	50.94	100.00	90.57	71.04
CPC 11683	2.75	9.15	69.10	47.28	101.80	92.58	68.41
CPC 11684	2.85	5.24	71.94	49.12	—	—	68.28
CPC 11685	3.10	6.67	68.34	43.32	—	—	63.40
Pygidia: Black Mountain							
CPC 11678	2.00	12.50	87.50	50.00	83.33	83.33	
CPC 11674	2.15	11.62	88.39	50.00	91.47	89.35	
CPC 11675	2.20	9.09	90.90	46.67	88.00	90.01	
CPC 11676	2.40	10.42	89.59	50.00	92.30	88.45	
CPC 11679	2.25	9.23	90.76	—	—	—	
Pygidia: Gola Beds							
CPC 11686	1.80	8.32	91.68	44.44	90.00	90.00	
CPC 8448	1.85	10.80	89.19	50.00	92.50	90.00	
CPC 8449	1.80	8.33	91.66	44.69	85.72	90.48	
CPC 8446	2.00	10.00	90.00	—	90.90	90.90	
CPC 11687	2.15	11.62	88.39	52.62	102.30	90.46	
CPC 8445	2.50	8.00	92.00	49.87	96.14	88.45	
CPC 8450	2.70	7.40	92.58	50.00	96.40	89.28	

Pseudagnostus clavus species group

Characteristic species: Pseudagnostus clavus Shergold, 1972, p. 31-34, pl. 3, figs 1-8; and below, p. 84, Pl. 8, figs 7-12, Gola Beds of Momedah Creek, and 'Chatsworth Limestone' of Black Mountain, both localities in the Boulia area, western Queensland; late Upper Cambrian, pre-Payntonian, *Pseudagnostus bifax* with *P. denticulatus* and *Pseudagnostus clarki maximus* with *P. papilio* Assemblage-Zones.

Characteristics: Generally the shields are subquadrate in outline with straight transverse anterior cephalic and posterior pygidial margins. The borders are wide (sag.) in relation to the cephalic and pygidial lengths, and parietal surfaces frequently show well defined deliquiate marginal furrows. In the *clavus* group the glabella is narrow (tr.), laterally constricted, and has a small rhomboid anterior lobe. The axial glabellar node lies to the rear of the sagittal confluence of the anterolateral lobes. A faint chevronate furrow may develop between the axial glabellar node and the anterolateral lobes. Similarly, a V-form furrow is visible on some specimens between the anterolateral and anterior lobes. The pygidial acrolobe is usually visibly constricted, a third pair of lobes is usually present on parietal surfaces behind the defined anterior part of the axis, and there is evidence of seven or eight metameres from a count of the notulae. The small, thorn-like pygidial spines, lying slightly in front of a transverse line across the rear of the deuterolobe, deflect outwards slightly from the lateral margins of the pygidium, and carry their lines rearwards.

A small group of Australian species having subcircular shields might be regarded as distinct from the remainder of the group. They are related to it, however, on glabellar characteristics and the structure and segmentation of the pygidium.

Other species: The following species are tentatively assigned to the *clavus* species group. Some may eventually fall elsewhere when their type specimens are better understood: *Homagnostus* cf. *acutus* Kobayashi (1938, p. 173-4, pl. 15, fig. 4), *Elvinia* Limestone, Mount Hunter, British Columbia, Canada. *Euplethagnostus angulatus* Lermontova (1940, p. 126, pl. 49, figs 15, 15a), Orlina Mountains, Kuznets Basin, Siberia, USSR. *Pseudorhaptagnostus punctatus* Lermontova (1940, p. 126, pl. 49, figs 14, 14a), Orlina Mountains, Kuznets Basin, Siberia, USSR. *Pseudorhaptagnostus simplex* Lermontova (1951, p. 12-13, pl. 2, figs 11-15, *non* figs 16-17 (*convergens* group)), Boshche-Kul, SE Kazakhstan, USSR. *Pseudagnostus cavernosus* Rosova (1960, p. 12-14, pl. 1, figs 1-4), Tolstochinsk Suite, Salair region, Orlina Mountains, Siberia, USSR. *Pseudagnostus vulgaris* Rosova (1960, p. 14-16, pl. 1, figs 5-13, text-fig. 4), Tolstochinsk Suite, as above. *Pseudagnostus bituberculatus* Ivshin (*in* Khalfin, 1960, p. 165, pl. Cm-18, figs 6a-b), Sayan Altay, Siberia, USSR. *Pseudagnostus quadratus* Lazarenko (1966, p. 46-7, pl. 1, figs 24-29), Olenek River Area, N. Siberian Platform, *Irvingella-Cedarellus felix* and

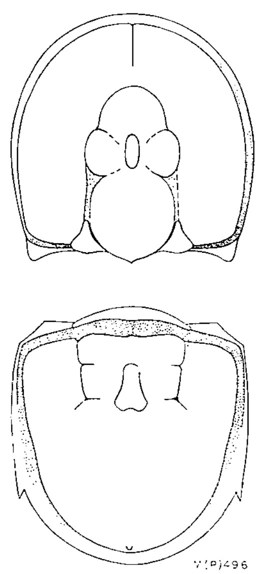

Fig. 34. External testaceous morphology of *Pseudagnostus papilio* Shergold, 1972, diagrammatically represented from cephalon CPC 8447, x13, and pygidium CPC 8448, approx. x17.

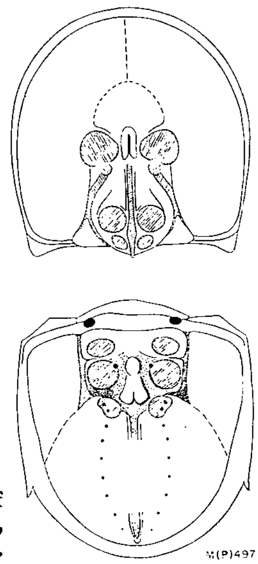

Fig. 35. Parietal morphology of *Pseudagnostus papilio* Shergold, 1972, diagrammatically represented.

Plicatolina perlata Zones. *Pseudagnostus cyclopygeformis* (Sun) *sensu* Kobayashi (1960b, p. 341, pl. XIX, fig. 6, *non* fig. 7 (*clarki* group)), Tanggok, S. Korea, *Kaolishania* Zone. From western Queensland *Pseudagnostus coronatus, Pseudagnostus denticulatus, Pseudagnostus* sp. A, *Pseudagnostus* sp. B, and *Pseudagnostus* sp. C are described below.

Distribution: The *clavus* species group as constituted above appears most commonly represented in the USSR (Kazakhstan and Siberian Platform) and Australia (western Queensland). Solitary representatives may occur in British Columbia and South Korea.

Age: In Queensland representatives of the *clavus* group are pre-Payntonian in age. The Korean occurrence has a late Changshanian age. In the USSR the group occurs within the *Irvingella* to *Lotagnostus trisectus* time interval, and may have a similar age in Canada, i.e. a little earlier than the occurrences of Asia and Australia.

PSEUDAGNOSTUS CLAVUS Shergold, 1972
(Pl. 8, figs 6-12; Text-fig. 36)

1972 *Pseudagnostus clavus* Shergold, p. 31-34, pl. 3, figs 1-8.

Holotype: CPC 8453a, an exfoliated pygidium from the Gola Beds, Momedah Creek, Boulia district, western Queensland (Shergold 1972, pl. 3, figs 5-6).

Occurrence: Plesiotype material illustrated herein, CPC 11698-704, is from the 'Chatsworth Limestone', Black Mountain, horizon K116, K118, and K121, at 138, 165, and 171.4 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zone of *Pseudagnostus bifax* with *P. denticulatus;* pre-Payntonian A, Assemblage-Zone of *P. clarki maximus* with *P. papilio.*

Material: Further material includes eight cephala and six pygidia.

Size: Cephalic lengths range between 1.05 and 3.30 mm (sag.); pygidial lengths (Lp_2) range between 2.30 and 3.00 mm.

Comment: The original type series of *Pseudagnostus clavus* consists almost entirely of exfoliated shields showing details of parietal morphology. Those now recovered and illustrated are mainly preserved with shell, which may explain the differences at first apparent between the collections. Both series are identical in the shapes and proportions of their shields and are here considered conspecific.

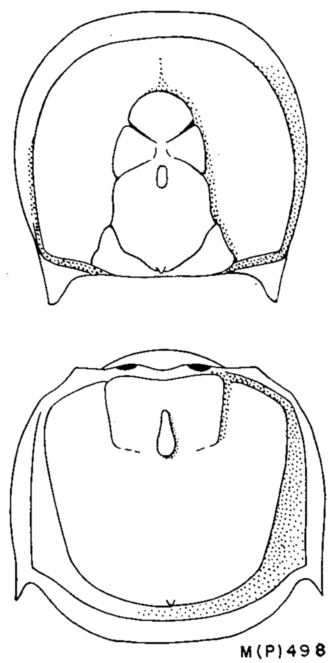

Fig. 36. External testaceous morphology of *Pseudagnostus clavus* Shergold, 1972, based on cephalon CPC 11700, x17, and pygidium CPC 11702, x13.

Description of external testaceous surfaces: The cephalon is subquadrate, expanding forwards, with a straight transverse anterior margin. Its length (sag.) varies between 87 and 100% of the maximum width (tr.), depending on preservation. The borders are slightly convex, upturned laterally, 7-11% of the cephalic length (sag.) anteriorly, and in marked contrast to the concave borders of the moulds (see Shergold, 1972, pl. 3). The shape of the acrolobe mirrors that of the margin but is not so noticeably constricted as when the shell is exfoliated (loc. cit., figs 2-3). The glabella, which accounts for two-thirds of the cephalic length (sag.), tapers anteriorly. In marked contrast to the moulds, the furrows are poorly developed on the shell, but the shape of the lobes appears similar. The posterior lobe, however, is more posteriorly expanded in shelly specimens. The axial node, lying half way along the length of the glabella, is one-third of the cephalic length (sag.) from the rear of the cephalon. The terminal node is nearly effaced, again in contrast to moulds.

Pygidial testaceous and parietal surfaces have the same shapes, Lp_2:Wp_1 82-84%, similar wide borders, Lb:Lp_2 9-16%, and posterolateral spines of similar size and orientation. The furrowing is partly effaced on the shells, and the axial node is less obvious. The articulating half-ring, a simple crescentic bar, was not previously described, nor were the fulcral points, seen to be high and sharp, nor the facets, which are steeply inclined to squared off anterolateral corners.

PSEUDAGNOSTUS CORONATUS sp. nov.
(Pl. 6, figs 1-6; Text-fig. 37)

Name: L., *coronatus,* crowned, referring to the relationship of cephalic acrolobe and glabella.

Holotype: CPC 11692, a complete partly exfoliated cephalon, illustrated on Pl. 6, fig. 2.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K105, K106, and K109, at 7.3, 51, and ?80 m from the base of the measured section; and also at B507a″ on previously collected sections.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zones of *Pseudagnostus clarki patulus* with *Caznaia squamosa* and *P. clarki prolatus* with *C. sectatrix.*

Material: Material is limited to six cephala and three pygidia, specimens CPC 11692-7 forming the illustrated paradigm.

Size: Cephalic lengths (sag.) range between 3.35 and 4.00 mm; pygidial lengths (Lp_2) between 3.20 and approximately 3.35 mm.

Diagnosis: A rhaptoid species of *Pseudagnostus* with subcircular shields. The cephalon lacks a median preglabellar furrow and has relatively narrow borders; its glabellar furrowing is poorly differentiated; and the axial glabellar node lies rearwards of the fusion of the anterolateral lobes. The pygidium has wide borders, compact constricted acrolobe, traces of axial transverse furrows, and spines sited near the rear of the deuterolobe.

Differential diagnosis: Overall morphology suggests close comparison with *Pseudagnostus araneavelatus* Shaw (1951, p. 113, pl. 24, figs 12-14). Cephala of *P. coronatus* and that species are strikingly similar, having the same shape and degree of effacement, and similar glabellar characteristics. The difference between the two species on cephalic characteristics rests on the araneavelate prosopon of the American species, although a hint of a comparable texture exists on CPC 11693 (Pl. 6, fig. 3), and the slightly larger basal lobes of the Australian one. The pygidium of *P. araneavelatus* (Shaw, loc. cit., figs 15-16) is proportionately shorter (sag.), having a more circular outline. Its acrolobe is unconstricted and its axis more strongly effaced.

The cephalon of *P. coronatus* is also similar in shape to that of *Pseudagnostus* (*Rhaptagnostus*) *acutifrons* (Troedsson) (1937, p. 22-24, pl. 1, fig. 9), and glabellar morphology appears essentially similar. But *acutifrons* has a median preglabellar furrow which is not observed in *coronatus*. It differs further on pygidial characteristics, being more obviously rhaptoid, probably a circumstance of preservation and is proportionately considerably longer.

The cephalon of *Pseudagnostus clavus* Shergold (1972, p. 31-4, pl. 3, figs 1-4) differs in its more quadrate shape and the lower degree of effacement of its glabellar structures. The pygidia of *coronatus* and *clavus* are, however, very closely comparable, with the same shape, same wide borders, and similarly constricted acrolobe. *P. coronatus* is slightly more effaced, its notular structures being less clearly visible.

Similar differences are recorded between pygidia of *P. coronatus* and those of *P. cavernosus* Rosova (1960, p. 12-14, pl. 1, figs 1-4), *P.* (*Pseudorhaptagnostus*) *simplex* Lermontova (1951, p. 12-13, pl. 2, figs 11-14), and *P.* (*Pseudorhaptagnostus*) *punctatus* Lermontova (1940, p. 126, pl. 49, fig. 14a). The pygidia of all these species seem to be closely comparable morphologically. All, with the exception of *cavernosus* (in which it is not known), have cephala with median preglabellar furrows which are lacking in *P. coronatus*. The pygidia of *P. vulgaris* Rosova (1960, p. 14-16, pl. 1, figs 9-13) have differently shaped, elongated acrolobes.

Pygidial comparison may also be made with *Pseudagnostus josepha* (Hall) *sensu* Frederickson (1949, p. 362, pl. 72, fig. 17). No notulae are shown on Frederickson's specimens and their axes are more greatly effaced.

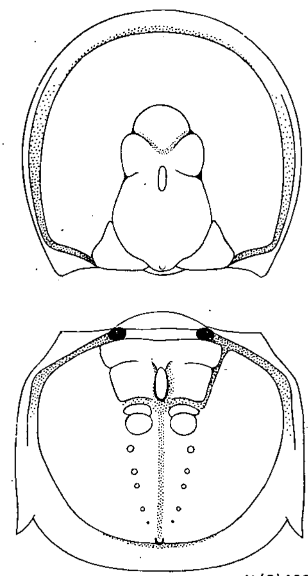

Fig. 37. ***Pseudagnostus coronatus*** **sp. nov., external testaceous cephalic morphology based on CPC 11692, x10, and parietal pygidial morphology based on CPC 11697, x10.5.**

General description: As all the known specimens are moulds, or have only the thinnest vestiges of shell, all observations are recorded under a general heading. The cephalon is subcircular, with its length only fractionally greater than its maximum width ($Lc:Wc_1$ is 101-103%), with narrow borders anteriorly 8-11% of the cephalic length (sag.), and prominent marginal furrow, narrow but deeply incised. The acrolobe is unconstricted and lacks a median preglabellar furrow. The glabella, occupying 63-68% of the maximum cephalic length (sag.), is quite strongly effaced. When visible the anterior lobe is small and rhomboid, separated from the lateral lobes by faint V-form furrows similar to those of *Pseudagnostus clavus.* The anterolateral lobes themselves are poorly defined but they have small raised areas on their forward corners. They are separated from the remainder of the posterior lobe by faint furrows sloping outwards and backwards from the sagittal line. The axial node lies rearwards of the point of fusion of the anterolateral lobes, 36-41% of the distance along the cephalon from the rear. The posterior lobe is angulate at the back and slightly convex. The basal lobes are large, triangular, and poorly differentiated from the posterior lobe. The glabella is characterized by a marked constriction between the anterolateral and posterior lobes, opposite the high point of the axial node. The surface of the acrolobe in some specimens (Pl. 6, fig. 3) is perhaps faintly araneavelate.

Like the cephalic shield, that of the pygidium is subcircular in outline; Lp_2:Wp_1 is 77-84%. Its lateral margins are near parallel, and its posterior margin unevenly rounded. Posterolateral spines are small and lie a little in front of the rear of the deuterolobe. The borders are broad throughout, 11-15% of the pygidial length (Lp_2) posteriorly. The marginal furrow is shallow and wide. The axial furrows are well-defined, as are the first and second transverse furrows, and converge rearwards. The axial node lies across the bulk of the second segment. Behind the defined axis are raised patches, the muscle-scar impression of the third segment, and behind these an uncertain number of notulae, perhaps representing a further five metameres. The intranotular axis is unclear. The acrolobe is markedly constricted and comparable in shape to that of *Pseudagnostus clavus.* An interpretation of the morphology of the parietal surface is illustrated on Text-figure 37.

PSEUDAGNOSTUS DENTICULATUS sp. nov.
(Pl. 8, figs 1-5; Text-fig. 38)

Name: L., *denticulatus,* denticulate, referring to the small denticle-like posterolateral spines.

Holotype: CPC 11705, cephalon preserved with shell, illustrated in Plate 8, fig. 1.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K117, K118, K119, at 149, 156, and 157 m from the base of the measured section; and also at horizons B507b and B507c (see Appendix 1).

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zone of *Pseudagnostus bifax* with *Pseudagnostus denticulatus.*

Material: Four cephala and eight pygidia. The illustrated material comprises specimens CPC 11705-9.

Size: Cephala range in length (sag.) between 2.05 and 3.00 mm; and pygidia (Lp_2) between 2.10 and 3.10 mm.

Diagnosis: A species of *Pseudagnostus* with a combination of distinguishing characteristics: the cephalon is anteriorly rounded; the glabella short, paucifurrowed externally with its node at one-third the length of the cephalon; borders are narrow. The pygidium has a near-circular outline, is posteriorly rounded, has rounded, slightly constricted acrolobe, and posterolateral spines which are mere denticles thrown outwards and backwards from the margins, their ends lying in advance of the rear of the deuterolobe.

Differential diagnosis: In one or more characteristics *Pseudagnostus denticulatus* resembles a variety of previously described species. *P. araneavelatus* Shaw (1951, p. 113, pl. 113, figs 12-16), from the uppermost George Formation of Vermont, is the closest species in terms of shield shapes; the pygidia in particular are very similar, but the spines are smaller and placed farther forwards in the Australian specimens. They lack the characteristic surface markings of *P. araneavelatus.*

Pseudagnostus coronatus is also similar, differentiated basically by its relatively longer cephalon and more strongly constricted pygidial acrolobes. In *Pseudagnostus* sp. B (below) the pygidial acrolobe is not constricted at all. Degree of constriction of this feature also differentiates *P. denticulatus* from the Alaskan pygidium assigned by Palmer (1968, p. B30, pl. 12, fig. 6) to *Pseudagnostus vulgaris* Rosova, and that illustrated (op. cit., pl. 7, fig. 10) as *P. communis* (Hall & Whitfield). One other pygidium, near identical save for its narrower borders, is that figured as *P. prolongus* (Hall & Whitfield) from the *Ptychaspis* fauna of Idaho by Lochman & Hu (1959, p. 412-3, pl. 57, fig. 10).

The cephalon most strongly resembles that of *Pseudagnostus cyclopygeformis* Sun, *sensu* Kobayashi (1960b, p. 341, pl. XIX, fig. 6), a South Korean specimen, and *P. clavus* Shergold (*supra*) from the Gola Beds. Both the cephalon and pygidium of the latter species, however, have quadrate outlines which readily differentiate them from *P. denticulatus.*

Description of external testaceous surfaces: The cephalon is ovoid to subcircular, anteriorly rounded, the length (sag.) being 88-94% of the maximum width (tr.). The borders are 7-10% of the cephalic length (sag.), slightly convex (sag.), and slightly upturned. The cephalic marginal furrow is at all places shallow. The cephalic acrolobe is unconstricted, gently convex (tr.), and lacks a median preglabellar furrow. The glabella is short, 63-67% of the cephalic length (sag.), tapering very gradually forwards. Its furrows are obscure on the specimens at hand, but the anterior lobe is divided from the anterolateral lobes by very faint V-form furrows, and the latter lobes from the remainder of the posterior lobe by equally faint chevronate depressions. The posterior lobe is elevated and bulbous at the rear, is angulate, and has a small posterior terminal node. The axial glabellar node is low and elongate, and its high spot is situated about one-third of the cephalic length from the rear of the cephalon. The glabella is constricted immediately behind the anterolateral lobes. The basal lobes are large, undivided, and triangular.

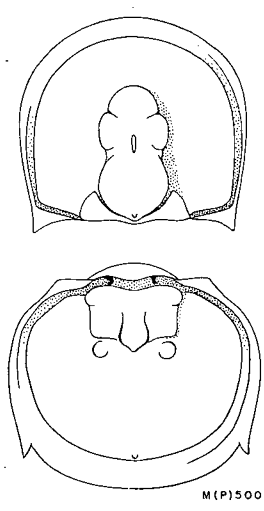

Fig. 38. External testaceous morphology of *Pseudagnostus denticulatus* sp. nov., based on cephalon CPC 11705, x10, and pygidium CPC 11709, x8.5.

The pygidium, which is almost circular in outline, is posteriorly and laterally rounded, and has rounded anterolateral margins. Its length (Lp_2) varies between

81 and 87% of its maximum width (tr.), which lies near the midlength of the shield. The borders, which are broader than those of the cephalon, 11-16% of the pygidial length (sag.), are slightly convex and widest posterolaterally. The marginal furrow is wide and shallow. Posterolateral spines are mere spinules, incongruously placed, oriented outwards, backwards, and adventrally, like small hooks, with the terminations on a transverse line across the base of the deuterolobe or a little in front of it. The acrolobe is slightly constricted to give a subparallel-sided appearance. The axis is relatively short, anteriorly enclosed by axial furrows having variable degree of anterior divergence. The axial node is sited squarely on the second axial segment. No features of the notulae are shown, except the small terminal node at the rear of the deuterolobe. The articulating facets are not steeply inclined, and the fulcral points are not prominent. The articulating half-ring is typical of *Pseudagnostus,* a curved bar, separated from the axis by a posteriorly bowed platform within the articulating furrow, flanked by deep apodemal pits.

PSEUDAGNOSTUS sp. A
(Pl. 7, figs 1-2; Text-fig. 39)

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K103, K104, and K105, at 1.6, 6, and 7.3 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zone of *Pseudagnostus clarki patulus* with *Caznaia squamosa.*

Material: Limited to three pygidia, of which specimens CPC 11710 and 11711 are figured.

Size: Lengths (Lp_2) vary between 2.50 and 3.19 mm.

Partial diagnosis: Apparent diagnostic characteristics of *Pseudagnostus* sp. A. are: a subrectangular to trapezoidal outline with posteriorly flared flanks; hooked posterolateral spines, posteriorly placed on a transverse line across the rear of the deuterolobe; squared-off posterior margin behind the spine bases; broad posterior margin and marginal furrow.

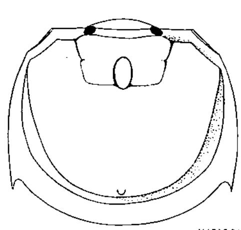

Fig. 39. *Pseudagnostus* **sp. A, external testaceous morphology, based on CPC 11710, x8.**

Differential diagnosis: Three previously described species have a similar pygidial shape and comparable degree of effacement to *Pseudagnostus* sp. A, namely: *Pseudagnostus* (*Euplethagnostus*) *subangulatus* Lermontova (1940, p. 126, pl. 49, fig. 15a), *P. cyclopyge* (Tullberg) *sensu* Lake (1906, p. 27-8, pl. II, fig. 21), and *P. longicollis* Kobayashi (1966b, p. 283, fig. 7).

Though it has in common effacement, identically shaped pygidial flanks, similarly situated spines, and equally wide borders, *Pseudagnostus subangulatus* has a more prominently angulate posterior margin than that of *P.* sp. A. The two species appear, however, to be morphologically closely related. *P. cyclopyge sensu* Lake is again similarly effaced and has similarly positioned spines, but has an appreciably narrower posterior border. *P. longicollis* is less strongly effaced and more quadrate in outline. Its posterior margin and articulating half-ring are comparable to those of *P.* sp. A, but it has considerably longer spines.

General description: The pygidial shield is subrectangular to trapezoidal in outline with slightly flared flanks diverging posteriorly: the length to width ratio for assigned specimens is 77-84%. Stout posterolateral spines are situated posteriorly on a level with the rear of the deuterolobe. They are hooked, bent slightly adventrally. The posterior margin is subtrapezoidal. Both lateral and posterior borders are wide, as is the marginal furrow, the posterior border ranging between 11 and 20% of the pygidial length. The articulating facets are steeply inclined. The articulating half-ring is appreciably thickened mesially and envelops two deep apodemal pits laterally. The axis, which occupies 78-88% of the pygidial length (sag.), is enclosed by axial furrows converging slightly posteriorly. Axial segmentation is variable, ranging from faint to effaced, with usually only the second transverse furrow discernible. On one specimen, CPC 11710 (Pl. 7, fig. 1), this also is effaced. Accessory furrows and notular lines are effaced on all specimens. The axial node is small and sited to the rear of the second axial segment.

PSEUDAGNOSTUS sp. B
(Pl. 7, figs 3-4; Text-fig. 40)

Occurrence: 'Chatsworth Limestone', Black Mountain, horizon K106, 51 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zone of *Pseudagnostus clarki patulus* with *Caznaia squamosa.*

Material: Two pygidia, CPC 11712 and 11713.

Size: Pygidial lengths (Lp_2) of the two specimens are 3.00 and 3.30 mm.

Partial diagnosis: This species appears to be differentiated by the combination of quadrate shape, posteriorly gently rounded, wide borders and marginal furrows, elongated rectangular acrolobe, and posterolateral spines placed in advance of a line across the rear of the deuterolobe.

Differential diagnosis: Pseudagnostus sp. B seems closely comparable with *P.* sp. A in degree of effacement, shape of the axis, and position of the axial node. The borders are slightly wider (sag.), the acrolobe more rectangular, and the posterior margin is possibly more evenly rounded. The species are, however, readily differentiated on the positions of their posterolateral spines. In *P.* sp. B they are small, thorn-like, and pointed outwards from the line of the lateral margin, whereas in *P.* sp. A they are longer, hooked, and their distal extremities are curved adaxially. In *P.* sp. A they lie on a transverse line close to the rear of the deuterolobe, but in *P.* sp. B they lie considerably in advance of this position.

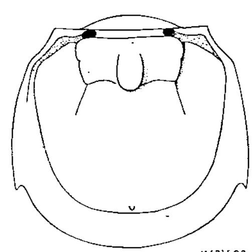

Fig. 40. ***Pseudagnostus*** **sp. B, external testaceous morphology, based on CPC 11713, x10.**

Pseudagnostus sp. B also resembles *P. elix* sp. nov., from which it is distinguished by a greater degree of effacement, thicker and wider (sag.) borders, and a more rectangular acrolobe. Similar differences separate *P.* sp. B from *Pseudagnostus josepha* (Hall) *sensu* Frederickson (1949).

General description: The pygidial shield is quadrate, the lateral margins curving abaxially only gently, and has a gently rounded posterior margin. Marginal furrows are wide and shallow. The posterolateral spines are small, deflected outwards from the margins, and lie in advance of the rear of the deuterolobe. The acrolobe is slightly constricted, long, rectangular. The axial furrows diverge only slightly forwards. The transverse furrows of the first axial segment are effaced, and those of the second only lightly incised. The axial node is sited centrally on the second transverse segment. Postaxial structures are effaced. The nature of the articulating half-ring is not known, but the articulating facets are concave and steeply inclined, and there are marked fulcral points.

PSEUDAGNOSTUS sp. C
(Pl. 7, figs 5-7)

Occurrence: 'Chatsworth Limestone', Black Mountain, horizon K111, 112 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, *Pseudagnostus clarki prolatus* with *Caznaia sectatrix* Assemblage-Zone.

Material: Five specimens—four cephalic fragments and a single pygidium, specimens CPC 11714-6 forming the illustrated paradigm.

Size: The cephala are generally too poorly preserved to measure. That figured on Plate 7, fig. 5 has a glabellar length (sag.) of 2.40 mm, and fig. 7, 2.15 mm. The pygidium has a length (Lp_2) of 2.60 mm.

Partial diagnosis: The cephalon is similar to that of *Pseudagnostus coronatus* sp. nov., but has a deeper marginal furrow and narrow upturned border. The pygidium has an ovoid outline with wide borders, subcircular unconstricted acrolobe, and posterolateral spines situated slightly in advance of the rear of the deuterolobe.

Differential diagnosis: The closest species morphologically is *Pseudagnostus coronatus,* which occurs at lower levels in the Black Mountain succession. *P.* sp. C has a deeper cephalic marginal furrow and upturned border. Cephalic proportions, as far as can be assessed, are comparable. The pygidium of *P.* sp. C has an unconstricted acrolobe, subcircular rather than trapezoidal as in *P. coronatus,* and proportionately less wide.

Several previously described species have unconstricted acrolobes. That of *Pseudagnostus araneavelatus* Shaw (1951, p. 113, pl. 24, figs 12-16) differs proportionately, being considerably shorter (sag.) and transversely oval. The pygidium figured by Palmer (1968, p. B30, pl. 12, fig. 6) as *P. vulgaris* Rosova has comparable acrolobe and borders, and differs only in possessing traces of accessory furrows, which are absent in *P.* sp. C. *Pseudagnostus punctatus* (Lermontova) (Lermontova, 1940, p. 126, pl. 49, fig. 14a) also has a similar acrolobe and borders, but has considerably more massive posterolateral spines placed somewhat farther to the rear. *P.* sp. C. may also be related to *Pseudagnostus jeholensis* Kobayashi, 1951, but the quality of the published illustrations prevents detailed comparison.

General description: The cephalon is subovoid, with length (sag.) slightly greater than maximum width (tr.). It has a narrow border, which is upturned, especially anterolaterally, and a deep marginal furrow. The acrolobe is appreciably convex, and anteriorly lacks a median preglabellar furrow. The glabella, occupying about two-thirds of the total cephalic length, is similar to that of *P. coronatus.* Anterior and anterolateral lobes are poorly differentiated; the anterior furrow is nearly obliterated. The glabella has a marked constriction about its midlength, at which point a pair of pits is situated in the floor of the axial furrows. The posterior lobe is strongly elevated at the rear and bluntly pointed. The basal lobes are tear-drop shaped and laterally extensive.

The pygidium has a similar ovoid shape to the cephalon (Lp_2:Wp_1 is 87%, Wp_2:Wp_1 is 80%). The posterolateral spines are small, situated slightly in advance of the rear of the deuterolobe. The acrolobe is oval, unconstricted laterally, and appreciably convex. A good portion of the dorsal surface of the axis is lacking on the only specimen available. It appears to occupy, however, 83% of the pygidial length (Lp_2) and anteriorly 50% of the width (Wp_2). The border is wide and flat, 17% of the total length (sag.) posteriorly, and the marginal furrow is shallow and wide. The articulating facets slope strongly abaxially and culminate adaxially in small points. The articulating half-ring is eroded away.

Pseudagnostus bilobus species group

Characteristic species: Pseudagnostus bilobus Shaw, 1951, p. 112-3, pl. 24, figs 17-22, basal Highgate Formation, Missisquoi River, Highgate Falls, Vermont, USA.

Characteristics: The *P. bilobus* species group is possibly derived from that of *Pseudagnostus clavus,* as evidenced by the shapes of the shields, the presence of wide borders and deliquiate marginal furrows, and the position of the axial glabellar node with respect to the anterolateral lobes. The *bilobus* species group is characterized by an emphasis on the depth of impression of the chevronate median lateral glabellar furrows seen only faintly developed in the *clavus* group. Additionally, the V-form anterolateral furrows may also be emphasized, as in *P. bilobus* and the unnamed Mexican species of Robison & Pantoja-Alor (1968), so that the glabellar furrows appear to intersect in the form of a cross. This feature particularly characterizes exfoliated cephala. The pygidium possesses posterolateral spines situated at the level of the rear of the deuterolobe or behind it on the posterior pygidial margin. The axial furrows of the pygidium generally enclose a third pair of axial lobes, in actual fact the muscle scars of the third metamer, resembling those found in the *clavus* group. Unlike the latter group, these lobes may be represented as low swellings on the external testaceous surface of the shield.

Comment: Species possessing these characteristics have formerly been classified with *Pseudagnostus, Neoagnostus, Hyperagnostus,* or *Machairagnostus* (see discussion of subgenera of *Pseudagnostus* above). Until a thorough revision of the type materials on which these genera are based is undertaken, the species concerned are considered best left under *Pseudagnostus* s.l. Should generic or subgeneric separation from *Pseudagnostus* be warranted the *bilobus* species group should be placed in *Neoagnostus,* which has priority over both *Hyperagnostus* and *Machairagnostus. Pseudagnostus bilobus* Shaw has previously been considered a probable species of *Machairagnostus* (Harrington & Leanza, 1957, p. 63).

Other species: Belonging to the *P. bilobus* species group with some certainty are the following: *Neoagnostus aspidoides* Kobayashi(1955, p. 473-4, pl. VII, fig. 5, the holotype cephalon, *non* fig. 4 designated paratype pygidium = a geragnostoid), McKay Group, 0.75 m E of Grant Mine, Jubilee Mountain, S of Harrogate, British Columbia, Canada. *Hyperagnostus binodosus* Kobayashi (1955, p. 475, pl. VII, fig. 2, holotype cephalon, ?3, paratype pygidium), McKay Group, McKay Creek, British Columbia, Canada. *Machairagnostus tmetus* Harrington & Leanza (1957, p. 64, figs 6-7), Salta Province, Argentina. *Pseudagnostus longicollis* Kobayashi (1966b, p. 283, fig. 7), green shale and marl at Huangluohsien, Jehol, NE China. Undetermined pseudagnostid, Robison & Pantoja-Alor (1968, p. 780, pl. 97, fig. 23), Tiñu Formation, Nochixtlán, Oaxaca district, Mexico. Possibly also belonging to the *bilobus* group are: *Agnostus canadensis* Billings (1860, p. 304, figs 3a, b; 1863, p. 233, figs 252a, b; 1865, p. 397, figs 374a, b), from the boulder conglomerates at Lévis, Quebec, Canada. *Pseudagnostus canadensis* (Billings) *sensu* Rasetti (1944, p. 234, pl. 36, figs 8-13), as above. *Agnostus janei* Clark (1923, p. 124, fig. 8; 1924, p. 19, pl. 3, fig. 5), as above, synonymized with *Pseudagnostus canadensis* (Billings) by Rasetti (1944). *Rhaptagnostus acutifrons* Troedsson (1937, p. 22-4, pl. 1, fig. 9), Cambrian-Ordovician passage beds at Charchaq Ridge, W. Quruq-tagh, eastern Tienshan, China. *Agnostus cyclopyge* Tullberg *sensu* Sun (1939, p. 30, pl. 1, figs 1-3), Paoshan Shale, Pupiao district, western Yunnan, China. *Pseudagnostus araneavelatus* Shaw (1951, p. 113, pl. 24, figs 12-16), basal Highgate Formation, Missisquoi River, Highgate Falls, Vermont, USA, forming a link with the *clavus* group through the Australian *coronatus-denticulatus* lineage. Tentatively assigned are: *Pseudagnostus josephus* (Hall, 1863) *sensu* Wilson (1954, p. 284, pl. 25, figs 5, 22), boulder BC-2, in Woods Hollow Shale, Marathon Uplift, Texas. *Trinodus priscus* Kobayashi (1955, p. 476, pl. VII, fig. 6), McKay Group, McKay Creek, British Columbia, Canada, which may represent the pygidium of *Neoagnostus aspidoides* Kobayashi.

Distribution: Including possible species as delineated above, the *bilobus* group is distributed in the USA (Texas, Vermont), Canada (British Columbia, Quebec), Mexico (Oaxaca), Argentina (Salta), China (Tienshan, Jehol, Yunnan), and Australia (western Queensland).

Age: Apart from the Texan occurrence, which has a Franconian age assigned by Wilson (1954), the representatives of the *bilobus* group all occur in beds close to the Cambrian-Ordovician boundary. Its representatives have a Fengshanian age in China, and an equivalent Payntonian age in Australia, both of these occurrences being latest Cambrian. The group occurs in the early Ordovician *Missisquoia* Zone in British Columbia and Vermont, in the early Tremadocian *Parabolina argentina* Zone of Argentina, and with the *Kainella-Evansaspis* faunas of British Columbia, the last being the youngest recording.

PSEUDAGNOSTUS QUASIBILOBUS sp. nov.
(Pl. 12, figs 1-7; Text-fig. 41)

Name: L., *quasi,* simulating, prefixing the existing specific nomen *bilobus* and referring to the similarity of the two species.

Holotype: CPC 11717, partly exfoliated cephalon, illustrated in Plate 12, fig. 1.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K138, K139, at 374 and 375 m from the base of the measured section, and at B510 and B510b collected in 1957; Ninmaroo, horizons K168, K169, at 67 and 68.5 m from the base of the measured section.

Age: Late Upper Cambrian, Payntonian, *Pseudagnostus quasibilobus* with *Tsinania nomas* Assemblage-Zone.

Material: 11 cephala and 13 pygidia, from which the figured specimens CPC 11717-23 were selected.

Size: Cephala range in length (sag.) between 1.95 and 2.70 mm; and pygidia (Lp_2) between 1.10 and 2.15 mm.

Diagnosis: A species of *Pseudagnostus* with the following combination of characteristics: quadrate shields; the presence of a median preglabellar furrow; deep chevronate median lateral furrows meeting sagittally in front of the axial glabellar node; weak V-form anterior lateral furrows; long (sag.) rounded anterior glabellar lobe; short pygidium with moderately wide borders and stout posterolateral spines lying on a transverse line across the rear of the deuterolobe.

Differential diagnosis: Pseudagnostus quasibilobus has similarly shaped shields and similar glabellar furrowing to *P. bilobus* Shaw (1951, p. 112-3, pl. 24, figs 17-22), *P. josephus* (Hall) *sensu* Wilson (1954, p. 284, pl. 25, figs 5, 25), *Agnostus cyclopyge* Tullberg *sensu* Sun (1939, p. 30, pl. 1, figs 1-3), *P. longicollis* Kobayashi (1966b, p. 283, fig. 7), and the undetermined pseudagnostid of Robison & Pantoja-Alor (1968, p. 780, pl. 97, fig. 23). It differs from *cyclopyge sensu* Sun, *longicollis,* and *araneavelatus* Shaw in possessing a median preglabellar furrow. *P. quasibilobus* has shorter pygidial spines than *P. bilobus,* but they are similar in shape and orientation. The acrolobe is also shorter (sag.), and more closely resembles that of *P. araneavelatus* Shaw.

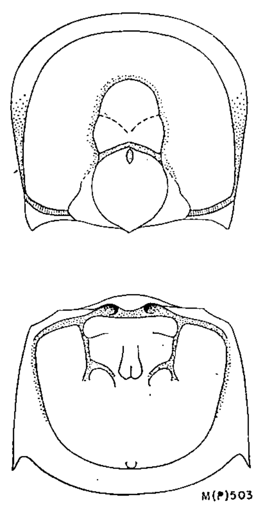

Fig. 41. External testaceous morphology of *Pseudagnostus quasibilobus* sp. nov.; cephalic reconstruction based on CPC 11717, x13; pygidial reconstruction based on CPC 11723, x12.

Pseudagnostus quasibilobus, P. bilobus, and their allies form a distinct species group within *Pseudagnostus,* deriving the shape of its shields and the shape and proportions of its glabellae from pseudagnosti of the *P. clavus* type. The tendency to overdeepen the median lateral glabellar furrows characterizes the group and differentiates it from that of *P. clavus,* in which the anterior lateral glabellar furrows are thus emphasized.

General description: The cephalic shield is quadrate, anteriorly transverse and straight, rounded off at the corners. The maximum width (tr.) lies on a line across the front of the glabella; $Lc_1:Wc_1$ is 89-102%. The lateral flanks converge backwards as in *Pseudagnostus clavus*. The cephalic acrolobe is unconstricted and the borders moderately wide, without overdeepened marginal furrows, $Lb:Lc_1 = 9\text{-}11\%$. The glabella, occupying two-thirds of the cephalic length (sag.), $G:Lc_1 = 63\text{-}70\%$, is laterally constricted at the median lateral furrows and anteriorly acutely rounded. The median lateral furrows are strongly defined, chevronate, and divide the glabella into two parts. The anterior lateral glabellar furrows are much fainter and V-form. The anterolateral lobes have low relief, but the rear of the posterior lobe is strongly angulate and elevated, bearing a prominent terminal node. The axial glabellar node lies at the apex of the median lateral furrows, 44-46% of the cephalic length (sag.) from the rear of the cephalon. The basal lobes are large, triangular, and laterally extensive. The surface of the cephalic shell on specimens CPC 11717, 11718, and 11719 (Pl. 12, figs 1-3) is faintly granulose.

The pygidium also has a quadrate outline, but with flanks slightly curving outwards. The posterolateral spines continue the line of the lateral margins backwards. The posterior margin, like the anterior margin of the cephalon, is straight (tr.). The maximum width of the pygidium lies across the middle of the deuterolobe, $Lp_2:Wp_2 = 71\text{-}85\%$. The borders, as in the cephalon, are moderately wide; $Lb:Lp_2 = 8\text{-}17\%$. The pygidial acrolobe is decidedly constricted, and posteriorly evenly rounded. The axial furrows defining the anterior part of the axis are deep, and they also define a third axial segment behind the median axial node. The first axial segment is narrow (exsag.), the second considerably wider (exsag.). The posterior end of the axial node is cleft as in other pseudagnostinids described above. No details of the parietal morphology are preserved on the material at hand.

Order PTYCHOPARIIDA Swinnerton, 1915

Suborder PTYCHOPARIINA Richter, 1933

Superfamily PTYCHOPARIACEA Matthew, 1887

Family PTYCHOPARIIDAE Matthew, 1887

Subfamily EULOMINAE Kobayashi, 1955

Genera, subgenera, and type species: Euloma (*Euloma*) Angelin, 1854, type species *Euloma laeve* Angelin, 1854; *Euloma* (*Proteuloma*) Sdzuy, 1958, type species *Conocephalites geinitzi* Barrande, 1868; *Eulomina* Ružička, 1931, type species *Eulomina mitratum* Ružička, 1931; *Pareuloma* Rasetti, 1954, type species *Pareuloma brachymetopa* Rasetti, 1954; *Dolgeuloma* (*Dolgeuloma*) Rosova, 1963, type species *Dolgeuloma abunda* Rosova, 1963; *Dolgeuloma* (*Pseudoacrocephalites*) Rosova, 1968, type species *Dolgeuloma dolganensis* Rosova, 1963; *Duplora* Shergold, 1972, type species *Duplora clara* Shergold, 1972. A further subgenus of *Euloma, E.* (*Plecteuloma*), is described below.

Genus EULOMA Angelin, 1854
Subgenus PLECTEULOMA nov.

Name: L., *plectrum,* n., prefixing the generic name *Euloma.* *Plecteuloma,* as *Euloma,* has a neuter gender.

Type species: Designated herein, *Euloma (Plecteuloma) strix* sp. nov., from the 'Chatsworth Limestone', Black Mountain, western Queensland.

Diagnosis: A subgenus of *Euloma* with anteriorly tapering glabella relatively short and shallow glabellar furrows, small palpebral lobes, ocular strigae, median preglabellar plectrum, and a small transverse pygidium composed of two segments, with sinuous posterior border, comparable in shape to that of *Euloma* Angelin.

Differential diagnosis: Euloma (Plecteuloma) is most closely comparable to *Proteuloma* Sdzuy, but the latter lacks a plectrum, its palpebral lobes are smaller, and its pygidium is triangular rather than transversely elongated. *Plecteuloma* lacks a preglabellar boss, which differentiates it from *Euloma (Euloma)* and *Pareuloma.* Larger palpebral lobes also distinguish it from the latter. *Dolgeuloma* also has a low boss, and is further differentiated from *Plecteuloma* by a thickened (sag.) cranidial border, both of which features are most greatly exaggerated in *Dolgeuloma (Pseudoacrocephalites).*

EULOMA (PLECTEULOMA) STRIX subgen. et. sp. nov.
(Pl. 30, figs 1-8; Text-fig. 42)

Name: L., *strix,* furrow or groove, referring to the presence of ocular strigae.

Holotype: CPC 11835, a cranidium preserved with shell, figured in Plate 30, figs 1-2.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K103, K104, K105, and K106, at 1.5, 6, 7, and 51 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zone of *Pseudagnostus clarki patulus* with *Caznaia squamosa.*

Material: 16 cranidia, 3 pygidia, and 8 librigenae. The figured specimens are numbered CPC 11835-41.

Size: Cranidia range in length (sag.) between 2.00 and 4.40 mm, and the two measured pygidia both have lengths (Lp_1) of 1.50 mm.

Diagnosis: As for the subgenus.

Differential diagnosis: As *Euloma (Plecteuloma)* is monotypic, comments here are intended to amplify those made in the subgeneric differential diagnosis. In its cranidial characteristics *Euloma (Plecteuloma) strix* is most similar to the Tremadocian *E. (Proteuloma) geinitzi* (Barrande) (see Sdzuy, 1955, pl. 3, figs 77-89; pl. 4, figs 90-92; 1958, pl. 3, figs 7-17), from the Leimitz Schieffer of Germany and the Montagne Noire of southern France. The glabella of *geinitzi* tends to be more rectangular than that of *Plecteuloma strix,* which tapers markedly forwards, and the anterior cranidial marginal furrow is deeper and wider, and lacks the characteristic pits of *Euloma* (*Euloma*) spp., although *E.* (*Proteuloma*) *monile* (Salter, 1873) has them. In *E.* (*Plecteuloma*) *strix* these pits are developed, together with a plectrum. Neither *E.* (*Plecteuloma*) *strix* nor *E.* (*Proteuloma*) *geinitzi* has a boss, which distinguishes them from species of *Euloma* (*Euloma*) and *Dolgeuloma*. On the other hand, the pygidia of *strix* and *geinitzi* are dissimilar in shape, that of the former being most closely comparable with that of *Euloma* (*Euloma*) *laeve* Angelin, as shown by Tjernvik (1956, pl. XI, fig. 3) from Öland. The large palpebral lobes of *Euloma* (*Euloma*), and, as indicated above, the presence of a low preglabellar boss, readily distinguish its species from *E.* (*Plecteuloma*) *strix*.

Description: The cranidium is anteriorly gently rounded. The glabella, occupying 52-54% of the total cranidial length (sag.) (C:Lc), tapers forwards and is acutely rounded anteriorly. Three pairs of furrows are evident, none deeply incised. The preoccipital glabellar furrows are mesially discontinuous, curvilinear, adaxially posteriorly directed parallel to the sagittal line. The median furrows are fainter, also discontinuous, and gently curved. The anterior lateral furrows are very faint, merely pits or grooves on the anterolateral glabellar flanks. All furrows connect abaxially with the axial furrows.

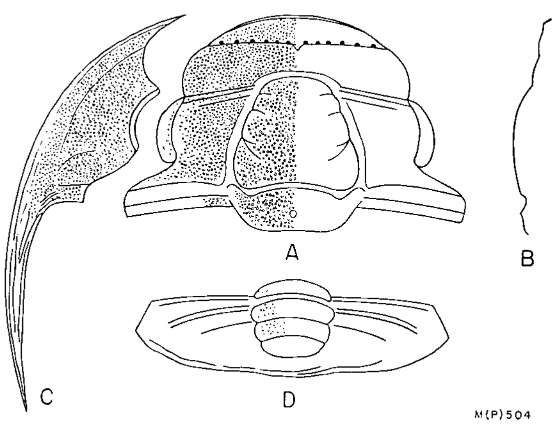

Fig. 42. External testaceous morphology of *Euloma* (*Plecteuloma*) *strix* subgen. et sp. nov.; (A) and (B) cranidium based on CPC 11835, x7; (C) librigena based on CPC 11839, x7; and (D) pygidium based on CPC 11838, x8.

The occipital ring is sagittally wide, but appreciably narrower at each side. It is slightly wider (tr.) than the preoccipital glabellar lobes. A small but conspicuous node lies on the sagittal line at the centre of the ring on all specimens. The occipital furrow is wide (tr.), anteriorly curvilinear sagittally, posteriorly curvilinear abaxially.

The relatively small palpebral lobes (A:G = 45-61%) lie between the anterior part of the preoccipital glabellar lobes and the anterior lateral glabellar furrows. They are separated from the glabella by palpebral areas a little over half as wide (tr.) as the maximum glabellar width (tr.). The palpebral lobes are narrow (tr.), only slightly curved, and stand well above the surrounding palpebral areas. Anteriorly they are connected by distinct ocular ridges to the anterolateral corners of the glabella. These ocular ridges are duplicated by the presence of visible ocular strigae. Pits are formed in front of the point at which the anterior sections of the ocular ridges intersect the axial furrows. The ocular ridges cross the axial furrows and may be faintly discerned extending around the periphery of the frontal lobe, united to form a parafrontal band.

The preocular areas and preglabellar field are confluent. Combined, they form a gently convex (sag., exsag.) roll, sloping anteriorly into a well-defined pitted marginal furrow. About ten pits lie in the floor of this furrow, which is interrupted sagittally by a narrow plectrum connecting the convex (sag.) anterior border with the preglabellar field. The anterior sections of the facial suture run initially directly forwards parallel to the sagittal line, then swing across the convexity of the preglabellar field to intersect the anterior cranidial margin at obtuse angles. The posterior sections diverge rapidly outwards from the rear of the palpebral lobes and enclose transversely elongate, exsagittally narrow, posterolateral limbs. The posterior cranidial border is straight, transverse, or slightly inclined posterolaterally.

The librigena of *Euloma* (*Plecteuloma*) *strix* is transversely narrow, with narrow lateral borders combining with the posterior ones and thickening slightly at the posterolateral corners to produce long, gracefully curved slightly advanced genal spines. Some specimens preserve a well developed rim-like eye socle.

The pygidium is transversely elongate, sagittally narrow; L:W is 31-35%. It is characterized by a sinuous posterior margin and very narrow anterolateral articulating facets. The axis is short (sag.), almost as wide as long, and composed of two segments and a small, poorly defined, terminal piece. Two pleural segments are also defined, bearing wide (exsag.) pleural furrows, and separated by very weak interpleural furrows. The pleural and axial furrows merge at their extremities into a flattened, relatively wide marginal furrow, which follows the line of the posterior margin. The margins themselves are sinuous, curving slightly rearwards behind the axis, curving slightly forwards on either side of it.

The cephalic prosopon is densely granulose overall, the granules overlying faint traces of a caecal network on the preglabellar and preocular areas. No details of this network can be adequately described at the present time, although the radiating arrangement of granules immediately in front of the glabella indicates that they follow a radiating caecal system. The librigena has the same dense granulation as the cranidium, combined with a system of anastomosing lirae situated on the genal spine and extreme margins of the lateral borders. The pygidium is faintly granulose, again with lirate margins.

Genus DUPLORA Shergold, 1972

Type species: Duplora clara Shergold, 1972, p. 73-4, pl. 16, figs 3-7, from the Gola Beds, Momedah Creek, western Queensland; by original designation, monotypical.

Duplora clara Shergold, 1972
(Pl. 30, figs 9-11)

1972 *Duplora clara* Shergold, p. 73-4, pl. 16, figs 3-7.

Holotype: The cranidium from the Gola Beds, CPC 9777, figured by Shergold (op. cit., pl. 16, figs 3-4).

Occurrence: The type material is from the Gola Beds, but additional material referable to this species has been collected from the 'Chatsworth Limestone' of Black Mountain, horizons K111, K113, K115, and K116, at 112, 127, 132, and 138 m from the base of the measured section. Further material was yielded by collections B507c and B509, from previously collected sections.

Age: Late Upper Cambrian, pre-Payntonian B, *Pseudagnostus clarki prolatus* with *Caznaia sectatrix* and *Pseudagnostus bifax* with *P. denticulatus* Assemblage-Zones.

Material: The present sample consists of 5 cranidia; no pygidia, librigenae, or hypostomata were found. Compared with material from the Gola Beds, preservation is poor, with few cranidia retaining the true anterior cranidial border. The figured paradigm comprises specimens CPC 11842-4.

Comments: The additional material adds no new information to that previously published, and there appears to be no marked difference between samples collected from the Gola Beds and those from Black Mountain. Previously unclassified with respect to family, *Duplora is* now placed in Eulominae Kobayashi, because, apart from the nature of the anterior border of the cranidium, the general arrangement of the glabellar and ocular characteristics are clearly comparable to those of *Euloma* (*Plecteuloma*).

Superfamily CONOCORYPHACEA Angelin, 1854
Family SHUMARDIIDAE Lake, 1907
Genus KOLDINIOIDIA Kobayashi, 1931

Type species: Koldinioidia typicalis Kobayashi, 1931, p. 187-8, pl. X, figs 8b, 9, from the Chiushukou Shale, Chiushukou and Hualienchai, Manchuria; designated by Kobayashi (1931).

Other species: Apart from the type species the following late Cambrian and early Ordovician Shumardiidae have been subsequently assigned to *Koldinioidia: Koldinioidia infrequens* (Resser & Endo) (*in* Endo, 1931, p. 86, fig. 14; *in* Endo & Resser, 1937, p. 229-30, pl. 57, fig. 14), known from a single cephalon from the same locality and horizon as the type species. *Koldinioidia aspinosa* Kobayashi (1933a, p. 100, pl. X, figs 5-6), from the *Tsinania canens* Zone of Paichiashan Hill, Wuhutsui Basin, Liaotung, southern Manchuria; this species is also recorded by Endo (1939, p. 9, pl. 1, fig. 23) from the Kaolishan Limestone of Shantung, China. *Koldinioidia yenchouensis* Resser & Endo (*in* Endo & Resser, 1937, p. 229, pl. 56, fig. 10), known from a solitary cephalon from the Yenchou Formation at Yenchoucheng, 7 km S of Yentai, Manchuria. *Koldinioidia paiensis* Endo (*in* Endo & Resser, 1937, p. 339, pl. 71, fig. 5), a single cephalon from the Yenchou Formation of Paichiashan Hill, near Chinchiachengtzu, Manchuria; and Endo (1939, p. 9, pl. 1, figs 21, 22) from the Tawenkou Formation of Taianfu, Shantung, China. *Koldinioidia sulcata* Robison & Pantoja-Alor (1968, p. 796-7, pl. 104, figs 20-23) from the Tiñu Formation, Nochixtlán, Oaxaca district, Mexico.

Distribution: China (Shantung), Manchuria, Mexico, and Australia (western Queensland).

Age: Latest Upper Cambrian to earliest Ordovician.

Diagnosis: Kobayashi's original diagnosis must be modified in the light of recent discoveries outside Asia. *Koldinioidia* is a shumardiid genus without palpebral lobes, facial sutures, or cephalic borders. The posterolateral cephalic angles are developed into short spines; the glabella is posteriorly parallel-sided; and when visible, the frontal lobe is distinctly pointed anteriorly with ogival outline.

Concept of genus: The type species of *Koldinioidia* is not readily accessible and its original description and illustration are inadequate for the precise classification of species subsequently found. Kobayashi (1931, p. 188) mentions the presence of palpebral lobes in this species, but they are not clearly seen on his illustrations, nor can the outline of the anterior part of the glabella be accurately discerned. Kobayashi (1933a, p. 99), however, considered *K. infrequens* (Resser & Endo, 1931) to be synonymous with *K. typicalis,* as they were from the same horizon and locality. If that is the case, then the morphology of the single known cephalon of *K. infrequens,* USNM 86839, may contribute to a better understanding of *Koldinioidia.*

Koldinioidia infrequens is characterized by elongate posterolateral cephalic angles which may have terminated in spines, subsequently lost in preparation. Anteriorly, the glabella is fused to the preglabellar area, and the outline of the frontal lobe is effaced. Posteriorly, the glabella is well defined by deep axial furrows, and bears two pairs of shallow pits along its flanks. Although the occipital ring is broken away, it appears to have been separated from the glabella by a strong occipital furrow, and to have been appreciably convex (tr.) and extensive (sag.) rearwards, projecting backwards some distance behind the posterior cephalic margin. The posterior cephalic margin furrows terminate abruptly and do not continue into the genal angles. There are no traces of palpebral lobes.

The remaining species assigned to *Koldinioidia,* except perhaps *K. aspinosa sensu* Kobayashi, have well defined preglabellar furrows and anteriorly pointed glabellae. *K. yenchouensis,* again a single cephalon, USNM 86838, has been damaged during preparation, and it is not known whether genal spines were originally present. *K. paiensis* and *K. aspinosa* cannot be adequately interpreted from their original descriptions, and specimens later referred to both species by Endo (1939, p. 9) from Shantung are possibly not conspecific.

KOLDINIOIDIA cf. CYLINDRICA (Shergold, 1972)

(Pl. 58, figs 1-4)

cf. 1972 *Eoshumardia cylindrica* Shergold, p. 65-6, pl. 18, figs 7-8.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K103, K104, K105, K106, K107, K108, K109, K111, and K112, at 1.6, 6, 7, 51, 68, 73, 80, 112, and 120.5 m from the base of the measured section; and at previously collected horizons B507a″ and B509.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zones of *Pseudagnostus clarki patulus* with *Caznaia squamosa* and *P. clarki prolatus* with *C. sectatrix.*

Material: The present paradigm consists of 20 cephala, of which specimens CPC 12890-3 are figured; no pygidia are known.

Size: Cephala of *K.* cf. *cylindrica* measure between 0.86 and 2.30 mm in sagittal length.

Comments: The species *cylindrica* was referred in the first instance to *Eoshumardia* because of its obtusely rounded frontal glabellar lobe, and generally broadly semicircular cephalon lacking genal spines. Although the typical nuchal spine of *Eoshumardia* is lacking, the species does have a nuchal node. Further material collected from Black Mountain shows morphology lying between *Koldinioidia,* as interpreted above, and *Shumardia.* The degree of rounding or pointedness of the anterior glabellar contour depends greatly on the degree of orientation of the illustrated specimen. When tilted forwards slightly the frontal lobe appears to be laterally slightly expanded as in *Shumardia* and anteriorly obtusely rounded (see Shergold, 1972, pl. 18, fig. 8). When tilted slightly backwards from the horizontal plane, or levelled, the frontal contour is seen to be slightly ogival and pointed (see here Pl. 58, fig. 3). Some exfoliated cephala tend to show a degree of effacement of the preglabellar furrow which is reminiscent of *Koldinioidia infrequens* Resser & Endo.

Koldinioidia cf. *cylindrica* is differentiated from other species of the genus by its generally broader (tr.) cephalon. Its glabella is more obtusely angled or rounded than in *K. payntonensis, K. sulcata,* or *K. yenchouensis. Koldinioidia aspinosa* Kobayashi, 1933, is perhaps the most closely comparable species, but is difficult to interpret from its description and illustration. The specimen, USNM 96099, figured under this name by Endo (1939, pl. 1, fig. 23), is certainly morphologically close to *K.* cf. *cylindrica,* and may be conspecific. Whether Endo's specimen is conspecific with that of Kobayashi is disputable, and not readily proven without examination of the Manchurian specimen. *K.* cf. *cylindrica* from Black Mountain occurs earlier in time than *K. cylindrica* from the Gola Beds, and when better material has been collected from the latter may prove specifically distinct. At the present time a dearth of material prevents a close comparison of species from the two sections.

KOLDINIOIDIA PAYNTONENSIS sp. nov.
(Pl. 58, figs 6-10)

Name: Derived from the property known as Paynton Downs, on the Boulia 1:250 000 Geological Series Sheet SF/54-10, western Queensland.

Holotype: CPC 12896, the cephalic mould illustrated in Plate 58, fig. 7.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K136, K138, and K139, at 348, 374, and 375 m from the base of the measured section; and at B510 on previously collected sections; Mount Datson, horizon K175, 40 m from the base of the measured section.

Age: Late Upper Cambrian, early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas.*

Material: The species is known from 16 cephala, of which specimens CPC 12894-9 are illustrated; no pygidia are known.

Size: Measured cephala range in length (sag.), Lc, between 0.80 and 2.30 mm.

Diagnosis: A species of *Koldinioidia* possessing genal spines, an anteriorly well-defined and pointed glabella, two pairs of glabellar pits, posterior marginal furrows running into the genal angles, and a faintly granulose testaceous surface.

Differential diagnosis: The species is differentiated from the type, *Koldinioidia typicalis* Kobayashi, in having a narrower (tr.) anteriorly tapering and pointed glabella, and granulose test. In *K. infrequens* the shell has been exfoliated and the anterior part of the glabella appears to be fused to the preglabellar area; the posterior cephalic marginal furrows fail to continue to the genal angles; and the occipital ring is apparently longer (sag.). *K. aspinosa* and *K. paiensis* cannot be readily interpreted from their original descriptions or illustrations. They may be closely comparable with the Australian species, as may be *K. yenchouensis,* whose genal angles and preglabellar area have been damaged during preparation. *K. sulcata* is almost identical, differing only in its possession of a median preglabellar sulcus and a smooth external testaceous surface.

Description: Koldinioidia payntonensis has a semicircular cephalon with width (tr.) almost twice the length (sag.), with high convexity (tr., sag.). Around the anterior and anterolateral margins no border or marginal furrow is developed. Posteriorly, however, a sinuous border with concentric marginal furrow is well defined, the furrow passing into the genal angles, at which delicate spines are developed.

The glabella tapers gently forwards, and is anteriorly pointed. Two pairs of pits lie on the glabellar flanks and open into the axial furrows. The anteriormost pair is associated with what Robison & Pantoja-Alor (1968, p. 797) term 'accessory furrows', running inwards and obliquely forwards from the margins of the frontal glabellar lobe.

The occipital ring is transversely wider than the preoccipital glabellar lobes, but sagittally narrow. It is divided from the glabella by a sagittally well-defined arcuate occipital furrow which terminates abaxially in pits similar to those occupying the glabellar flanks. A faint nuchal node may be present.

Superfamily OLENACEA Burmeister, 1843

Family OLENIDAE Burmeister, 1843

Subfamily PELTURINAE Hawle & Corda, 1847

Genus PROTOPELTURA Brögger, 1882

Type species: Peltura praecursor Westergaard (1909, p. 48), which occurs in the Zone of *Protopeltura praecursor* (Va), Subzones *Leptoplastus neglectus, Ctenopyge praecurrens,* and *Ctenopyge flagellifera* (*fide* Henningsmoen, 1957, p. 230). A full discussion of the concept of *Protopeltura* is given by Henningsmoen (op. cit., pp. 220, 229).

?Protopeltura sp.
(Pl. 46, figs 8-10)

Occurrence: 'Chatsworth Limestone', Black Mountain, horizon K121, 171 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian A, Assemblage-Zone of *Pseudagnostus clarki maximus* with *P. papilio.*

Material: Two fragmentary cranidia, of which one, CPC 12000, is figured, and an associated librigena, CPC 12855.

Size: The cranidium illustrated in Plate 46, figs 8-9, has an estimated length (sag.) of 4.70 mm.

Differential diagnosis: The general appearance of the remains is more robust than that of Scandinavian material, and the cranidial border is considerably thicker (sag.) than on any other species assigned to *Protopeltura.* General ocular, glabellar, and genal characteristics are, however, closely comparable. In particular comparison may be made with *P. holtedahli* Henningsmoen (1957, p. 227, pl. 23, figs 16-22), *?Protopeltura* differing, apart from the above-mentioned characteristics, in having fainter glabellar furrows and ocular ridges. Apart from its curtailed genal spine, the librigena most closely resembles that assigned to *Parabolina brevispina* Westergaard (1922, pl. VI, figs 7, 11) and *Protopeltura intermedia* Westergaard (1922, pl. XIV, fig. 20).

In all the large collection of trilobites from the Black Mountain section, *?Protopeltura* sp. is the only one with Baltic affinity. Its horizon, K121, was collected as conodont trough sample 29 by Druce & Jones (1971), who isolated *Westergaardodina mosseburgensis,* which is also of Scandinavian occurrence. This conodont apparently has an age in Scandinavia no younger than Westergaard's (1947) Zone 5d (Zone Vc, *Peltura scarabaeoides* of Henningsmoen, 1957).

Description: The cranidium represents an olenid with small forward-placed eyes, close to the glabella, lying opposite its anterolateral corners. The posterolateral limbs are highly convex (tr.), the preocular facial suture sinuously curved, and the posterior margin likewise sinuous, with distinct anterior deflection near its intersection with the facial suture. Anteriorly the preocular facial sutures diverge strongly, but for a very short distance only, intersecting the cranidial border at acute angles. The latter is narrow laterally, thickening substantially sagittally, and is gently angled anteriorly. The preglabellar field is narrow (sag.) but appreciably convex (sag.) in profile (Pl. 46, fig. 8). The glabella is subparallel-sided with slight anterior taper, and is anteriorly acutely rounded. Two pairs of faint furrows, the preoccipital and median lateral, extend adaxially and posteriorly inwards from the axial furrows. The occipital ring is largely eroded away and the presence or absence of a nuchal node cannot be confirmed. The surface of the cranidium appears to be overall finely granulose.

The associated librigena is transversely narrow, with narrow (tr.) posterior and lateral borders whose differentiating furrows are confluent at the genal angle. If a genal spine is developed at all it is extremely small. A very clearly defined caecal network, reminiscent of that seen in conocoryphids, is preserved (Pl. 46, fig. 10).

Superfamily SOLENOPLEURACEA Angelin, 1854
Family DOKIMOCEPHALIDAE Kobayashi, 1935
Genus LORRETTINA Shergold, 1972

Type species: Lorrettina macrops Shergold, 1972, p. 68-69, pl. 17, figs 1-4, from the Gola Beds, Momedah Creek, Boulia district, western Queensland; by original designation.

Comment: Original material from the Gola Beds is supplemented by further specimens from Black Mountain. These include pygidia and librigenae, previously unknown.

LORRETTINA MACROPS Shergold, 1972
(Pl. 53, figs 1-8; Text-fig. 43)

1972 *Lorrettina macrops* Shergold, p. 68-69, pl. 17, figs 1-4.

Holotype: CPC 9771a, a cranidium with vestiges of shell, see Shergold (op. cit., pl. 17, fig. 1).

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K112, K114, K116, K117, and K118, at 120.5, 128.5, 138, 149, and 156 m from the base of the measured section, and at previously collected localities B507c and B509.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zones of *Pseudagnostus clarki prolatus* with *Caznaia sectatrix* and *P. bifax* with *P. denticulatus* at Black Mountain; pre-Payntonian A, *P. clarki maximus* with *P. papilio* Assemblage-Zone at Momedah Creek.

Material: The supplementary material includes 39 cranidia, 4 librigenae, and 12 pygidia. The illustrated paradigm comprises specimens CPC 11989-95.

Size: Cranidial lengths (sag.) range between 2.60 and 10.00 mm, and pygidia up to 4.20 mm.

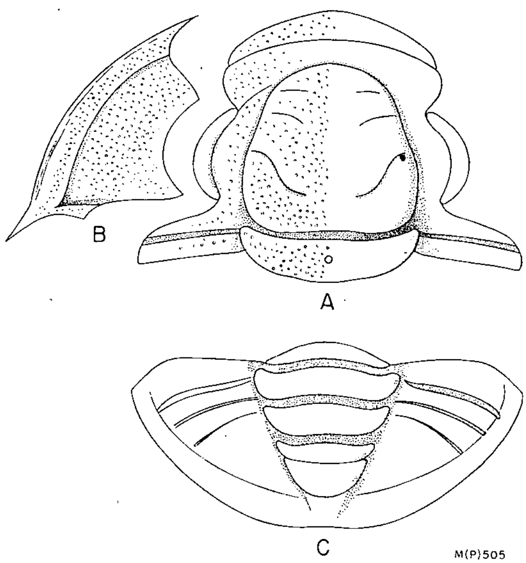

Fig. 43. External testaceous morphology of *Lorettina macrops* Shergold, 1972; (A) cranidium based on CPC 11991, x4.5; (B) librigena based on CPC 11990, x6.5; and (C) pygidium based on CPC 11989, x5.5 approx.

Diagnosis: The additional material allows a firmer diagnosis than was previously possible. *Lorrettina macrops* is a dokimocephalid species characterized by a combination of strongly convex (tr., sag.) cranidium with large palpebral lobes extending from the middle of the preoccipital lobes to the anterior lateral glabellar furrows, long (tr.) blade-like posterolateral limbs, a nuchal node, small laterally deflected genal spines, transversely subtriangular pygidium with slight post-axial notch in its posterior margin, and containing three axial rings and three faint pleural segments; overall the testaceous surface is finely granulose.

Description: The following notes amplify the previous (1972) description. Cranidial characteristics have been described previously, but the additional specimens allow further observation of details. Cranidial proportions, based on the 39 specimens, are: G:Lc 61-67%, Cn:Lc 76-84%, A:G 51-70%, and A:Gn 41-60%. During holaspid morphogenesis it is apparent that the length of the glabella increases in proportion to the length of the cranidium. The palpebral lobes, however, are constantly longer (exsag.) in early holaspides and become progressively shorter as the glabellar length increases. The structures of the preglabellar area and field are better shown on the supplementary material from Black Mountain (Pl. 53), and long (tr.) blade-like posterolateral limbs, bearing deep but narrow (exsag.) marginal furrows are preserved (Pl. 53, fig. 5).

The librigena has a trapezoidal outline, with short (tr.) posterior marginal furrow confluent at the spine base with well defined lateral marginal furrows. The posterior border is short (tr.), the spine base is narrow (tr.), and the genal spine is very short and small, deflected outwards from the rearwards continuation of the lateral margins. Anteriorly the librigena has a short prong. The greater part of its surface is granulose, and the lateral margins are also lirate.

The pygidium is also trapezoidal, with a distinct post-axial curve in the posterior margin: its L:W ratio on measured specimens is 50-60%. The axis is short, tapers rearwards, and is composed of two axial rings, with a third rather indistinct and merging with the terminal piece. Only the first pleural segment is defined by deep, wide pleural furrows, bisecting the segment equally. The borders are relatively broad, and the margins are entire.

As is evident from the illustrations, *Lorrettina macrops* is a thick-shelled trilobite.

Genus WUHUIA Kobayashi, 1933

Type species: Solenopleura belus Walcott, 1905, p. 90 *nom. nud.* = *Conocephalina belus* (Walcott); Walcott, 1913, p. 138, pl. 13, figs 12, 12a, from the lower part of the Chaumitien Limestone, 25 ft below the top of Pagoda Hill, 1 mile W of Tsinan, Shantung, China: designated by Kobayashi (1933a).

Other species: Ptychoparia dryope Walcott (1905, p. 78 *nom. nud.* = *Conocephalina dryope* (Walcott), Walcott, 1913, p. 138-9, pl. 13, figs 11, 11a, *non* fig. 11b; = *Wuhuia dryope* (Walcott), Kobayashi 1933a, p. 145), from the same locality as the type species, and of Fengshanian age. *Wuhuia belus* (Walcott) *sensu* Kobayashi (1933a, p. 145, pl. XV, fig. 1), from the Fengshanian *Tsinania canens* Zone of Hsishan, Wuhutsui Basin, Liaotung, southern Manchuria. Two species recorded under *Conocephalina* by Sun (1935), *C. belus* (Walcott) (op. cit., p. 39, pl. 3, fig. 28) from the *Kaolishania pustulosa* Zone of the Wolungshan Formation of Huolu, Hopei, and *C. waltheri* Sun (op. cit., p. 39-40, pl. 6, figs 22-23) from the Fengshanian of Tawenkou, Taian, Shantung, may also belong to *Wuhuia,* but cannot be adequately interpreted from the existing descriptions and illustrations.

Wuhuia sp. cf. *W. dryope* (Walcott) is recorded below from the Black Mountain section, western Queensland.

Distribution: China (Shantung, ?Hopei), southern Manchuria, and Australia (western Queensland).

Age: Fengshanian in Asia, pre-Payntonian in Australia.

Comments: Walcott's (1913, p. 138) description of *Wuhuia belus* serves as a diagnosis for the genus, amplified by the comments of Kobayashi (1933a, p. 145). The genus has been classified by Lochman-Balk (*in* Moore, 1959) within the family Ptychaspididae, but the ptychaspidid appearance of the anterior part of the cranidium results from the type specimen's having lost its anterior cranidial border. Examination of the closely related *W. dryope* (Walcott) (USNM 57979) shows that this border may have been at least as long (sag.) as the preglabellar field. Kobayashi (loc. cit.) mentions the possession of only two pairs of lateral glabellar furrows, but in fact the anterior lateral ones are present, although very faint, on the glabellae of both *W. belus* and *W. dryope*. Both species have furrowing entirely compatible with that seen in Dokimocephalidae as a group, and in conjunction with the long palpebral lobes placed close to the glabella, long bladed posterolateral limbs, and the short deflected genal prong seen on the librigena of *W. dryope,* there can be little doubt that they are more closely related to Dokimocephalidae than Ptychaspididae as these families are presently constituted. The closest late Cambrian genus on morphological grounds is *Lorrettina,* described above. *Wuhuia* differs in having straight axial furrows not laterally swollen, more triangular posterolateral limbs, and more semicircular pygidium with one additional segment in both axial and pleural zones.

WUHUIA sp. cf. WUHUIA DRYOPE (Walcott, 1905)
(Pl. 52, figs 8-9)

Occurrence: 'Chatsworth Limestone', Black Mountain, horizon K103, 1.6 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zone of *Pseudagnostus clarki patulus* with *Caznaia squamosa.*

Comments: The single cranidial fragment, CPC 12856, with length (sag.) of 10.80 mm, is closest to Walcott's species *Conocephalina dryope*. The shape and furrowing of the glabella are similar, and the proportionate lengths (sag.) and convexities (sag.) of the preglabellar field and anterior cranidial border are quite comparable; nor can the two species be separated on size and positioning of the palpebral lobes.

The type cranidium of *Wuhuia dryope* is exfoliated and smooth, whereas that of *Wuhuia* sp. is only partly exfoliated and bears fine granules. *Wuhuia belus* (Walcott) has a coarse granulation.

Nordia lepida Rozova (1968, p. 108-9, pl. VII, figs 1-4), from the Yurak horizon of the Kulyumbze River area of the NW Siberian Platform, is another species whose cranidial morphology is similar to that of *Wuhuia* sp.

Wuhuia sp. is the oldest representative of the genus yet recorded. All other described species are of Fengshanian age in Asia (equivalent to Payntonian in Australia). The species occurs almost 275 m below the base of the Payntonian in the late Cambrian succession of Black Mountain.

Family KINGSTONIIDAE Kobayashi, 1933
Genus WANWANASPIS Kobayashi, 1966

Type species: Kingstonia semicircularis Kobayashi, 1933b, p. 278, pl. VI, figs 7-8, from the Wanwankou Dolomite, Wanwankou, Nuhsintai Basin, Manchuria: designated by Kobayashi (1966b).

Other species: According to Kobayashi (1966b, p. 264), two other species should be included in the genus. They are: *Kingstonia humilis* Kobayashi (1933b, p. 279, pl. VI, fig. 1), which occurs in the same beds as the type species; and *Kingstonia convexa* Kobayashi (1933b, p. 278, pl. VI, figs 9-10) again from the same beds.

Comments: Kobayashi (1962, p. 68-70) has summarized available knowledge of Asian Kingstoniidae. He erected the genera *Wanwanaspis* and *Wanwanoglobus* (Kobayashi, 1966b, p. 264-5) to cover the late Cambrian Kingstoniidae previously referred to *Kingstonia*. These genera differ only in degree of convexity (sag., tr.). As far as can be ascertained, Australian material may be largely contained within *Wanwanaspis*.

WANWANASPIS cf. SEMICIRCULARIS (Kobayashi, 1933)
(Pl. 52, figs 1-4)

cf. 1933 *Kingstonia semicircularis* Kobayashi, 1933b, p. 278, pl. VI, figs 7-8.

Holotype: Kobayashi (op. cit.), pl. VI, fig. 7, a cranidium, Geological Institute, University of Tokyo.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizon K137, at 366 m from the base of the measured section, and at horizon B510b of previous collectors; Mount Ninmaroo, horizon K168, at 67 m from the base of the measured section; and Mount Datson, horizon K178, at 166 m from the base of the measured section.

Age: Late Upper Cambrian, Payntonian, Assemblage-Zones of *Pseudagnostus quasibilobus* with *Tsinania nomas,* and *Mictosaukia perplexa.*

Material: Fragments of two cranidia, one librigena, and five pygidia. Illustrated material comprises specimens CPC 11982-5.

Size: The single measurable cranidium has an estimated length (sag.) of 4.10 mm; the pygidia range in length (Lp_1) between 1.60 and 4.40 mm.

Comment: Not all Kobayashi's species of *Wanwanaspis* can be compared, owing to inadequacy of his descriptions and illustrations. The Australian species here described appears to be most closely related to *W. semicircularis,* but the material is insufficiently well preserved to confirm the determination.

Description: The following descriptive notes are intended to amplify the observations of Kobayashi on *Wanwanaspis semicircularis,* which are equally applicable to the Australian species.

When shell is preserved both cranidium and pygidium are almost featureless, the former showing only faint occipital and anterior marginal furrows. Overall, the cranidium is strongly convex (tr. sag.), is gently rounded anteriorly, and has short posterolateral limbs. A vague glabellar outline is seen on exfoliated material: it is widest (tr.) at the base, tapers forwards, and is probably acutely rounded anteriorly. No details of furrowing have been observed; nor is anything known of the palpebral lobes.

The associated librigenal fragment (Pl. 52, fig. 1) has long spines, distally curving outwards.

The smallest pygidia, lengths (sag.) 1.60-2.50 mm, are posteriorly slightly pointed, but larger ones are rounded. The length to width ratio ranges between 66 and 69%. When shell is preserved the axis and borders are effaced (Pl. 52, fig. 3), but removal of the shell reveals up to six axial rings (Pl. 52, fig. 4). Borders are weakly differentiated even on parietal surfaces, as are the pleural segments, with the exception of the first, which bears strong pleural furrows. Characteristic of the pygidia available are the steeply inclined articulating facets and the presence of strong fulcral points. Similarly, the articulating half-ring has a strongly curved anterior margin projecting well beyond the anterior margin of the pleurae.

WANWANASPIS PYGIDION sp. nov.
(Pl. 52, figs 6-7)

Name: Gk, *pygidion,* dim., little tail, noun in apposition.

Holotype: CPC 11987, the pygidium illustrated in Pl. 52, fig. 6.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K138 and K139, at 374 and 375 m from the base of the measured section, and at B510b of previous collectors; Mount Ninmaroo, horizons K163 and K165, at 20 and 50 m from the base of the measured section.

Age: Late Upper Cambrian, early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas.*

Material: Fragments of eight pygidia of which CPC 11987-8 are figured.

Size: The available pygidia range in length (sag.) between 2.60 and 5.00 mm (Lp_1).

Diagnosis: A species of *Wanwanaspis* with elongated (sag.) pygidium, slightly pointed posteriorly when preserved with shell, and with axial furrows effaced posteriorly.

Differential diagnosis: Wanwanaspis pygidion has a proportionately longer pygidium than that of *W.* cf. *semicircularis* (Kobayashi): L:W is 71-85%, compared with 66-69%. As in the type species, the posterior margin of the shield is pointed when shell is preserved but rounded when exfoliated. In *W.* cf. *semicircularis* the axial furrows are completely effaced externally and only weakly discernible on parietal surfaces. In *W. pygidion* these furrows are visible on the shell, at least anteriorly, and are readily observed on exfoliated specimens. *W. pygidion* has seven axial rings and six pleural segments; *W.* cf. *semicircularis* has six axial rings and an indeterminate number of pleurae.

Description: The pygidia are subtriangular, posteriorly pointed when shell is preserved, rounded when exfoliated; L:W is 71-85%. On the testaceous surface axial furrows define a gently convex axis anteriorly. The posterior end of the structure is effaced, as are the marginal furrows. Exfoliated material (Pl. 52, fig. 7) shows the presence of seven axial rings and six pleural segments. *W. pygidion* has an articulating half-ring with strongly curved anterior margin, and very strongly inclined articulating facets on the first pleural segment. Fulcral points are well developed, lying approximately half-way between the axial furrows and the anterolateral margins of the shield. The margins are entire.

?WANWANASPIS sp. undet.
(Pl. 52, Fig. 5)

Occurrence: 'Chatsworth Limestone', Black Mountain, horizon K131, at 309 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian A, Assemblage-Zone of *Pseudagnostus clarki maximus* with *P. papilio.*

Material: A single exfoliated pygidium, CPC 11986.
Size: Length (Lp_1) (sag.) 3.30 mm, width (tr.) 6.30 mm.

Comments: A single pygidium from K131 is referred questionably to *Wanwanaspis* on the following characteristics: effaced shell, and almost effaced parietal surface; semicircular outline; absence of marginal furrows or borders; strongly inclined articulating facets and fulcral points. *?Wanwanaspis* sp. undet. has only four axial rings, and is more transverse than other species described here; L:W is 52%.

Superfamily DIKELOCEPHALACEA Miller, 1889
Family SAUKIIDAE Ulrich & Resser, 1930

The following saukiid genera are described from the Burke River Structural Belt: *Prosaukia* Ulrich & Resser, 1933, *Anderssonella* Kobayashi, 1936, *Sinosaukia* Sun, 1935, *?Calvinella* Walcott, 1914, *Lophosaukia* Shergold, 1972, and the new genera *Caznaia, Galerosaukia,* and *Mictosaukia.*

Although highly fragmented, much of the saukiid material is very well preserved, allowing observations of both external testaceous and parietal surfaces, which are often strikingly different in appearance. When highly granulose surfaces are exfoliated the end result is usually a smooth or punctate limestone mould providing considerable contrast to the original testaceous surface. Granules are often observed to be perforated, and many of the resulting punctae of exfoliated surfaces are seen to lie in the interspaces of the caecal network.

A prominent manifestation of this caecal network in Saukiidae is seen in the new genus *Galerosaukia.* The type species, *G. galerita,* has a non-granulose test and shows features which are merely hinted at in other genera but concealed by granulation. The librigena of *G. galerita* shows a prominent raised 'genal diverticulum' following the abaxial margin of the subocular groove. On approaching the posterior border it veers abruptly outwards and intersects the genal angle as a prominent ridge which separates the lateral and posterior marginal furrows. Anteriorly, it runs round the front of the palpebral lobe, at some distance from it, and merges with the rear of the preglabellar ridge (raised preglabellar field) of the cranidium. A similar situation is seen in the species of *Anderssonella* described here, but in these a reticulate caecal network on the librigena, and the granulosity of the preglabellar field and preocular areas, to some extent obscure the diverticulum.

This genal diverticulum must be regarded as a major caecal diverticulum. The term 'ocular diverticulum' does not describe it adequately as it has been used previously (Shergold, 1973) to describe a part of the caecal network in the Middle Cambrian *Meneviella viatrix,* in which the diverticulum is associated with the ocular ridges. In the saukiids under study the diverticulum is not associated with ocular ridges or palpebral lobes, and although the latter terminate against it anteriorly, they appear not to merge with it.

In other trilobites, e.g. Kainellidae, a parafrontal band merges laterally at the axial furrows with anterolateral continuations of the palpebral lobes (see *Mendosina laciniosa* (Shergold, 1972)), and it seems that band and lobes also reflect a major caecal diverticulum. In the Saukiidae described below, the preglabellar ridge lies in a similar position to the parafrontal band of the Kainellidae, and also carries this diverticulum. That the genal diverticulum is connected to the preglabellar ridge is readily observable, as is the connexion of the lobes to the band in other trilobites. The taxonomic significance of these differences is probably great, but with the present scant knowledge of caecal systems in trilobites cannot yet be fully utilized. Of other trilobites related to Saukiidae, the ptychaspidid *Quadraticephalus calchas* (Walcott) (*sensu* Kobayashi, 1933a, p. 122-3, pl. XII, fig. 9) shows a duplicated genal diverticulum running down the mid-length of the librigena, and a similar duplication is seen in *Galerosaukia* sp. (Pl. 21, figs 8-9) among the specimens figured here.

Genus PROSAUKIA Ulrich & Resser, 1933

Type species: Dikelocephalus misa (Hall) restricted, designated Ulrich & Resser (1933, p. 141-4, pl. 24, figs 1-9), from the Franconia Formation, Wisconsin, USA. Raasch (1952, p. 142-3) has placed *Prosaukia resupinata* Ulrich & Resser and *P. concava* Ulrich & Resser in synonymy with *P. misa* (Hall). The type species occurs in association with *Ptychaspis miniscaensis* (Owen) and *Chariocephalus whitfieldi* Hall in the late Franconian of the Upper Mississippi Valley (Bell et al., 1952, p. 177; Grant, 1962, p. 974; and others).

Other species: Species referred to *Prosaukia* are too numerous to list here. A good deal of variation exists among them and it is doubtful if all, and especially many of the Asian species, are congeneric. Ulrich & Resser (1933) subdivided the genus into four species groups based on *P. misa, P. longicornis, P. tuberculata,* and *P. berlinensis.* These groups were differentiated mainly on the presence or absence of a nuchal spine, and degree of smoothness of the test, even though all specimens studied by Ulrich & Resser were sandstone moulds. Twenty-eight specific and varietal taxa were recognized, including the type species. Raasch (1952) has subsequently reduced this number to twelve species and subspecies, including the type.

Prosaukia misa (Hall, 1863) is characterized by a narrow convex (sag.) preglabellar field, shallow but transversely continuous anterior cranidial marginal furrow, and anteriorly angled anterior cranidial margin. The preglabellar area is transversely relatively wide (tr.). The glabella is broad-based, tapering forwards. A nuchal node is not reported, although Bell et al. (1952, p. 192) believe that it may exist. The librigena has a long, non-advanced, distally incurving genal spine. The lateral marginal furrow does not contact the posterior one at the genal angle, and the latter passes for some distance into the spine base, running parallel to the adaxial margin of the spine. The pygidium assigned to *Prosaukia misa* is transverse, has swept-back pleurae (5 or 6) which continue across the wide borders to the margin, and has an interrupted posterior margin. The axis has 3 (4) segments, and is continued by a pronounced post-axial ridge to the posterior margin of the shield.

Described below are *Prosaukia* sp. A, whose cranidium, as preserved, conforms with the morphology of that of the type species, and *Prosaukia* sp. indet., based on a cranidial fragment also similar to *P. misa.* Three further species are tentatively referred to *Prosaukia,* although within the Ulrich & Resser (1933) concept of the genus they would fall quite clearly into one or other of their species groups. *?Prosaukia nema* sp. nov. appears to be one of the group of species, lacking a preglabellar field, referred by Ulrich & Resser to their group of *P. misa,* but which may be linked to the genus *Saukiella* through species such as *S. fallax* (Walcott). *?Prosaukia absona* conforms even less closely to the concept of *P. misa* as it lacks a preglabellar field, possesses a dense granulosity and librigena with advanced spine, all characteristics which might ally it perhaps to *Saukia.* However, the glabellar shape and structure of the pygidium differ from that genus. The species *absona* is thus temporarily assigned to *Prosaukia. ?Prosaukia cornigra* has a sagittally interrupted anterior cranidial marginal furrow, effaced glabellar furrows, and very strongly developed nuchal spine. The lateral and posterior marginal furrows of its librigena meet at the genal angle and continue together into the genal spine-base. The species could be classified within the *longicornis* group of Ulrich & Resser, but is more probably descended from the new genus *Caznaia* described below, and on a different evolutionary lineage from that of *Prosaukia* s.s.

Distribution: Widespread in North America; north China (Shantung); southern Manchuria; South Korea; Vietnam (Tonkin); and Australia (western Queensland).

PROSAUKIA sp. A
(Pl. 15, figs 5-6; Text-fig. 44)

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K107, K108, K109, K111, and K112, at 68, 73, 80, 112, and 120 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zones of *Pseudagnostus clarki patulus* with *Caznaia squamosa* and *P. clarki prolatus* with *C. sectatrix.*

Material: Four fragmentary cranidia preserved as limestone moulds, of which CPC 11742 is illustrated (Pl. 15).

Differential diagnosis: No definite comparison can be made with other species of *Prosaukia,* as none of the specimens of sp. A yet recovered preserve the anterior cranidial border. However, the general shape of the glabella, the arrangement of the preglabellar field (as preserved), and the deduced courses of the facial sutures are entirely compatible with the type species, *Prosaukia misa* (Hall), as figured by Ulrich & Resser (1933, pl. 24, figs 1-9) and Bell, Feniak, & Kurtz (1952, pl. 38, figs 1a-d.) The Australian species is granulose, however, whereas *P. misa* is apparently smooth. By virtue of this granulose prosopon Ulrich & Resser would no doubt have classified sp. A with their tuberculate and non-spinose species group of *Prosaukia,* that of *P. tuberculata* Ulrich & Resser (1933, pl. 28, fig. 5) (see also Bell & Ellinwood, 1962, pl. 59, figs 2-3), but the other characteristics mentioned above suggest closer affinity with the *P. misa* group. As far as can be assessed *Prosaukia baubo* (Walcott) (1913, pl. 17, fig. 2) may be the most closely comparable Asian species of the genus.

Description: All specimens lack the anterior cranidial border, and the illustrated specimen (CPC 11742) also wants the greater part of its glabella. Sufficient fragments are available, however, to state that the glabella is relatively long (sag.) and narrow (tr.), tapers very slightly forwards, and has an obtusely rounded contour to the frontal lobe, although somewhat flattened out sagittally. Three pairs of glabellar furrows are well defined. The preoccipital furrows are deep abaxially, but become shallow mesially and confluent sagittally. The median lateral furrows are shorter and less wide (exsag.), running parallel to the preoccipital furrows, slightly backwards. The anterior lateral furrows are short, curved, and narrowly incised. They run over the convexity (tr.) of the anterior lateral margins of the frontal part of the glabella, arching gently to isolate a short (sag. and exsag.) frontal lobe. The axial furrows are shallow posteriorly, deepening anteriorly, and constricted slightly at the levels of the median and anterior lobes and the median and anterior lateral furrows. The preglabellar furrow is shallow and gently concave. In front of the preglabellar furrow a narrow (sag.) preglabellar field is gently convex (sag.), sloping to the anterior marginal furrow. The nature of the anterior cranidial border is not known.

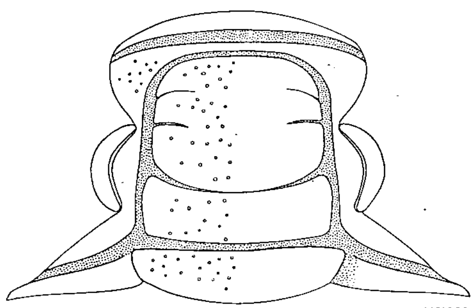

Fig. 44 ***Prosaukia*** **sp. A, diagrammatical reconstruction of cranidium based on CPC 11742, x4.5.**

The palpebral lobes extend from the anterior part of the preoccipital glabellar lobes as far as the median lateral furrows. They are gently arcuate, lie close to the glabella, and are separated from the axial furrows by narrow, steeply inclined palpebral areas. The anterior branch of the facial suture runs from the front of the palpebral lobes outwards at an angle of about 30°. The posterior branch runs to the posterior cranidial margin, enclosing short triangular posterolateral limbs.

The surface of the cranidium is granulose.

PROSAUKIA sp. indet.
(unfigured)

Occurrence: 'Chatsworth Limestone', Black Mountain, horizon K128, 240 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian A, Assemblage-Zone of *Pseudagnostus clarki maximus* with *P. papilio.*

Material: A single external mould of a cranidial fragment, CPC 11748 (not illustrated).

Comments: The available fragment shows sufficient of the preglabellar area to suggest identification with *Prosaukia.* It has a narrow (sag.), concave (sag.) preglabellar field, anteriorly flanked by a cranidial marginal furrow, as in *Prosaukia* sp. A, but the anterior cranidial border is not preserved.

?PROSAUKIA NEMA sp. nov.
(Pl. 15, fig. 7)

Name: Gk., *nema,* thread, noun in opposition, referring to the thread or wire-like anterior cranidial border.

Holotype: CPC 11737, an incomplete cranidium, preserved as a limestone mould in medium grey, fine to medium grained calcarenite.

Occurrence: 'Chatsworth Limestone', Dribbling Bore, horizon K186, 29 m from the base of the measured section.

Age: Late Upper Cambrian, early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas.*

Material: A single readily determinable but incomplete cranidium, and a second cranidial fragment. Both specimens occur in the same layer.

Size: The specimen has a sagittal length of approximately 7.75 mm.

Diagnosis: A species questionably assigned to *Prosaukia* with a narrow (sag.) raised and wirelike arcuate anterior cranidial border; confluent preglabellar and cranidial marginal furrows excluding the preglabellar field; deeply incised and transversely connected preoccipital glabellar furrows; granulose surface.

Differential diagnosis: ?Prosaukia nema sp. nov. resembles certain species separated by Ulrich & Resser (1933, p. 139) as the 'group of *Prosaukia misa*'. In particular, the diagnostic characteristics of *?P. nema* are shared, to differing degree, by species described from the Upper Mississippi Valley as *P. demissa* (Ulrich & Resser, 1933, p. 147-8, pl. 25, figs 17-18), *P. subrecta* (op. cit., p. 148-9, pl. 26, figs 1-3), and *P. curvicostata* (op. cit., p. 145-7, pl. 25, figs 1-7), all of which Raasch (1952) would synonymize with *P. curvicostata. ?P. nema* is distinguished from *P. curvicostata* by its granulose surface and its more anteriorly situated palpebral lobes. In its granulosity it is similar to the 'group of *Prosaukia tuberculata*' whose nominal species is the most similar in appearance. Species of the *tuberculata* group, however, have a narrow (sag.), convex (sag.) preglabellar field, whereas in the cited species of Ulrich & Resser's *misa* group the preglabellar furrow and anterior marginal furrow are united to form a concave depression of varying depth.

Saukiella(?) paiensis Resser & Endo (*in* Endo, 1931, p. 89, fig. 17; *in* Endo & Resser, 1937, p. 286-7, pl. 55, fig. 17), specimen USNM 86916, from the Yenchou Formation of Chinchiachengtzu, southern Manchuria, and *?Prosaukia nema* are morphologically closely related. Both specimens have the same wirelike anterior cranidial border, similarly shaped glabellae with only two pairs of furrows well-defined, and similarly granulose tests. *S(?) paiensis,* however, appears to have a considerably wider (tr.) preglabellar area, and its frontal lobe has a truncate rather than rounded outline. The specimen which Kobayashi (1933a, pl. 12, figs 14-15) assigned to *Saukiella paiensis* is very small, and possesses a very narrow (sag.) convex preglabellar field, not seen on the Manchurian specimen. Other species assigned to *Saukiella* are also similar to both *?P. nema* and *S. paiensis,* e.g. *S. fallax* (Walcott) (see Longacre, 1970, p. 49-50, pl. 5, figs 1-3). This species differs from those quoted above in the shape of its glabella, which appears comparable with the type species of *Saukiella.*

General description: The glabella is subrectangular, strongly convex (tr. and sag.), subparallel-sided, marginally widest (tr.) at the preoccipital lobes, and tapering thence very gently forwards. It is evenly and obtusely rounded anteriorly. The preoccipital furrows are well incised, abaxially slightly inclined inwards and rearwards, confluent and deepest sagittally, the whole arrangement having a gentle posterior arcuate curve. The median lateral furrows are straight, inclined slightly inwards and backwards. They are more faintly impressed than the previous furrows, and are not confluent sagittally. Anterior glabellar furrows are most faintly defined. Neither the preoccipital nor the median lateral furrows are connected with the axial furrows.

The occipital ring is about two-thirds as wide (sag.) as the preoccipital lobes, with an arcuate bar-like appearance. Transversely, it is wider than the preoccipital lobes and any other part of the glabella, and is separated from the glabella by a continuously transverse deep occipital furrow, arching very gently rearwards.

The palpebral lobes are narrow (tr.) and slightly raised above the palpebral areas, and extend from the rear of the frontal lobe backwards to the anterior part of the preoccipital lobes. Anteriorly they continue as faint ocular ridges across the preocular fixigenal areas. The palpebral areas are narrow (tr.), and steeply inclined to the axial furrows.

The preocular sections of the facial suture diverge only slightly forwards. The orientation of the posterior sections is not known. The preocular areas are triangular and convex (exsag.). The preglabellar furrow is merged with the anterior marginal furrow to form a distinct concave (sag.) groove which separates the glabella from the anterior cranidial border. The last is arcuate forwards, narrow (sag.), convex (sag.), and forms a wire-like raised rim.

The surface of the glabella, and that of the occipital ring, are faintly granulose, but the remainder of the cranidium appears smooth, at least as far as can be ascertained from the illustrated specimen.

?Prosaukia cornigra sp. nov.
(Pl. 16, figs 1-6; Text-fig. 45)

Name: L., *cornigra,* bearing horns, in this instance referring to the presence of the long addorsally curved nuchal spine, and strong outwardly deflected genal spines.

Holotype: CPC 11743, the large exfoliated cranidium illustrated in Plate 16, fig. 6.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K130 and K131, at 272 and 309 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian A, Assemblage-Zone of *Sinosaukia impages.*

Material: The species is known from the fragments of 12 cranidia, 9 librigenae, and 2 pygidia, specimens CPC 11743-7 forming the type series.

Size: Only the holotype is sufficiently complete to assess quantitatively. All fragments, however, are of large individuals, some larger than the holotype, which has a sagittal length of 26.60 mm.

Diagnosis: A species questionably assigned to *Prosaukia,* characterized by very long stout addorsally inclined nuchal, and stout laterally directed genal, spines; large eyes situated towards the rear of the cranidium, with narrow (tr.) palpebral areas; a sagittally interrupted anterior cranidial marginal furrow; and weak, nearly effaced, glabellar furrows.

Differential diagnosis: ?Prosaukia cornigra is most closely comparable with species described by Ulrich & Resser (1933, p. 139) as belonging to the 'group of *Prosaukia longicornis*'. The nature of the spines, and especially that of the occipital ring, are very similar in *cornigra* and *longicornis* (see Ulrich & Resser, op. cit., pl. 27, figs 12-21). The glabella of *?P. cornigra* differs from all other species assigned to *Prosaukia* — although it tapers irregularly forwards, it seems to be proportionately wider (tr.) than in previously described species, that of *Prosaukia ampla* Ulrich & Resser (op. cit., pl. 27, figs 22-25) being the most similar. A feature not normally associated with *Prosaukia,* but shown by *?P. cornigra,* is the degree of effacement of the glabellar furrows. On testaceous specimens they must have been almost entirely effaced. Moreover, effacement also affects the anterior cranidial marginal furrows, which in most *Prosaukia* species is deepened sagittally.

In many respects *?Prosaukia cornigra* is comparable to species of *Caznaia* gen. nov. Common characteristics are the nature of the preglabellar area and the glabellar shape. They differ in the size and position of the palpebral lobes, the larger posterolateral limbs of *Caznaia,* and the presence of the nuchal spine in the *?Prosaukia.* Morphologically, *?P. cornigra* is intermediate between *Caznaia* on the one hand and *Prosaukia* (of the *longicornis* group) on the other.

General description of exfoliated surfaces: The glabella (G) occupies 65% of the total cranidial length (sag.) on the holotype, tapers anteriorly, and is evenly and acutely rounded at the front. Its sides are slightly sinuous, being widest (tr.) at the preoccipital lobes and slightly constricted at the preoccipital furrows. The preoccipital lobes occupy approximately one-third of the total glabellar length (exsag.). The preoccipital furrows are shallow, abaxially curved to the rear, and faintly connected sagittally. The median lateral furrows are even fainter, slightly curved, and also directed rearwards, but they are not confluent sagittally. Anterior lateral furrows are not visible.

The occipital furrow is shallow and sinuous, with a marked sagittal anterior curvature, and abaxial posterior curvature. The occipital ring is a little wider (tr.) than the preoccipital lobes, and is characterized by the presence of a long, stout, addorsally directed nuchal spine (Pl. 16, figs 2, 4). This spine is apparently derived from the front part of the occipital ring (Pl. 16, fig. 6) and on some specimens faint furrows lie transversely on either side of the spine base, indicating that it is drawn from the whole width (tr.) of the occipital ring (Pl. 16, fig. 2). On other specimens a faint node lies sagittally immediately in front of the nuchal spine (Pl. 16, fig. 3).

The palpebral lobes are large (on the holotype A:G = 52%), crescentic, extending from the level of the occipital furrow to the median lateral glabellar furrows. They are close to the glabella and are connected to it by faint ocular ridges (Pl. 16, fig. 6). The palpebral furrows are deeply incised; the palpebral areas are narrow (tr.) and appreciably convex (tr.).

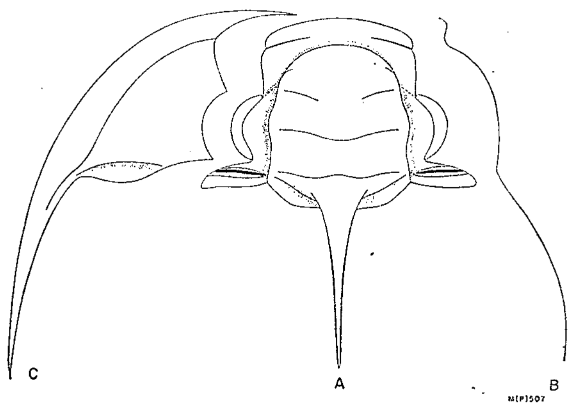

Fig. 45. Reconstruction of the cephalic components of ?*Prosaukia cornigra* sp. nov.; cranidium based on CPC 11743, x1; and librigena based on CPC 11744, x0.8.

The anterior sections of the facial suture are slightly curved abaxially, and run at near right angles to the anterior cranidial margin. They enclose a narrow (sag.) preglabellar area consisting of a gently convex (sag.) preglabellar field, a marginal furrow which is sagittally effaced, and a gently convex (sag.) border. The border and the preglabellar field are of equal length (sag.). The marginal furrow, in spite of its sagittal effacement, is well impressed abaxially. The posterior sections of the facial suture enclose narrow, blade-like posterolateral limbs, carrying wide (exsag.) marginal furrows.

The librigenae are characterized by genal spines deflected laterally as in *Galerosaukia*. They are further comparable with that genus in possessing posterior marginal furrows which pass into the bases of the genal spines. These furrows are not confluent with those of the lateral margins, but are separated from them by narrow raised ridges. The lateral borders are rather wide (tr.).

Fragments alone are available for study of the pygidium. These indicate a semicircular shape, evenly rounded posteriorly. At least three, possibly four, axial segments can be seen, and there appear to be four pleural segments. The latter are equally divided by wide (exsag.) and shallow pleural furrows, and separated by similarly wide and shallow interpleural furrows. The axis is bluntly terminated, and a post-axial ridge is not developed. The borders appear to carry the convexity of the pleural zone to the margins without the intervention of marginal furrows.

All parts of ?*Prosaukia cornigra* yet recovered are exfoliated. Mildly exfoliated surfaces are faintly granulose, but deeper stripping of the shelly laminae reveals punctations (Pl. 16, fig. 1). A portion of the caecal system of the pygidium is faintly visible on the illustrated specimen, CPC 11746 (Pl. 16, fig. 1).

?PROSAUKIA ABSONA sp. nov.
(Pl. 15, figs 1-4)

Name: L., *absona,* discordant, inharmonious, not conforming to type.

Holotype: CPC 11738, the partly exfoliated cranidium figured in Pl. 15, fig. 2.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K138 and K139, at 374 and 375 m from the base of the measured section; and also at B510 which is not on the measured section but which is faunally equivalent to K138.

Age: Late Upper Cambrian, early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas.*

Material: Fragments of two cranidia, a librigena, and a pygidium are assigned to this species. Specimens CPC 11738-41 are illustrated.

Size: The holotype cranidium has an estimated length (sag.) of 3.60 mm. Its glabella has a length of 2.40 mm. The pygidium is rather large, having a sagittal length (Lp_2) of 10.80, and an estimated width (tr.) of 14.00 mm.

Diagnosis: A species tentatively, and temporarily, referred to *Prosaukia,* characterized by a broad (tr.) anterior cranidial border lying close to the glabella, with preglabellar and anterior marginal furrows merged; small arcuate palpebral lobes sited close to the glabella anteriorly but removed appreciably from it posteriorly, and extending backwards close to the posterior marginal furrow. The librigena has an advanced genal spine, and the pygidium is ovoid in shape with wide borders, pleurae strongly directed rearwards, and slightly crenulate margins. Cranidium, librigena, and pygidium are all densely granulose.

Differential diagnosis: In the shape of its glabella, and the width (tr.) and positioning of its anterior cranidial border, *?Prosaukia absona* resembles the North American species *Prosaukia dilata* Ulrich & Resser (1933, p. 163-4, pl. 31, figs 28-30) and *P. subaequalis* Ulrich & Resser (1933, p. 151-2, pl. 26, figs 9-10). Of the Asian species referred to *Prosaukia,* it resembles, by the same characteristics, *P. rotundolimbata* Endo (*in* Endo & Resser, 1937, p. 361-2, pl. 72, fig. 17). The strongly granulose shields of *?P. absona* differentiate the species from *P. subaequalis,* and it is distinguished from *P. dilata* by the shape of its pygidium. *P. rotundolimbata* differs on several counts, including the shape of the glabella and cranidial border, and the degree of segmentation of its pygidium.

?Prosaukia absona diverges substantially from the concept of the type species of *Prosaukia, P. misa,* but is classified within the genus by comparison with the species listed above. The main difference lies in the arrangement of the morphological components constituting the preglabellar area. In *misa* and its allies a distinctive convex (sag.) preglabellar field separates the preglabellar and anterior marginal furrows, but in the species mentioned above the preglabellar field is excluded by the merging of these furrows. A similar situation exists with *?Prosaukia nema* sp. nov. (*supra*), and possibly all mentioned species should be separated into a further species group of *Prosaukia.*

Description: The glabella is squat, tapering forwards, and anteriorly has a flattened outline. The preoccipital and median lateral lobes have approximately equal size (exsag.), but the anterolateral lobes are a little narrower (exsag.). The preoccipital glabellar furrows are short, deep, and narrow (exsag.) linear incisions directed slightly to the posterior. The median lateral furrows are similarly incised, linear, but more nearly transverse. The anterolateral furrows are faint, arched forwards, and about the same length (tr.) as the median lateral ones. Only the preoccipital furrows are connected with the axial furrows. The occipital ring, which is poorly preserved on the available material, has approximately the same dimensions as the preoccipital glabellar lobes.

The palpebral lobes are elevated, convex, and narrow (tr.), and bear a narrow flange on their outer edges. They extend from the rear of the preoccipital glabellar lobes forwards to the level of the median lateral glabellar furrows, and are close to the glabella anteriorly, but conspicuously removed from it posteriorly. The palpebral areas are thus considerably wider (tr.) posteriorly (Pl. 15, fig. 1). Their convexity is slightly variable, becoming concave in the areas immediately adjacent to the preoccipital glabellar lobes.

The anterior sections of the facial suture diverge from the front of the eye and intersect nearly at right angles with the anterior cranidial margins. The preocular areas are slightly convex (exsag.). The anterior cranidial margin is slightly curved forwards, moderately wide (sag.), close to the front of the glabella, but lying below its upper surface in lateral profile. The preglabellar furrow and anterior marginal furrow are merged sagittally, the furrow so formed being immediately in front of the frontal glabellar lobe. The posterolateral limbs appear to be short and blunt.

The librigena assigned to this species has an advanced genal spine, which is unusual in *Prosaukia,* and may not belong to the species. It has a relatively narrow border (tr.), shallow marginal furrows, and a distinct ocular groove. It possesses the same degree of granulation as the holotype of *?P. absona.*

The pygidium is typically prosaukioid, with a suboval outline, entire but slightly crenulated posterolateral margins, and broad borders. The pleurae sweep backwards strongly from the axial furrows, eventually to lie almost parallel to the sagittal axis of the shield. There is evidence of four pleural segments, unequally bisected by pleural furrows which are shallow distally but much deeper and narrower proximally. The interpleural furrows, with the exception of the first, are poorly defined. The axis is short and conical, with four, perhaps five, segments, the last fused to a terminal piece. A post-axial ridge is discernible crossing the broad, slightly upturned posterior border.

The surfaces of the glabella, palpebral and preocular areas, the librigena, with the exception of its borders, and the pygidium are quite densely granulose. The anterior cranidial border is not granulose but striated, as is the librigenal border and genal spine. The pygidium shows a pattern of raised terraced lirations concentric with the posterior pygidial periphery. A portion of the caecal network of the palpebral area is well illustrated in Plate 15, fig. 1, specimen CPC 11739.

Genus ANDERSSONELLA Kobayashi, 1936 (*pro Anderssonia* Sun, 1924)

Type species: Ptychaspis (*Anderssonia*) *fengtienensis* Sun, 1924, p. 78-9, pl. V, figs 7a-c, from the Shakuotun Limestone of Fengtien, northern China. Sun based the subgeneric concept of *Anderssonia* on this species (op. cit., p. 78), thus indicating a designation.

Other species: Besides the type species Sun also described *Ptychaspis (Anderssonia) tani* (1924, p. 79-80, pl. V, fig. 6), from the Chaumitien Limestone of Shantung, China. *Anderssonella beauchampi* sp. nov. and *A. eweyi* sp. nov. are described below from sections at Black Mountain and Mount Ninmaroo.

Comments: Sun (1924, p. 77-8) regarded *Anderssonia* as a subgenus of *Ptychaspis,* from which it was distinguished by 'its slight, convex frontal limb, large and elongate palpebral lobes, narrow fixed cheeks and the narrow elevated frontal limb'. *Anderssonia* having been found preoccupied, Kobayashi (1936, p. 922) proposed the new name *Anderssonella.* At the present time *Anderssonella* is regarded as a genus distinct from *Ptychaspis,* but is retained in Ptychaspididae Raymond, 1924 (Lochman-Balk *in* Moore, 1959, p. 0320). It would appear, however, that *Anderssonella* more closely resembles *Prosaukia* than *Ptychaspis* and should be classified with the Saukiidae. In fact, the cranidium differs from that of *Prosaukia* only in its more anteriorly tapered glabella, and in the courses of the anterior sections of the facial suture. Whereas in *Prosaukia* these diverge anteriorly from the front of the palpebral lobe and make an acute angle on intersection with the anterior cranidial border, those of *Anderssonella* diverge forwards and then curve inwards (adaxially) on an arcuate course to intersect the cranidial border at a rounded or obtuse angle.

The pygidium assigned by Sun (1924, pl. V, fig. 7c) to *Anderssonia fengtienensis* = *Anderssonella* is quite different from those associated with *Anderssonella*-like cranidia in Queensland. The Chinese pygidium is reminiscent of that of some North American species attributed to *Tellerina.* Australian pygidia, on the other hand, are almost identical with those of North American species of *Prosaukia.*

Age and Distribution: Anderssonella has a Fengshanian age in China and a Payntonian age in Australia.

ANDERSSONELLA BEAUCHAMPI sp. nov.

(Pl. 20, figs 1-5; Pl. 21, figs 1-2; Text-fig. 46)

Name: After Mr E. L. Beauchamp, owner of Warenda Station in the Black Mountain area.

Holotype: CPC 11749, the largest of the incomplete cranidia available (Pl. 20, fig. 1).

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K136, K137, K138, and K139, i.e. between 348 and 376 m from the base of the measured section.

Age: Late Upper Cambrian, early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas.*

Material: The species is known from 15 cranidial fragments, 4 librigenal fragments, and 4 pygidia. Specimens CPC 11749-52, 11754-5b are illustrated.

Size: The smallest cranidium has a length (sag.) of 2.20 mm, and the largest an estimated length of 10.00 mm. Various specimens, too incomplete to measure, fall within this range. The pygidia are very small and too fragmentary for accurate measurement.

Diagnosis: A species of *Anderssonella* with strongly granulose glabella and genae, and irregular lines made up of linked granules on the anterior cranidial border. The preglabellar field is narrow (sag.), markedly convex (sag.), and separated from the glabella by a very narrow (sag.) preglabellar furrow. The ridge-like preglabellar field passes laterally into low, poorly defined, ocular ridges. The librigena is characterized by a marked subocular groove flanked laterally by a prominent raised diverticulum running concentric to it. A prominent caecal network is associated with this diverticulum. The pygidium is similar in shape to that of *Prosaukia,* with markedly broad and concave posterolateral borders, four (or faintly five) pleurae sharply deflected rearwards at the geniculation, and four axial rings.

Differential diagnosis: Anderssonella beauchampi has comparable glabellar features to those of the type species, *A. fengtienensis* (Sun), long and prominent palpebral lobes. The Australian species is readily distinguished by its surface granulosity—*A. fengtienensis* is smooth, and *A. tani* (Sun) is punctate. As indicated above *A. fengtienensis* has a dissimilar pygidium which possibly belongs to a *Tellerina* species. The prominent preglabellar field seen in *A. beauchampi* is present to some extent in certain species of *Prosaukia,* e.g. *P. beani* Ulrich & Resser (1933, p. 165-6, pl. 28, fig. 21), which has a markedly convex structure. In *P. beani,* however, the anterior marginal furrow of the cranidium is not evenly deepened sagittally, as it is in *A. beauchampi,* and the diagnostic courses of the anterior facial sutures are differently oriented.

Description: The anterior cranidial margin is transverse, very nearly straight, the glabella is barrel-shaped, widest (tr.) at the preoccipital furrows, tapering gently forwards, anteriorly obtusely and evenly rounded. The preoccipital furrows are deep and slightly sigmoidal abaxially, become shallow mesially, and are transversely connected across the sagittal line. The median lateral furrows are similarly oriented, but are less deeply incised and have only a slight tendency to unite sagittally. The anterior lateral furrows are short, faint, transverse, and unconnected

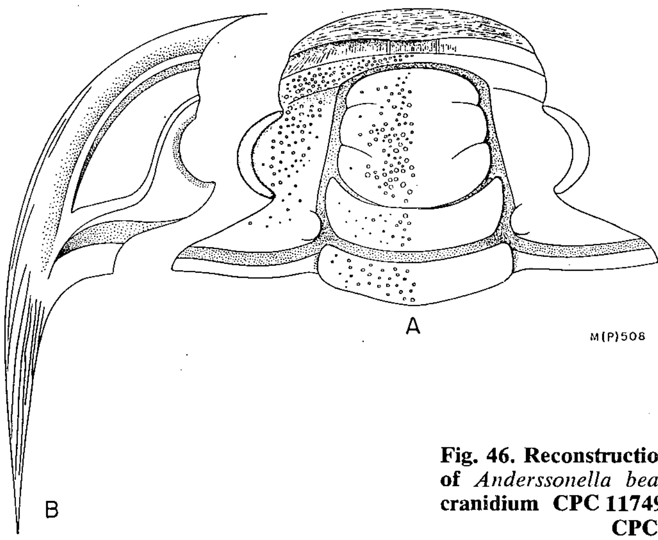

Fig. 46. Reconstruction of the cephalic components of *Anderssonella beauchampi* sp. nov.; based on cranidium CPC 11749, x4 approx., and librigena CPC 11755a, x9.

sagittally. In most specimens the preoccipital and median lateral furrows are confluent with the axial, but not the anterior lateral, furrows. The median and anterior lateral glabellar lobes are markedly less wide (tr.) than the preoccipital lobes.

The occipital furrow is wide (sag.), deep, and transverse. The occipital ring has similar sagittal width to the preoccipital lobes, but is transversely wider, and in lateral profile is slightly elevated above the dorsal level of the glabella. As far as can be seen from available material there is no nuchal node or spine.

The palpebral lobes lie well forward, extending between the preoccipital and anterior lateral glabellar furrows, are fully half the glabellar length (exsag.), and elevated above the surrounding palpebral areas. The latter are wide (tr.) and gently convex (tr.). The anterior section of the facial suture diverges initially from the front of the palpebral lobe and curves adaxially to join the cranidial margin at an obtuse angle. The preglabellar field is very short (sag.), convex (sag.), and ridge-like, flattening laterally into triangular preocular areas. Faint ocular ridges connect the palpebral lobes with the ridge-like preglabellar field at the anterolateral corners of the frontal lobe. A wide (sag.) shallow anterior cranidial marginal furrow separates the preglabellar field from the cranidial border. The cranidial border is wide (sag.), with a slight mesial thickening. In early holaspides bacculae are present on the fixigenae opposite the preoccipital glabellar lobes, but are apparently resorbed during holaspid morphogenesis. The courses of the postocular sections of the facial suture are not known, at least from the cranidial fragments. Librigenal evidence indicates long, narrow, blade-like posterolateral limbs.

The librigena is characterized by a long genal spine, prominent subocular groove, and wide marginal furrows and borders. A prominent diverticulum follows at some distance the course of the subocular groove as far as the end of the posterolateral limb, then deflects parallel to the posterior marginal furrow as far as the genal angle. The posterior marginal furrow is deep and passes into the base of the genal spine.

The pygidium is subrectangular, rounded posteriorly. Four, possibly five, deep pleural furrows are transverse and parallel as far as the geniculation, at which point they deflect strongly to the rear and fade out on the lateral pygidial borders. Interpleural furrows are slightly less prominent than the pleural furrows and run parallel to them. Four axial rings and a terminal piece are present on the axis. The posterolateral borders are concave and broad, with slightly raised posterolateral margins.

The surfaces of glabella and genae are covered with perforated granules of various sizes. The density of granulation is quite dependant on preservation—dense when the shell is preserved, less so as it is stripped away (Pl. 20, figs 3-4). The anterior cranidial border bears a combination of discontinuous raised lines and linked granules giving an overall reticulate appearance. The lateral border of the librigena is apparently smooth. The pygidial surface is densely, but minutely, granulose.

The caecal network of the cranidium is not well displayed. Three short diverticula lie in the floor of the anterior marginal furrow of the cranidium, one on the sagittal line, the others flanking on each side. The librigena on the other hand has a reticulate caecal display associated with the prominent diverticulum. No details of the caecal system are known from the available pygidia.

ANDERSSONELLA EWEYI sp. nov.
(Pl. 20, fig. 6; Pl. 21, figs 5-6)

Name: After Mr D. Ewey, owner of Cazna Downs Property in the Black Mountain area.

Holotype: CPC 11756, a cranidial fragment showing the characteristic prosopon of the glabella and anterior cranidial border (Pl. 21, fig. 5).

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K143 and K144, at 409 and 417 m from the base of the measured section; Mount Ninmaroo, horizons K161 and K163, at 7 and 20 m from the base of the measured section.

Age: Late Upper Cambrian, early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas*.

Material: The species is erected on evidence from seven cranidial fragments, a single librigena, and a single pygidium. The figured paradigm comprises specimens CPC 11753, 11756, 11757.

Size: The smallest specimen complete enough to measure has a cranidial length of 3.25 mm, and the largest an estimated 5.50 mm. The associated pygidium has a maximum transverse width of 21.50 mm.

Diagnosis: A species of *Anderssonella* distinguished by its prosopon. The glabella is densely granulose, but the preocular areas and anterior cranidial border bear sinuous raised lines and linked granules. The border of the librigena carries strong raised lines, irregular and sinuous, running into the genal spine; the genal field is granulose. The pygidium has granulose pleurae, overlying a strong pattern of concentric terrace lirae.

Differential diagnosis: The diagnostic prosopon differentiates *Anderssonella eweyi* from all other species of the genus. Further, the pygidial pleurae run obliquely rearwards from the axial furrows, whereas in *A. beauchampi* they run parallel to each other, at least as far as the geniculation. Cranidial characteristics are almost identical with those of *beauchampi,* and quite similar to those of *A. fengtienensis* and *A. tani* also.

Description: The anterior cranidial outline is transverse, almost straight. The glabella is subparallel-sided rather than barrel-shaped, with its greatest width (tr.) at the preoccipital lobes. As in *Anderssonella beauchampi* the preoccipital furrows are transverse, arching slightly rearwards, deep abaxially, but becoming shallow adaxially. The median lateral furrows are similarly oriented, faintly continuous sagittally, but less deeply incised. The anterior lateral furrows are short, faint and discontinuous, more or less rectilinear, and transversely oriented. All furrows are much stronger on exfoliated specimens. The sides of the glabella are somewhat constricted at the middle of the preoccipital lobes, a constriction caused by the presence of a complementary baccula on the margins of the fixed cheek flanking the axial furrows.

As far as can be assessed, the position of the palpebral lobes, nature of the preglabellar area, preocular areas, and anterior cranidial border are the same as in *A. beauchampi.*

Anterolaterally the librigena is only slightly wider than that of *A. beauchampi,* but the width increases gradually rearwards to the genal spine. The lateral marginal furrow is narrow (tr.), deep, and not confluent with the posterior marginal furrow, being separated by a narrow ridge carrying the genal diverticulum into the genal angle. As in other species of *Anderssonella* the subocular groove is abaxially flanked by a prominent diverticulum which is deflected laterally near the ends of the posterolateral limbs to run parallel with the posterior marginal furrow. The latter is narrow (exsag.) and deep, and runs for a considerable distance into the base of the genal spine (Pl. 21, fig. 6).

The pygidium is *Prosaukia*-like, subquadrate, but apparently posteriorly rounded. Unlike the previously described species the pleurae strike obliquely rearwards from their origins at the axial furrows, again dying out on the broad pygidial borders. There are four pleurae having strong, wide, pleural furrows and separated by faint interpleural ones. The pleural bands are granulose along their lengths. The number of axial rings is unknown, as is the shape of the posterior margin. A wide posterolateral doublure is evident (Pl. 20, fig. 6).

Genus Galerosaukia nov.

Name: Derived from the L., *galerus,* hood or helmet, combined with the generic nomen *Saukia:* 'the hooded *Saukia*'.

Type species: Galerosaukia galerita gen. nov. et sp. nov., from the late Upper Cambrian early Payntonian of Black Mountain (see below).

Other species: Described below are *Galerosaukia ptyxis* sp. nov., from the early Payntonian of Mount Ninmaroo, and *Galerosaukia* sp. from the early Payntonian of Black Mountain.

Diagnosis: A saukiid genus having a preglabellar field which appears to be folded over the anterior extremity of the glabella; wide (tr.) occipital ring and preoccipital glabellar lobes which give the appearance of a platform or base upon which the remainder of the glabella is established; small palpebral lobes situated at some distance from the glabella and placed anteriorly on the genae. No diagnostic characteristics can be derived from either the pygidium or librigena.

Differential diagnosis: Galerosaukia most closely resembles *Lichengia* Kobayashi, 1942, both genera having a thickened and upraised preglabellar field, although the feature is emphasized to its greatest extent in *Galerosaukia.* Conversely, although both genera share a tendency to lateral expansion of the occipital ring and preoccipital glabellar lobes, this is more pronounced in *Lichengia. Galerosaukia* has smaller eyes, placed farther forward on the genae and farther removed laterally from the glabella. *Lichengia* may be further differentiated by its laterally divergent preocular facial sutures; those of *Galerosaukia,* though divergent initially, close to become convergent at the cranidial margin. Both the glabellar expansion and the raising of the preglabellar field are features seen, but only conservatively developed, in the species of *Anderssonella* described above. Ignoring characteristics associated with the preglabellar field, the two genera are very similar. Of the two species of *Galerosaukia* described here, *G. ptyxis* most closely resembles *Anderssonella beauchampi* sp. nov., and *G. galerita* resembles *Lichengia onigawara*

Kobayashi. *Galerosaukia* therefore appears to represent an intermediate stage in the derivation of *Lichengia* from an anderssonelloid stock. However, the derivation of both *Galerosaukia* and *Lichengia* from a prosaukioid stock might also be argued: *Prosaukia beani* Ulrich & Resser, *P. lodensis* Ulrich & Resser, and *P. granosa* Ulrich & Resser all have features which, if emphasized, could have given rise to the morphology of either *Lichengia* or *Galerosaukia.*

Lichengia onigawara Kobayashi (1942, p. 297-8, fig. 1) is based on *Prosaukia brizo* Sun (1935, p. 43-4, pl. 4, figs 22-23) *non* Walcott (1913). It is from the Upper Licheng Formation of Shanyaocheng, Licheng, near Shansi, northern China, where it is associated with *Tsinania canens* and *Quadraticephalus calchas,* of Fengshanian age. In Australia, *Galerosaukia ptyxis* succeeds *G. galerita* stratigraphically. Tsinaniidae are associated with both, and with the latter a species comparable with *Quadraticephalus teres* Resser & Endo, 1937.

Age and Distribution: Distributed in western Queensland, of early Payntonian age.

GALEROSAUKIA GALERITA gen. et sp. nov.
(Pl. 22, figs 1-5; Text-fig. 47)

Name: L., *galerita,* wearing a hood, referring to the appearance of the preglabellar field.

Holotype: CPC 11758, an incomplete and partly exfoliated cranidium, illustrated in Plate 22, fig. 1.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizon K141, 396 m from the base of the measured section.

Age: Late Upper Cambrian, early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas.*

Material: The species is based on the remains of three cranidia, five librigenae, and a single pygidium, from which the figured specimens, CPC 11758-61, were drawn.
Size: The holotype cranidium (CPC 11758) has a glabellar length (sag.) of 4.50 mm, and estimated cranidial length of 6.00 mm. The two remaining cranidia are too poorly preserved to measure. The associated pygidial fragment indicates an estimated length of 6.20 mm, and width (tr., max.) of 11.60 mm.

Diagnosis: A species of *Galerosaukia* with smooth and finely punctate surface; non-advanced genal spines; squat glabella, markedly widened (tr.) at the preoccipital and median lateral side lobes, tapering forwards.

Differential diagnosis: Contrasts and comparisons are given in the differential diagnosis of *Galerosaukia ptyxis,* which follows.

Description: The anterior cranidial outline is very gently curved forwards, almost transverse. The glabella is widest (tr.) at the preoccipital lobes, being greater than 80% of the glabellar length (sag.), narrowing slightly at the median lateral lobes, thence tapering more rapidly forwards. The frontal lobe is anteriorly evenly rounded. Apart from the preoccipital furrows, which are shallow, wide, transversely connected across the sagittal line, and arch backwards, furrowing is almost effaced.

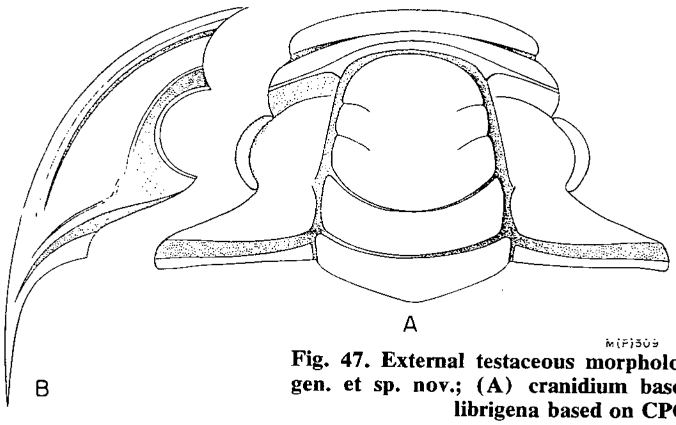

Fig. 47. External testaceous morphology of ***Galerosaukia galerita*** **gen. et sp. nov.; (A) cranidium based on CPC 11758, x6; (B) librigena based on CPC 11761, x6.**

The median lateral furrows are very faint, slightly curved, and posteriorly inclined. The anterior lateral furrows are short, faint notches on the anterolateral flanks of the glabella. The axial furrows are quite shallow at the sides of the glabella, but deepen considerably into pits at the anterolateral glabellar margins.

The preglabellar field is a narrow (sag.) convex ridge which runs concentric with the contour of the frontal glabellar lobe, and is separated from it by an equally narrow (sag.), V-shaped preglabellar furrow. This preglabellar ridge slopes steeply into the preglabellar furrow posteriorly, but slopes away anteriorly across a gently convex surface towards the anterior cranidial border, with no appreciable break of slope at the marginal furrow. In dorsal viewing this ridged preglabellar field appears to be raised over a depressed glabella, but in actual fact, in lateral view, the frontal lobe has appreciable sagittal convexity and the preglabellar ridge lies, in profile, considerably below it. The shrouded appearance of the frontal lobe is exaggerated by the deep preglabellar furrow with its steep anterior side. The preglabellar ridge thickens (exsag.) at the anterolateral margins of the glabella, then passes laterally across the preocular areas as an elevated line (manifestly a diverticulum). The anterior cranidial border is sagittally a mere continuation of the slope of the preglabellar field. At the anterolateral margins of the cranidium, however, a deep marginal furrow is developed, and the border stands raised above this. On some specimens these lateral parts of the marginal furrow are transversely connected by a line of discontinuous pits (Pl. 22, figs 3-4).

The palpebral lobes are prominently raised above gently convex (tr.) and adaxially sloping palpebral areas. They extend from the level of the preoccipital glabellar furrows to the anterior lateral furrows, and are fully one-half the glabellar length (G) in size. Bacculae are developed on the inner posterolateral corners of the fixigenae opposite the markedly widened (tr.) preoccipital glabellar lobes. Nothing is known of the nature of the posterolateral limbs.

The librigena is greatly reminiscent of that of *Anderssonella beauchampi,* except that it is smooth, and thus nearly identical with that of *Galerosaukia* sp. (below). The lateral borders are wide, the marginal furrows deep, the posterior one not connecting with the lateral one, but curving into the base of the genal spine. Likewise the 'genal' diverticulum follows, at some distance, the line of the subocular groove, and at the geniculation veers through 120° to run parallel with the posterior marginal furrow into the spine base.

The pygidium is semicircular, somewhat flattened posteriorly. Little is known of the axis, which is mostly eroded on the single pygidial fragment available. There are three, faintly four, pleural segments, with deep and wide (exsag.) pleural furrows which bisect them into equal pro- and opisthopleural bands. They are slightly inclined rearwards to the margin of the pygidium and run parallel to each other as far as the geniculation, then curve sharply rearwards, as in species of *Prosaukia*. The lateral pygidial borders are narrow, smooth, and gently concave. Postaxially the border is very narrow and slopes adventrally. The lateral and posterior margins of the pygidium are entire.

Fragments of all cranidia, the pygidium, and the genal field of the librigena, have smooth surfaces, both testaceous and parietal, with randomly dispersed and oriented punctae. Raised terrace lirae run down their length of the genal spines.

GALEROSAUKIA PTYXIS sp. nov.
(Pl. 21, figs 3-4; Pl. 22, figs 6-9)

Name: Gk, *ptyxis,* fold, noun in apposition, referring to the folded appearance of the preglabellar field.

Holotype: CPC 11762, an incomplete cranidium preserved with shell and illustrated in Plate 22, fig. 8.

Occurrence: 'Chatsworth Limestone', Mount Ninmaroo, horizons K165, K167, K168, K169, and K170, at 50, 59, 67, 68.5, and 70 m from the base of the measured section; Black Mountain, horizon B510b, whose exact position is uncertain but which is near the top of the 'Chatsworth Limestone'.

Age: Late Upper Cambrian, early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas.*

Material: 13 cranidial fragments and 9 librigenae. No pygidia have been assigned to the species. Specimens CPC 11762-7 form the illustrated paradigm.
Size: Measurable cranidia have lengths (sag.) ranging between 3.50-10.20 mm.

Diagnosis: A species of *Galerosaukia* with prominent 'fingerprint' prosopon on its cranidium, inosculating raised lines on the borders of the cheek and cranidium, and prominent reticulate caecal pattern on the librigena. The last is characteristically narrow (tr.) and bears laterally deflected spines. The palpebral lobes are well forwards on the fixigenae, and the palpebral areas slope steeply into the axial furrows, raising the palpebral lobes above the level of the dorsal surface of the glabella.

Differential diagnosis: Galerosaukia ptyxis is distinguished from *G. galerita* immediately by its wrinkled cranidial and librigenal surfaces. In detail, its preoccipital glabellar lobes are less wide (tr.), the palpebral lobes more elevated above the dorsal surface of the glabella, the palpebral areas more convex (tr.), and the preglabellar ridge less well defined (sag.). The cranidium is further distinguished from that of *galerita* in having a transversely continuous anterior marginal furrow and transversely continuous median lateral glabellar furrows. The librigena is much narrower (tr.) and the genal spine would appear to be deflected laterally to a greater extent.

Description: The anterior cranidial margin is gently arcuate in dorsal view. The glabella is barrel-shaped, tapering gradually forwards, and evenly rounded, sometimes slightly flattened anteriorly. There is no appreciable lateral extension of the preoccipital glabellar lobes, in contrast with *Galerosaukia galerita,* but the occipital ring is appreciably wider (tr.) than any part of the glabella. The preoccipital glabellar furrows are deep abaxially, inclined posteriorly, and transversely connected across the sagittal line, where they become shallow and wide (sag.). The median lateral furrows are similarly oriented, transversely connected, but less deeply incised. The anterior lateral furrows are short, faint, and arched forwards at their midpoints. The axial furrows are deep, with prominent pits at the anterolateral corners of the glabella.

The occipital ring is much wider (tr.) than the preoccipital lobes, is widest (sag.) mesially, and bears a small nuchal node.

As in *G. galerita* the preglabellar field is a narrow (sag.) raised ridge steeply sloping into the preglabellar furrow and gently sloping to the anterior marginal furrow. The ridge passes laterally across the preocular areas, in front of the palpebral lobes, and on to the librigena. The preocular areas are appreciably convex (exsag.). The anterior cranidial marginal furrow is deepest laterally, shallow, but nevertheless present, sagittally. The cranidial border is sagittally wide, forming a plectrum, narrower laterally. The palpebral areas are strongly inclined to the axial furrows, and raise the palpebral lobes above the level of the dorsal surface of the glabella. The lobes are thus prominent, elevated, anteriorly sited between the preoccipital and anterior lateral glabellar furrows, and remote from the glabella.

The anterior branches of the facial suture curve outwards initially then inwards, as in *G. galerita,* cutting the anterior cranidial border at obtuse angles. The posterior branches run directly back from the rear of the palpebral lobes, and enclose broad, triangular fixigenae on which bacculae are sited adjacent to the axial furrows opposite the preoccipital glabellar lobes.

The librigena is narrow (tr.) and sliver-like, with broad lateral borders and stout genal spines oriented outwards and gently backward. It bears a deep subocular groove and marginal furrow, but the genal diverticulum, although present, is difficult to pick out from the caecal network unless the specimen is exfoliated. Its posterolateral course, however, is well marked by a ridge running parallel to the posterior marginal furrow and continuing into the base of the genal spine, thus effectively separating the lateral and posterior marginal furrows.

The hypostome and pygidium are unknown.

Galerosaukia ptyxis is characterized by a very prominent caecal network well seen on the palpebral areas, preocular areas, and librigenae. Raised inosculating terrace lines characterize the anterior border of the cranidium and the lateral border and genal spine of the librigena. The glabella bears a reticulate pattern of short, interlinked, and sinuous raised markings sagittally and exsagittally oriented.

GALEROSAUKIA sp.
(Pl. 21, figs 7-9)

Occurrence: 'Chatsworth Limestone', Black Mountain, horizon K137, 366 m from the base of the measured section.

Age: Late Upper Cambrian, early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas.*

Material: A single cranidial fragment (CPC 11768), and two incomplete librigenae (CPC 11769, 11770), one an external mould.

Comment: The illustrated cranidium (Pl. 21, fig. 7) resembles *Galerosaukia galerita* in its smooth, punctate surface and forwardly situated palpebral lobes, distant from the glabella and posterior cranidial margin. The specimen lacks its anterior cranidial margin, whose relation to the preglabellar field is uncertain. It seems, however, that the preglabellar ridge, prominent in *G. galerita,* is lower and less distinct in this species, a condition approaching that of *Anderssonella.* Although the preoccipital glabellar lobes are laterally extended (tr.), they are not nearly so prominent as in *galerita.* The librigena is, however, most closely comparable in size and shape. Its only distinction from that of *G. galerita* is that its genal diverticulum is duplicated by a second weaker one running concentric to it abaxially.

Genus CAZNAIA nov.

Name: Derived from the property known as Cazna Downs, Boulia district, western Queensland. A feminine gender is assigned.

Type species: Designated herein, *Caznaia squamosa* gen. et sp. nov., from the pre-Payntonian B interval at Black Mountain (see below).

Other species: Caznaia sectatrix sp. nov., also from the Black Mountain section (see below).

Distribution: On present knowledge the genus is confined to western Queensland.

Diagnosis: A saukiid genus distinguished by the following complex of characteristics: barrel-shaped glabella with sinuous sides, tapering anteriorly; small palpebral lobes lying between the median and anterior lateral glabellar furrows; long, broad-based, triangular posterolateral limbs; anteriorly divergent facial suture; short, convex (sag.) preglabellar area differentiated into border and preglabellar field adaxially only when shell is preserved; transverse pygidium with slight anterior curvature (sag.) in the posterior margin; pleural furrows dividing the pleural segments unequally.

Differential diagnosis: Among saukiid genera *Caznaia* resembles, and is possibly ancestral to, *Anderssonella.* The two genera have common glabellar shapes, and similar small palpebral lobes. They differ in the structure of the preglabellar area: *Caznaia* lacks the transverse anterior marginal furrow in specimens preserved with shell. Apart from the greater degree of posterior curvature of the pleural segments of *Anderssonella,* the pygidia are also essentially similar. The cranidium of *Caznaia* also resembles that of *Quadraticephalus* in its narrow (tr.) preglabellar area, not well differentiated into field and border, but differs in the shape of the glabella, and on pygidial characteristics. One of the species assigned to *Caznaia, C. sectatrix,* resembles *Iranaspis* because its furrowing is almost completely effaced. *Iranaspis* and *Caznaia* may be differentiated on pygidial and glabellar shapes, and the absence of a confluent preglabellar-preocular furrow in the latter. Kobayashi's (1935c) illustrations of *Shirakiella* also look similar to *Caznaia,* but this genus is known only from cranidia and the nature of the preglabellar area is not clear from the published illustrations (Kobayashi, 1935c, pl. VII, figs 7-13, 15-18). Possibly the two genera are morphologically close.

CAZNAIA SQUAMOSA gen. et sp. nov.
(Pl. 25, figs 1-6; pl. 26, figs 1-6; Text-fig. 48)

Name: L., *squamosa,* scaly, referring to the appearance of the test.

Holotype: CPC 11806, a testaceous cranidium, illustrated in Plate 25, fig. 1.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K103, K104, K105, K106, K107, at 1.5, 6, 7, 51, and 68 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zones of *Pseudagnostus clarki patulus* with *Caznaia squamosa* and *P. clarki prolatus* with *C. sectatrix.*

Material: The species is known from fragments of 44 cranidia, 21 pygidia, and 15 librigenae, from which specimens CPC 11806-16 were selected for illustration.
Size: Cranidia range in length (sag.) between 5.70 and 13.40 mm, and pygidia (sag.) between 4.20 and 8.00 (Lp_2).

Diagnosis: A species of *Caznaia* gen. nov. with large coarse densely packed granules which give the test a scaly appearance.

Differential diagnosis: See under *Caznaia sectatrix.*

Description: The glabella is barrel-shaped, widest (tr.) at the front of the preoccipital lobes, constricted at the median lateral lobes and furrows, and again slightly expanded at the frontal lobe. Anteriorly, the outline is of the glabella obtusely rounded, in some cases transverse. The preoccipital furrows are linear, oblique, posteriorly directed, and faintly connected across the sagittal line. The median lateral furrows are similarly oriented, but much fainter, and are unconnected sagittally. The anterior glabellar furrows are very weak, merely notches in the outline of the glabella. Depending on preservation, the glabella (G) occupies 60-70% of the cranidial length (sag.): on shelly specimens this parameter varies between 67 and 70%, on exfoliated specimens 60 and 67%.

The occipital furrow is narrow (sag.), shallow, but distinct. The occipital ring is wider (tr.) than the preoccipital lobes, but narrower (sag.), and has low sagittal convexity. A small nuchal node is preserved on exfoliated cranidia.

The palpebral lobes are semi-crescentic, narrow (tr.), connected to the antero-lateral corners of the glabella by very faint ocular ridges (Pl. 25, fig. 1). They are small (A:G 29-46%), sited on the genae between the preoccipital and median lateral glabellar furrows. There is evidence suggesting that the palpebral lobes become smaller as the size of the specimen increases. The palpebral areas are relatively wide (tr.), slightly wider (tr.) posteriorly than anteriorly. The posterior sections of the facial suture enclose long (tr.), broad-based, triangular postero-lateral limbs. A:H varies between 60 and 97% depending on the size of the specimen, being nearly unity in early holaspides. The anterior sections of the

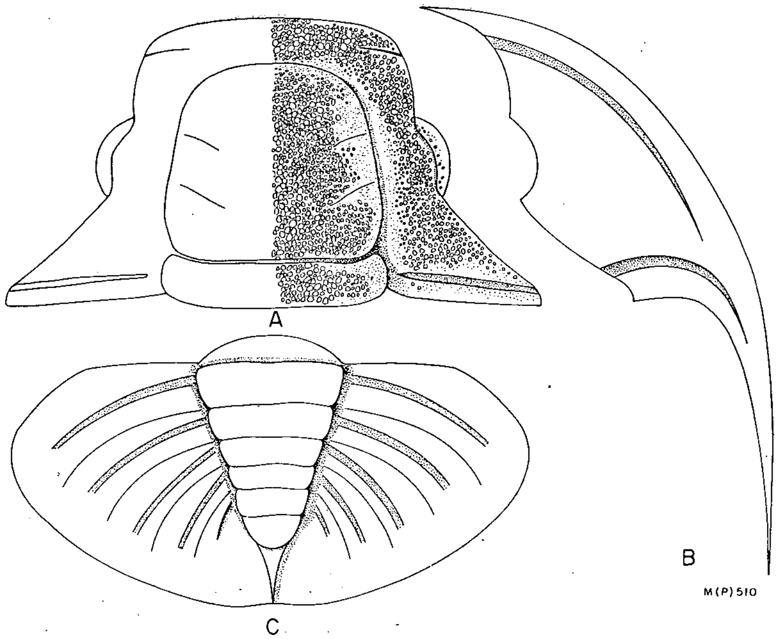

Fig. 48. Reconstruction of the external testaceous morphology of *Caznaia squamosa* gen. et sp. nov.; (A) cranidium based on CPC 11809, x6; (B) librigena based on CPC 11816, x4.5 approx.; and (C) pygidium based on CPC 11811, x3.5.

facial suture strike directly forwards from the front of the palpebral lobes, but curve slightly abaxially before reaching the anterior margins. They enclose a preglabellar area composed of a narrow (sag.) preglabellar field, which is defined only on exfoliated specimens, a shallow, ill-defined marginal furrow, and relatively wide (sag.), convex (sag.) cranidial border, very gently curved anteriorly. On specimens preserved with their shell, the marginal furrow is effaced, and sagittally there appears to be no differentiation between cranidial border and preglabellar field, although this furrow is defined abaxially.

The librigenae are broad (tr.), with relatively narrow borders. The most important feature is the course of the posterior marginal furrow, which curves into the base of the genal spine and is not connected with the lateral marginal furrow. The two furrows are separated by a slightly convex ridge. Similar features are seen in the related genera *Anderssonella* and *Galerosaukia*.

Pygidia are broad and transverse, at least twice as wide (tr.) as long (sag.). They are thus shallowly semicircular, with a gentle anterior curvature behind the axis. They have comparatively narrow (tr.), short (sag.) axes, strongly elevated, and composed of four segments together with a terminal piece. The axial furrows defining it have only a low degree of posterior taper. A prominent post-axial ridge carries the axis rearwards close to the posterior pygidial margin. There are also four pleural segments separated by well-defined interpleural furrows which are as strong as the pleural ones. The latter run obliquely across the pleuron, dividing it into two unequal parts. Both pleural and interpleural furrows curve rearwards distally, and die out before reaching the pygidial margins. A narrow, very slightly concave (tr.) border is thus formed. The pygidial margins are entire, non-spinose.

The cranidial prosopon is composed of large, scale-like granules, densely packed together on the glabella, preglabellar area, and occipital ring, less dense and more normally granulose on the posterolateral limbs. When the shell is gradually removed, a less dense granulation becomes apparent, and when this layer is exfoliated the underlying surface is seen to be punctate. A coarse granulation is also present on the librigena, but is rather faint. The librigenal borders are lirate. Caecal systems are present only on the preglabellar fields of exfoliated specimens, and associated with genal diverticula at the bases of the palpebral lobes on the free cheeks. All available pygidia show punctate surfaces, presumably due to exfoliation. One specimen, however (Pl. 26, fig. 2), shows traces of the caecal network on the pleura and borders. The pygidial doublure (Pl. 26, fig. 3) is lirate.

CAZNAIA SECTATRIX sp. nov.

(Pl. 26, fig. 7; Pl. 27, figs 1-6; Text-fig. 49)

Name: L., *sectatrix*, following, referring to the succession of *Caznaia squamosa* by *C. sectatrix* in time.

Holotype: CPC 11823, the exfoliated cranidium illustrated in Plate 27, fig. 1.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K107, K108, K109, K111, K113, at 68, 73, 80, 112, and 127 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zones of *Pseudagnostus clarki prolatus* with *Caznaia sectatrix* and *P. bifax* with *P. denticulatus*.

Material: 24 cranidia, 4 librigenae, and 6 pygidia. Specimens CPC 11817-23 form the illustrated paradigm.

Size: Cranidia range in length (sag.) between 6.45 and 13.80 mm. The associated pygidia are insufficiently complete to measure.

Diagnosis: A species of *Caznaia* with medium to dense granulation; proportionately long (sag.) glabella, and short (sag., exsag.) preglabellar area and palpebral lobes. The marginal cranidial furrow is effaced even on moulds. There are three pleural and three axial segments in the pygidium.

Differential diagnosis: C. sectatrix differs from *C. squamosa* in the characteristics listed in the diagnosis (above) and description (below). It is the species of *Caznaia* morphologically most similar to *Iranaspis harrisoni* King (1937, p. 7, pl. II, fig. 1a); the cranidium differs only on the positioning of the anterior cranidial marginal furrow, present faintly abaxially in *Caznaia sectatrix,* and possibly the positioning of the palpebral lobes, which in *C. sectatrix* are farther forwards. Pygidia of species of *Caznaia* and *Iranaspis* are, however, quite distinct. There is also a resemblance between cranidia of *C. sectatrix* and *Saukia aojii* Kobayashi (1933a, pl. XIII, fig. 1), *Tellerina paichiaensis* Kobayashi (1933a, pl. XIII, fig. 9), *Plethopeltella orientalis* (Kobayashi) (1933b, pl. VI, fig. 5), and *P. resseri* (Kobayashi) (loc. cit., fig. 6) but it is doubtful that any of the species cited are congeneric.

Description: Caznaia sectatrix is morphologically so similar to *C. squamosa* that only selected features are described below.

The glabella, though similar to that of *C. squamosa,* has sides more rectilinear than barrel-shaped, although the maximum width (tr.) remains at the level of the front of the preoccipital lobes. The glabella is slightly longer (sag.), occupying 63-71% of the total cranidial length, according to mode of preservation. Glabellar furrowing, when visible, is quite similar. The occipital ring appears comparable in both species, possessing sagittally a nuchal node in each.

The palpebral lobes of *C. sectatrix* are similarly situated with respect to the glabellar furrowing to those of *C. squamosa,* but are proportionately smaller in relation to the glabellar length; A:G is 29-40%, compared with 32-46% in *C. squamosa.* The courses of the anterior sections of the facial suture in *C. sectatrix* appear to close more rapidly to the cranidial border when specimens are viewed in dorsal aspect, but in lateral view it is seen that the preglabellar area has greater transverse convexity than that of *C. squamosa,* which accounts for this discrepancy. The A:H ratio of *C. sectatrix,* 58-76%, is smaller than that of *C. squamosa,* 58-97%, thus emphasizing the different eye lengths of the two species.

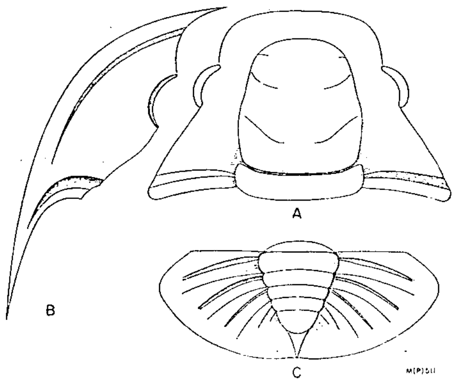

Fig. 49. Reconstruction of *Caznaia sectatrix* gen. et sp. nov.; (A) cranidium based on CPC 11823, x1.5 approx.; (B) librigena based on CPC 11822, x5; and (C) pygidium based on CPC 11820, x2.5 approx.

The pygidia of *C. sectatrix* differ in having one segment fewer in both pleural and axial zones, and the borders are perhaps a little wider (tr.).

Caznaia sectatrix has a considerably less dense and finer surface granulation, and most specimens show a degree of punctation, probably resulting from their mode of preservation in much finer limestone than that in which *C. squamosa* is normally found.

Genus SINOSAUKIA Sun, 1935

Type species: Sinosaukia pustulosa Sun, 1935, p. 52-3, pl. V, figs 1, 3-4, 6-11; *non* figs 2a-b, 5a-b = *Lophosaukia?,* from the Upper Wolungshan Formation, Huolu, and Kaolishan Formation, Taian, Shantung, north China; by original designation. The species was subsequently figured by Endo (1939, p. 13, pl. 2, figs 31-2) and Lu (1957, p. 284, pl. 148, fig. 1).

Other species: Sinosaukia impages sp. nov., from the pre-Payntonian A and Payntonian intervals at Black Mountain, western Queensland, and *Sinosaukia* sp. indet., from the early Payntonian of the same place, are described below.

Distribution: North-central China and western Queensland, Australia.

Comment: The genus *Sinosaukia* was regarded by Lochman-Balk (*in* Moore, 1959) as synonymous with *Saukia,* but the structure of the anterior cranidial margin appears to be sufficiently distinct to warrant the retention of the genus (see Hupé, 1955, p. 195, fig. 170.7; and Kobayashi, 1960b, p. 404-5, fig. 13g). The combination of distinguishing characteristics is: an anteriorly expanding frontal lobe, and constricted median lateral lobes which give the genus a waisted appearance about the middle of the glabella; an anterior cranidial border which is flange-like, slightly triangular sagittally, lying in a near horizontal plane; and large palpebral lobes.

Kobayashi (1960b, p. 405) has placed great emphasis on the row of large tubercles which characterizes the anterior cranidial margin of *Sinosaukia pustulosa.* These are absent on the Australian material described below, which is nevertheless similar in most other respects. *Sinosaukia* relates to *Lophosaukia* in the condition of its anterior cranidial border. Both have a triangular appearance, but in *Sinosaukia* the border is never as extensive (sag.), and never slopes forwards and downwards to the same degree as in *Lophosaukia.* The two genera are also distinguished on the shapes of their glabellae, constricted and pyriform in *Sinosaukia,* varyingly shaped in *Lophosaukia,* and the length and position of the palpebral lobes, which extend much farther rearwards in *Sinosaukia.*

SINOSAUKIA IMPAGES sp. nov.
(Pl. 17, figs 1-7)

Name: L., *impages,* noun in apposition, a border or frame around the panel of a door, referring to the appearance of the anterior cranidial border.

Holotype: CPC 11771a, a partly exfoliated cranidium, illustrated on Plate 17, fig. 1, with counterpart mould, CPC 11771b, Plate 17, fig. 2.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K128, K130, K131, K133, K134, and K135, at 240, 272, 309, 325, 329, and 335.5 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian A, *Sinosaukia impages* Assemblage-Zone; early Payntonian, *Pseudagnostus quasibilobus* with *Tsinania nomas* Assemblage-Zone.

Material: Nine cranidial fragments, four librigenal fragments, and pieces of four pygidia. The type series comprises CPC 11771a-6.

Size: Available cranidia range in length (sag.) between 3.80 and 5.40 mm. The holotype has a cranidial length of 5.40 mm, G is 4.10 mm, and Gn 5.00 mm.

Diagnosis: A species of *Sinosaukia* lacking pustules on its anterior cranidial margin, but with a smooth, lirate, or faintly granulose adventrally sloping and slightly triangular anterior cranidial border, according to preservation. The borders of the librigena are strongly sculptured with raised terraced lirae. The pygidium is apparently short (sag.), with wide borders, and only two pleural segments.

Differential diagnosis: Sinosaukia impages differs from the type species, *S. pustulosa* Sun, primarily on the absence of the prominent row of pustules on the anterior cranidial border. The shape of the anterior cranidial margin, the shape of the glabella, and the density of granulation of the glabella, are comparable. As far as can be judged from the fragmentary evidence, the pygidium of *S. impages* is proportionately broader, and has fewer segments, than that of *S. pustulosa.*

Description: Sinosaukia impages has a subpyriform glabella, with wide (tr.) preoccipital lobes, constricted (tr.) median lateral lobes, and forward expanding frontal lobe, with obtusely rounded anterior contour. The preoccipital furrows are deep and wide (sag.), posteriorly curved, and united sagittally. The median lateral furrows are short, slightly curved notches on the lateral glabellar margins. The anterior lateral furrows are somewhat longer (tr.), gently arched forwards, and faint. The occipital ring is as wide (tr.) as the preoccipital glabellar lobes.

The palpebral lobes are separated from the palpebral areas by deep and wide palpebral furrows. They are appreciably convex (tr.), arcuate in dorsal view, and extend from the occipital furrow forwards to the confluence of the anterior lateral furrows with the axial furrows. The anterior sections of the facial suture run almost directly forwards from the front of the palpebral lobes and cut the anterior margins at angles a little greater than 90°. The preglabellar furrow is wide (sag.), relatively shallow, and lies anterior to the frontal glabellar lobe, rather than below it as in *Lophosaukia.* The anterior cranidial margin is narrow and rounded anterolaterally, widening (sag.) slightly anteriorly and forming a flat triangular area which slopes very slightly adventrally.

The librigena is similar to that of *Lophosaukia,* with broad lateral borders and narrow marginal furrows. The subocular groove, however, is very shallow, and the density of granulation much higher.

Available pygidial fragments allow one to deduce a short (sag.), semicircular shield with entire margins, broad and slightly concave borders, and rather convex axis. The last appears to consist of no more than two rings and a terminal piece, and only two pleural segments are evident on the pleural field. These bear narrow (exsag.) furrows, no more than grooves, oriented outwards and backwards, which are rectilinear, and bisect the pleuron equally.

The cranidium, and especially the glabella, is densely granulose; when shell is preserved the anterior cranidial border is seen to be both granulose and striated with raised lirae (Pl. 17, fig. 5), but almost smooth when the shell is removed (Pl. 17, fig. 6). The librigenal areas around the palpebral lobes are densely granulose, but the borders bear highly sculptured raised lirae which carry backwards into the genal spines. The pygidium bears coarse raised lirae oriented concentric to its periphery. All surfaces are punctate when the shell is removed.

SINOSAUKIA sp. indet.
(Pl. 17, figs 8-9)

Occurrence: 'Chatsworth Limestone', Black Mountain, horizon K138, at 374 m from the base of the measured section; and at B510, which is probably an equivalent horizon but not on the line of section.

Age: Late Upper Cambrian, early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas.*

Material: Three cranidial fragments, of which CPC 11777-8 are illustrated.

Size: The illustrated cranidium, CPC 11778, has an estimated length (sag.) of 7.00 mm, Gn is 6.00 mm, and G is 4.90 mm.

Comments: This species resembles *Sinosaukia impages* sp. nov. in the shape of its glabella and the size and position of its palpebral lobes, but the structure of the anterior cranidial border differs; there is a slight plication on the margin opposite the anterolateral corners of the glabella. The granulation of the glabella is dense, but no granules are developed on the anterior border, which is lirate.

Genus Lophosaukia Shergold, 1972

Type species: Lophosaukia torquata Shergold (1972, p. 62-64, pl. 18, figs 1-6), from the Gola Beds of Momedah Creek, 19 km east-northeast of Black Mountain; by original designation.

Other species: Species tentatively referrable to *Lophosaukia* have been listed by Shergold (1972). *Saukia(?) orientalis* Resser & Endo (*in* Endo & Resser, 1937) and *Prosaukia(?) orientalis* Kobayashi (1933a) certainly appear to belong to it, but some reservation must now be expressed over the inclusion of *Ptychaspis angulata* Mansuy *chinensis* Sun and *Prosaukia ulrichi* Kobayashi. The following further Asian material might be suggested as classifiable under *Lophosaukia* as a result of a study of Asian material housed in the U.S. National Museum. *'Eosaukia' baruvasi* Kobayashi (*pars*) (1957, pl. V, figs 13-20), from Tarutao Island, Peninsular Thailand; the bulk of the remainder of the specimens referred to *'E.' baruvasi* by Kobayashi (pl. V, figs 1-9) are referred below to *Mictosaukia* gen. nov. *Ptychaspis chinhsiensis* Sun (*pars*) (1924, p. 64-66, pl. IV, fig. 8a, ?8e), from the Shakuotun Limestone, Shakuotun, Chinhsihsien, Fengtien, China; this cranidium is reminiscent of that figured below as *Lophosaukia acuta. Ptychaspis cadmus* Walcott (1905, p. 70; 1913, p. 182, pl. 16, figs 19, 19a) from collection C41, lower part of the Chaumitien Limestone, 4.3 km SW of Chaumitien, Shantung, China. The illustrated specimens themselves, USNM 58111-2, are not determinable, but associated material belongs to a *Lophosaukia* species similar to *L. torquata.* A further species is described below from Black Mountain as *Lophosaukia acuta,* and another from Mount Datson as *Lophosaukia* sp. D. Three other taxa, *Lophosaukia* spp. A, B, and C, are noted from the Black Mountain and Dribbling Bore sections.

Distribution: In Australia the genus is known from western Queensland ('Chatsworth Limestone', Gola Beds), east-central Northern Territory (Huckitta/Marqua area) (Gilbert-Tomlinson *in* Casey & Gilbert-Tomlinson, 1956), and northwestern New South Wales (Comarto) (personal observation).

Lophosaukia torquata Shergold, 1972
(Pl. 18, figs 1-6)

1972 *Lophosaukia torquata* Shergold, p. 62-64, pl. 18, figs 1-6.

Holotype: CPC 9765, a cranidium figured by Shergold (op. cit., pl. 18, figs 1-3), from the Gola Beds of Momedah Creek, 19 km east-northeast of Black Mountain.

Occurrence: Originally described from the Gola Beds, the species has subsequently been found in the 'Chatsworth Limestone' of Black Mountain, where it occurs at horizons K114, K115, K116, K117, K118, at 128.5, 132, 138, 149, and 156 m from the base of the measured section, and perhaps at K120, 164 m from the base. The species also occurs in samples B507a″ and B507c, which are not accurately located with respect to the line of section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zone of *Pseudagnostus bifax* with *P. denticulatus.*

Material: Additional to the original paradigm are 15 cranidial, 25 librigenal, and 11 pygidial fragments. Four of these specimens, CPC 11779-82, are illustrated.

Diagnosis: See Shergold (1972, p. 61).

Differential diagnosis: The additional material allows amplification of the affinities of *Lophosaukia torquata,* which was previously described from cranidia alone. The librigena has wide borders and very long genal spines which are deflected outwards and backwards. Anteriorly the librigena is extended into an adventrally directed prong whose distal extremity is slightly expanded. In this respect *L. torquata* resembles some of the librigenae which Kobayashi (1957, pl. 5, figs 13-15) referred to *'Eosaukia' buravasi,* from Tarutao Island, Peninsular Thailand. The pygidium of *L. torquata* is narrow (sag.) and transversely elongated, very strongly resembling that of *Saukia(?) orientalis* Resser & Endo (*in* Endo & Resser, 1937).
Description: As there is little to add to the description of the cranidium already given (Shergold, op. cit.), this section describes the librigena and pygidium, previously not known.

The librigena is appreciably convex (tr. and exsag.), the margins not evenly curved but bulging anterolaterally. The borders are wide, especially anterolaterally, adorned with a low-density system of anastomosing raised lirae running nearly concentric with the margins. These lines are absent from the posterior librigenal border, which is smooth or has faint caecal markings when preserved with shell, punctate when exfoliated. Posteriorly the margins are drawn out into very long, stout genal spines, bearing identical sculpture with the lateral borders, and curved outwards from the exsagittal line. Anteriorly the margins are drawn into an adventrally oriented prong, swollen somewhat distally, which fits into the triangular anterior cranidial border. The facial suture cuts off a low ocular rim, mounted over a prominent subocular groove. The genal field bears perforated granules of various sizes, approximately arranged in five concentric rows, running more or less exsagittally. Exfoliated specimens show faintly the caecal system linking these granules.

The pygidium is transverse and narrow (sag.), its sagittal length being less than half the transverse width on the figured specimen (P. 18, fig. 6); Lp:Wp is 40%. The axis, transversely wide and sagittally short, runs backwards to the posterior pygidial margin, its terminal piece merging with the border. There are three axial rings, and a possible fourth; and three pleural segments evenly divided by wide (exsag.) and deep pleural furrows. The opisthopleuron of the first segment is confluent across the axial furrows with the first axial ring. Interpleural furrows are faint but always visible. All furrows arch outwards and rearwards across the transverse convexity of the pleural field and terminate abruptly at a flat, flange-like border. Granules are present on both pleural bands and the axial rings. The exfoliated specimen illustrated (Pl. 18, fig. 6) is additionally faintly punctate.

Lophosaukia acuta sp. nov.
(Pl. 18, figs 7-9)

?1916 *Ptychaspis angulata* Mansuy (*pars*), p. 34, pl. VI, figs 1a-b; *non* pl. V, figs 12a-b.

?1957 *Prosaukia angulata* (Mansuy); Lu, p. 284, pl. 147, fig. 12[=Mansuy, 1916, pl. VI, fig. 1a.]

non 1915 *Ptychaspis angulata* nov. sp.; Mansuy, p. 25-26, pl. III, figs 2a-v.

Name: L., *acuta,* acute, refering to the more acutely rounded frontal lobe of this species.

Holotype: CPC 11783, a near-complete exfoliated cranidium, illustrated in Plate 18, figs 7-9.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K116 and K117, 138 and 149 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zone of *Pseudagnostus bifax* with *P. denticulatus.*

Material: Three cranidia.

Size: The holotype has an estimated sagittal length of 5.50 mm. Its glabella (G) measures 4.20 mm, and the transverse width between the outer (abaxial) edges of the palpebral lobes is 8.00 mm.

Diagnosis: A species of *Lophosaukia* with thickened and massive anterior cranidial border; acutely rounded frontal glabellar lobe; very long posterolateral limbs; and high cranidial convexity (sag.).

Differential diagnosis: Most closely comparable to, and possibly synonymous with, *Lophosaukia acuta* are the specimens figured by Mansuy (1916, p. 34, pl. VI, figs 1a-b) from Loung-Co in Tonkin Province, Vietnam, as *Ptychaspis angulata.* From the material available the only distinguishing feature is the possibly more extensive cranidial border in *angulata.* That of *L. acuta* is not altogether complete, preventing direct comparison. Furthermore, Mansuy's specimen is tilted backwards, emphasizing the extent of the feature.

Lophosaukia acuta is similar to *L. torquata* in the arrangement of lobes and furrows, in convexity (sag.), in the positioning of its palpebral lobes, and in the density of its surface granulation. The species differ mainly in the shape of their frontal lobes, whose flanks are divergent forwards in *torquata,* convergent forwards in *acuta.*

Description: As a full description of *L. acuta* would for the larger part merely duplicate that given previously (Shergold, 1972 and above) for *L. torquata,* only selected features are discussed here.

The frontal lobe is more acutely rounded anteriorly than that of *L. torquata.* It is also a little more convex (sag.); when viewed in lateral profile (Pl. 18, fig. 7), with the dorsal surfaces of the occipital ring and preoccipital lobes in a horizontal plane, the anterior lateral glabellar furrows lie near vertical and the dorsal surface of the frontal lobe lies in the same plane. As in *L. torquata* the preglabellar furrow is very deep and lies partly below the frontal lobe in profile so that the latter overhangs it.

The palpebral lobes are close to the glabella, about half the glabellar length (sag.) (A:G is 52%, A:Gn is 42%), extending from the posterior half of the preoccipital lobes to the level of the median lateral furrows. The palpebral lobes are separated from the palpebral areas by deep palpebral furrows. The lobes themselves are grooved by a central furrow, as in *L. torquata.* The posterolateral limbs are very long and blade-like, perhaps a little longer proportionately than those of *torquata.*

It has been found impossible to differentiate the librigenae and pygidia which might belong to *L. acuta* from those of *L. torquata,* and their identity cannot be resolved until fully articulated material becomes available.

LOPHOSAUKIA sp. A
(Pl. 19, figs 2, 6)

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K124, K125, and K126, at 200, 202.5, and 232 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian A, Assemblage-Zone of *Pseudagnostus clarki maximus* with *P. papilio.*

Material: Four cranidial fragments and remains of five librigenae. Specimens CPC 11786-7 are illustrated.

Comment: None of the cranidia possess preparable frontal cranidial borders and they cannot be assigned definitely to *Lophosaukia.* One of the librigenae, however, CPC 11787, is very similar to that of *L. torquata.* Until better material is available these specimens are best considered left under open nomenclature.

LOPHOSAUKIA sp. B
(Pl. 19, figs 3-5)

Occurrence: 'Chatsworth Limestone', Dribbling Bore, horizons K185, K186, K187, and K189, at 0, 29, 31, and 46 m from the base of the measured section; and at B777 collected in 1957 from the same horizon as K187.

Age: Late Upper Cambrian, early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas.*

Material: Fragments of two cranidia and nine librigenae, of which specimens CPC 11788-90 are illustrated.

Comment: The illustrated material shows the prominent prong on the anterolateral extremity of the librigena which is characteristic of *Lophosaukia.* As no cephala or pygidia, which can be identified specifically, have been found the present material must be left under open nomenclature. The general appearance and surface sculpture on some of the illustrated specimens resembles that of some of the librigenae referred to *'Eosaukia' buravasi* (Kobayashi, 1957, pl. 5, figs 13-15) from Peninsular Thailand.

Lophosaukia sp. C
(Pl. 19, fig. 7)

Occurrence: 'Chatsworth Limestone', Black Mountain, horizon K139, at 375 m above the base of the measured section.

Age: Late Upper Cambrian, early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas.*

Material: An external mould of a single cranidial fragment.

Size: The cranidial length (sag.) is estimated to be more than 2.20 mm; the glabella (G) measures 1.60 mm (sag.).

Comment: This species of *Lophosaukia* has a narrow (sag.) triangular anterior cranidial border lying nearly in the horizontal plane, combined with an anteriorly tapering frontal glabellar lobe.

It differs from the earlier *L. torquata* and *L. acuta* in the shape and orientation of the anterior cranidial border, but is allied by the same characteristic to *L.* sp. D. It is distinguished from the latter, and from the type species, by its anteriorly tapering glabella, in which it is similar to *L. acuta.* It is distinguished from all other described species of *Lophosaukia* by its dense surface granulation, although the fact that it is only a small specimen may influence this observation.

Lophosaukia sp. D
(Pl. 19, fig. 1; Pl. 24, fig. 10)

Occurrence: 'Chatsworth Limestone', Mount Datson, horizons K175 and K178, 40 and 166 m from the base of the measured section.

Age: Late Upper Cambrian, Payntonian, Assemblage-Zones of *Pseudagnostus quasibilobus* with *Tsinania nomas,* and *Mictosaukia perplexa.*

Material: A single cranidium (CPC 11784) which is matched with a single pygidium (CPC 11804). Other parts of this species may be described as *Lophosaukia* sp. B from the Dribbling Bore section.

Comments: The species is characterized by its quadrate frontal lobe and narrow (sag.) triangular anterior cranidial border lying in or near the horizontal plane of the cranidium, and a short (sag.), transversely triangular pygidium with effaced furrows and narrow border. *Lophosaukia* sp. D is distinguished from *L. torquata* by the extent and orientation of its anterior cranidial border. This structure is a fairly wide (sag.) deltoid area in *L. torquata* and is turned adventrally at right angles to the horizontal plane of the cranidium. In *L.* sp. D the triangulation is much reduced, the apex is obtusely rather than acutely angled, and it lies much closer to the horizontal plane. Furthermore, the preocular facial sutures run nearly straight and only slightly divergent to the anterior margin, whereas in *L. torquata* and *L. acuta* they diverge more obviously. The frontal lobe of *L.* sp. D is more quadrate than that of *L. acuta,* but less so than that of *L. torquata.*

Description: The glabella is rectangular, parallel-sided, anteriorly evenly rounded, the frontal lobe being slightly wider (tr.) than the remainder of the glabella. This lobe has the same appreciable convexity (sag.) as the other species of the genus described above, with its dorsal surface at near right angles to the horizontal plane of the cranidium. The preoccipital furrows are wide (sag.) and deep, mesially confluent and curved rearwards. The median lateral furrows are short, faint, linear or with slight posterior median deflection. The anterior lateral furrows are very faint, almost indiscernible. The occipital ring is wider both transversely and sagittally than the preoccipital glabellar lobes.

The palpebral lobes are arcuate, well elevated above the palpebral areas, with an outer (abaxial) crescentic groove (palpebral ledge). They extend from the rear of the preoccipital glabellar lobes to the confluence of the median lateral furrows with the axial furrows, and are close to the glabella. The palpebral areas are thus narrow (tr.) and convex (tr.) 'pads'.

The anterior sections of the facial suture run straight forwards from the front of the palpebral lobes and cut the anterior cranidial margin at angles of approximately 110°. Anteriorly the cranidial border is broadly triangular, the enclosing sutures making an angle approaching 120° at its apex, with anterolateral margins curved slightly inwards. This border lies closer to the horizontal plane than in *L. torquata*.

The glabella bears large perforated granules, but the palpebral areas and lobes are either smooth or very finely granulose, as is the cranidial border.

The referred pygidium is short (sag.) but transversely elongated and triangular. The axis has two, or faintly three, axial rings, and two pleural segments are faintly indicated. The latter bear wide, faint pleural furrows, but their interpleural furrows are completely effaced on the single exfoliated specimen at hand. The pleurae extend nearly to the pygidial margins, and are separated from them by a very narrow and flat border. A post-axial ridge extends similarly close to the posterior margin.

Genus CALVINELLA Walcott, 1914

Type species: Dikelocephalus spiniger Hall, 1863, p. 143, pl. 10, figs 1-2, ?3, (*fide* Ulrich & Resser, 1933, p. 220), from the Trempealeau Formation, Trempealeau, Wisconsin, USA.

Other species: Species of *Calvinella* are too numerous to list here. Ulrich & Resser alone described 15 species and subspecies, and most others are also described from North America. Described below is *?Calvinella solitaria* sp. nov. from Black Mountain, western Queensland.

Comment: The species *solitaria* is tentatively assigned to *Calvinella* until further material, allowing observation of the details of the pygidium, is available. The illustrated cranidia differ significantly from those of the type species, *Calvinella spiniger* (Hall) (see below), the only positive characteristics for generic determination being the presence of a nuchal node or spine, and the dimensions and orientation of the preglabellar area. A greater degree of morphological correlation exists with Asian species and accordingly, as a temporary measure, the Australian material is questionably classified with them under *Calvinella*.

Distribution: North America (Wisconsin, Minnesota, Texas, Missouri, Nevada, ?New Jersey), Vietnam (Tonkin), South Korea, southern Manchuria, northern China, questionably Australia (western Queensland).

?CALVINELLA SOLITARIA sp. nov.
(Pl. 23, figs 1-7)

Name: L., *solitaria,* solitary, unaccompanied by other trilobites at the site of discovery.

Holotype: CPC 11791, a silicified cranidium preserved in chert, illustrated in pl. 23, fig. 1.

Occurrence: Ninmaroo Formation, Black Mountain, horizon K145, 461 m from the base of the measured section.

Age: Late Upper Cambrian, late Payntonian, *Mictosaukia perplexa* Assemblage-Zone.

Material: Five cranidial fragments, three librigenae, and two pygidial fragments, from which the illustrated paradigm, CPC 11791-6, has been selected.

Size: Only the holotype is well enough preserved for accurate measurement. It has a sagittal length of 4.90 mm, Gn is 4.00 mm, G is 3.20 mm, and the length of the palpebral lobes, A, is approximately 1.40 mm.

Diagnosis: A species tentatively assigned to *Calvinella* with the following complex of characteristics: a narrow anteriorly tapering glabella; glabellar furrows almost effaced on late holaspides, except for preoccipital furrows; small palpebral lobes placed well forwards on the genae; an occipital spine in small specimens, resorbed to a nuchal node in larger ones; four pygidial segments divided equally by pleural furrows; granulose surface.

Differential diagnosis: ?Calvinella solitaria differs from the type species, *C. spiniger* (Hall) (see Ulrich & Resser, 1933, p. 220-4, pl. 37, figs 18-29; pl. 38, figs 1-3, 34-35), in having a shorter (sag.) preglabellar area, narrower (tr.) glabella, and smaller palpebral lobes placed farther foward. Their librigenae are quite dissimilar, as far as can be judged from the fragments at hand.

In characteristics associated with the size and shape of the glabella and the extent of the preglabellar area, the most similar North American species is *Calvinella pustulosa* Ulrich & Resser (1933, p. 228-230, pl. 39, figs 1-10) from the basal Trempealeau Formation of Wisconsin; the shape and segmentation of the pygidium are also similar. It differs from *?C. solitaria* by its larger palpebral lobes sited farther to the rear of the genae, its denser surface granulation, and probably also the shape of its librigenae.

Among the Asian species, *?C solitaria* is morphologically closest to *C. walcotti* Mansuy (*non* Ulrich & Resser), especially to the specimen described by Sun (1924, p. 68-72, pl. V, fig. 2) from the Shakuotun Limestone of Fengtien, north China, and refigured by Lu (1957, pl. 148, fig. 5). Sun's specimen has similarly shaped and paucifurrowed glabella, and anteriorly sited palpebral lobes. Its main difference from *?C. solitaria* lies in the greater convexity (sag., exsag.) of the preglabellar area. In the respects noted here close morphological comparison may also be made with the specimen from the *Tsinania* Zone of the Wuhutsui Basin, southern Manchuria, illustrated by Kobayashi (1933a, p. 127, pl. XIII, fig. 1) as *Saukia aojii:* only coarser granulation seems to set this species aside from *?C. solitaria.* The majority of Mansuy's (1915, pl. II, pl. III) paradigm of *C. walcotti* have considerably deeper and more obvious glabellar furrows than those of *solitaria,* and bear larger granules, although the structure of the librigena in subsequently illustrated material (1916, p. 33-4, pl. V, figs 10a-j, 11a-b) is very similar.

Description: The anterior cranidial outline is evenly and gently rounded. The glabella is overall narrow (tr.), tapering unevenly forwards, constricted slightly at the levels of the preoccipital and median lateral furrows and bulged outwards (abaxially) at the corresponding lobes, and obtusely rounded anteriorly. The preoccipital furrows are shallow, arched gently rearwards and transversely connected, widening (sag.) mesially. The median lateral furrows in most specimens are very faint, slightly sloping backwards and inwards, and are not transversely connected. The anterior lateral furrows are extremely faint shallow notches lying on the anterolateral flanks of the glabella. One latex cast from an external mould (Pl. 23, fig. 5) shows much deeper furrows similar to those of *Calvinella walcotti* Mansuy (*sensu* Mansuy, 1915, 1916).

The occipital furrow is shallow, with a marked mesial platform on the holotype. The occipital ring is wider (tr.) than the preoccipital lobes and bears a nuchal spine in small specimens, which is resorbed to a node in larger ones.

The palpebral lobes are elevated, and separated from the palpebral areas by definite furrows. They extend from the preoccipital to the anterior lateral furrows, and are placed forwards on the cheek, being separated from the posterior cranidial marginal furrow by an area of gena equivalent to the total eye length (exsag.); they are close to the glabella. The palpebral areas have low convexity (tr.) and slope gently to the axial furrows. In front of the preglabellar furrow lies a narrow (sag.), gently convex preglabellar field which merges laterally with the preocular areas. This is separated from a slightly more convex (sag.) anterior border by a very shallow marginal furrow, indistinct mesially but deepened laterally. The anterior border and preglabellar field have approximately equal width (sag.). The anterior section of the facial suture diverges slightly from the front of the palpebral lobes and intersects the anterior margin at an obtuse angle. The posterior section encloses long (tr.) triangular posterolateral limbs.

The librigena is characterized by broad lateral and posterolateral borders with deep and narrow marginal furrows confluent posterolaterally. A prominent subocular groove is evident on one latex cast (Pl. 23, fig. 7), flanked by a prominent diverticulum, and a concentric series of raised, possibly caecal, lines. This specimen (CPC 11796) also possesses a long, narrow genal spine.

The pygidium has a rounded-triangular outline with presumably narrow borders and moderately wide doublure. The specimen illustrated in Plate 23, fig. 4 shows traces of four pleural segments divided equally by broad (exsag.) shallow pleural furrows reaching close to the pygidial margins. An associated meraspid pygidium has five pleural segments, and a long axis approaching close to the posterior pygidial margin, also with five segments.

The surface of the glabella is covered with a dense granulation. Librigenae in addition have raised concentric lirae on their borders and spines.

Genus MICTOSAUKIA nov.

Name: Derived from Gk, *miktos,* mixed or blended, prefixing the generic nomen *Saukia,* referring to the association of cranidium, pygidium, and librigenae which separately might resemble two different previously described genera.

Type species: Herein designated, *Tellerina orientalis* Resser & Endo *in* Endo, 1931, p. 89, figs 1-7; *ni* Endo & Resser, 1937, p. 293-4, pl. 57, figs 1-7, Wanwan Formation, near Tawenkou, 2.5 km NE of Niuhsintai Colliery, Manchuria [= *Ptychaspis chinhsiensis* Sun (*sic*) *sensu* Kobayashi, 1931, p. 182, pl. XXI, figs 1-2, pl. XXII, figs 12-16, Chiushukou Shale, Chiushukou, Houti, Hualienchai, Manchuria], because all its parts except the hypostoma are known.

Other species: The following species may be assigned to *Mictosaukia: Ptychaspis callisto* Walcott (1905, p. 72; 1913, p. 183-4, pl. 16, figs 14, 14′), upper limestone member of the Kiulung Group, 4.3 km southwest of Yenchuang, Sintai district, Shantung, China. *Ptychaspis bella* Walcott (1906, p. 585; 1913, p. 180, pl. 17, fig. 9), collection C74, top of Kichou limestones, 6.5 km east of Fanglanchon, Shansi, China. *Ptychaspis chinhsiensis* Sun (*pars*) (1924, p. 64-66, pl. IV, figs 8b, 8c, 8f, *non* figs 8a, 8e = *Lophosaukia?* sp., or 8d?), Shakuotun Limestone, Chinhsihsien, Fengtien, China. *'Eosaukia' buravasi* Kobayashi (*pars*) (1957, p. 376-8, pl. 5, figs 1-5, 7-10, *non* figs 6, 11, 13-20 = *Lophosaukia?* sp.), Tarutao Island, Peninsular Thailand. *Saukia globosa* Robison & Pantoja-Alor (1968, p. 795-6, pl. 104, figs 12-19), Tiñu Formation, Nochixtlán, Mexico. *Saukia wirtzi* Wolfart (1970, p. 43-47, pl. 8, figs 8-9; pl. 9, figs 2, 3?, 4-7; pl. 10, figs 1-2, 3?, 4-6, 7?; pl. 11, figs 1-3), Tremadocian, Surkh Bum, Afghanistan. Some of the species illustrated as *Ptychaspis walcotti* by Mansuy (1915, 1916) may subsequently prove to belong to *Mictosaukia.* The presence of the genus may be suspected in South Korea (*Dictyites* Zone), where it is possible that fragments have been described by Kobayashi (1935c, p. 315, pl. IV, fig. 11) as *Calvinella walcotti* (Mansuy) and (fig. 17) as *Calvinella?* sp. Some of the specimens placed in *Tellerina coreanica* Kobayashi (loc. cit., figs 12, 13) may also prove congeneric. *Mictosaukia perplexa* sp. nov. is described below.

Distribution: China (Shansi, Shantung, Fengtien), Manchuria, South Korea?, Peninsular Thailand, possibly North Vietnam, Afghanistan, Mexico, and Australia (western Queensland).

Age: Late Cambrian (in Asia, Fengshanian, late Yenchouan, and Wanwanian; in Australia Payntonian) to early Ordovician (Tremadocian in Afghanistan and Mexico).

Diagnosis: A saukiid genus with cranidial characteristics resembling *Saukia* in having a narrow (tr.) glabella gently rounded anteriorly, and similar configuration of the anterior cranidial border, but resembling *Tellerina* in the extent of the preglabellar area and in possessing long, thin posterolateral limbs. The late holaspid librigena has only a small genal spine, and the lateral and posterior marginal furrows terminate together in front of the genal spine base. The pygidium is transverse, subtriangular, with axis reaching close to the posterior margin, pleura bisected equally by pleural furrows, and narrow borders (tr.) without well-defined marginal furrows.

Differential diagnosis: Mictosaukia differs from *Saukia* in having a narrower (tr.) preglabellar area, and obliquely directed anterolateral cranidial marginal furrows. The palpebral lobes are set less close to the axial furrows and the posterolateral limbs are considerably longer (tr.). The librigena of *Mictosaukia* has a much shorter genal spine and crenulate posterolateral margins on exfoliation of the shell. Among other trilobites the asaphacean *Symphysurina woosteri* Ulrich (*in* Walcott, 1925, pl. 21, fig. 5) has similar 'peculiar depressions on the underside of the doublure'. The pygidium of *Mictosaukia,* as typified by that of *M. orientalis* (Resser & Endo) (see 1937, pl. 57, fig. 6), is shorter (sag.) and more transversely triangular than that of *Saukia.*

The new genus is differentiated from *Tellerina* on the following points: the genal spines of the latter are always long and stout, and while the lateral and posterior marginal furrows unite in a similar way at the genal angle, they are continued in *Tellerina* well into the spine bases. *Tellerina* has a proportionately broader glabella, anteriorly obtusely rounded, quite unlike the narrow (tr.), more acutely rounded glabella of *Mictosaukia.* The anterior glabellar furrows are usually faint in the latter, giving the appearance of an extended (sag.) frontal lobe. This feature is seen in neither *Saukia* nor *Tellerina.* The unequal division of the pygidial pleura of *Tellerina* and *Calvinella* is not shared by *Mictosaukia,* whose pleura, like those of *Saukia,* are equally bisected.

MICTOSAUKIA PERPLEXA sp. nov.
(Pl. 24, figs 1-9)

Name: L., *perplexa,* puzzling, a reference to the initial uncertainty regarding the constitution of this species.

Holotype: CPC 11805, an incomplete cranidial mould figured in Plate 24, fig. 9.

Occurrence: 'Chatsworth Limestone', Mount Datson, horizons K178, K180, and K181, at 166, 185, and 197 m from the base of the measured section; Dribbling Bore, horizon K192, 105 m from the base of the measured section.

Age: Late Upper Cambrian, late Payntonian, Assemblage-Zone of *Mictosaukia perplexa.*

Material: 37 cranidial and 11 librigenal fragments, specimens CPC 11797-803, 11805, forming the illustrated paradigm.

Size: Most of the cranidia are incomplete—the occipital ring is usually broken away—and many others lack the preglabellar area. As a measurement of size glabellar lengths (sag.) are thus quoted. For available measured specimens Gn varies between 6.10 and 11.50 mm, and G between 4.90 and 9.20 mm.

Diagnosis: A species of *Mictosaukia* having very long (tr.) posterolateral limbs; anteriorly expanding glabella with effaced median and anterior lateral furrows; faintly granulose moulds; librigena with very short spines; displaying anastomosing terrace lines on testaceous specimens.

Differential diagnosis: The cranidium of *Mictosaukia perplexa* is morphologically very similar to the specimen figured by Walcott (1913, p. 180, pl. 17, fig. 9) as *Ptychaspis bella.* The latter specimen is preserved mainly with shell intact: only the glabella is exfoliated, and this lacks the faint granulation of *M. perplexa.* The characteristic librigenal prosopon of the Australian species is present on the palpebral and preocular areas of *M. bella,* and both species have a granulose anterior cranidial border of approximately equivalent dimensions (sag., tr.).

Ptychaspis callisto Walcott is also preserved as fragments as limestone moulds. The median lateral glabellar furrows are slightly better defined on the former, but there is little other difference in the cranidium. *M. callisto* appears to have had a finely granulose test, as evidenced by unfigured external moulds in Walcott's collections, but the illustrated specimen (USNM 58095) is highly exfoliated and punctate, as are many specimens of *M. perplexa.* The exfoliated and punctate librigena which is Walcott's figure 14a has the same characteristics as that figured here on Plate 24, fig. 3, and similar crenulate margins.

The cranidia and librigenae listed above which Kobayashi (1957) referred to *'Eosaukia' baruvasi,* although preserved in an arenaceous matrix, are also extremely similar to *Mictosaukia perplexa* as figured below. The librigenae have similar small genal spines and crenulate margins, but are granulose rather than lirate. Three of Kobayashi's librigenae (op. cit., pl. V, figs 13-15), the two pygidia (loc. cit., figs 16-17), and probably the three cranidia (loc. cit., figs 18-20) appear to represent together a species of *Lophosaukia,* a genus also associated with *Mictosaukia* in Queensland.

Saukia globosa Robison & Pantoja-Alor and *Tellerina orientalis* Resser & Endo have very similar pygidia, but cranidially *S. globosa* is morphologically more similar to *M. perplexa* than *T. orientalis.* It has, however, a granulose librigena with a much longer spine than is evident in other species assigned to *Mictosaukia.* Although exfoliated and poorly preserved, the librigena of *orientalis* shows the small spine typical of *perplexa.*

Saukia wirtzi Wolfart differs from *M. perplexa* in having a wider (tr.) preglabellar area, and anteriorly a distinctly pointed outline (sag.). The librigenae illustrated by Wolfart (1970, pl. 10, figs 4a-b) are similarly lirate and short-spined. As in other species of *Mictosaukia,* the glabellar furrowing anterior to the preoccipital furrow is ill defined. *S. wirtzi* shares pygidial characteristics with *M. orientalis* (Resser & Endo) and *M. globosa* (Robison & Pantoja-Alor), and bears a short nuchal spine in early holaspides (Wolfart, 1970, pl. 8, figs 8-9).

Description: The anterior cranidial outline is gently and evenly rounded. The glabella is long and narrow, widest (tr.) at the preoccipital lobes and across the frontal lobe, somewhat constricted about the preoccipital and median lateral furrows and the median lateral lobes to give an apparent anterior expansion. The frontal lobe is anteriorly obtusely rounded. The preoccipital furrows are transversely connected, wide (sag., exsag.) and deep, arching rearwards. The median lateral furrows are shallow, curving rearwards, unconnected mesially. The anterior lateral furrows are slightly curved, very faint and short. The occipital ring, slightly wider (tr.) than the preoccipital lobes, lies below or at the level of the dorsal surface of the glabella in lateral profile, and is without a nuchal node or spine.

The preglabellar furrow is narrow and deep (sag.), and separates the glabellar from a preglabellar area which is sagittally undifferentiated into preglabellar field and border. The preglabellar area is convex (sag.), falling away steeply to the preglabellar furrow and anteriorly to the cranidial margin (Pl. 24, figs 7-8). Laterally, the preglabellar furrow merges with a transverse depression separating the preglabellar area from the preocular fixigenal areas (Pl. 24, figs 2, 9). The palpebral lobes are relatively small, placed to the rear of the genae, extending from near the middle of the preoccipital glabellar lobes to mid or anterior parts of the anterior lateral lobes, and separated from steeply inclined palpebral areas by well-defined palpebral furrows. The anterior section of the facial suture runs directly forwards from the front of the palpebral lobe, but the posterior section is deflected strongly outwards to enclose long (tr.) straight posterolateral limbs.

The librigena is appreciably convex (tr., exsag.) with thickened lateral borders and stout genal spine bases. The lateral marginal furrow is wide and shallow, and the posterior marginal furrow much restricted by the elongated posterolateral limbs of the cranidium. Exfoliated librigenae show the presence of up to eight overlapping crenulations, separated by chevronate depressions, sited on the posterolateral margins, just in front of the genal spine bases. Progressive stripping of the shell to reveal these features is illustrated in Plate 24, figs 3-5.

The surface of the glabella on the exfoliated material available is faintly granulose, but some smooth specimens are punctate. The testaceous librigena is strikingly lirate, the numerous raised lirae running concentric to the exsagittal curvature. The lateral borders and spines are similarly lirate. Exfoliated specimens show punctae inserted between these lirae which appear to be expressions of a suppressed granulosity (Pl. 24, fig. 6).

Family PTYCHASPIDIDAE Raymond, 1924

Genus PTYCHASPIS Hall, 1863

Subgenus ASIOPTYCHASPIS Kobayashi, 1933

Type species: Ptychaspis ceto Walcott (1905, p. 73; 1913, p. 185-6, pl. 16, figs 17, 17a-b, 17d, *non* fig. 17c), from the Chaumitien Limestone of Shantung, China; designated by Kobayashi (1933a). The species has subsequently been recorded by Kobayashi (1933a, 1951), Resser & Endo *in* Endo & Resser (1937), and Endo (1939).

Other species: Ptychaspis calyce Walcott (1905, p. 72; 1913, p. 184, pl. 16, figs 15, 15a) from the Chaumitien Limestone of Shantung, China; *Ptychaspis subglobosa* Grabau *in* Sun (1924, p. 72-5, pl. V, figs 3a-d), also recorded by Kobayashi (1933a, p. 118-9, pl. XII, figs 1-7; 1935c, p. 318, pl. V, fig. 13) and Sun (1935, p. 28, pl. IV, figs 10-12), from Shantung and Hopei, China, Wuhutsui Basin, southern Manchuria, and South Korea; *Asioptychaspis sphaira* Kobayashi (1933a, p. 119, pl. XII, figs 11-13), from the Wuhutsui Basin, southern Manchuria; *Ptychaspis brevicus* Sun (1935, p. 28-9, pl. IV, figs 7-9), from Huolu, northern China; *'Ptychaspis' sphaerica* Resser & Endo (*in* Endo, 1931, p. 89, text-figs 10-13; *in* Endo & Resser, 1937, p. 273, pl. 55, figs 10-13), from the Wuhutsui Basin, southern Manchuria; *'Ptychaspis' asiatica* Resser & Endo *in* Endo & Resser (1937, p. 272-3, pl. 56, figs 4-9), from the Taitzuho Valley, southern Manchuria. Questionable species are: *Ptychaspis shansiensis* Sun (1935, p. 29-31, pl. IV, figs 1-6), from Shansi, northern China; and *Ptychaspis? fengshanensis* Sun (1935, p. 31-2, pl. IV, fig. 13), from Hopei, northern China. The Australian species is *Ptychaspis* (*Asioptychaspis*) *delta* sp. nov., from Black Mountain, western Queensland.

Distribution: Northern China, southern Manchuria, South Korea, Australia.

Comment: Asioptychaspis is differentiated from *Ptychaspis* (type *Dikelocephalus miniscaensis* Owen, 1852) by its adventrally curved posterior pygidial margin. This difference in itself is considered insufficient to warrant distinct generic classification, so that *Asioptychaspis* is here regarded as a subgenus of *Ptychaspis*.

PTYCHASPIS (ASIOPTYCHASPIS) DELTA sp. nov.
(Pl. 29, figs 1-4)

Name: Gk, *delta,* letter D, referring to the shape of the pygidium.

Holotype: CPC 11825a, pygidium preserved with shell, illustrated in Plate 29, fig. 2, with counterpart mould CPC 11825b, Plate 29, fig. 3.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizon K138, 374 m from the base of the measured section.

Age: Late Upper Cambrian, early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas.*

Material: One cranidium and three pygidia. Specimens CPC 11824-6 are illustrated.

Size: All specimens are small. The cranidial length (sag.) measures 2.50 mm, Gn is 2.10 mm, and G 1.75 mm. The holotype pygidium has a sagittal length (Lp_2) of 2.20 mm, an axial length (sag.) of 1.70 mm, and a width (tr.) of 4.10 mm. The three pygidia vary in length between 2.10 and 3.40, and in width between 3.70 and 7.00 mm.

Diagnosis: A species of *Ptychaspis* (*Asioptychaspis*) characterized by sinuous pygidial margins, posteriorly rounded, and somewhat elongated (sag.), adventrally sloping posterior border. The cranidium has a relatively wide (sag.), convex (sag.) preglabellar area lying more or less in the horizontal plane of the specimen, and directly visible when viewed dorsally.

Differential diagnosis: The cranidium of *Asioptychaspis delta* is distinguished from all previously described species of the subgenus by its anteriorly wide (sag.) preglabellar area, which approaches that of *Quadraticephalus* spp. in proportion to the remainder of the cranidium. The glabellar furrowing, though faint, is typical of *Ptychaspis,* having two transversely continuous furrows (preoccipital and median lateral) and a third pair mesially discontinuous (anterior lateral). The pygidium closely resembles those of both *Asioptychaspis subglobosa* and *A. sphaira* in its downturned borders but is differentiated from both by being posteriorly extended into a relatively wide (sag.) post-axial area.

Description: The cranidium is anteriorly gently rounded. The glabella is rectangular, parallel-sided with a slight constriction at the preoccipital glabellar furrows, anteriorly obtusely rounded. The preoccipital furrows are faint, posteriorly arched, and mesially continuous, laterally becoming confluent with the axial furrows. The median lateral furrows run concentric with the preoccipital ones but are slightly fainter. The anterior lateral furrows are very faint, more or less transverse, mesially discontinuous.

The occipital ring is transversely wider than the preoccipital glabellar lobes, but sagittally considerably narrower, and bears a small nuchal node.

The palpebral lobes, placed well forwards and sited between the preoccipital and anterior lateral furrows, are close to the glabella, and separated from it by narrow (tr.) convex palpebral areas. The anterior sections of the facial suture appear to diverge considerably from the front of the palpebral lobes, curving outwards before closing in to cut the anterior cranidial margin at obtuse angles. The courses of the posterior sections cannot be definitely followed, but they enclose broadly triangular posterolateral limbs. The preglabellar furrow is shallow, with a pair of pits at the anterolateral corners of the frontal lobe. The preglabellar area, undifferentiated into preglabellar field and border, is gently convex (sag.), sloping forwards from an indefinite point on its transverse mid-length.

The pygidium is triangular, with sinuous sides, acutely rounded rear, and pointed anterolateral corners; L:W varies between 48.50 and 56.75%. Its margins are entire and slightly sloping adventrally. The axis is elevated and has four segments, together with an ovoid terminal piece. The articulating half-ring is a very narrow (sag.) crescentic bar or band. There are three pleural segments with straight and shallow pleural furrows dividing each pleuron equally. The interpleural furrows are faint, paralleling the pleural ones. The borders are reasonably wide, especially posteriorly, and downsloping.

All specimens are finely and minutely granulose, having a sandpaper texture. Additionally the borders of the pygidium are characterized by raised terrace lirae running concentric with the margins, and most prominent in the post-axial area.

Genus QUADRATICEPHALUS Sun, 1924

Type species: Quadraticephalus walcotti Sun (1924, p. 63, pl. IV, figs 6a-d), from the Kaolishan Limestone of Taian, Shantung, China; by original designation.

Other species: Kobayashi (1960b, p. 402) has listed all previously described species which he considers to constitute the genus. Included are *Quadraticephalus? convexus* Sun, 1924, and *Ptychaspis shansiensis* Sun, 1935, which are probably not congeneric. The latter appears to belong to *Asioptychaspis,* as does one of Walcott's (1913, pl. 16, fig. 13a) illustrated specimens of *Quadraticephalus calchas*. Cranidia and librigena assigned by Kobayashi (1957, pl. IV, figs 13-15) to *Coreanocephalus planulatus* appear to be compatible with the concept of *Quadraticephalus* as presently understood. *Coosia? bianos* Walcott (1913, p. 210-211, pl. 21, figs 10, 10a) has undoubtedly a cranidium of the type of *Quadraticephalus linyuensis* Sun or *Q. howelli* Sun, and its pygidium is very closely related to the material described below from western Queensland. It seems very likely that the librigena (USNM 58127) described by Walcott (1913, p. 186, pl. 21, fig. 14), from the same locality as the cranidium and pygidium, under *Ptychaspis?* sp. undet., belongs also to *Q. bianos* (Walcott). Similarly, the librigena (USNM 58121), also described (Walcott, op. cit., pl. 17, fig. 6) as *Ptychaspis?* sp. undet., may belong to a species of *Quadraticephalus.*

Distribution: Northern and southern China (Shantung, Hopei, Yunan), southern Manchuria, South Korea, Peninsular Thailand, and Australia (western Queensland and Northern Territory).

Comment: Intergrading morphological characteristics, especially in the cranidium, gave rise during the late Payntonian (late Fengshanian) to a complex of ptychaspidid genera which includes *Asioptychaspis, Quadraticephalus, Changia,* and *Coreanocephalus*. Generally, cranidia of *Asioptychaspis* and *Quadraticephalus* are readily differentiated by the orientation of their preglabellar areas, sloping strongly adventrally in the former, but broad (sag.) and more or less horizontally inclined in the latter; but gradations apparently occur. These are evident in

Walcott's collections from the inclusion of specimens with *Quadraticephalus*-type preglabellar area and *Asioptychaspis*-type glabellar structure within *Quadraticephalus calchas* (Walcott), and in Kobayashi's collections from the illustrations of *Q. coreanicus* (Kobayashi, 1960b, pl. 20, figs 2 and 5) where a similar situation prevails. Early holaspid cranidia (undescribed), presumably of *Q. calchas,* from the Walcott collection have typical *Asioptychaspis* glabellar furrowing and inflated frontal lobes, and the preglabellar area is decidedly short (sag.). Several described species of *Quadraticephalus* have also been assigned pygidia remarkable for their similarity to those of known *Asioptychaspis* species, e.g. *Q. elongatus* Kobayashi (1935c, p. 321, pl. VI, figs 8-9).

The morphological differences between cranidia of *Quadraticephalus* and *Changia* Sun, 1924, are slight, and fragmentary material cannot be adequately determined unless palpebral lobes are preserved together with the glabella. Resser (1942b, p. 48) regarded these genera as synonymous, but as interpreted by Kobayashi (1933a, 1935c), they can be differentiated by the size and position of the palpebral lobes and the shape of the posterolateral limbs. In *Quadraticephalus* the palpebral lobes are small and placed well forwards adjacent to the anterior lateral glabellar lobes, and the posterolateral limbs are quite broadly triangular. In *Changia* the palpebral lobes are considerably longer (exsag.), extending rearwards to the middle of the preoccipital lobes, and the posterolateral limbs are accordingly narrow (exsag.) and blade-like. The pygidium is known for only one of the three species listed for *Changia* by Kobayashi (1960b, p. 401): the type species, *C. chinensis* (see Sun, 1924, pl. IV, fig. 5g). Although this pygidium is damaged it is not very different from those described below as *Quadraticephalus* cf. *teres* or from *Q. bianos* (Walcott). It is likely that in its undistorted state it had a similar outline to the pygidia of these species but that it had an additional segment in both pleural and axial regions.

Coreanocephalus has characteristics intergrading with both *Changia* and *Quadraticephalus.* The type species, *Coreanocephalus kogenensis* Kobayashi (1935c, p. 313, pl. IV, figs 15a, 16), can only be differentiated from *Changia* on account of its broad flat-lying preglabellar areas, as distinct from the convex structure of *Changia.* Its palpebral lobes are of similar length (exsag.), and its posterolateral limbs of similar shape. *Coreanocephalus* (?) *tenuisulcata* Kobayashi (1935c, p. 314, pl. IV, figs 6-8) does in fact have the convex (sag.) preglabellar area. Having slightly smaller palpebral lobes, placed farther forwards, and convex (sag.) preglabellar area, *C. planulatus* Kobayashi (1957, pl. IV, figs 13-15) is also similar to *Quadraticephalus.*

QUADRATICEPHALUS cf. TERES Resser & Endo *in* Endo & Resser 1937
(Pl. 28, figs 1-9; Text-fig. 50)

cf. 1937 *Quadraticephalus teres* Resser & Endo *in* Endo & Resser, p. 278, pl. 56, fig. 12.

Occurrence: The type specimen, USNM 86903, was described from the Yenchou Formation, near Hsichangshutung, 10 km northeast of Liaoyang, Manchuria. The Australian material is from the 'Chatsworth Limestone' of Mount Ninmaroo, horizons K168, K169, and K170, at 67, 68, and 68.5 m from the base of the measured section; and at Mount Datson, horizon K178, 166 m from the base of the measured section there. A comparable species is known from the Northern Territory (see below).

Age: Late Upper Cambrian, Payntonian, Assemblage-Zones of *Pseudagnostus quasibilobus* with *Tsinania nomas* and of *Mictosaukia perplexa.*

Material: Fragments of 9 cranidia, 12 pygidia, and 3 librigenae. The illustrated series comprises specimens CPC 11827a-34.

Size: None of the cranidia are complete enough to assess their sizes quantitatively. The pygidia are more complete, and vary in sagittal length between 4.00 and 15.50 mm.

Diagnosis: The species is diagnosed by Resser & Endo (1937, p. 278).

Differential diagnosis: Cranidia of *Quadraticephalus* cf. *teres* are most similar morphologically to that of *Q. teres* Resser & Endo, 1937, from Manchuria, having similar subrectangular glabella, obtusely rounded anteriorly, and similarly sized and oriented palpebral lobes (although these are not well preserved on the Manchurian material). Similar glabellar and preglabellar morphology is also evident on the cranidia which Kobayashi (1957, pl. IV, figs 13-15) assigned to *Coreanocephalus planulatus* from Thailand, and those which Sun (1924, pl. IV, figs 6a-c) illustrated as the type species of *Quadraticephalus, Q. walcotti.* The cranidia of these species, together with *Q. coreanicus* Kobayashi (1935c, pl. VI, figs 1-5, see 1960b, p. 402), are differentiated from those of *Q. pyrus* Kobayashi (1933a, pl. XIII, fig. 8) and *Q. manchuricus* Kobayashi (loc. cit., figs 2-7) from the Wahutsui Basin of southern Manchuria principally by their glabellar outlines, the Manchurian species having anteriorly tapering glabellae. All these species are differentiated from *Q. calchas* (Walcott) (1913, pl. 16, fig. 13, *non* fig. 13a; and *sensu* Kobayashi (1933a, pl. XII, figs 8-9)) by their weaker glabellar furrowing and less inflated frontal glabellar lobes. They are all differentiated from *Q. linyuensis* Sun (1935, pl. VI, figs 5-6) from Hopei, China, *Q. howelli* Sun (loc. cit., figs 11a-b) and *Q. bianos* (Walcott) (1913, pl. 21, fig. 10), from Shantung, China, by their less extensively developed preglabellar areas.

The pygidium of *Q.* cf. *teres* is most similar in shape and segmentation to that of *Q. bianos* (Walcott) (Walcott's original figure, pl. 21, fig. 10a, is quite unrepresentative of the actual specimen, USGM 58229). Other pygidia attributed to species of *Quadraticephalus* are more transverse, sagittally shorter, and have fewer segments, e.g. *Q. manchuricus* (see Kobayashi, 1933a, pl. XIII, figs 6-7) and *Q. coreanicus* (see Kobayashi, 1935c, pl. VI, figs 4-5, as interpreted by Kobayashi 1960b, p. 402).

Librigenae of *Q.* cf. *teres* are similar to those ascribed to most other species, and to those of *Changia, Coreanocephalus,* and *Caznaia* (below).

'Quadraticephalus' aff. *teres* has previously been reported from the Huckitta region of the Northern Territory by Gilbert-Tomlinson (*in* Casey & Gilbert-Tomlinson, 1956).

Description: The cranidium is gently angled anteriorly. The glabella is long (sag.), relatively narrow (tr.), widest (tr.) at the preoccipital glabellar lobes, very slightly constricted adjacent to the palpebral areas, and gently rounded anteriorly. Only faint indications of the glabellar furrowing are present laterally on the glabellar flanks of some specimens; others are apparently unfurrowed. Where visible three pairs are seen. The occipital ring is broken on most specimens and it is impossible to gauge its width (tr.). It appears to have a small nuchal node (Pl. 28, fig. 3).

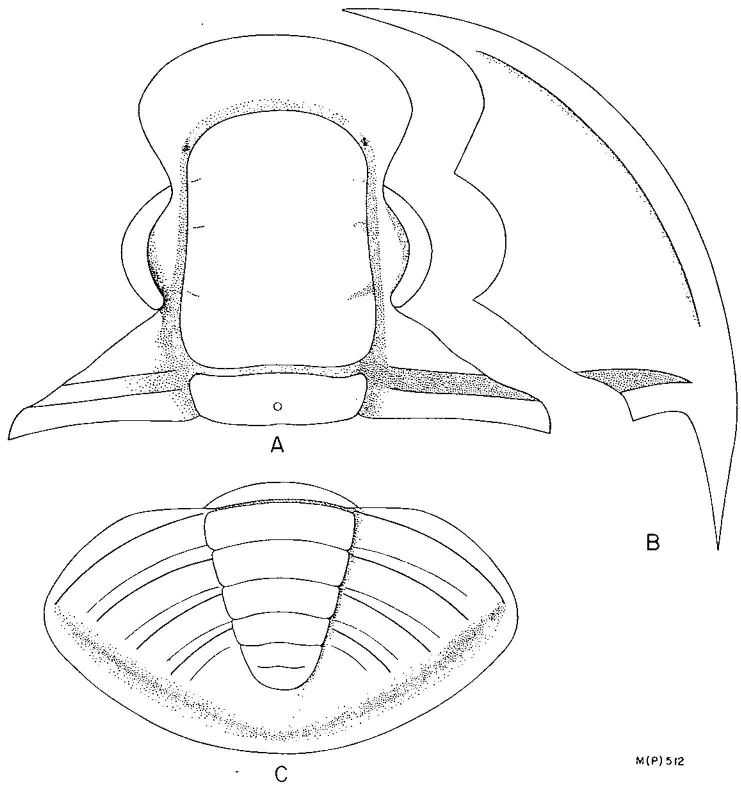

Fig. 50. Reconstruction of *Quadraticephalus* cf. *teres* Resser & Endo *in* Endo & Resser, 1937; (A) cranidium based on CPC 11828, x5; (B) librigena based on CPC 11833, x3; and (C) pygidium based on CPC 11829, x8.5.

A faint median ridge runs almost the length (sag.) of the glabella on exfoliated surfaces.

The palpebral lobes are crescentic, pointed anteriorly and bluntly rounded posteriorly. Distinct furrows separate them from the palpebral areas, which are very narrow (tr.). The palpebral lobes are thus close to the glabella, sited on the genae between the rear of the median lateral glabellar lobes and the anterior lateral furrows. Evidence from the librigenae indicates that the posterolateral limbs were large and triangular. The anterior sections of the facial suture diverge from the front of the palpebral lobes, then swing in a slightly sigmoidal curve to the anterior cranidial margin. The preglabellar furrow is shallow and fairly wide (sag.), and bears two pits, one at each of the anterolateral corners of the frontal lobe. Adjacent to the glabella the preglabellar field is gently convex (sag.), but flattens as it passes to the anterior cranidial margin, where there is apparently neither marginal furrow nor well differentiated border.

The librigena is characterized by a long sinuous margin along the course of the postocular facial suture, and a short posterior margin. The structure as a whole is gently convex (tr., exsag.) with a faint marginal depression, but no furrow or border apart from a slightly upraised rim. The genal spine is short.

The pygidium is rounded-triangular, with entire margins and broad flat or gently concave (tr.) borders, without marginal furrows. All specimens show four pleura, divided by narrow (exsag.) pleural furrows which follow the transverse convexity of the shield, fade out across the borders, and bisect the pleura equally. The interpleural furrows are very faint and obliterated on most specimens. The axis, consisting of five segments and a small triangular terminal piece, ends somewhat in front of the posterior margin of the shield, and is separated from it by a very faint post-axial ridge.

The surfaces of cranidium, librigena, and pygidium are smooth.

Family IDAHOIIDAE Lochman, 1956

Genus MALADIOIDELLA Endo *in* Endo & Resser, 1937

Type species: Maladioidella splendens Endo *in* Endo & Resser, 1937, p. 346-7, pl. 69, figs 13-18, from the Daizan Formation, Paichiashan, Manchuria, by original designation.

Other species: Crepicephalus chinchiaensis Endo *in* Endo & Resser, (1937, p. 345, pl. 69, fig. 20), Daizan Formation, Paichiashan, southern Manchuria. *Maladioidella convexolimbata* Endo *in* Endo & Resser (1937, p. 347-8, pl. 69, fig. 10) is considered not to be congeneric with the two species cited above. *Maladioidella elongata* Endo (1944, p. 84, pl. 8, fig. 12) is not readily interpretable from the published account or illustration. *Maladioidella* cf. *chinchiaensis* and *Maladioidella* sp. are described below from western Queensland.

Distribution: Southern Manchuria, northern China, Australia.

Age: Daizanian (in Manchuria and China = ?pre-Payntonian in Australia) to Payntonian (Australia).

Comments: Crepicephalus chinchiaensis is referred here to the genus *Maladioidella* because of the similarity of its preglabellar area to those seen in three of Endo's type cranidia (Endo, 1937, pl. 69, figs 13, 14 and 16). The genus is removed from the family Pterocephaliidae, where it was classified by Lochman-Balk (*in* Moore, 1959), and placed in Idahoiidae Lochman, 1956, because the shape of its glabella, the structure of its preglabellar area, and the positioning of the palpebral lobes with respect to the glabella are so similar to those of *Idahoia* Walcott, 1924. *Maladioidella* apparently lacks the nuchal spine typical of *Idahoia.*

MALADIOIDELLA cf. CHINCHIAENSIS (Endo *in* Endo & Resser, 1937)

(Pl. 51, figs 4-6)

cf. 1937 *Crepicephalus chinchiaensis* Endo *in* Endo & Resser, p. 345, pl. 69, fig. 20.

Comment: Endo's species *Crepicephalus chinchiaensis* comes from horizon F9 on the Paichiashan Hill section, southern Manchuria (Endo, 1937, p. 303-5), 15 m above horizon F10 containing the type species of *Maladioidella, M. splendens,* and 44.7 m below the Yenchouan Stage characterized by tsinaniid and saukiid faunas. The Australian species occurs in a similar stratigraphical position with regard to the base of the Payntonian Stage.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K121 and K123, at 171.5 and 185 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian A, Assemblage-Zone of *Pseudagnostus clarki maximus* with *P. papilio.*

Material: The material includes fragments of four large cranidia and four librigenae. Specimens CPC 11997-9 are figured.

Differential diagnosis: The specimens are referred to *M.* cf. *chinchiaensis* because the nature of the palpebral areas and lobes on the type specimen are not clearly defined. Australian and Manchurian species are comparable in glabellar and preglabellar features. In both, the preglabellar area has similar length (sag.) and both have the long (sag.) anterior cranidial border.

M. chinchiaensis differs from the type species, *M. splendens,* in having a shorter (sag.) preglabellar field and correspondingly longer anterior cranidial border. The glabella is somewhat more quadrate and distinctly less acutely rounded anteriorly, and the ocular ridges are less well defined. *M.* cf. *chinchiaensis* has considerably shorter (tr.) posterolateral limbs than *M. splendens,* and probably its palpebral lobes are sited a little farther to the rear.

Description: The cranidium is strongly rounded anteriorly. The glabella, proportionately quite short (sag.), tapers forwards, has a slight constriction opposite the anterior end of the palpebral lobes, and is obtusely rounded anteriorly. When preserved with shell, the glabellar furrows are effaced, but parietal surfaces show faint traces of three furrows. The occipital furrow is weak and the occipital ring poorly differentiated from the glabella.

The palpebral lobes are arcuate, short (exsag.), extending across the mid-length of the glabella between the preoccipital and anterior glabellar furrows. They are placed close to the glabella. Palpebral furrows are poorly defined. Faint ocular ridges connect the front of the palpebral lobes to a weakly defined parafrontal band which runs immediately anterior to the shallow preglabellar furrow.

The preocular facial sutures diverge appreciably from the front of the palpebral lobes, and cut sagittally equally sharply to enclose a long (sag.) cranidial border and short (sag.) preglabellar field. The anterior cranidial marginal furrow is faint, shallow, and bowed rearwards sagittally. The postocular facial sutures enclose relatively short triangular posterolateral limbs which bear deep and distally wide (exsag.) posterior marginal furrows.

The librigena has a sharply defined eye socle, and shallow lateral marginal furrows which curve posterolaterally to separate a very broad spine base. The genal spine is, however, short and delicate. Anteriorly the lateral margin is extended into a long projection which in articulated specimens would surround the anterior cranidial border.

Both shell and parietal surfaces are minutely punctate.

MALADIOIDELLA sp.
(Pl. 51, fig. 3)

Occurrence: 'Chatsworth Limestone', Dribbling Bore, horizon K189, 46 m from the base of the measured section.

Age: Late Upper Cambrian, early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas.*

Material: A single cranidium CPC 11996.

Size: The cranidial length (sag.) is estimated at 3.20 mm.

Comment: The specimen is morphologically close to *Maladioidella* cf. *chinchiaensis,* differing only in its longer (sag.) preglabellar field and straighter axial furrows. It is, however, considerably younger, occurring well up in the Payntonian at Dribbling Bore. It is also similar to *M. splendens* (Endo), differing in its shorter posterolateral limbs and less acutely rounded frontal lobe.

Idahoiid genus undet.

(Pl. 34, fig. 8)

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K104, K105, at 6 and 7 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zone of *Pseudagnostus clarki patulus* with *Caznaia squamosa.*

Material: Two very poorly preserved cranidia, the most complete, CPC 12857, having a length of 7.60 mm.

Comment: Too poorly preserved to make adequate comparison with existing genera, the illustrated specimen possesses a parallel-sided, gently tapering glabella bluntly rounded anteriorly; rather small palpebral lobes close to the glabella and posteriorly sited on the genae; triangular posterolateral limbs; long preocular facial sutures enclosing a wide (tr.) preglabellar area; very gently convex (sag.) preglabellar field, and rather wide (sag.) flat anterior cranidial border. There are no visible glabellar furrows, and the occipital furrow is also effaced. The majority of these characteristics, and especially the structural composition of the preglabellar area, suggest that the specimen is representative of the family Idahoiidae.

Familiae INCERTAE SEDIS

Genus ATRATEBIA nov.

Name: Compounded from L., *atra,* black or blackened, and L., *teba,* hill, referring to specimens from Black Mountain.

Type species: Atratebia nexosa gen. et sp. nov., from the 'Chatsworth Limestone' of Black Mountain, western Queensland; monotypical.

Distribution: Confined, as far as is known, to western Queensland.

Diagnosis: A genus of uncertain familial classification with the following complex of characteristics: parallel-sided glabella with effaced furrows; wide (tr.) occipital ring; large semicircular palpebral lobes sited close to the glabella; long (sag.) convexo-concave preglabellar field, and wide (sag.) border, contained by linear preocular branches of the facial suture, which converge at angles approaching 60°; long (tr.), narrow blade-like posterolateral limbs; subtrapezoidal pygidium, sometimes flattened posteriorly, with short (sag.) conical axis and fluted, weakly fulcrate pleurae; entire margins in late holaspides, and wide, dished borders.

Differential diagnosis: On cranidial characteristics *Atratebia* is morphologically most similar to *Yosimuraspis* Kobayashi (1960a, p. 238). Characteristics of the palpebral lobes, glabella, and the courses of the preocular sections of the facial suture, are nearly identical. *Yosimuraspis,* however, has longer and wider postero-lateral limbs. The pygidia of the two genera are dissimilar; that of *Yosimuraspis* resembles *Haniwa* (Remopleuridacea) rather than *Atratebia. Atratebia* has no marginal spines in late holaspides.

In the structure of its glabella and palpebral lobes, *Atratebia* also closely resembles *Mendosina* gen. nov., but the two genera are readily distinguishable on the nature of their preglabellar fields. That of *Mendosina* is convex (sag.) and kainelloid in appearance, whereas that of *Atratebia* resembles certain dikelocephalaceans, e.g. Pterocephaliinae. The pygidia of *Atratebia* and *Mendosina* share a common structure and are differentiated solely by the lack of spines in late holaspides of the former. Pygidia assigned to these genera closely resemble those which Palmer (1965) has considered to belong to *Sigmocheilus* (Pterocephaliinae).

ATRATEBIA NEXOSA sp. nov.

(Pl. 35, figs 1-6; Text-fig. 51)

Name: L., *nexosa,* involved, complicated, referring to the intricacy of the familial classification of the species.

Holotype: CPC 11868a, the cranidium illustrated in Plate 35, fig. 1. Its counterpart, CPC 11868b, is illustrated in the same plate as fig. 2.

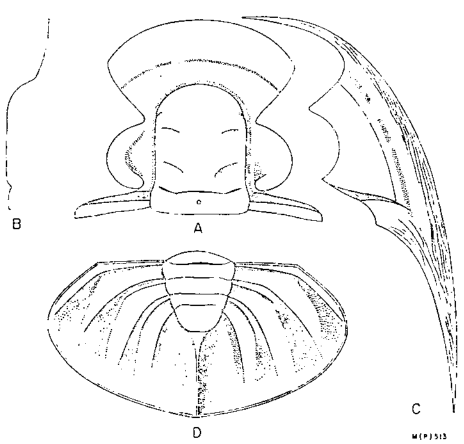

Fig. 51. Reconstructed components of *Atratebia nexosa* gen. et sp. nov.; (A) and (B) cranidium based on CPC 11868a, x4; (C) librigena based on CPC 11872, x4.5; and (D) pygidium based on CPC 11871, x3.5.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K108, K109, K110, K111, K116, and K121, at 73, 80, 91, 112, 138, and 171 m from the base of the measured section. The species is also well represented in sample B507b from an older collection.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zones of *Pseudagnostus clarki prolatus* with *Caznaia sectatrix* and *Pseudagnostus bifax* with *P. denticulatus;* pre-Payntonian A, *Pseudagnostus clarki maximus-P. papilio* Assemblage-Zone.

Material: The species is known from the fragments of 10 cranidia, 2 librigenae, and 9 pygidia, from which the illustrated specimens CPC 11868-72 have been selected.

Size: Measured cranidia range in sagittal length between 4.40 and 6.40 mm; pygidial lengths (Lp_2) range between 1.30 and 5.40 mm.

Diagnosis: See the generic diagnosis, which is based on this species.

Differential diagnosis: Atratebia nexosa strongly resembles *Mendosina laciniosa* (Shergold, 1972) in the morphology of its pygidium, being differentiated solely by the lack of spines in late holaspid instars. There is also strong resemblance in the size, shape, and position of the palpebral lobes, the shape of the glabella and its style of furrowing, and the relative width (tr.) of the occipital ring. The genera are differentiated mainly on the nature of their preglabellar fields (cf. Shergold, 1972, pl. 6, figs 1-5 with herein Pl. 35, figs 1-2). Cranidially, *Atratebia nexosa* is also morphologically close to *Yosimuraspis vulgaris* Kobayashi (1960a, p. 238-9, pl. XII, figs 9-20) from the Bunkoku Formation (Warendian) of South Korea. The pygidium of this species, however, more closely resembles that of *Haniwa,* as described above.

Description: The glabella is parallel-sided, anteriorly gently rounded, Gn occupying 68-76% and G 55-64% of the cranidial length (sag.). On the illustrated specimens the glabellar furrows are virtually effaced, but included in the paradigm are others with visible traces. In these the preoccipital furrows are sigmoidal, adaxially directed rearwards, as in Kainellidae; the median lateral furrows are similarly oriented, but shorter and less deeply incised; and the anterior lateral furrows are curvilinear, transverse, and very faint. None of these furrows reaches the axial furrows.

The occipital furrow is narrow (sag.), and clearly defined, but abaxially it becomes markedly sinuous and less distinct. The occipital ring, with low convexity (sag.), is narrow (sag.), but wider (tr.) than the preoccipital glabellar lobes. A small nuchal node is borne sagittally.

The large palpebral lobes which characterize the species are semicircular, wide (tr.), and separated by indistinct palpebral furrows from narrow (tr.) palpebral areas. The lobes occupy approximately half the glabellar length (G) and 57-66% of parameter Gn. They extend between the front of the occipital ring and the anterior lateral glabellar furrows. Anteriorly they contact the axial furrows, but are separated from them posteriorly by small bacculae. The anterior sections of the facial suture strike outwards from the front of the palpebral lobes at angles of nearly 60° from the sagittal line. They are linear or only slightly curved, but enclose a long (sag.) preglabellar area composed of a gently convex preglabellar field delimited by an indistinct marginal furrow, which separates it from a wide (sag.), also gently convex, cranidial border. The posterior sections of the facial suture enclose relatively long (tr.), narrow (exsag.) posterolateral limbs, usually broken away.

Librigenae assigned to *Atratebia nexosa* are narrow (tr.) with relatively wide lateral borders and confluent posterior and lateral marginal furrows, extending into the genal spine bases. They have stout non-advanced genal spines.

Pygidia are transverse, subtrapezoidal, with lengths (sag.) (Lp_2) in late holaspides varying between 50 and 54% of the maximum width (tr.). In the two early holaspides which are available this length is proportionately shorter; Lp_2:Wp is 38-43%. The pygidia of *A. nexosa* are characterized by distinct pleural fulcra, and the opisthopleural bands are exaggerated to give a decidedly fluted appearance to the pleural zone. Pleural furrows strongly defined adaxially, less so distally, separate a wide (exsag.) opisthopleuron from a very narrow (exsag.) propleuron. Interpleural furrows are equally well-defined, but again more deeply impressed proximally. Four pleural segments are visible. The axis is relatively narrow (tr.), conical, with straight sides converging rearwards and merging into a distinct post-axial ridge. There are four axial rings and an ill-defined terminal piece. The pygidial borders are wide (tr., sag.) and concave. The margins are entire and non-spinose in late holaspides, but at least one pair of spines is present in early holaspides. Similarly, whereas the posterior pygidial margin is evenly rounded in late holaspides, in earlier instars it has a decided flattening or anterior sagittal curvature, which is reminiscent of some of Palmer's (1965) Pterocephaliinae, e.g. *Sigmocheilus, Strigambitus,* and some species of *Pterocephalia.*

The prosopon of *Atratebia* is generally quite smooth, although terraced lirae are visible on the margins of the pygidium and borders of the librigena.

Genus MENDOSINA nov.

Name: From L., *mendosa,* faulty or incorrect, referring to the previous erroneous assignation of the species *laciniosa* Shergold 1972 to *Richardsonella.*

Type species: Designated herein, *Richardsonella laciniosa* Shergold, 1972, p. 37-40, pl. 6, figs 1-5; pl. 7, figs 1-4, from the Gola Beds of the Momedah anticline, Momedah Creek, Boulia area, western Queensland.

Other species: Mendosina sp. is described below from the Black Mountain section.

Diagnosis: A genus of uncertain familial classification with the following complex of characteristics: rectangular glabella; large semicircular palpebral lobes extending rearwards close to the posterior marginal furrow, and also close to the glabella; convex (sag.) preglabellar field limited anteriorly by a transversely continuous marginal furrow, and narrow (sag.) convex cranidial border; occipital ring wider (tr.) than the preoccipital glabellar lobes; transverse pygidium with fluted pleura, short conical axis extending into a post-axial ridge, concave borders, and serrate margins.

Age: Late Upper Cambrian, pre-Payntonian A, Assemblage-Zones of *Pseudagnostus clarki maximus* with *P. papilio* at Momedah Creek; pre-Payntonian B, Assemblage-Zone of *P. clarki patulus* with *Caznaia squamosa* at Black Mountain.

Comments: In an earlier publication (Shergold, 1972) a case was made for the inclusion of the species *laciniosa* in *Richardsonella.* In the light of more recent discoveries at Black Mountain, the new genus *Mendosina* is proposed for this species. *M. laciniosa* differs from species of *Richardsonella* in the shape of its glabella, which is dikelocephalacean, and in the shape of its palpebral lobes, which are more semicircular than arcuate, as normally found in remopleuridaceans. The structure of the preglabellar area is similar to that of Kainellidae, and Remopleuridacea in general. The characteristics of the pygidium, however, again have a stronger resemblance to certain Dikelocephalacea, and can be closely compared with the pygidium of *Sigmocheilus flabellifer* (Hall & Whitfield) (see Palmer, 1965, pl. 15, fig. 3). Apart from possessing marginal spines, the pygidium of *Mendosina laciniosa* is homeomorphic with that of *Atratebia nexosa* sp. nov., which might equally well be referred either to Remopleuridacea or Dikelocephalacea. On Black Mountain the ranges of the two genera overlap.

MENDOSINA sp.
(Pl. 51, figs 1-2)

Occurrence: 'Chatsworth Limestone', Black Mountain, horizon K106, 51 m from the base of the measured section; and at previously collected horizon B507b, not located on the line of section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zone of *Pseudagnostus clarki patulus* with *Caznaia squamosa.*

Material: The external mould of an incomplete cranidium, CPC 12874, and a near complete cranidial testaceous surface, CPC 12875.

Size: The external mould has an estimated length (sag.) of 5.50 mm, and the external surface a length of 5.00 mm.

Comments: Mendosina sp. occurs earlier in time than *M. laciniosa.* The two specimens cited are classified with *Mendosina* on account of the similarity of their glabellar shapes and structure of their preglabellar areas with the type species. Glabellar furrowing is considerably fainter on the specimens from Black Mountain, and the palpebral lobes are shorter (exsag.). They extend from the extremely faint anterior lateral glabellar furrows rearwards to the middle of the preoccipital lobes, whereas they extend to the level of the occipital furrow in *M. laciniosa.* Accordingly, *Mendosina* sp. has triangular rather than band-like posterolateral limbs. Bacculae, so prominent in *M. laciniosa,* are not developed in *Mendosina* sp.

Superfamily REMOPLEURIDACEA Hawle & Corda, 1847

The familial classification of Remopleuridacea adopted in this paper is a combination of those previously given by Whittington (*in* Moore, 1959) and Kobayashi (1953). The following familial and subfamilial groupings are recognized:

Remopleurididae Hawle & Corda, 1847

Remopleuridinae Hawle & Corda, 1847, comprising: *Remopleurides* Portlock, 1843, *Amphytrion* Hawle & Corda, 1847, *Hypodicranotus* Whittington, 1952, *Robergia* Wiman, 1905, *Teratorhynchus* Reed, 1903, *Remopleuridiella* Ross, 1951.

Apatokephalinae Kobayashi, 1953, comprising: *Apatokephalus* Brögger, 1896, *Tramoria* Reed, 1899, *Menoparia* Ross, 1951, *Scinocephalus* Ross, 1951, *Eorobergia* Cooper, 1952, *Protapatokephalus* Raymond, 1937, and questionably *Hukasawaia* Kobayashi, 1953, *Linguakainella* Kobayashi, 1953, and *Apatokephaloides* Raymond, 1924.

Macropyginae Kobayashi, 1937, comprising: *Macropyge* Stubblefield, 1927, and *Lichapyge* Callaway, 1877.

Kainellidae Ulrich & Resser, 1930

The family comprises: *Kainella* Walcott, 1924, *Richardsonella* Raymond, 1924, *Pseudokainella* Harrington, 1938 = *Parakainella* Kobayashi, 1953, and *Sigmakainella* Shergold, 1972.

The genera *Apatokephalina* Sivov, 1955, *Artokephalus* Sivov & Jegorova, 1955, *Portentosus* Jegorova, 1955, *Haniwa* Kobayashi, 1933, and *Yosimuraspis* Kobayashi, 1960 are regarded as Remopleuridacea incertae familiae. Loganellidae Rasetti (*in* Moore, 1959) and Hungaiidae Raymond, 1924 are considered to be Dikelocephalacea.

Family KAINELLIDAE Ulrich & Resser, 1930

Kainellidae is preferred to Richardsonellidae Raymond, 1924, because the constitution of the genus *Richardsonella* is debatable: its species are known only from disarticulated parts, whereas complete specimens of *Kainella* are known. The dividing line between cranidia of *Richardsonella* and *Kainella* on the one side and *Pseudokainella* on the other is not clearly defined. When pygidia have been assigned to *Richardsonella* all are different, and as previously indicated (Shergold, 1972, p. 37), more than one type of cranidium has been placed there.

Genus SIGMAKAINELLA Shergold, 1972

Type species: Sigmakainella translira Shergold, 1972, p. 44-46, pl. 8, figs 1-6; pl. 9, figs 3, 6, from the Gola Beds of Momedah Creek, Boulia district, western Queensland: by original designation.

SIGMAKAINELLA TRANSLIRA Shergold, 1972
(Pl. 32, figs 1-4)

1972 *Sigmakainella translira* Shergold, p. 44-46, pl. 8, figs 1-6; pl. 9, figs 3, 6.

Holotype: CPC 9715, the cranidium illustrated by Shergold (1972, pl. 8, figs 1-2).

Occurrence: Additional material referred to this species is from the 'Chatsworth Limestone' of Black Mountain, horizons K111, K112, K113, K114, K116, and K117, at 112, 120, 127, 128.5, 138, and 149 m from the base of the measured section. The species is also present in samples labelled B507a′ and B507a″, collected in 1957.

Age: At Black Mountain *Sigmakainella translira* has a pre-Payntonian B age, occurring in the *Pseudagnostus clarki prolatus* with *Caznaia sectatrix* and *Pseudagnostus bifax* with *P. denticulatus* Assemblage-Zones. At Momedah Creek, from which it was originally described, the species has a pre-Payntonian A age, occurring in the *Pseudagnostus clarki maximus* with *P. papilio* Assemblage-Zone.

Material: The present samples include 17 cranidial fragments, 3 librigenae, and 2 pygidia, all of which are entirely comparable with material figured and described from the Gola Beds. Supplementary material illustrated comprises CPC 11845-8.

Comments: The specimens yield no additional information. All materials are poorly preserved and generally fragmentary. The exception is the cranidium illustrated in Plate 32, fig. 1, which has a sagittal length of 5.80 mm, a small specimen compared with those previously illustrated.

Sigmakainella longilira Shergold, 1972
(Pl. 33, fig. 1)

1972 *Sigmakainella longilira* Shergold, p. 46-47, pl. 9, figs 1-2.

Holotype: CPC 9723, the pygidium illustrated by Shergold (1972, pl. 9, fig. 1), from the Gola Beds of Momedah Creek, Boulia district, western Queensland.

Occurrence: The specimen at hand is from the 'Chatsworth Limestone' of Black Mountain, horizon K123, 185 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian A, *Pseudagnostus clarki maximus* with *P. papilio* Assemblage-Zone, both on Black Mountain and at Momedah Creek.

Material: A single incomplete pygidium, CPC 11855.

Comments: The illustrated pygidium, CPC 11855 (Pl. 33, fig. 1), has pleural characteristics identical with those of *Sigmakainella longilira* from the Gola Beds, and is considered conspecific with the previously described material.

Sigmakainella primaeva sp. nov.
(Pl. 31, figs 1-4; Text-fig. 52)

Name: L., *primaeva,* early, referring to the age of this species compared with others previously described.

Holotype: CPC 11849, the cranidium illustrated in Pl. 31, fig. 1.

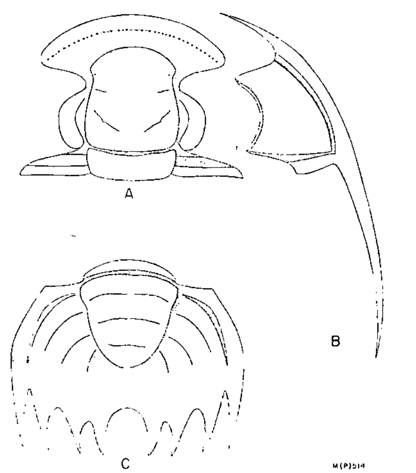

Fig. 52. Reconstructed components of *Sigmakainella primaeva* **sp. nov.; (A) cranidium based on CPC 11849, x2.5 approx.; (B) librigena based on CPC 11852, x3.5; (C) pygidium based on CPC 11851, x4.5.**

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K103, K104, and K106, at 1.6, 6, and 51 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zone of *Pseudagnostus clarki patulus* with *Caznaia squamosa.*

Material: The available material consists of seven cranidial fragments, one pygidium (external mould), and two librigenal fragments. Specimens CPC 11849-52 are illustrated.

Size: Measured cranidia range in sagittal length (Lc) between 7.25 and 10.80 mm.

Diagnosis: A species of *Sigmakainella* characterized by relatively deep median lateral glabellar furrows, apparently long (sag.) frontal lobe, and proportionately small palpebral lobes. The anterior sections of the facial suture are more directly transverse than sigmoidal. The pygidium is distinguished by its conical, strongly tapering axis.

Differential diagnosis: Sigmakainella primaeva differs from *S. translira* Shergold and *S. longilira* Shergold by the characteristics listed in the diagnosis. Cranidia of *primaeva* appear to have a finer more delicate prosopon than those of *translira.* Compared with this last species, *S. primaeva* has a proportionately longer (sag.) glabella, and the palpebral lobes are correspondingly shorter (exsag.). The pygidium of *primaeva,* as far as can be judged, has a similar shape to that of *translira.* Four pairs of spine bases are discernible on specimen CPC 11851, illustrated in Plate 31, fig. 3. Although the segmentation is comparable, the axis is considerably more conical than that of *translira,* and the post-axial ridge is more prominent. The orientation of the pygidial lirations is transverse, as in *translira.*

Description: The glabella is prominent, with low convexity (sag.) in lateral profile, tapers forwards, and is evenly rounded anteriorly. The flanks swell abaxially adjacent to the palpebral lobes, and are markedly constricted where the anterior tips of the palpebral lobes meet the axial furrows. Two pairs of glabellar furrows are sharply defined. The preoccipital glabellar furrows are directed rearwards, slightly sigmoidal, deep but narrow (exsag.). The median lateral furrows are transverse, curvilinear, less deeply incised. A third, anterior lateral, pair of furrows is situated on some specimens in front of the intersection of palpebral lobes and axial furrows. These are very faint and very short and may be related to the indistinct parafrontal band, which is merged into the frontal glabellar lobe. None of the glabellar furrows is confluent with the axial furrows. For the illustrated cranidia Gn:Lc is 83%, G:Lc is 68%, A:Gn is 47-53%, and A:G is 56-63%.

The occipital furrow is sinuous, deeply incised abaxially, shallow and with prominent platform sagittally. The occipital ring has low convexity (sag.), is slightly wider (tr.) than the preoccipital glabellar lobes, and is of even sagittal/exsagittal width. There is no nuchal node.

The palpebral areas are narrow (tr.) crescents, steeply inclined to the axial furrows, and separated from the palpebral lobes by broad, shallow furrows. The palpebral lobes are similarly crescentic, relatively wide (tr.), and elevated in anterior profile. They contact the axial furrows both anteriorly and posteriorly. The courses of the posterior sections of the facial suture are unknown from the cranidium, but associated librigenae indicate a narrow (exsag.), blade-like postero-lateral limb. The anterior sections of the facial suture diverge appreciably, being transverse for the major part of their courses, curving only at their extremities. They enclose a very gently concave preglabellar field, surrounded by a pitted marginal furrow, and evenly arcuate border, which is striated and thickened somewhat sagittally.

The librigena has a shallow subocular groove and slightly convex genal field. Posterior and lateral marginal furrows are prominent, but shallow, concave depressions which do not intersect at the genal angle. A long delicate genal spine is oriented in an advanced position.

The pygidial shape is inadequately known from the only available specimen. Its axis is considerably elevated and convex (tr.), is conical, and tapers strongly rearwards. It possesses three segments, the last indistinct and merging into a terminal piece. The segmental furrows are deep abaxially, curvilinear forwards, and shallow sagittally. A faint post-axial ridge runs to the posterior pygidial margin. Four pairs of spine bases are visible on the left hand margin (Pl. 31, fig. 3), indicating the presence, in this species, of swept-back pleurae. Prominent is the wide doublure (tr.), similar to that of *Sigmakainella translira* (see Shergold, 1972, pl. 8, fig. 5).

The cranidial prosopon is well defined as a system of anastomosing raised lirae arching concentrically forwards on the glabella and librigena, and as crescentic lirae on the anterior cranidial and librigenal borders. Similar lirae, concentrically arranged, and arching rearwards, are visible on the pygidial doublure. On the axis they curve faintly forwards. On the preglabellar field, and on the genal field of the librigena, the concentric arrangement of the lirae is interrupted by a radially disposed caecal network which gives a reticulate appearance. Direct comparison with the caecal network of *S. translira* may be made (compare Shergold, op. cit., pl. 8, fig. 3). Where the caeca pass across the cranidial marginal furrow, their interspaces are pitted: about 30 such pits are present on the holotype cranidium (see Pl. 31, fig. 1).

?SIGMAKAINELLA TRISPINOSA sp. nov.
(Pl. 32, figs 5-6)

Name: L., *trispinosa,* three-spined.

Holotype: CPC 11853a, the pygidium illustrated in Plate 32, fig. 6, together with counterpart mould, CPC 11853b.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K119, K121, K123, at 157, 171, and 185 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian A, Assemblage-Zone of *Pseudagnostus clarki maximus* with *P. papilio.*

Material: Three fragmentary pygidia, of which only the holotype, CPC 11853, is figured.

Diagnosis: A species questionably assigned to *Sigmakainella* with three, instead of four, pleural segments which are swept backwards into free spines of unequal length, and two axial rings. The geniculation is close to the axial furrows.

Differential diagnosis: Only *Kainella,* among the Kainellidae, has three pygidial pleural segments, but they are quite different in structure to those of *?Sigmakainella trispinosa,* as is the overall shape of the pygidium. Comparing *?S. trispinosa* with *S. translira,* similar pygidial shapes are evident, but the spines of the former are fewer, three instead of four pairs, and extended farther posteriorly, and there are two segments, not three, in the axis. In both species the geniculation is close to the axial furrows, and both have the same style of anastomosing lirae.

Description: The general pygidial shape is ovoid, elongate, with the geniculation close to the axial furrows, and abaxially curving flanks. Three pleural segments are extended backwards into long free spines, longest in the first pleural segment, and progressively shorter to the third segment. Interpleural furrows are effaced, but the pleural furrows are wide and shallow, deepening adaxially. The geniculation is evident on all three pleural segments, but is interrupted posteriorly by a prominent post-axial ridge. The pleural zones, between the geniculation and the axis furrows, are gently concave. The axis is very short (sag.), and wide (tr.), semi-ovoid in shape. It is composed of an articulating half-ring, in the form of a band, and two axial segments, of which only the first is well developed. Segmental furrows arch forwards and are deepest laterally. An indistinct terminal piece has a slight depression sited sagittally, the function of which is not understood.

Genus RICHARDSONELLA Raymond, 1924, emend. Rasetti, 1944

Type species: Dikelocephalus megalops Billings, 1860, p. 311, fig. 9, from the boulder conglomerates of Lévis, Quebec, Canada; designated by Raymond (1924, p. 438).

Other species: Species assigned to *Richardsonella* and comments on the concept of the genus have been considered previously (Shergold, 1972, p. 36-37).

?RICHARDSONELLA sp.
(Pl. 31, figs 5-6)

Occurrence: 'Chatsworth Limestone', Black Mountain, horizon K111, 112 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zone of *Pseudagnostus clarki prolatus* with *Caznaia sectatrix.*

Material: A single incomplete cranidium, preserved with shell, CPC 11854, illustrated in Plate 31, figs 5-6.

Comments: This species, which resembles some species of *Sigmakainella,* is referred questionably to *Richardsonella* on account of the courses of its preocular facial sutures. Whereas in *Sigmakainella* these are basically transverse, in the species assigned here to *Richardsonella* they diverge forwards obliquely at considerably lesser angles. This characteristic serves to differentiate cranidia of *Richardsonella* from those of *Kainella* and *Pseudokainella.*

In *?Richardsonella* sp. the glabella tapers forwards, and is almost straight-sided, which further differentiates it from any species of *Sigmakainella.* In the characteristics of its glabella and preglabellar field, *?Richardsonella* sp. most closely approaches *R. elongata* Rasetti (1944, p. 256, pl. 39, fig. 52), the type species *R. megalops* (Billings, 1860) (see Rasetti, 1944, p. 255, pl. 39, figs 48-9), and *R. eurekensis* Kobayashi (1935a, p. 55, pl. 9, fig. 9).

Description: The glabella is straight-sided, tapering forwards, and anteriorly evenly rounded. Two pairs of glabellar furrows are defined: the preoccipital furrows are sigmoidal, posteriorly curved, deeper than the remaining pair of furrows; the median lateral furrows are shallow, transverse, and curvilinear. None of these furrows merges with the axial furrows, and none is continuous across the sagittal line. A slight constriction occurs in the anterolateral flanks of the glabella, where the palpebral lobes intersect the axial furrows. The occipital furrow and ring are poorly preserved, but there appears to be a shallow sagittal platform in the floor of the former. The glabella, G, occupies 67% of the total estimated cranidial length, Lc.

The palpebral areas are narrow (tr.) crescents, separated by shallow palpebral furrows from gently convex, adaxially inclined palpebral lobes. The latter, also crescentic, contact the axial furrows both anteriorly and posteriorly. Anteriorly narrow ocular ridges connect the palpebral lobes with the constricted frontal glabellar lobe. The palpebral lobes occupy 68% of the glabellar length, G. The anterior sections of the facial suture arch gently outwards and forwards to the anterolateral corners of the cranidium. They enclose a gently concave (sag.) preglabellar field, anteriorly flanked by a pitted marginal furrow and evenly curved anterior border, sagittally thickened. About 30 pits lie in the floor of the marginal furrow.

The prosopon, as in *Sigmakainella translira,* consists of coarse anastomosing lirae, arching forwards. The caecal system is not well preserved.

Familiae INCERTAE SEDIS

Genus HANIWA Kobayashi, 1933

Type species: Haniwa sosanensis Kobayashi, 1933a, p. 148-9, pl. XV, figs 2-5, from the *Tsinania* Zone of Sanki-rei, South Korea; by original designation.

Other species: Haniwa quadrata Kobayashi (1933a, p. 149, pl. XV, figs 7-8), *Tsinania canens* Zone of Paichiashan Hill, Wuhutsui Basin, Liaotung, southern Manchuria; also recorded by Kobayashi (1935c, p. 244, pl. VII, figs 1-2, 5-6, 19-20) from the *Dictya* Zone, Kasetsu-ji, South Korea. *Haniwa convexa* Kobayashi (1935c, p. 245, pl. VII, fig. 3), *Dictyites* Zone, Doten, South Korea, and *Tsinania canens* Zone, Wuhutsui Basin, Liaotung, southern Manchuria. *Haniwa conica* Kobayashi (1935c, p. 245-6, pl. VII, fig. 4), *Dictya* Zone, Doten, South Korea. *Haniwa oblongata* Kobayashi (1935c, p. 246, pl. VII, fig. 14; pl. VIII, fig. 14), Kasetsu-ji, South Korea. *Haniwa ambolti* Troedsson (1937, p. 64-66, pl. IV, figs 13-14), western Quruq tagh, eastern Tien-shan. *Haniwa suni* (Kobayashi) (*pro Ptychaspis suni* Kobayashi, 1931, p. 181: pl. 22, fig. 7; *fide* Resser 1942, p. 149), Chiushukou Shale, Hualienchai, Niuhsintai Basin, Manchuria. *Haniwa* sp. Kobayashi (1933a, p. 149, pl. XV, fig. 16), *Tsinania canens* Zone, Hsishan, Manchuria. *Haniwa* sp. Kobayashi (1935c, p. 246, pl. VII, figs 21-22), *Dictya* Zone, Kasetsu-ji, South Korea. *Haniwa* (?) sp. Kobayashi (1935c, p. 247, pl. IV, figs 3-4), *Eoorthis* Zone, Doten, South Korea. Described below is *Haniwa mucronata* from the Payntonian of Black Mountain, western Queensland.

Age and Distribution: Generally associated with Tsinaniidae in the Fengshanian of Asia (China-Tien Shan, Manchuria and South Korea), and in the Payntonian of Australia (western Queensland).

Comment: Only two previously described species, *Haniwa sosanensis* Kobayashi and *H. oblongata* Kobayashi, have been assigned a pygidium. The cranidia from Black Mountain are in all respects similar to previously described species, but associated tails differ in having marginal spines.

HANIWA MUCRONATA sp. nov.

(Pl. 33, figs 2-7; pl. 34, figs 1-7; Text-fig. 53)

Name: L., *mucronata,* mucronate or spined, referring to the spinose pygidium.

Holotype: CPC 1·1862, the pygidium preserved with shell and illustrated in Plate 34, fig. 1.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K138 and K139, at 374 and 375 m from the base of the measured section; and from previously collected samples at Black Mountain labelled B510 and B510b.

Age: Late Upper Cambrian, early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas.*

Material: The species is known from the remains of 20 cranidia, 10 librigenae, 4 hypostomata, and 23 pygidia. The illustrated paradigm comprises specimens CPC 11856-67.

Size: Measured cranidia range in sagittal length (Lc) between 1.90 and 5.00 mm; pygidia (Lp_2) measure 1.40-4.10 mm.

Diagnosis: A species of *Haniwa* Kobayashi characterized by the presence of four pairs of marginal pygidial spines, and slightly advanced genal spines.

Differential diagnosis: Haniwa mucronata is distinguished from other species ascribed to the genus in possessing pygidial spines. In the type species, *H. sosanensis,* the margin is apparently entire, and no mention is made of a spinose margin in *H. oblongata* Kobayashi (1935c, p. 246). The cranidium of the Australian species is most closely comparable to that of *H. quadrata* Kobayashi (1933a, p. 149, pl. XV, figs 7-8; 1935c, p. 244, pl. VII, figs 1-2, 5-6, 19-20), but the glabella is perhaps a little more acutely rounded anteriorly. This characteristic apart, the courses of the facial suture, the size and position of the palpebral lobes, and the glabellar furrowing, where visible, invite direct comparison. The preglabellar areas in late holaspides of *H. mucronata* and that of *Yosimuraspis vulgaris* Kobayashi, 1960a, are similar in structure, suggesting that they might be classified together. The pygidium of *H. mucronata,* though longer (sag.), also resembles that of *Y. vulgaris* in its basic structure, which is kainelloid.

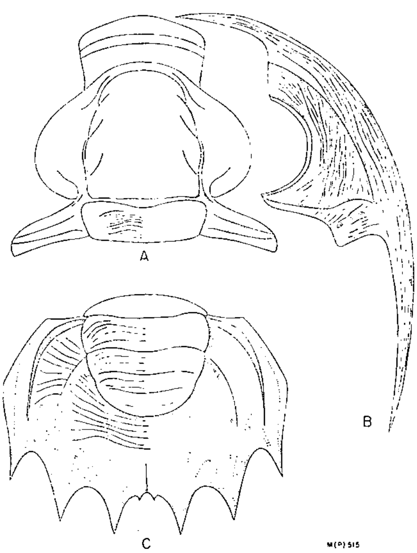

Fig. 53. Reconstructed components of *Haniwa mucronata* sp. nov.; (A) cranidium based on CPC 11857, x6; (B) librigena based on CPC 11860, x4; and (C) pygidium based on CPC 11863, x8.

Description: The glabella has curvilinear sides, and is acutely rounded anteriorly. It is widest (tr.) at the level of the median lateral glabellar lobes, equally narrow (tr.) at the occipital ring and anterior lateral glabellar furrows. Three pairs of furrows are represented in early holaspides (Pl. 33, fig. 5) as pits; in late holaspides the furrows are invariably effaced and ill defined (Pl. 33, fig. 3). In the last, the median lateral furrows appear as short depressions sloping inwards from the axial furrows, and the anterior lateral furrows are transverse curvilinear grooves. The frontal lobe of the glabella is very short (sag.), crescentic, and possibly defined on the available material as the result of the addorsal imprint of the hypostoma. The glabella, G, occupies 53-61% of the total cranidial length (sag.); Gn is 72-77%.

The occipital furrow is narrow (sag.), sharply defined, transverse or curved slightly rearwards sagittally. The occipital ring is considerably wider (tr.) than the preoccipital glabellar lobes. It bears a small, but distinct, nuchal node.

The palpebral lobes are very large, occupying 72-90% of the glabellar length (sag.), G. Early holaspides appear to have proportionately longer (exsag.) lobes than late holaspides. They are semicircular, narrow (tr.), with well defined palpebral furrows in early holaspides which become increasingly effaced with increase in size. Posteriorly they are close to the axial furrows, separated from the glabella by small bacculae, and extend rearwards to the occipital furrow. Anteriorly, the palpebral lobes extend as far as the anterior lateral glabellar furrows, and are extended thence by short ocular ridges, to a transverse line across the front of the glabella, and merge there with an ill-defined band immediately in front of the preglabellar furrow. The palpebral areas are convex (tr.) and semicircular, bacculate between the rear of the palpebral lobes and the axial furrows.

From the point at which the ocular ridges and palpebral lobes coalesce, the anterior sections of the facial suture course almost directly forwards to the cranidial margin. The angle of intersection of the two anterior branches of this suture, projected to the sagittal line, is low, about 30°. They therefore enclose a narrow (tr.) preglabellar area constituted by a gently convex (sag.) preglabellar field, and a slightly concave (sag.), upturned cranidial border widening sagittally. The posterior sections of the facial suture enclose comparatively long, blade-like posterolateral limbs, rarely preserved on the available material. The librigenae assigned to *Haniwa mucronata* are characterized by very well defined eye socles. Specimen CPC 11860 shows the eye socle to be separated from the visual surface above and the remainder of the gena below, by sharply incised furrows. The genal spines, slightly advanced in orientation, are long and gently curved adaxially. A sinuous furrow runs from the posterior edge of the eye socle towards the genal angle, in front of the posterior marginal furrow. It intersects the posterolateral angle of the librigena at the confluence of the lateral and posterior marginal furrows.

The hypostomata illustrated in Plate 34, figs 6-7 are mould and counterpart of the same specimen. The median body and posterior lobe together are an elongate ovoid, nearly twice as long (sag.) as wide (tr.). Maculae are quite distinct on the internal mould (fig. 7). In general, the hypostoma of *H. mucronata* is characterized by very narrow, lirate lateral and posterior borders. No information is available concerning the anterior wings or the anterior margin, although the latter appears to have an even arcuate curve.

The pygidium has a subquadrate outline, with spinose posterior margin; Lp_1 is 63-73% of the maximum width (tr.). The axis is short (sag.), but wide (tr.), occupying (La_1) 58-69% of the total length (Lp_1), and is composed of three segments together with a very short terminal piece, and a prominent bar-like articulating half-ring. The latter is differentiated from the remainder of the axis by a narrow (sag.), transverse furrow, whereas the intersegmental furrows are wide and curvilinear. The articulating half-ring of the second axial segment is invariably visible (Pl. 34, fig. 4), and sometimes also that of the third segment (Pl. 34, fig. 1). There are three poorly defined swept-back pleural segments, and on late holaspides, traces of a fourth, in that minute spines associated with this segment are sometimes present (Pl. 34, Fig. 1). Pleural furrows are well developed only on the first pleural segment, those following becoming increasingly effaced rearwards. Interpleural furrows are effaced. The pleural segments end distally in small spines (Pl. 34, fig. 3) of which four pairs are visible in late holaspides. The pleural furrows pass into the bases of these spines. The geniculation is pronounced, as in kainelloid remopleuridaceans, close to the axial furrows.

The prosopon of the cranidium is coarsely lirate, and as in other Remopleuridacea the lirae arch forwards. One small specimen (Pl. 33, fig. 2) shows a reticulate prosopon on its palpebral area and preglabellar field due to the superposition of the lirae on the caecal system. Librigenae and pygidia have similarly lirate surfaces. In the last the liration curves forwards on the axial segments, rearwards on the pleural ones. Apart from possessing lirate margins, the hypostomata are smooth.

Superfamily LEIOSTEGIACEA Bradley, 1925
Family LEIOSTEGIIDAE Bradley, 1925
Subfamily LEIOSTEGIINAE Bradley, 1925
Genus LEIOSTEGIUM Raymond, 1913, *sensu* Walcott, 1925
Subgenus LEIOSTEGIUM Raymond, 1913, *sensu* Walcott, 1925

Type species: Bathyurus quadratus Billings, 1860, p. 321-322, fig. 27, from the Lévis conglomerates, Quebec, Canada; designated by Raymond (1913, p. 68).

Other species: Barrandia? maccoyi nom. transl. Walcott (1884, p. 96, pl. xii, fig. 5), Pogonip Group, Eureka, Nevada. *Leiostegium quadratum* (Billings) *sensu* Raymond (1913, p. 68, pl. VII, fig. 17), Lévis conglomerates, Quebec. *Leiostegium puteatum* Raymond (1924, p. 455-6, pl. 14, figs 12, 13, 16, 19; 1925, p. 194, pl. 14, figs 12, 13, 16, 19; 1937, p. 1098-9), 'Highgate limestone' at Highgate Center, Vermont. *Leiostegium cingulosum* Raymond (1924, p. 456-7, pl. 14, figs 18, 21), 'Highgate formation', 2.5 km north of Highgate Center, Vermont. *Asaphellus obtectus* Raymond (1924, p. 428, pl. 13, figs 14, 18) [= *Bellefontia obtecta* Raymond, 1925, p. 171, pl. 13, figs 14, 18], basal Grandge Formation, 7.3 km north of Highgate Center, Vermont. *Leiostegium manitouensis* Walcott (1925, p. 104, pl. 23, figs 12-19), basal Manitou Formation, 3 km below Manitou Park Hotel, Colorado, and Chushina Formation, Mount Extinguisher, near Mount Robson, British Columbia. *Leiostegium obtectum* (Raymond) (Raymond, 1937, p. 1099, pl. 4, fig. 29), basal Grandge Formation, 7.3 km north of Highgate Center, Vermont. *Leiostegium elongatum* Raymond (1937, p. 1099, pl. 4, fig. 30), locality as above. *Leiostegium douglasi* Harrington (1937, p. 113-5, pl. VI, figs 11-14; 1938, p. 181, pl. 6, figs 1-5, 8) [= *Lloydia* (*Leiostegium*) *douglasi* Harrington, 1937 (Harrington & Leanza, 1957, p. 81, figs 24, 3a-c)], *Kainella meridionalis* Zone, Salta Province, Argentina. *Leiostegium manitouense* Walcott *sensu* Ross (1951, p. 105-6, pl. 27, fig. 1), Zone D, Garden City Formation, NE Utah. *Leiostegium mudgei* Ross (1958, p. 565-6, pl. 83, figs 21-26), Valmy Formation, Crum Canyon, Nevada. *Leiostegium* sp., Ross (1958, p. 566, pl. 83, figs 19, 20), locality as above. *Leiostegium manitouensis* Walcott *sensu* Berg & Ross (1959, p. 114, pl. 21, figs 10-13, 17, 24), Manitou Formation, Missouri Gulch, Williams Canyon, Deadmans Canyon, Colorado. *Leiostegium*

(*Leiostegium*) sp., Berg & Ross (1959, p. 114-5, pl. 22, figs 1-2), Trout Creek, Colorado, Manitou Formation. *Leiostegium* (*Leiostegium*) *floodi* sp. nov. is described below from the lower Ninmaroo Formation of western Queensland.

Distribution: USA (Nevada, Colorado, Utah, Vermont), Canada (Quebec, British Columbia), South America (Argentina), Australia (western Queensland).

Age: Early Ordovician: Zones D-?E of Ross (1951), in western USA; zones unknown in Vermont; *Kainella meridionalis* Zone in Argentina; Datsonian, Assemblage-Zone of *Oneotodus bicuspatus* with *Drepanodus simplex* in Australia.

Comment: The concept of *Leiostegium* followed here is that of Walcott (1925), which is based on his species *manitouensis* rather than the type species. This situation has arisen because the original illustrations of *Leiostegium quadratum* (Billings) are difficult to interpret, as is that of Raymond (1913, pl. VII, fig. 17). It is acknowledged that Walcott's species may not be congeneric with the type species. *Leiostegium* is presently divided into four subgenera: *Leiostegium* (*Leiostegium*) Raymond, 1913, *Leiostegium* (*Perischodory*) Raymond, 1937, *Leiostegium* (*Evansaspis*) Kobayashi, 1955, and *Leiostegium* (*Manitouella*) Berg & Ross, 1959, whose concepts have been briefly reviewed by Berg & Ross (1959, p. 113-4). The species *manitouensis* is referred by Berg & Ross to the nominate subgenus, and as the Australian specimens described below are most closely comparable with *L.* (*L.*) *manitouensis,* they, too, are referred to *Leiostegium* (*Leiostegium*).

Leiostegium (Leiostegium) floodi sp. nov.
(Pl. 45, figs 6-8)

Name: The species is named after T. Flood Esq., resident of Boulia, and owner of the property of Old Goodwood, on which Black Mountain is situated.

Holotype: CPC 11941, the small cranidium, the most completely preserved specimen, illustrated in Plate 45, figs 7-8.

Occurrence: Ninmaroo Formation, Black Mountain, horizon K146, at 731 m from the base of the measured section.

Age: Early Ordovician, Datsonian, Zone of *Oneotodus bicuspatus* with *Drepanodus simplex.*

Material: Two cranidia, CPC 11941-11942, preserved as moulds in pale oolitic limestone.

Size: The holotype has a length (sag.), Lc, of 5.90 mm. The larger specimen, CPC 11942, has a glabellar length (G) alone of 11.30 mm, compared with 4.60 mm for the holotype.

Diagnosis: A species assigned to *Leiostegium* (*Leiostegium*) having posteriorly placed palpebral lobes, faint glabellar furrows even on exfoliated surfaces, and visible ocular ridges.

Differential diagnosis: Of the described species of *Leiostegium* (*Leiostegium*), the species *floodi* most closely resembles *L.* (*L.*) *manitouensis* Walcott (1925, p. 104, pl. 23, figs 12-19; also Berg & Ross, 1959, p. 114, pl. 21, figs 10, 13, 17, 24), from the Manitou Limestone of Colorado. These species differ only in the characteristics listed under the diagnosis. They have similarly shaped glabellae, and similar relationships of glabella to marginal furrows and cranidial borders.

Description: The anterior cranidial outline is arched forwards, and evenly rounded. The glabella (G), occupying on the type specimen 78% of the cranidial length (sag.), is subparallel-sided, tapering gently forwards, and is obtusely rounded anteriorly. Three pairs of glabellar furrows are visible on both illustrated specimens, but are much fainter on the larger specimen. The preoccipital furrows are strongly curvilinear, distally curved sharply rearwards to orient parallel to the sagittal line; the median lateral furrows are short and gently curved, arching anteriorly; the anterior lateral furrows are similar to those preceding.

The occipital furrow is narrow (sag.), well defined, and separates a narrow (sag.) simple occipital ring from the glabella. This ring lies slightly below the level of the dorsal surface of the glabella in lateral profile (Pl. 45, fig. 8).

The palpebral lobes are also well defined, arcuate and long, sited between the occipital furrow and the median lateral furrows. For the holotype, A:G is 54%, and A:Gn is 48%. The palpebral areas are gently convex (tr.), moderately wide (tr.), and separated from the preocular areas by visible, but faint, duplicated ocular ridges which curve across the convexity of the fixigenae to intersect the axial furrows adjacent to the anterior lateral glabellar lobes. A pair of deep pits lies in the axial furrows adjacent to the anterior lateral glabellar furrows.

The anterior sections of the facial suture run outwards initially then inwards to the cranidial margin, enclosing a flat-lying cranidial border (in a horizontal plane) which is evenly and arcuately rounded anteriorly. The glabella abuts against this border, which is therefore narrower sagittally than exsagittally. The posterior sections of the facial suture enclose long (tr.), blade-like posterolateral limbs.

The surface of the exfoliated cranidium is finely punctate. No traces of the caecal network are visible. The apparent granulosity of the holotype cranidium is the result of dissociation of the ammonium chloride coating used during photography.

Subfamily PAGODIINAE Kobayashi, 1935
Genus Pagodia Walcott, 1905

The concept of the genus *Pagodia* has been clarified by Öpik (1967a, p. 257), who has also discussed the subgeneric grouping of the species. Three further subgenera of *Pagodia* are presented below. The genus now embraces the following broad groups of intergrading species regarded here as subgenera:

Pagodia (*Pagodia*), based on *Pagodia lotos* Walcott (1905, p. 64; 1913, p. 162-3, pl. 15, figs 12, 12a), from the Lower Chaumitien Limestone of Taian, Shantung, China;

Pagodia (*Idamea*), based on *Idamea venusta* Whitehouse (1939, p. 232-3, pl. XXIV, figs 4-6; see also Öpik 1967a, p. 260-1, pl. 18, fig. 6, text-fig. 88), from the Georgina Limestone of the Glenormiston area, western Queensland, of Idamean age;

Pagodia (*Wittekindtia*), based on *Pagodia* (*Wittekindtia*) *variabilis* Wolfart (1970, p. 38-42, pl. 6, figs 2-8; pl. 7, figs 1-9; pl. 8, figs 1-7), from the 'Lower Tremadocian' of Afghanistan;

Pagodia (*Oreadella*) subgen. nov., proposed for the species group characterized by *Pagodia buda* Resser & Endo (*in* Kobayashi, 1933a, p. 112, pl. XI, fig. 11; Resser & Endo *in* Endo & Resser, 1937, p. 253-4, pl. 53, figs 10-14; pl. 71, figs 6-8; pl. 72, figs 1-3; see also Endo, 1939, p. 6-7, pl. 1, figs 16-17), from the Yenchou Formation of Paichiashan, near Chinchiachengtzu, southern Manchuria, and from the Kaolishan Formation of the Taian district, Shantung, China;

Pagodia (*Lotosoides*) subgen. nov., erected on the basis of *Lotosoides calcarata* sp. nov., for species similar to *Idamea* and *Pagodia,* but possessing a pair of long pygidial spines. *L. calcarata* is from the pre-Payntonian of the Black Mountain section, Boulia area, western Queensland, Australia;

Pagodia (*Datsonia*) subgen. nov., based on *Pagodia* (*Datsonia*) *subterior* sp. nov., for species with very narrow anterior cranidial borders, and very shallow marginal furrows, combined with glabellae of the *Oreadella* type. *P.* (*D.*) *subterior* is from the Mount Datson and Dribbling Bore sections, Boulia area, western Queensland, Australia.

PAGODIA (PAGODIA) Walcott, 1905

Type species: Pagodia lotos Walcott (1905, p. 64; 1913, p. 162-3, pl. 15, figs 12, 12a, 12a′), from the lower Chaumitien Limestone, Pagoda Hill, 1.5 km west of Tsinan, Shantung, China; designated by Walcott (1913, p. 160).

Other species: Questionably assigned to *Pagodia* (*Pagodia*) are: *Pagodia macedo* Walcott (1905, p. 66; 1913, p. 163, pl. 15, figs 13, 13′), Chaumitien Limestone, near Chaumitien, Shantung, China. *Pagodia duliujiangensis* Chien (1961, p. 124-5, pl. III, figs 11-12), Sandu Shale, Yangjiawan, Sandu, Kweichow, China (doubtful assignment). *Pagodia hemisphaerica* Resser & Endo (*in* Endo & Resser, 1937, p. 254, pl. 53, figs 15-16), Paishan Formation, Tschanghsingtao, southern Manchuria, could be referred also to *Idamea. Pagodia richthofeni* Kobayashi (1933a, p. 111, pl. XI, figs 6-8), *Dictyella* Zone, Paichiashan, Liaotung, southern Manchuria, could equally belong to *Pagodia* (*Oreadella*) on pygidial characteristics. *Pagodia coreanica* Kobayashi (1960b, p. 367-8, pl. XIX, figs 27-29), *Dictyites* Zone, South Korea (classified mainly on pygidial characteristics).

Distribution: China (Shantung, Kweichow), Manchuria, South Korea, and Australia (western Queensland).

Age: Late Cambrian (possibly Idamean to Payntonian equivalents).

Diagnosis: The anterior cranidial margin is evenly and gently rounded; the glabella tapers slightly forwards and is unconstricted laterally; its furrows are obscure; the palpebral lobes are situated opposite the middle of the glabella; ocular ridges are faint; the pygidium is semicircular and characterized by a depressed border encircling the pleural zone completely; the margin is entire.

PAGODIA (PAGODIA) sp.
(Pl. 36, fig. 3)

Occurrence: 'Chatsworth Limestone', Black Mountain, horizon K106, 51 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zone of *Pseudagnostus clarki patulus* with *Caznaia squamosa.*

Material: A single complete pygidium, CPC 11873, and a second fragment.
Size: The complete pygidium has a sagittal length (Lp_1) of 2.60 mm.

Description: The pygidium illustrated (Pl. 36, fig. 3) has a semicircular outline. Its axis is long (sag.) with flanks converging slightly rearwards, widest (tr.) at the first segment. It contains four segments, with a possible fifth, a bluntly rounded, elevated terminal piece, and a semicrescentic articulating half-ring. The fulcra are widely spaced (tr.), and the articulating facets are short and steeply inclined. There are four pleural segments with broad, deeply incised pleural furrows. The first pair of pleural furrows run across the anterolateral border to the pygidial margin, but those remaining are arrested at the depressed border which, beginning at the second pleural segment, runs around the periphery almost equally wide (tr., sag.) throughout. The margin of the pygidium is entire, without spines. The pygidial prosopon is coarsely granulose, most densely so on the borders.

Comments: This pygidium undoubtedly belongs to a species of *Pagodia* (*Pagodia*). Apart from being slightly less transverse, it resembles in all respects that figured by Walcott (1913, pl. 15, fig. 12a) as *Pagodia lotos*. It is also identical with the pygidium figured by Endo (1939, pl. 1, fig. 7, USNM 96093b) as *Pagodia buda* Resser & Endo, from the Kaolishan Formation, 1.5 km west of Taianfu, Shantung. The pygidium of *P.* (*P.?*) *duliujiangensis* Chien (1961, pl. III, fig. 11) has fewer segments and wider (tr., sag.) borders.

PAGODIA (OREADELLA) subgen. nov.

Name: Derived from L. *oreas, -adis,* mountain nymph.

Type species: Pagodia buda Resser & Endo (*in* Kobayashi, 1933a, p. 112, pl. XI, fig. 11), a species occurring in the Yenchou Formation of Paichiashan, Wuhutsui Basin, Liaotung, southern Manchuria, and the Kaolishan Formation of Taian, Shantung, China (Endo, 1939): designated herein.

Other species: With certainty the subgenus includes: *Pagodia bia* Walcott (1905, p. 65; 1913, p. 161, pl. 15, figs 10, 10′, *non* fig. 10a), Chaumitien Limestone of Tsinan, Shantung, China. *Pagodia dolon* Walcott (1905, p. 66; 1913, p. 161-2, pl. 15, figs 11, 11′), lower Chaumitien Limestone, 4.3 km southwest of Chaumitien, Shantung, China. *Pagodia damesi* Kobayashi (1933a, p. 111, pl. XI, fig. 4), Paichiashan, Wuhutsui Basin, southern Manchuria, and possibly the Upper Wolungshan Formation of Huolu, Hopei, China (Sun, 1935, p. 26). *Pagodia convexa* Endo (*in* Endo & Resser, 1937, p. 319, pl. 71, fig. 15, *non* fig. 14), Yenchou Formation, Paichiashan, southern Manchuria. *Pagodia thaiensis* Kobayashi (1957, p. 372-3, pl. IV, figs 5-7), Tarutao Island, Peninsular Thailand. Questionably included are: *Pagodia lorenzi* Kobayashi (1933a, p. 112, pl. XI, fig. 5), Wuhutsui Basin, southern Manchuria. *Pagodia trisulcata* Endo (*in* Endo &

Resser, 1937, p. 318, pl. 67, fig. 24, *non* fig. 25) from the same locality. *Pagodia angustilimbata* Endo (1944, p. 63, pl. 8, fig. 15), Paishan Formation, Lashushan, Kuantung, Manchuria. *Pagodia mina* Endo (1944, p. 63, pl. 9, fig. 5), from the same locality.

Distribution: China (Shantung, Hopei), Manchuria (Liaotung, Kuantung), Peninsular Thailand, and Australia (western Queensland).

Age: Late Cambrian (Idamean to Payntonian equivalents).

Diagnosis: A subgenus of *Pagodia* characterized by a gently curved anterior cranidial outline; glabella with concave flanks at the level of the median lateral lobes, expanded at the frontal lobe; non-bifurcate preoccipital glabellar furrows; palpebral lobes situated opposite the middle of the median lateral glabellar lobes; small, semicircular pygidium, with entire margins, and borders developed laterally only.

Differential diagnosis: The diagnostic characteristics differentiate *Oreadella* from other subgenera of *Pagodia.* Above all, the cranidium is distinguished by its constricted glabellar flanks, and the pygidium by its lack of a posterior border. In *Pagodia* (*Pagodia*), which has a similarly shaped pygidium, the depressed border is continuous around the periphery of the pleural zone, whereas in *Pagodia* (*Oreadella*) it is present only laterally (see Walcott, 1913, pl. 15, fig. 12a for comparison with *P.* (*Pagodia*) *lotos*). Neither *Pagodia* (*Idamea*) nor *P.* (*Lotosoides*) shows borders when specimens are preserved with shell.

PAGODIA (OREADELLA) cf. BUDA Resser & Endo, 1933
(Pl. 36, figs 1-2; Text-fig. 54)

Synonymy inferred by this determination is:

cf. 1933 *Pagodia buda* Resser & Endo (MS); *in* Kobayashi, 1933a, p. 112, pl. XI, fig. 11.

cf. 1937 *Pagodia buda* Resser & Endo *in* Endo & Resser, p. 253-4, pl. 53, figs 10-14; pl. 71, figs 6-8; pl. 72, figs 1-3.

cf. 1939 *Pagodia buda* Kobayashi; Endo, p. 6-7, pl. 1, fig. 16, *non* fig. 17 = *Pagodia* (*Pagodia*).

Cotypes: The cotypes are labelled USNM 86867, and the paratypes MSMSM Ry Co. 1119; see Resser & Endo *in* Endo & Resser (1937, p. 254).

Occurrence: In Australia the species occurs in the 'Chatsworth Limestone' of Black Mountain, horizon K110, at 91 m from the base of the measured section. The species *Pagodia* cf. *buda* has previously been reported by Gilbert-Tomlinson *in* Casey & Gilbert-Tomlinson (1956, p. 65, 71) from the Huckitta region of the Northern Territory.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zone of *Pseudagnostus clarki prolatus* with *Caznaia sectatrix.*

Material: A single cranidium, CPC 11874, and a single pygidium, CPC 11875.

Size: The cranidium has a sagittal length estimated at 5.80 mm, with a glabella 4.70 mm long; the pygidium measures 3.60 mm (Lp_1).

Comment: The specimens from Black Mountain resemble *Pagodia* (*Oreadella*) *buda* in many respects and cannot adequately be separated at specific level on present knowledge. The Manchurian and Australian species have similarly constricted glabellar flanks, similar relationship of glabella to cranidial margins and border, similar glabellar furrowing, and similarly placed palpebral lobes — opposite the median lateral glabellar furrows. Ocular ridges are poorly defined on all species of *Oreadella.* The pygidium of the Australian specimen has the same shape, same segmentation, and same condition of its borders as that of the Manchurian specimens figured by Endo & Resser (see 1937, pl. 53, fig. 14). The only difference that can be obviously seen is the coarse granulation of the shell of the Manchurian *P.* (*O.*) *buda.* On the material from Black Mountain, however, the shell has been exfoliated from both cranidium and pygidium, and no granulation is visible, the surfaces of both shields being punctate. The addition of the confer (cf.) in the determination refers solely to the uncertainty of the nature of the external testaceous surface, which cannot be resolved by the available material.

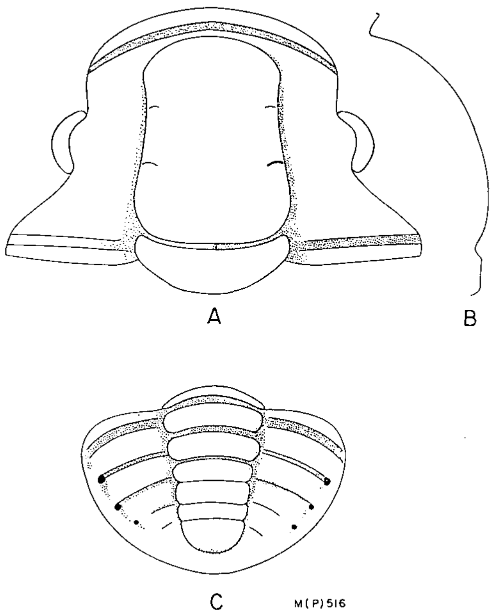

Fig. 54. *Pagodia* (*Oreadella*) **cf.** *buda* **Resser & Endo** *in* **Kobayashi, 1933; (A) and (B) cranidium reconstructed from CPC 11874, x6.5 approx.; (C) pygidium based on CPC 11875, x7.**

PAGODIA (LOTOSOIDES) subgen. nov.

Name: Derived from the species name *lotos* Walcott and the suffix, Gk — *oides,* similar to, having a feminine gender.

Type species: Pagodia (*Lotosoides*) *calcarata* sp. nov., see below, from Black Mountain, western Queensland, Australia: here designated.

Other species: Pagodia (*Lotosoides*) *turbinata* sp. nov., from the same place.

Distribution: Australia (western Queensland).

Age: Late Cambrian, pre-Payntonian A and pre-Payntonian B.

Diagnosis: Lotosoides combines the following characteristics: curved anterior cranidial margin with addorsally raised anterior border and deep marginal furrows: straight-sided glabella, tapering forwards, acutely rounded anteriorly; palpebral lobes widely spaced (tr.) from the glabella, and placed behind its mid-length; discernible ocular ridges; pygidium with widely spaced (tr.) fulcra, no border when shell is preserved, and a pair of lateral spines, formed from the opisthopleuron of the first and propleuron of the second pleural segments.

Differential diagnosis: Characteristics of the cranidium are almost identical with those of *Pagodia* (*Idamea*), and quite similar also to *Pagodia* (*Pagodia*). These subgenera, and *Lotosoides,* differ from *Pagodia* (*Oreadella*) in lacking a constricted glabella, and in having larger palpebral lobes differently sited. *Lotosoides* is differentiated from all other subgenera on the presence of pygidial spines, although these apart, the overall structure of the pygidium is similar to that of *Idamea.*

The cranidium of *Lotosoides* strongly resembles that of *Kaolishania,* and particularly that of *K. australis* Shergold, 1972, described from the Gola Beds of Momedah Creek. In fact, *K. australis* and the species of *Lotosoides* described here are differentiated only on the basis of their glabellar furrows, and the deflected genal spines of *Lotosoides*. Pygidia are also similar, but *K. australis* differs in the structure and orientation of its lateral spines. In respect to these spines, the pygidium of *Lotosoides* is a homeomorph of that of *Prochuangia* (see *P. mansuyi* Kobayashi 1933a, pl. X, figs 6-7, from South Korea).

PAGODIA (LOTOSOIDES) CALCARATA subgen. et sp. nov.
(Pl. 37, figs 1-6; Text-fig. 55)

Name: L., *calcar,* a spur, referring to the pygidial spines.

Holotype: CPC 11879, the exfoliated cranidium illustrated in Plate 37, figs 1-2.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K111 and K116, at 112 and 138 m from the base of the measured section; and at B507c on previously collected sections.

Age: Late Upper Cambrian, pre-Payntonian B, *Pseudagnostus clarki prolatus* with *Caznaia sectatrix* and *P. bifax* with *P. denticulatus* Assemblage-Zones.

Material: The species is known from 18 cranidia, 12 pygidia, and a single librigena. Specimens CPC 11879-11884 are figured.

Size: Measured cranidia range in length (sag.) between 4.20 and 6.60 mm; pygidia (Lp_1) measure between 2.50 and 3.90 mm.

Diagnosis: A species of *Pagodia* (*Lotosoides*) subgen. nov. with prominent ocular ridges, and finely granulose prosopon.

Differential diagnosis: See under *Pagodia* (*Lotosoides*) *turbinata* below.

Description: The anterior cranidial outline is evenly and gently curved forwards. The glabella (G), occupying 74-78% of the total cranidial length (sag.), is more or less straight-sided, but tapers forwards to a marked degree, and is acutely rounded anteriorly. It is widest (tr.) across the front of the preoccipital glabellar lobes. Three pairs of glabellar furrows are visible: the preoccipital furrows are shallow, sigmoidal, posteriorly directed, bifurcate abaxially with a short rectilinear furrow transversely developed from the sigmoid one; the median lateral furrows are equally faint, transverse curvilinear; the anterior lateral furrows are very faint, very short, and lie on the anterolateral glabellar flanks opposite the intersection of the ocular ridges with the axial furrows.

The occipital furrow is transverse medially, curved sharply rearwards abaxially. The occipital ring is narrow (sag.), of equal width (tr.) to the preoccipital lobes, and in lateral profile rises only to the level of the glabellar side lobes.

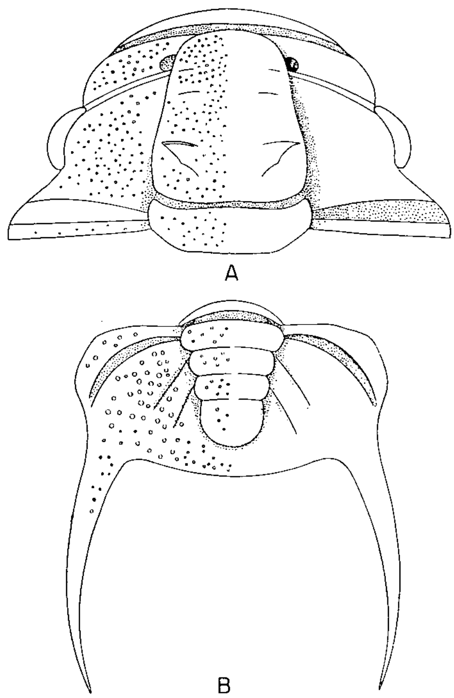

Fig. 55. *Pagodia* (*Lotosoides*) *calcarata* **subgen. et sp. nov.; (A) cranidium reconstructed from CPC 11879, x5; (B) pygidium based on CPC 11881, x6.**

The palpebral lobes are small, subcrescentic, with shallow palpebral furrows. The lobes occupy 27-33% of the glabellar length (G), and are sited between the middle of the median lateral glabellar lobes and the middle of the preoccipital glabellar lobes. The area (H) between the rear of the palpebral lobes and the posterior marginal furrow is about equal to the length of the lobes themselves. The palpebral areas are wide (tr.), wider posteriorly than anteriorly. The palpebral lobes pass anteriorly into prominent, narrow (exsag.), non-duplicated ocular ridges which run across the curvature of the fixigenae and intersect the axial furrows at the anterior lateral glabellar furrows. A little in front of this intersection a pair of pits is developed in the floor of the axial furrows, and flanking these anteriorly the axial furrows are blocked by adaxial extensions of the preocular areas, which pass below the frontal lobe of the glabella.

The anterior sections of the facial suture run parallel and straight forward initially, curving half-way across the convexity (exsag.) of the preocular areas to intersect the anterior cranidial margin at obtuse angles. These sutures enclose gently convex (exsag.) preocular areas flanked anteriorly by a deep marginal furrow, deepest sagittally, a combination of marginal and preglabellar furrows, and an upturned (addorsal) cranidial border, the degree of upturning being most strong sagittally. The posterior sections of the facial suture enclose short (tr.), triangular posterolateral limbs bearing broad (exsag.) marginal furrows.

The librigena is characterized by a strongly advanced genal spine (Pl. 37, fig. 5), deflected outwards, and merging posterior and lateral marginal furrows.

The pygidium, which is nearly twice as wide (tr.) as long (sag.), is basically semicircular in shape, but its contours are interrupted by the presence of two marginal spines. The axis is parallel-sided, convex (tr.), composed of three axial segments, an articulating half-ring which has the same structure as the segments, and a blunt-ending terminal piece which is raised above the pleural zone. There is no post-axial ridge, the axis being strictly delineated from the pleura and borders. The axis occupies 84-88% of the total pygidial length (Lp_1, sag.). The anterolateral fulcra are wide-spaced (tr.), and lie near the margins of the pygidium. Three pairs of pleural furrows are present: the first runs arcuately to the lateral margin and defines the anterior limits of the spine bases; the second is short, faint, oblique, and does not reach the margin; and the third, very short and very weak, runs nearly parallel to the sagittal line, rearwards. A pair of long, delicate, incurving spines is developed from the opisthopleuron of the first and propleuron of the second pleural segment. Between the spine bases the margin of the pygidium is gently curved (Pl. 37, fig. 4). When the shell is removed (Pl. 37, fig. 6) a border becomes evident and the pleural furrows, apart from the first, are seen to terminate there.

The cranidium has a fine low-density granulation on its exfoliated surfaces, and there is no evidence from the available material to suggest that the granulation was any coarser on the shell, as pygidia with shell have a similar fine granulation. Little is known of the cranidial caecal network, but most exfoliated cranidia do show a sagittal keel, running the length (sag.) of the glabella, which is probably connected with the musculature. The pygidia caecal system is partially exposed on specimen CPC 11884 (Pl. 37, fig. 6), on which caeca may be seen crossing the border and joining the spine bases with the pleural zone. The prosopon of the librigena is identical with that of the pygidium, save that the lateral borders are both granulose and lirate.

PAGODIA (LOTOSOIDES) TURBINATA sp. nov.
(Pl. 36, figs 4-7; Text-fig. 56)

Name: L., *turbinata,* conical, referring to the shape of the glabella.

Holotype: CPC 11878, the cranidium preserved with shell, illustrated in Plate 36, fig. 7.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K108, K111, K115, and K116, at 73, 112, 132, and 138 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zones of *Pseudagnostus clarki prolatus* with *Caznaia sectatrix,* and *P. bifax* with *P. denticulatus.*

Material: Four cranidia and two pygidia; specimens CPC 11876-8 are figured.

Size: Cranidial lengths (sag.) measure between 6.00 and 6.10 mm, and the pygidial lengths (Lp_1) between 2.55 and 2.70 mm.

Diagnosis: A species of *Pagodia* (*Lotosoides*) subgen. nov. differentiated on account of its coarsely granulose prosopon, on both cranidium and pygidium, and relatively large palpebral lobes which extend rearwards to the rear of the pre-occipital glabellar lobes.

Differential diagnosis: Above all *Lotosoides turbinata* is distinguished from *L. calcarata* on the nature of its prosopon, differing in degree and density of granulation. Both species appear morphologically similar to cranidia ascribed by Endo (*in* Endo & Resser, 1937) to *Pagodia paraquadrata* (see pl. 71, fig. 12) and *Pagodia* *perquadrata* (pl. 67, fig. 26), but the published photographs show insufficient detail for firm comment, and the specimens are not readily available for comparison. Cranidia of *Lotosoides* spp. are also similar to those of *Pagodia* (*Idamea*) (see Öpik, 1967a), but pygidia are readily differentiated by the presence of marginal spines in the former.

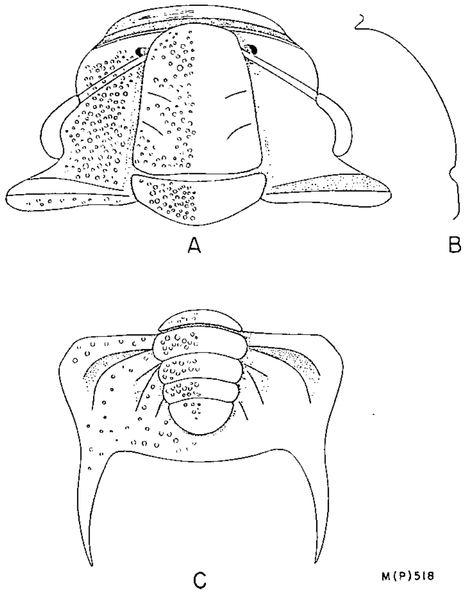

Fig. 56. *Pagodia* (*Lotosoides*) *turbinata* **subgen. et sp. nov.; (A) and (B) cranidium reconstructed from CPC 11876, x5; (C) pygidium based on CPC 11877, x8.**

Description: The cranidium is identical with that described above for *Lotosoides calcarata,* except that *L. turbinata* has coarser and more densely distributed granules, and its palpebral lobes appear to be slightly longer (exsag.), and extend rearwards from the middle of the median lateral lobes close to the rear of the preoccipital lobes. The shape and proportions of the glabella, and the nature of its furrowing and lobation, the nature of its ocular ridges, the proportionate widths of palpebral areas, and nature of the preocular areas and cranidial margin and border, are all extremely similar.

Similarly, the pygidium can be distinguished solely by the presence of larger granules. Possibly the spines are shorter, but as they are not fully preserved on the material at hand, the statement cannot be verified. Shape and segmentation are identical in the two Australian species of *Lotosoides.*

PAGODIA (DATSONIA) subgen. nov.

Name: Derived from Mount Datson, 2.8 km east-northeast of Granton Station, Boulia district, western Queensland.

Type species: Pagodia (*Datsonia*) *subterior* sp. nov., from sections at Mount Datson and Dribbling Bore, western Queensland; here designated, monotypical.

Distribution: Australia (western Queensland).

Age: Late Upper Cambrian, Payntonian.

Diagnosis: A subgenus of *Pagodia* with glabella constricted about the middle as in *Oreadella;* narrow (sag.), depressed anterior cranidial border; narrow (sag.) anterior cranidial marginal furrows; pygidium lacking depressed border, having six axial and five or six pleural segments, and entire, non-spinose margins.

Differential diagnosis: In terms of glabellar shape, furrowing, and size and position of the palpebral lobes, *Datsonia* and *Oreadella* are most similar. Cranidia of the former are differentiated solely on the nature of the cranidial border and marginal furrow (see diagnosis). The last characteristics also serve to differentiate *Datsonia* from all other subgenera of *Pagodia*. The pygidium is also most similar to *Oreadella*, in that it is semicircular, and lacks marginal furrows. That of *Datsonia*, however, has more segments.

PAGODIA (DATSONIA) SUBTERIOR sp. nov.
(Pl. 29, figs 5-10; Text-fig. 57)

Name: L., *subterior*, comp., lower, referring to the position of the anterior cranidial border with respect to the dorsal surface of the glabella.

Holotype: CPC 11885, the partly exfoliated cranidium illustrated in Plate 29, fig. 5.

Occurrence: 'Chatsworth Limestone', Mount Datson, horizons K176 and K178, at 140 and 166 m from the base of the measured section; Dribbling Bore, horizons K186, K188, K191, and K192, at 29, 32, 102, and 105 m from the base of the measured section; and at locality B777 (equivalent to K186 and K187) collected previously.

Age: Late Upper Cambrian, Payntonian, Assemblage-Zones of *Pseudagnostus quasibilobus* with *Tsinania nomas* and *Mictosaukia perplexa*.

Material: The species is known from 2 cranidial, 1 librigenal, and 19 pygidial fragments, of which specimens CPC 11885-90 are illustrated.

Size: The holotype cranidium has a sagittal length of 4.50 mm; and the measurable pygidia range in length (Lp_2) between 1.30 and 6.00 mm.

Diagnosis: Diagnostic characteristics are listed in the subgeneric diagnosis.

Description: The cranidium is anteriorly evenly and gently arcuate, characterized by its narrow (sag., exsag.) wire-like border. The glabella, similarly gently and obtusely rounded anteriorly, has concave flanks, being drawn in (adaxially) at the level of the anterior lateral glabellar furrows, and widest (tr.) across the frontal lobe. The furrowing is virtually effaced; traces of the preoccipital furrows are seen to curve inwards and rearwards, but median and anterior lateral furrows are very faint. A median keel runs the length of the glabella along the sagittal line. The only complete glabella occupies 82% of the total estimated cranidial length.

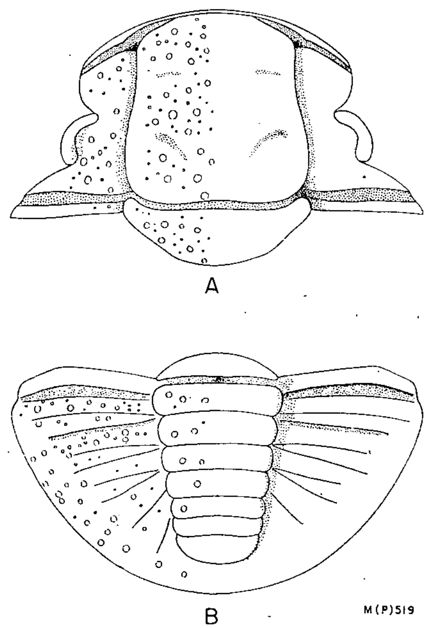

Fig. 57. ***Pagodia (Datsonia) subterior*** **subgen. et sp. nov.; (A) cranidium based on CPC 11885, x8; (B) pygidium based on CPC 11888, x10.**

The occipital furrow is sharply defined, transverse, slightly curvilinear. The occipital ring is as wide (tr.) as the preoccipital lobes but sagittally narrow.

The palpebral lobes are missing on all available material. They appear to have been small, and to have extended from the middle of the median lateral lobes to the middle of the preoccipital lobes. Compared with *Lotosoides,* they are comparatively close to the glabella, the palpebral areas having similar proportionate widths (tr.) to those of *Oreadella.* These areas have appreciable convexity (tr.). Anteriorly the palpebral lobes pass into faint ocular ridges which run to the axial furrows adjacent to the anterior lateral glabellar furrows.

The preocular sections of the facial suture run near parallel towards the cranidial margin, but the courses of the postocular sections are unknown. Like the palpebral areas, the preocular areas are relatively narrow (tr.). The cranidial border is, in dorsal aspect, narrow (sag.) and wire-like, depressed well below the dorsal surface of the glabella when viewed in lateral profile. Viewed obliquely the border slopes off steeply anteriorly in an adventral direction, is wide (sag.) downwards, and transversely lirate, as in *Pagodia* (*Idamea*) *baccata* Öpik (1967a, pl. 17, fig. 1). The marginal furrow, coincident with the preglabellar furrow, is narrow (sag.) and shallow.

A single librigenal fragment (Pl. 29, fig. 8), poorly preserved and incomplete, shows an advanced genal spine deflected outwards, as in *Lotosoides.*

The pygidium is subtriangular, slightly pointed posteriorly, with evenly and gently curved non-spinose margins: the length varies between 46 and 65% of the width. The axis is prominent, unevenly tapering rearwards, posteriorly bluntly rounded, and elevated above the posterior border. It is composed of five, sometimes six, axial segments, and a terminal piece. It does not reach the margin posteriorly, and forms 81-85% of the total pygidial length ($La:Lp_2$). Pleural fulcra are wide-spaced (tr.), the articulating facets being close to the anterolateral pygidial margins. Five or six pleural segments are visible on most specimens, having strong pleural furrows, equally bisecting the pleuron, and separated by extremely faint interpleural furrows. The first pair of pleural furrows runs direct to the margin and forms a notch on each of the anterolateral corners, a condition also noted in *Pagodia* (*Wittekindtia*) *variabilis* Wolfart (1970, p. 40, fig. 5). The remaining pleural furrows are arrested before reaching the margin and are separated from it by an unfurrowed border which continues the convexity (tr., sag.) of the pleural zone adventrally to the doublure. The last is very narrow (Pl. 29, fig. 7).

The surfaces of glabella, palpebral areas, librigenae, pygidial axis, and pleura are coarsely but sporadically granulose. In early holaspides (Pl. 29, fig. 10) these granules bear fine spines. When the shell is exfoliated, several specimens show a low density punctation. The nature of the caecal network is not known.

Family KAOLISHANIIDAE Kobayashi, 1935

Subfamily MANSUYIINAE Hupé, 1955 *sensu* Shergold, 1972

Genus MANSUYIA Sun, 1924

Type species: Mansuyia orientalis Grabau *in* Sun, 1924, p. 50-2, pl. 3, figs 7i-j [*non* figs 7a-d = *Taishania taianensis* Sun, 1935; *non* figs 7f-h = *Mansuyia chinensis* (Endo, 1933)], from the Fengshanian of Yehli, Machiakou, and Chihli, eastern Hopei, China; by original designation.

Other species: Other species are listed in Shergold (1972, p. 53). In summary they are: *Mansuyia tani* Sun (1935, p. 59, pl. 5, figs 12-15; [*non Mansuyia tani* Sun *sensu* Kobayashi, 1952 = *Mansuyia chinensis* (Endo, 1939)]. *Mansuyia trigonalis* Kobayashi (1960b, p. 364-5, pl. 21, fig. 18, text-fig. 5c). *Mansuyia manchurica* Kobayashi (1952, p. 148), based on *Hysterolenus* sp. indet., *vide* Endo (*in* Endo & Resser, 1937). *Paramansuyella planilimbata* Endo (*in* Endo & Resser, 1937, p. 359-60, pl. 70, figs 16-19). *Paramansuyella chinensis* Endo (1939, p. 9-10, pl. 2, figs 3-10, ?35), possible synonymy of this species given in Shergold (op. cit.).

Distribution: China (Shantung, Hopei), Manchuria (Liaotung), North Korea, South Korea, Australia (western Queensland).

Age: In Asia, late Changshanian (= late Daizanian) to Fengshanian; in Australia, pre-Payntonian A and Payntonian.

Diagnosis: See Lochman-Balk (*in* Moore, 1959) and Shergold (1972).

Differential diagnosis: Morphologically, *Mansuyia* is closely related to *Mansuyites* Shergold, and the new genera *Hapsidocare* and *Ceronocare.* The cranidium differs from that of *Mansuyites* mainly in the length (sag.) of the preglabellar area of late holaspides: meraspides and early holaspides (Pl. 38, figs 1-2) have a more closely comparable morphology to late holaspides of *Mansuyites.* In both genera the palpebral lobes are large, sited towards the rear of the genae, and remote from the glabella. Greater differences separate the holaspid, but not the meraspid, pygidia. They are distinguished by the orientation of the spines, deflected outwards from the margins in *Mansuyites,* running rearwards and more closely following the lateral margins in *Mansuyia* (see Sun 1924: pl. 3, figs 7i-j), and by the disposition of the borders — present only posterolaterally in *Mansuyites,* circumscribing the pleural zone in *Mansuyia.* The latter also has more pleural segments, but a similar number of axial ones.

Mansuyia differs from *Hapsidocare* and *Ceronocare* in the shape of its preglabellar area, and its palpebral lobes lie farther to the rear. In the pygidium *Hapsidocare* has no pygidial 'bowl', the margin between the spine bases being transverse and straight, or only gently curved, similar to the condition found in *Kaolishania.*

MANSUYIA cf. ORIENTALIS Sun, 1924
(Pl. 38, figs 1-11; Pl. 39, figs 1-2; Text-fig. 58)

cf. 1924 *Mansuyia orientalis* (Grabau) Sun, p. 50-52, pl. 3, figs 7i-j, *non* figs 7a-h, see above.
cf. 1942a *Mansuyia orientalis* (Sun); Resser, p. 31.
cf. 1957 *Mansuyia orientalis* (Grabau) Sun; Lu, p. 282, pl. 145, fig. 5.
cf. 1960 *Mansuyia hopeiensis* Kobayashi, 1960b, p. 364, text-fig. 5a.
cf. 1966b *Mansuyia hopeiensis* Kobayashi; Kobayashi, p. 275.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K130, K131, K133, K134, K135, and K136, at 272, 309, 325, 329, 335, and 348 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian A, *Sinosaukia impages* Assemblage-Zone; early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas.*

Material: Fragments of 26 cranidia and 13 pygidia. The illustrated paradigm comprises specimens CPC 11891-902.

Size: Cranidial lengths (sag.) measure between 2.30 and 10.70 mm; some smaller specimens and some larger ones are too incomplete for an estimate of length parameters. Pygidial lengths (sag.) measure between 0.95 and 5.10 mm.

Comments: The types of *Mansuyia orientalis* Sun (Geological Survey of China Nos 563, 564) are limited to two pygidia from the Fengshan Limestone of Yehli, northern China. These are characterized by an effacement of pleural, interpleural, and marginal furrows, a long axis reaching close to the posterior pygidial margin, and slender, delicate lateral spines which carry the line of the anterolateral margins rearwards. The pygidial 'bowl' is not deep. Sun (1924, p. 50) quotes the presence of six pleural and seven axial segments, but these figures may be applicable to other pygidia figured at the same time which are now known to be referable to *M. chinensis* (Endo), and which have a different structure. In a later paper, Sun (1935) referred cranidia previously figured (1924, pl. 4, figs 4a-d) as *Chuangia batia* Walcott to *Mansuyia orientalis*. These look very similar to others figured by Endo (1939, pl. 2, figs 3-6) as *Paramansuyella chinensis*, now considered referable to *Mansuyia chinensis*. The type pygidia of *M. orientalis* are thus left without cranidia.

Pygidia occurring between 272 and 348 m in the Black Mountain section are most comparable with the types of *Mansuyia orientalis*. Associated cranidia differ from those of any other described species. They are characterized by long (sag.), narrow (tr.), paucifurrowed glabellae, proportionately long (sag.) preglabellar areas, anteriorly rounded in meraspides and early holaspides, and gently angled in late holaspides, and large palpebral lobes placed towards the rear on the cheeks. In these characteristics the specimens at hand resemble the species of *Mansuyites* occurring in the Gola Beds at Momedah Creek but the associated pygidia cannot be confused.

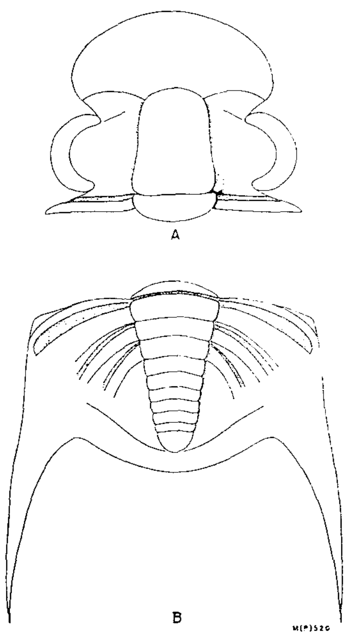

Fig. 58. ***Mansuyia*** **cf.** ***orientalis*** **Sun, 1924; (A) cranidium reconstructed from CPC 11895, x3.5; (B) pygidium reconstructed from CPC 11900, x5 approx.**

Description: The glabella is long (sag.), 53-63% of the cranidial length (sag.), narrow (tr.), parallel-sided in early holaspides and meraspides, developing an anterior taper in late holaspides. Glabellar furrows are effaced in late holaspides, but two pairs are faintly present in some early holaspid specimens (see Pl. 38, figs 3, 6), in which they are represented as notches on the lateral glabellar margins.

The occipital furrow is shallow, faint, with sagittal anterior curvature. The occipital ring is low in lateral aspect, in plan view just wider (tr.) than the preoccipital glabellar lobes. In meraspides it bears a faint nuchal node.

The palpebral lobes are crescentic in early holaspides, semicircular in late holaspides, large, extending from the level of the occipital furrow, forwards at least to the anterior lateral glabellar furrows; A:G is 62-72%. The palpebral furrows are faint; the palpebral areas wide (tr.), with low convexity. The fronts of the palpebral lobes are connected by duplicated ocular ridges to the anterolateral corners of the glabella. They are cut by the axial furrows but are probably represented by a parafrontal band which follows the anterior contour of the frontal lobe.

The preocular sections of the facial suture diverge rapidly from the front of the palpebral lobes at angles of approximately 90°. They enclose a broad (tr., sag.) concave preglabellar field, which rises anteriorly into an ill-defined border, evenly rounded in early holaspides, gently angled in late ones. The postocular sections of the facial suture enclose narrow (exsag.), but relatively long (tr.), blade-like posterolateral limbs. The preocular areas and the front of the glabella lie on the same transverse line. On some specimens small bacculae are seen adjacent to the preoccipital lobes of the glabella. In others there are small swellings on the preglabellar field opposite the anterolateral corners of the glabella.

Small meraspid pygidia are triangular, twice as wide (tr.) as long (sag.). Their axes are composed of nine segments, together with a terminal piece, and reach the pygidial margins posteriorly. They have six pleural segments defined by well developed pleural furrows, but poorly defined interpleural ones. Their lateral borders are pronounced, originating behind the spine bases, but becoming deflected adventrally behind the axis. The long, slender, and delicate lateral spines are derived from the opisthopleuron of the first and propleuron of the second pleural segment. These immature pygidia strongly resemble the holaspid pygidia of *Mansuyites* (Shergold, 1972). In holaspid pygidia the axis is shorter (sag.), and the lateral borders continue faintly around it posteriorly. The pleural furrows become increasingly effaced with increase in size, but the overall shape of the meraspid pygidium is retained.

Mansuyia cf. *orientalis* has a very faintly granulose surface in late holaspides. Early ones show a 'fingerprint' prosopon on their glabellae. Invariably the margins of the preglabellar areas are weakly lirate, as are the pygidial spines. One pygidium (Pl. 38, fig. 8) shows traces of the caecal system, and in particular the propleural diverticulum branching abaxially.

MANSUYIA cf. TANI Sun, 1935
(Pl. 39, figs 3-7, Text-fig. 59)

cf. 1935 *Mansuyia tani* Sun, p. 59, pl. 5, figs 12-15.

non 1952 *Mansuyia tani* Sun; Kobayashi, p. 147, pl. 13, figs 16-18.

non 1960b *Mansuyia tani* Sun; Kobayashi, p. 364, text-fig. 5b.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizon K139, at 375 m from the base of the measured section; and at B510b collected previously.

Age: Late Upper Cambrian, early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas*.

Material: Four cranidia and five pygidia, of which specimens CPC 11903-11906b are illustrated.

Size: Cranidia range in length (sag.) between 1.20 and 7.70 mm; and pygidia between 2.70 and 5.80 mm.

Comments: According to Sun (1935, p. 59), the main differences between *Mansuyia tani* and *M. orientalis* lie in the less concave preglabellar field and optical furrow of the former, and a more strongly tapering pygidial axis with nine segments. Sun's concept of *M. orientalis* differed from that presented here and the differences elucidated are more relevant to *M. chinensis* (Endo).

In effect, comparing Sun's illustrations of *M. tani* (1935, pl. 5, figs 12-15) with those of *M. orientalis* (1924, pl. 3, figs 7i-j), one sees that *M. tani* has a deeper pygidial 'bowl' and distinct and continuous lateral and posterior borders, and that the pygidial spines are deflected away from the lines of the lateral pygidial margins. These features are present among Australian specimens compared to *M. tani.* Associated cranidia from Black Mountain are essentially similar to those of *M.* cf. *orientalis,* but they are perhaps a little more strongly effaced, the glabella is proportionately shorter with respect to the cranidial length, and the palpebral lobes proportionately longer with respect to the glabella. Pygidia referred to *M.* cf. *tani* are not unlike those of *M. chinensis* (Endo). Although they have somewhat similar shapes, the Australian material has more segments in both axis (9) and pleural zone (6), and a more strongly delineated border.

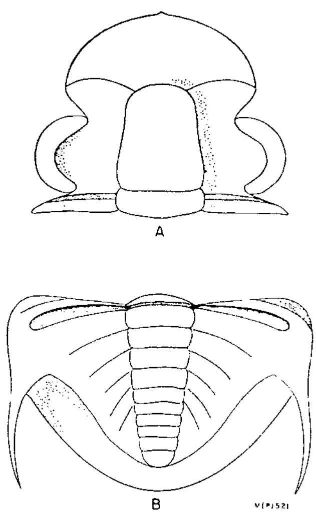

Fig. 59. ***Mansuyia*** **cf.** ***tani*** **Sun, 1935; (A) cranidium reconstructed from CPC 11903, x3.5 approx.; (B) pygidium reconstructed from CPC 11905, x5.**

Description: The glabella is parallel-sided, cylindrical in meraspides, tapering forwards in late holaspides, in both bluntly rounded anteriorly. Glabellar furrows appear to be completely effaced on the available material, as is the occipital furrow in late holaspides; G:Lc is 49-62%. The meraspid cranidium illustrated bears a nuchal node.

As in *Mansuyia* cf. *orientalis* the palpebral lobes are large, semicircular, and placed rearwards on the cheeks. The palpebral furrows are shallow, ill defined, and the palpebral areas wide (tr.), with low convexity (tr.). In late holaspides the palpebral lobes extend from the level of the occipital furrow to the level at which the anterior glabellar furrows might be expected in specimens en grande tenue; A:G is 60-79%, the proportionate length of the palpebral lobes increasing with size.

The preglabellar area and courses of the anterior sections of the facial suture are similar to those of *M.* cf. *orientalis,* but the anterior limits of the glabella are less readily recognized owing to effacement. As far as can be seen the postocular facial sutures are also similar to those of *M.* cf. *orientalis*. Ocular ridges are strongly defined on the illustrated meraspid cranidium, and the palpebral lobes of this specimen (CPC 11904) are so far forwards that the ridges are transversely oriented.

The associated pygidia are subtriangular; in early holaspides the length (sag.) is approximately half the width (tr.), but in late holaspides it increases to over 60% of the width. The pygidium is poorly fulcrate and the axial articulating half-ring is very narrow (sag.). The axis tapers unevenly rearwards and terminates in a slightly swollen end-piece close to the posterior pygidial margin. It is composed of nine axial segments. The pleurae, which number five, sometimes six, are equally bisected by shallow and wide pleural furrows, the first pair running transversely, the remainder obliquely rearwards. Interpleural furrows are effaced. All furrows terminate posterolaterally at a wide (tr.) marginal furrow running between the spine bases, which passes outwards into a slightly convex border. A pair of slender and delicate spines, with narrow (exsag.) bases derived from the opisthopleuron of the first and propleuron of the second pleural segments, diverge outwards from the lateral pygidial margins, curving gently outwards and inwards distally.

A very faint granulation is evident on some cranidia, but most often they are smooth. Weakly impressed lirae are present on the anterior cranidial border, and on the pygidial border and spines. The pygidial axis and pleura may also be finely granulose.

Genus HAPSIDOCARE nov.

Name: Gk, *hapsis,* arch or vault, combined with Gk, *kara,* head, referring to the shape of the cranidium; neuter.

Type species: Hapsidocare chydaeum sp. nov., from Black Mountain, western Queensland (see below); here designated.

Other species: Hapsidocare grossum sp. nov., also from the Black Mountain section, western Queensland (see below).

Distribution: Australia, western Queensland.

Age: Late Upper Cambrian, pre-Payntonian B.

Diagnosis: A mansuyiinid genus characterized by a long (sag.) and wide (tr.), concave preglabellar field strongly arched anteriorly; palpebral lobes placed about the midlength of the glabella; pygidial spines derived from the whole of the lateral flanks of the shield; downsloping posterior borders, transverse or only slightly curved.

Differential diagnosis: Cranidia of *Hapsidocare* resemble those of *Mansuyia* and *Mansuyites,* but are differentiated from both by the more anterior positioning of the palpebral lobes, and in having considerably longer and wider (exsag.) posterolateral limbs. Pygidia of *Hapsidocare* are quite different from those of any other mansuyiinid genus, having but a shallow pygidial 'bowl', spines developing from the whole length of the lateral pygidial flanks, and rounded anterolateral shield margins. The spines are apparently derived from the pygidial borders rather than from specified pleural segments, as in *Mansuyia* and *Mansuyites,* and the specimens described as *Kaolishania pustulosa* by Sun (1924, pl. 3, figs 8e-g). They are thus similar to the specimens previously figured from the Gola Beds (Shergold, 1972, pl. 12, fig. 2) as *K. australis.* The general appearance of the pygidium of *Hapsidocare,* and the mode of formation of the spines, resembles the condition of *Crepicephalus* and some other Crepicephalidae.

HAPSIDOCARE CHYDAEUM gen. et sp. nov.
(Pl. 40, figs 1-6; Pl. 41, figs 1-3, Text-fig. 60)

Name: L., *chydaeum,* abundant or common.

Holotype: CPC 11907, the cranidium preserved with shell, illustrated in Plate 40, figs 1, 3.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K103, K104, K105, and K106, at 1.6, 6, 7, and 51 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zone of *Pseudagnostus clarki patulus* with *Caznaia squamosa.*

Material: Fragments of 20 cranidia, 19 pygidia, and a single librigena, the illustrated paradigm comprising specimens CPC 11907-13.

Size: Measured cranidia range in length (sag.) between 6.75 and 14.00 mm; pygidia have lengths (sag.) between 4.35 and 10.15 mm.

Diagnosis: A species of *Hapsidocare* gen. nov. with coarse granulosity, delicate pygidial spines, and transverse linear or very slightly curvilinear posterior pygidial margins.

Description: In *Hapsidocare chydaeum* the glabella tapers forwards, and has sinuous lateral margins, being widest (tr.) at the preoccipital glabellar lobes and constricted at the median lateral furrows. At the front, the glabella is evenly and somewhat obtusely rounded. Glabellar furrowing is weak, on testaceous specimens almost effaced. Exfoliated specimens, however, have faint, oblique curvilinear preoccipital furrows; oblique, linear median lateral glabellar furrows; and very weak, short, transverse anterior lateral furrows. The glabella (G) occupies 49-55% of the total cranidial length (sag.).

The occipital furrow is only well defined sagittally, where it arches slightly forwards. Abaxially the furrow is effaced, but at its extreme distal ends is pitted. The occipital ring, lying just below the level of the glabella in profile, is a little narrower (tr.) than the preoccipital lobes. It is also sagittally narrow.

The palpebral lobes are crescentic, with fairly well defined palpebral furrows. They occupy 61-67% of the glabellar length (sag.) and are sited between the middle of the preoccipital lobes and the median lateral furrows of the glabella. Posteriorly they are separated from the marginal cranidial furrow by an area of fixigena amounting to 36-43% of the length of the palpebral lobes. The palpebral areas are wide (tr.), on average 39-43% of the maximum glabellar width (tr.), and gently convex (tr.).

From the front of the palpebral lobes, the preocular sections of the facial suture strike outwards, forming angles of approximately 110° at the sagittal line, thence curving sharply inwards to meet at an apex on the anterior cranidial margin sagittally. Postocular facial sutures diverge rapidly from the rear of the palpebral lobes to enclose short, triangular posterolateral limbs.

Ocular ridges are present but very faintly defined on most specimens. The preocular areas have appreciable convexity (exsag.), and are divided from the preglabellar field proper by well defined furrowing which continues adaxially to the front of the glabella. The preglabellar field is gently concave sagittally, more

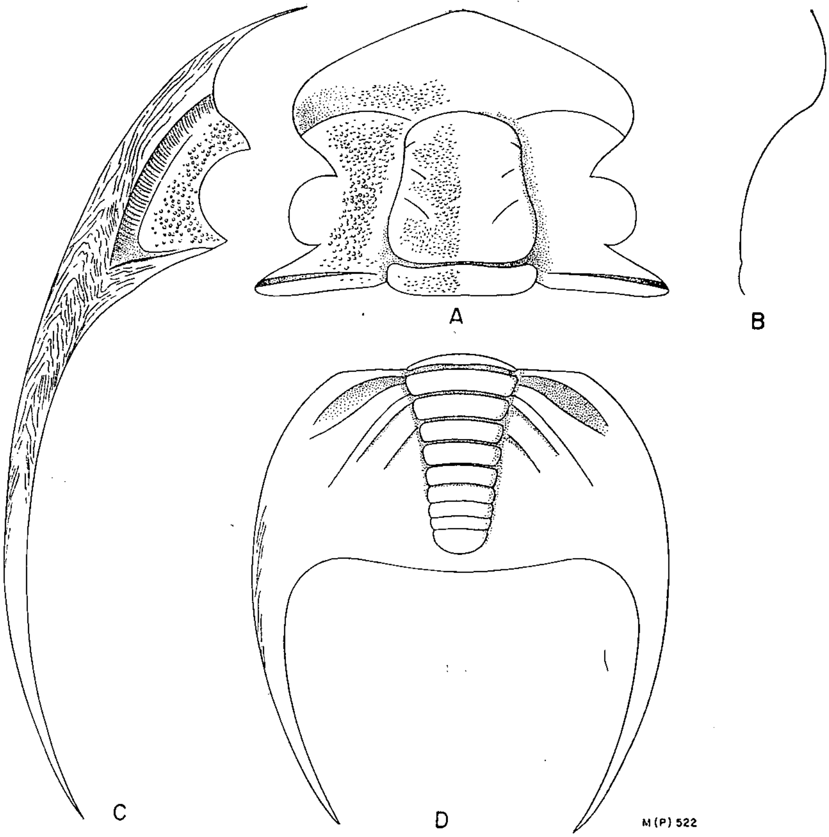

Fig. 60. ***Hapsidocare chydaeum*** **gen. et sp. nov.; (A) and (B) cranidial reconstruction from CPC 11907, x4; (C) librigena reconstructed from CPC 11910, x6.5 approx.; and (D) pygidium based on CPC 11911, x5.**

strongly curved in front of the preocular areas. It rises to a narrow upturned cranidial border, which has a markedly arched anterior contour.

The librigena is characterized by deep and wide lateral marginal furrows, but much narrower (exsag.) posterior ones. The genal field is distinctly convex (tr., exsag.). The borders are wide and gently convex, and extend posterolaterally into long, stout genal spines.

The pygidium is basically trapezoidal, the length (sag.) varying between 51 and 62% of the width (tr.) according to preservation. Characteristically, the fulcral points are rounded off, and the lateral margins convex outwards. The axis, with seven axial segments and a terminal piece, has concave flanks, and tapers unevenly rearwards, terminating almost at the posterior margin; La:Lp is 91-94%. There are four, perhaps five, pleural segments, with shallow pleural furrows and weak interpleural ones. A broad border is present at the spine bases, and as a result the pleural zone is constricted at this point. Posterolaterally the border becomes narrower, and slopes adventrally behind the axis. Between the spine bases the margin is linear, or slightly curvilinear, and transverse. The spines themselves are derived from the lateral borders rather than from the pleura. Their bases are therefore broad, occupying the complete length of the pygidial flanks. From these bases long, slender spines curve rearwards and distally inwards.

When the shell is preserved *H. chydaeum* has a coarse and dense, almost squamose, granulation. Exfoliated specimens have a finer granulation. Additionally, the cranidial border, the lateral librigenal borders and genal spines, and the pygidial spines are lirate, the lirae running in anastomosing chevrons along the length of the spines. Remnants of the caecal systems are partly exposed on the preocular areas of the cranidium illustrated in Plate 40, fig. 6, and the pleura of the pygidium in Plate 41, fig. 3.

HAPSIDOCARE GROSSUM sp. nov.

(Pl. 41, figs 4-7; Pl. 42, figs 1-5; Text-fig. 61)

Name: L., *grossum,* gross or large, referring to the massive pygidial spines.

Holotype: CPC 11914, the cranidial fragment illustrated on Plate 42, fig. 1.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K108, K109, K110, K116, K117, and possibly K118, at 73, 80, 91, 138, 149, and ?156 m from the base of the measured section; and at B507a″ collected in 1957.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zones of *Pseudagnostus clarki prolatus* with *Caznaia sectatrix* and *P. bifax* with *P. denticulatus.*

Material: 12 cranidial fragments, 6 librigenae, and 11 pygidia, of which specimens CPC 11914-21 are illustrated.

Size: The single cranidium complete enough for measurements (Pl. 41, fig. 7) has a length (sag.) of 7.75 mm. The holotype has a glabellar length (G) of 7.10 mm. Pygidia range in length (sag.) between 4.60 and 10.00 mm.

Diagnosis: A species of *Hapsidocare* gen. nov. having a finely granulose test, massive pygidial spines, deeper pygidial 'bowl' (i.e. the margin is more curved posteriorly), and narrow borders.

Differential diagnosis: Apart from the characteristics listed in the diagnosis, *H. grossum* differs from *H. chydaeum* in having a proportionately longer glabella, G:Lc 57%, Gn:Lc 71%, as against 49-56% and 61-67%. The preglabellar area appears to be less wide (tr.) in *H. grossum.* In comparing pygidia, *H. grossum* has one segment fewer in both axis and pleural zone, and its spine bases are apparently stouter (exsag.).

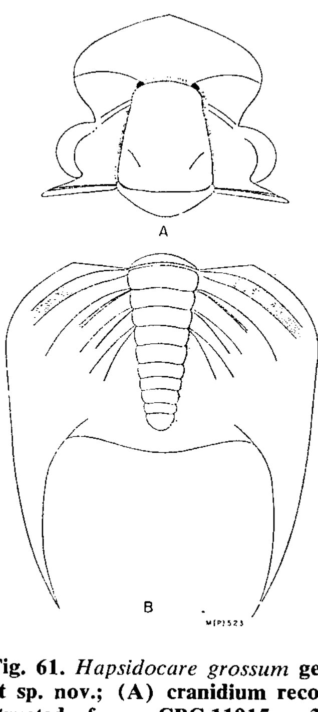

Fig. 61. ***Hapsidocare grossum*** **gen. et sp. nov.; (A) cranidium reconstructed from CPC 11915, x3.5 approx.; (B) pygidium based on CPC 11919, x2.5.**

Description: The description of this species is largely the same as that of *H. chydaeum.* The ocular ridges are more strongly defined and the glabella has a less bulbous appearance and straight flanks, although the degree of anterior taper is similar. The density of cranidial granulation is comparable, but the granules are on the whole smaller and finer.

In the pygidium there are definitely six, and only possibly seven, axial segments, and there are only three well defined pleural segments, with an ill defined fourth. The posterior pygidial margin is more fully curved between the spine bases, which themselves do not occupy the whole of the lateral pygidial flanks. In addition, the spines possibly diverge more rapidly outwards from the lines of the pygidial flanks.

In all other respects *H. grossum* is similar to *H. chydaeum*.

Genus MANSUYITES Shergold, 1972

Type species: Mansuyites futiliformis Shergold 1972, p. 55-8, pl. 13, figs 1-7; pl. 14, figs 1-6, from the Gola Beds of Momedah Creek, Boulia district, western Queensland; original designation.

MANSUYITES spp. indet.
(unfigured)

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K122, K123, K124, and K125, at 175, 185, 200, and 202.5 m from the base of the measured section; and at B507c and B509 on previously collected sections.

Age: Late Upper Cambrian, pre-Payntonian A, *Pseudagnostus clarki maximus* with *P. papilio* Assemblage-Zone.

Comment: Several poorly preserved cranidial and pygidial fragments occurring in the interval K122-K125 on the Black Mountain section can probably be referred to *Mansuyites*. Their pygidia have long, delicate spines, narrow spine bases, and deep pygidial 'bowls', all similar to those of *M. futiliformis,* which is from a comparable time interval at nearby Momedah Creek. None of the cranidia are sufficiently well preserved, however, for accurate comparison.

Subfamily TINGOCEPHALINAE Hupé, 1955, *sensu* Shergold, 1972
Genus PALACORONA Shergold, 1972

Type species: Palacorona bacculata Shergold (1972, p. 59-61, pl. 15, figs 1-5), from the Gola Beds, Momedah Creek, Boulia district, western Queensland; by original designation.

Other species: Palacorona torosa sp. nov., from the Dribbling Bore and Mount Datson sections, see below; *Palacorona* sp., from the Black Mountain section, see below.

Distribution: Australia (western Queensland).

Age: Late Upper Cambrian, pre-Payntonian A and Payntonian.

PALACORONA TOROSA sp. nov.
(Pl. 44, figs 1-6; Text-fig. 62)

Name: L., *torosa,* bulging, referring to the slight swelling (convexity) of the preglabellar field.

Holotype: CPC 11922, the cranidium preserved with shell, from Dribbling Bore, illustrated in Plate 44, fig. 3.

Occurrence: 'Chatsworth Limestone', Dribbling Bore, horizons K186 and K187, at 29 and 31 m from the base of the measured section; at K196, which is an isolated horizon to the east of the fault bisecting Dribbling Bore; and at B777, collected in 1957, and equivalent to either K186 or K187. The species questionably occurs at K175, 40 m above the base of the Mount Datson section.

Age: Late Upper Cambrian, early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas.*

Material: Known from nine cranidia, a single librigena, and three pygidia. The illustrated paradigm comprises specimens CPC 11922-7.

Size: The cranidial fragments range in length (sag.) between 6.00 and 17.00 mm (estimated); and the pygidia are between 12.50 and 20.50 mm long (sag.).

Diagnosis: A species of *Palacorona* with a marked tendency to swell out the preglabellar field; the front of the glabella lies slightly behind a transverse line across the paradoublural lines; the palpebral lobes are small, lying between the middle of the preoccipital lobes and the front of the median lateral lobes. The pygidium has a deep 'bowl', rearward tapering anterolateral flanks, and laterally directed spines, with bases derived from the pleural zone.

Differential diagnosis: The tendency to increase the convexity (sag.) of the preglabellar field is greater than in *Palacorona bacculata,* the only other species with which *P. torosa* can be compared, and the cranidial border is perhaps a little wider (sag.). Ocular ridges are more strongly developed in *P. torosa,* and seem to be duplicated. The glabellae in both species are expanded across the preoccipital lobes to include bacculae, a characteristic feature of Tingocephalinae. In *P. torosa* the front of the glabella lies to the rear of a transverse line across the paradoublural lines, whereas in *P. bacculata* the front of the glabella lies on or slightly in front of this line. The pygidium of *P. bacculata* is unknown, but that of *P. torosa* resembles those of *Ceronocare pandum* (see here, Pl. 43, fig. 7), and *Kaolishaniella transita* (see Sun, 1935, pl. 3, figs 1-5). It differs from both in the shape of its anterolateral flanks, and from the latter also in having lower relief in the pleural zone.

Description: The glabella (G), occupying 44-54% of the total cranidial length (sag.), tapers forwards and is truncate anteriorly. It is widest (tr.) at the level of the preoccipital lobes, which are spread laterally to include the bacculae of the fixigenae. The glabella is narrowest (tr.) at the level of the median lateral glabellar furrows. The preoccipital furrows are deep elongated pits, directed slightly posteriorly; the median lateral furrows are ovoid pits; and the anterior lateral furrows are ovoid depressions set some distance from the axial furrows. Preoccipital and median lateral furrows open into the axial furrows. A fourth pair of

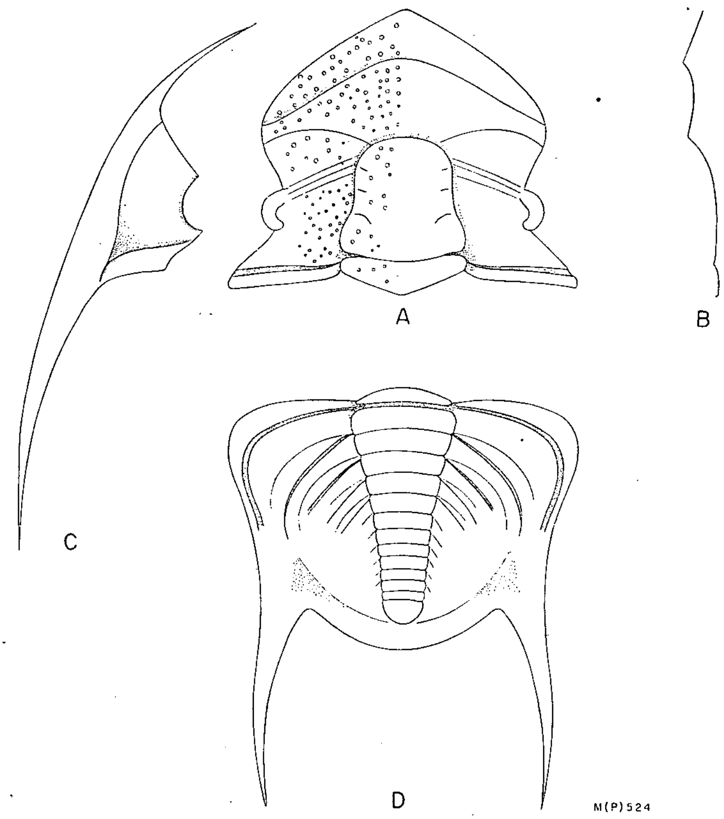

Fig. 62. ***Palacorona torosa*** **sp. nov.; (A) and (B) cranidial reconstruction based on CPC 11922, x3; (C) librigena based on CPC 11926, x1.3; and (D) pygidium based on CPC 11927, x1.6.**

furrows slopes inwards and forwards immediately in front of the anterior lateral furrows and appears to be connected to the ocular ridges and parafrontal band.

The occipital furrow is sagittally shallow and transverse, but is considerably deepened abaxially where it becomes confluent with the axial furrows. The occipital ring is markedly wider sagittally than exsagittally. Transversely it is as wide as the preoccipital lobes. The middle part of the occipital ring is broken away on all specimens: perhaps the species could have a nuchal spine. Fragments of occipital rings bearing spine-bases are found associated in the same deposits.

The palpebral lobes are small, occupying some 30% of the glabellar length, and extending from the middle of the preoccipital lobes, forwards as far as the front part of the median lateral lobes. They are small crescents attached to the axial furrows by strongly defined, duplicated ocular ridges which intersect the axial furrows in front of the anterior lateral furrows of the glabella. The palpebral areas have similar appreciable convexity (exsag.), and are separated from the preglabellar field by strongly arched paradoublural lines. The front of the glabella lies behind a transverse line connecting them.

The preocular sections of the facial suture diverge outwards rapidly until they intersect the paradoublural lines, then curve forwards and inwards in a gentle arch to meet sagittally at an acute angle. The preglabellar area is long (sag.), composed of a gently convex (sag.) preglabellar field, a faintly depressed triangular marginal furrow, and a relatively wide slightly upturned and convex anterior cranidial border. The postocular sections of the facial suture enclose reasonably broad and long (tr.) triangular posterolateral limbs.

The librigena has a long anterolateral prong which in articulation extended around the periphery of the preglabellar area. Lateral and posterior marginal furrows are well defined and confluent at the genal angles, where they unite to form a single furrow which cuts across the base of the stout genal spine.

The pygidium is triangular, the length (sag.) being approximately 70% of the width (tr.). The anterior margins are weakly fulcrate, and the articulating facets gently rounded with the anterolateral curvature. The anterolateral flanks are straight, converging rearwards towards the spine bases. The spines, derived from the opisthopleuron of the first and the propleuron of the second pleural segments, are deflected outwards and backwards, away from the pygidial margins. Between the spine bases the posterior margin is strongly triangular, forming a prominent 'bowl' which has a shallow border. A similar border adjacent to the first pleural segment runs into the front of the spine base laterally. There are six pleural segments, divided by weak interpleural furrows. The first pleural furrows are transverse and reach the pygidial margin, becoming confluent with the anterolateral marginal furrow. The remaining pleural furrows are weaker, obliquely directed rearwards, and fade out across the pleural zone. The axis converges unevenly rearwards, and is composed of at least eleven axial rings, and a tapered terminal piece. It reaches very close to the posterior margin, interrupting the marginal furrow.

The surfaces of the glabella and the palpebral and preocular areas bear randomly distributed scattered granules. Large granules of the preglabellar field are possibly associated with the caecal network. The cranidium and librigenal borders are smooth, as are the genal spines, pygidial spines, and borders. The pygidial axis is finely and faintly granulose.

PALACORONA sp.
(Pl. 45, fig. 1)

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K121, K122, K124, K126, and K128, at 171, 175, 200, 232, and 240 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian A, Assemblage-Zones of *Pseudagnostus clarki maximus* with *P. papilio* and *Sinosaukia impages.*

Comment: Several imperfectly preserved fragments are probably referable to *Palacorona.* The illustrated cranidium appears similar to *P. bacculata* Shergold, 1972, but its morphology is not well enough known for a specific determination. Noteworthy is the presence of a strong nuchal node.

Genus CERONOCARE nov.

Name: From Gk, *keron,* beehive, and *kara,* head, referring to the shape of the preglabellar area; neuter.

Type species: Ceronocare pandum sp. nov., from the Black Mountain section, western Queensland, see below; here designated.

Other species: Ceronocare sp., from the same section, see below.

Distribution: Australia, western Queensland.

Age: Late Upper Cambrian, pre-Payntonian B.

Diagnosis: Tingocephalinae with long and concave (sag.) preglabellar field; highly arched and anteriorly pointed preglabellar area; short (sag.) anteriorly truncate glabella; duplicated ocular ridges; pygidium with spines deflected strongly postero-laterally; shallow 'bowl', and parallel anterolateral flanks.

Differential diagnosis: The general shape of the glabella, the nature of its furrowing, and its relationships to the preocular areas, the general nature of the preglabellar area and overall organization of the pygidial morphology, are all strongly reminiscent of Mansuyiinae. But *Ceronocare* is diagnostically distinct from members of that subfamily. While cranidia are most similar to those of *Hapsidocare* (Mansuyiinae) with respect to glabellar and ocular features, pygidia are most reminiscent of those assigned by Sun (1935) to *Kaolishaniella* (Tingocephalinae). Both *Ceronocare* and *Kaolishaniella* have the elongated anterolateral pygidial flanks, and the spines directed strongly in posterior and lateral directions. *Kaolishaniella* has a deeper 'bowl', wider borders, and its spines are obviously developed from the opisthopleuron of the first and propleuron of the second pleural segments, whereas in *Ceronocare,* like *Hapsidocare,* they are divided from the lateral borders. Cranidia assigned to *Kaolishaniella* are quite different from those of *Ceronocare* (see Sun, 1935, pl. III, figs 8-12, 16).

CERONOCARE PANDUM gen. et sp. nov.
(Pl. 42, fig. 6; Pl. 43, figs 1-7; Text-g. 63)

Name: L., *pandum,* bent or curved, alluding in this instance to the wave-like or rippled prosopon of the preglabellar field.

Holotype: CPC 11929, the cranidium illustrated in Plate 43, fig. 1.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K111, K112, K113, K114, K116, and K117, at 112, 120, 127, 128.5, 138, and 149 m from the base of the measured section; and also at localities B507a′ and B507a″ collected in 1957.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zones of *Pseudagnostus clarki prolatus* with *Caznaia sectatrix* and *Pseudagnostus bifax* with *P. denticulatus.*

Material: Twelve cranidial and three pygidial fragments. Specimens CPC 11929-35 constitute the type series.

Size: Cranidia vary in length (sag.) between 2.80 and 13.50 mm, and the pygidium which is most complete has a sagittal length (Lp_1) of 2.90 mm.

Diagnosis: A species of *Ceronocare* gen. nov., with wide (tr.) late holaspid preglabellar area, and dense granulo-plicate prosopon.

Description: The cranidia have short (sag.), anteriorly truncate, forward tapering glabellae. In the largest specimen, the glabella occupies only 41% of the cranidial length (sag.). Meraspides and early holaspides, however, have proportionately longer (sag.) glabellae. Glabellar furrowing is faint: the preoccipital furrows are apparently oblique, sloping adaxially rearwards; the median lateral ones are more nearly transverse; and the anterior lateral ones are short (tr.), faint depressions.

The occipital furrow is similarly faint, transverse or posteriorly bowed sagittally, sinuous abaxially, and does not contact the axial furrows. The occipital ring is narrow (sag.), transversely as wide as the preoccipital lobes, and slightly raised above the glabella in lateral profile. It bears a nuchal node in meraspides, which is resorbed during holaspid morphogenesis.

The palpebral lobes are semicrescentic, relatively short (exsag.), about two-thirds of the glabellar length (G), and extend from the level of the middle of the preoccipital lobes to the median lateral glabellar lobes (middle part) in late holaspides. In meraspides they extend from the occipital furrow to the anterior lateral glabellar furrows. The palpebral areas are relatively wide (tr.), gently convex (tr.), with a tendency to develop bacculae opposite the middle of the preoccipital glabellar lobes. They are divided from the preocular areas by faint, but visible, duplicated ocular ridges. The anterior limits of the preocular areas lie on the same transverse line as the front of the glabella.

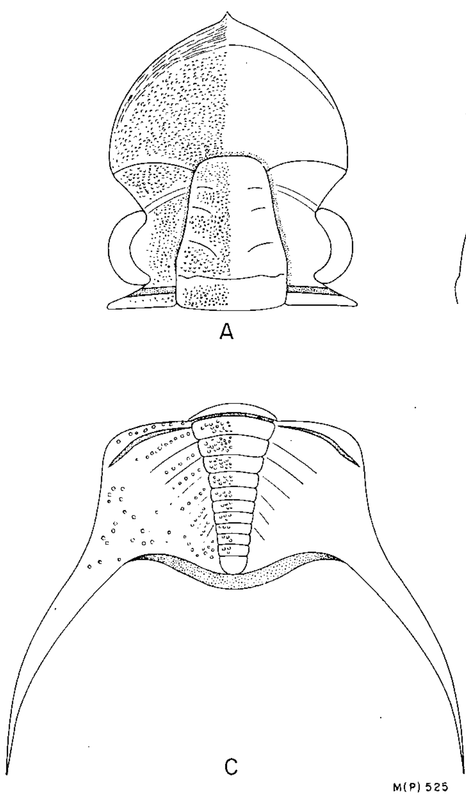

Fig. 63. Reconstruction of *Ceronocare pandum* gen. et sp. nov.; (A) and (B) cranidium based on CPC 11929, x3; (C) pygidium based on CPC 11934, x8.

The preocular sections of the facial suture diverge rapidly outwards to the level of the paradoublural lines, thence arch evenly and gradually inwards to meet anteriorly at a pronounced triangular apex sagittally. They enclose a long (sag.) preglabellar area, composed of a gently concave preglabellar field and a narrow concavo-convex cranidial border. The nature of the posterolateral limbs in this species is not known.

The librigena and hypostoma are also unknown.

The pygidium, which is known from one complete specimen and several fragments, is subtriangular, two-thirds as long (sag.) as wide (tr.). It has a shallow posterior 'bowl', but the anterolateral flanks are parallel and straight, and form a distinct angle with the near-flat articulating facets. The axis, occupying 96% of the total pygidial length (sag.), tapers evenly rearwards, and is composed of nine rings, together with an indistinct terminal piece. There are four pleural segments separated by indistinct interpleural furrows. The pleural furrows of the first segment are curvilinear transverse, and as in Pagodiinae continue to the lateral pygidial margins, which they intersect above (anterior to) the spine bases. The remaining pleural furrows are shallow, and terminate just before the lateral spine bases. Behind the fourth segment is a reasonably extensive unfurrowed area of pleural zone, as in *Mansuyites*. The lateral spines are stout-based, extend outwards and rearwards, and are drawn from the lateral borders. A narrow border is present between the spine bases following the slightly bowed posterior margin.

The cranidium has a dense surface texture (Pl. 43, fig. 6) composed of crest-like plications on the preglabellar field, granules on the glabella and occipital ring, and plications merging to form lirae on the cranidial border. The pygidium has a densely granulose axis, but much less densely granulose pleural zone. The nature of the caecal system is unknown.

CERONOCARE sp.

(Pl. 43, fig. 8; Text-fig. 64)

Occurrence: 'Chatsworth Limestone', Black Mountain, horizon K106, 51 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zone of *Pseudagnostus clarki patulus* with *Caznaia squamosa*.

Material: The external mould of a single cranidium, CPC 11936.

Size: The available cranidium has a length (sag.) of 14.15 mm.

Comments: Ceronocare sp. is differentiated from *C. pandum* in possessing a relatively narrower (tr.) preglabellar area, smaller palpebral lobes, weak ocular ridges, and a finely granulose prosopon.

Description: The solitary cranidium known has a length (sag.) of 14.15 mm; its small eye index (A:Gn) is 38.86%, and its large eye index (A:G) is 52.13%. An area of fixigena between the palpebral lobes and the posterior marginal furrow amounts to 38% of the length of the palpebral lobes. The length of the glabella (G) with respect to the total cranidial length (Lc) is 42%, the same as in the holotype of *C. pandum,* which is of comparable size. Glabellar furrowing, occipital furrowing, and the definition of the ocular ridges, are all slightly fainter than in the type species. The preglabellar area appears to be significantly narrower (tr.), but as it is incompletely preserved on the external mould the degree of difference cannot be exactly defined. *Ceronocare* sp. has preserved posterolateral limbs, not

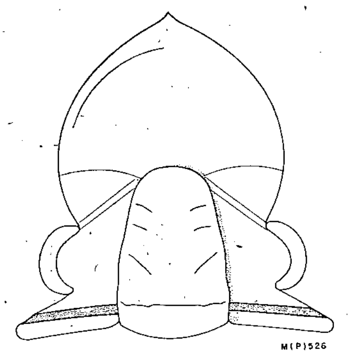

Fig. 64. ***Ceronocare*** **sp.; cranidial reconstruction based on CPC 11936, x3.**

seen in *C. pandum*. These are short (tr.), triangular, and proportionately broad-based. The prosopon is similar to that of *C. pandum* but the granulo-plications of the preglabellar field are considerably less dense, and the granulosity of the palpebral areas, preocular areas, and glabella is finer.

Family MISSISQUOIIDAE Hupé, 1955

Genus PARAKOLDINIOIDIA Endo *in* Endo & Resser, 1937

Type species: Parakoldinioidia typicalis Endo (*in* Endo & Resser, 1937, p. 329-330, pl. 71, figs 17-22, *non* fig. 23), from the Yenchou Formation of Paichiashan, and near Lashufang, Manchuria (see also Kobayashi, 1956, p. 18, pl. 2, figs 10-13); by original designation.

Comment: Parakoldinioidia, placed by Lochman-Balk (*in* Moore, 1957, p. 0519) in Order and Family Uncertain, seems morphologically comparable on cranidial characteristics with *Missisquoia* Shaw, 1951. If the association of cranidium and pygidium figured here is correct, then the pygidia also are morphologically comparable with those assigned to species of *Missisquoia* (see *M. typicalis* Shaw *sensu* Winston & Nicholls, 1967, pl. 13, figs 15, 18, and compare their illustrations of cranidia of *M. nasuta* Winston & Nicholls on the same plate with those of *Parakoldinioidia bigranulosa* figured below).

Missisquoiidae is here placed in Leiostegiacea because of the overall cranidial similarity to Leiostegiidae, on the relationship of glabella to preglabellar area, and to Kaolishaniidae (Tingocephalinae) on the general appearance of the glabella, and the elongated (sag.), triangular and multisegmented pygidium.

PARAKOLDINIOIDIA BIGRANULOSA sp. nov.

(Pl. 45, figs 2-5)

Name: L., *granulosa,* granulose; *bigranulosa* refers to the two distinct sizes of granules.

Holotype: CPC 11937, the cranidium illustrated on Plate 45, fig. 2.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizon K118, at 156 m from the base of the measured section; and at B507a′ and B507a″ collected in 1957.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zone of *Pseudagnostus bifax* with *P. denticulatus.*

Material: Two cranidia and two pygidia, CPC 11937-40.

Size: The largest cranidium (Pl. 45, fig. 2) measures 3.10 mm, and the smaller one has a glabellar length of 2.00 mm (sag.); pygidia considered to belong to this species measure (sag.) 1.40 and 2.40 mm.

Diagnosis: A species of *Paradoldinioidia* with a long (sag.), narrow (tr.), triangular anterior cranidial border, curving distally slightly adventrally; and surface granulation consisting of two quite distinct sizes of granules — randomly scattered large ones lie within a dense mass of smaller ones. The pygidium is triangular, strongly convex (tr.), with extremely narrow (tr.) subdorsal borders, and at least six pleural segments.

Differential diagnosis: Both cranidia illustrated here (Pl. 45) may be confidently compared with those of the type species *Parakoldinioidia typicalis* Endo (*in* Endo & Resser, 1937, pl. 71, figs 17-22), refigured by Kobayashi (1956, pl. 2, figs 10-12). Of the two, that figured in Plate 45, fig. 3, CPC 11938, is closest to any of those figured by Endo on glabellar characteristics. That figured in Plate 45, fig. 2, CPC 11937, the holotype of *P. bigranulosa,* has an apparently more swollen frontal glabellar lobe and its glabellar flanks are more constricted at the level of the median lateral glabellar lobes. It is, however, substantially larger than the other illustrated cranidium, and is regarded as conspecific in view of the limited material available.

The pygidium assigned to *P. typicalis* by Endo (*in* Endo & Resser, 1937, pl. 71, fig. 23), in my opinion, is not correctly associated. In view of the combination found at Black Mountain, it seems more likely that the three pygidia which Endo described as *Pagodia triangulata* (op. cit., pl. 71, figs 9-11), should be combined with the cranidia described as *Parakoldinioidia typicalis.* In this event pygidia of *P. bigranulosa* have fewer segments than those of *P. typicalis,* but are comparable in other respects. Pygidia figured by Endo in 1939 (pl. 1, figs 18-20) as *Pagodia triangulata* have similar segmentation to those of *Parakoldinioidia bigranulosa.* The one other species described under *Parakoldinioidia* by Endo (1937), *P. concavolimbata* (pl. 70, figs 20-22), has been referred to *Tingocephalus* by Kobayashi (1962, p. 35, pl. X, fig. 5).

Description: In the smaller of the two illustrated cranidia, CPC 11938, the glabella is parallel-sided, rounded-truncate anteriorly; but in the larger one, CPC 11937, it is markedly constricted at the level of the median lateral lobes, and the frontal lobe is swollen and more acutely rounded anteriorly. In both, however, a cleft is present sagittally in the anterior contour of the frontal lobe. The furrowing is deep and well defined: the preoccipital furrows are short, curvilinear, sharply directed rearwards; the median lateral furrows are shorter, similarly deepened, more transverse than posteriorly directed; and the anterior lateral furrows are extremely faint, and lie immediately in front of the median lateral furrows. This style and degree of glabellar furrowing strikingly resemble those observed in the genus *Missisquoia.*

The occipital ring is wider (tr.) than the preoccipital glabellar lobes, but the main part of the ring is missing on both specimens.

Palpebral lobes are also missing, but on CPC 11938 (Pl. 45, fig. 3) their extent can be assessed. They are small, and lie between the preoccipital and median lateral glabellar furrows, and some distance from the glabella. Very faint ocular ridges connect the palpebral lobes with the anterolateral corners of the glabella. The preocular sections of the facial suture are proximally curved outwards thence rapidly inwards, culminating at an acute angle in front of the cranidium, enclosing a small depressed deltoid preglabellar field and a narrow upturned cranidial border. The frontal cranidial spike so formed is gently convex (sag.), distally pointed adventrally. The courses of the postocular facial sutures are unknown, but it is likely that they enclose long and reasonably broad (exsag.) posterolateral limbs. The preocular areas are appreciably convex (exsag.), and the glabella projects forwards well beyond them.

Hypostoma and thorax are unknown.

The pygidium is triangular, extended posteriorly, the length (sag.) being 70-83% of the width (tr.). The borders are extremely narrow (tr.), lying more or less adventrally, below the curvature of the pleurae. Six or seven axial rings are evident on a strongly convex axis which terminates before reaching the posterior apex of the pygidium. Six strongly convex (tr.) pleural segments are separated by strong pleural furrows; the much weaker interpleural furrows being visible only anteriorly.

The cranidium is granulose. A dense mass of fine granules forms a matrix within which larger perforated granules are randomly scattered. The nature of the surface of the pygidium is not known.

Family TSINANIIDAE Kobayashi, 1933

Comments: Apart from the positioning of the palpebral lobes, the arrangement of the morphological elements making up the cranidial and pygidial structure of Tsinaniidae is found also among Asaphiscacea, particularly the subfamily Blountiinae (of Asaphiscidae). Pygidia of genera such as *Maryvillia* (*sensu* Rasetti, 1961) and *Blountia* (*sensu* Rasetti, 1965) are surprisingly similar to those of *Tsinania* and *Dictyites*. However, reference of Tsinaniidae to Asaphiscacea is not without problems, as the Blountiinae are confined to the early Upper Cambrian (Dresbachian of North America), whereas the Tsinaniidae appear quite suddenly in the late Upper Cambrian (Fengshanian of Asia, Payntonian of Australia), and there is no well documented phylogenetic continuity between them. Provenance of the Tsinaniidae is therefore a matter for speculation. Kobayashi (1960b, p. 396-8) has sought continuity through the Russian genera *Esseigania* (Kobayashi, 1943), *Koldinia* (Walcott & Resser, 1924), and *Koldiniella* (Sivov, 1955), the Canadian *Jubileia* (Kobayashi, 1938), and the Asian *Taipaikia* (Kobayashi, 1960); but many of these trilobites are very imperfectly known compared to Blountiinae and Tsinaniidae. Possibly the gross morphological correlation between these families results from a similar environmental adaptation.

Rather than classifying Tsinaniidae on the basis of homeomorphic characteristics, e.g. Shaw (1952), the origins of the family might be better resolved by an examination of the morphogenesis of its representative species. Among the Australian species described below, meraspid and early holaspid pygidia most distinctly resemble those of late holaspides of *Charchaqia* on the one hand (see *C. erugata* Whitehouse, Hill et al., 1971, pl. Cm VI, fig. 7) and *Leiostegium* on the other (see for comparison *Leiostegium* (*Leiostegium*) *douglasi* Harrington & Leanza, 1957, p. 80, fig. 24, 3a-c). Meraspid pygidia of Mansuyiinae (Leiostegiacea) are differentiated from those of Tsinaniidae only by their broader spine bases. Late holaspid pygidia also resemble certain Asaphacea, e.g. *Plesiomegalaspis, Megalaspides,* and *Promegalaspides* (see Tjernvik, 1956), which has led to Tsinaniidae being previously classified within that superfamily (Lochman-Balk *in* Moore, 1959, p. 0356), as has the genus *Charchaqia*. Meraspid cranidia with their distinctively raised, wire-like anterior cranidial borders have little in common with Asaphacean genera, having a more distinctly leiostegioid appearance. Accordingly, on the basis of morphogenetic similarity, Tsinaniidae are here classified within the Superfamily Leiostegiacea.

The Tsinaniidae contains only the two interrelated taxa *Tsinania* Walcott, 1914, based on *Illaenurus canens* Walcott, 1905, and *Dictyites* Kobayashi, 1936, based on *Illaenurus dictys* Walcott, 1905.

Dictyites was proposed by Kobayashi in 1936 (p. 922) to replace *Dictya* Kobayashi, 1933, a preoccupied name (see Lochman-Balk *in* Moore, 1959, p. 0356). Previously classified under *Tsinania,* species of *Dictyites* were differentiated by the presence of distinct depressed borders on both cranidium and pygidium (Kobayashi, 1933a, p. 137). These characteristics alone, however, are insufficient to justify *Dictyites* because: (1) as shown below, degree of exfoliation of the shell strongly influences the degree of definition of the borders; (2) the type pygidium of *Illaenurus dictys* Walcott (1913, p. 224, pl. 23, fig. 5a) has no trace of a depressed border in spite of its preservation as a mould; (3) early holaspid cranidia associated on the same piece of rock with the type cranidia of *I. canens* and *I. ceres,* both now referred to *Tsinania,* do have traces of an anterior cranidial border marked by a break in slope of the convexity (sag.) of the shield, and in fact the late holaspid cranidium of *I. canens* illustrated by Walcott (1913, pl. 23, fig. 3) also retains traces of this border. It is therefore necessary to review in some detail the types of species assigned by Walcott originally to *Illaenurus,* but now shared between *Tsinania* and *Dictyites.*

Among the originally illustrated specimens of *Illaenurus canens* Walcott, the type species of *Tsinania,* there are two similar, but nevertheless distinguishable, cranidia. That illustrated (Walcott 1913, pl. 23) as figure 3 (USNM 58279) is an exfoliated mould showing very little parietal morphology. It is sagittally elongate, and compared with Australian materials has a long glabella and relatively short (sag.) preglabellar area, gently angled anteriorly, which has a narrow but slightly flattened anterior border. On this specimen the preglabellar area is narrower (tr.) than the palpebral cranidial width (tr.). The second type of cranidium, figure 3a (USNM 58281), is also an exfoliated mould, but retains traces of shell anteriorly, and is preserved in an oolitic calcarenite quite distinct from the matrix of Walcott's figure 3. The specimen is smaller than USNM 58279, is more convex (sag.), and differs in having preocular facial sutures closing more rapidly forwards to enclose a narrower (tr.) preglabellar area with a greater degree of rounding anteriorly. Either the two type cranidia represent different species, or the observed differences between them represent different growth stages within the morphogenesis of a single species. The two illustrated pygidia (figs 3b, USNM 58280, and 3c, USNM 58282), both limestone moulds, have similar shape and convexity, and can only be regarded as conspecific. They have eight or nine axial rings, and lack depressed borders, possessing instead a smooth band which is continuous with the convexity (tr.) of the pleural zone to the margin. Walcott's (loc. cit.) figure 6 (USNM 58289), described as *Illaenurus* sp. indet. Walcott, appears merely to be a late holaspid of *Tsinania canens.*

The types of *Tsinania ceres* (Walcott, 1913, pl. 23, figs 4 USNM 58285 and 4a USNM 58286) occur together on a single block. All specimens are exfoliated, and the cranidium has a damaged and partly obscured anterior margin. The size of the cranidium and proportions of its preglabellar area are intermediate between the two cranidia, described above, attributed to *Tsinania canens.* Apart from being a little flattened, the pygidium, and those associated with it, are indistinguishable from those of *T. canens* of comparable size. It is possible, therefore, that *T. ceres* also represents a stage in the morphogenetic development of

T. canens, and should be incorporated into the synonymy of that species, as advocated by Kobayashi (1952). If so, then during the cranidial morphogenesis of *T. canens* all surface features, including those of the preglabellar area, are progressively effaced, and the area generally widens transversely, i.e. the preocular facial sutures diverge forwards to a greater extent. During pygidial morphogenesis, as evident from Walcott's specimens, there is merely a slight adjustment of proportions, the shields widening slightly with increasing length and becoming less triangular. Marginal furrows are effaced throughout the observed morphogenesis, but are likely to have been depressed in meraspides. By comparison with Australian species, anterolateral spines should also be expected in meraspides and early holaspides of Chinese species. One such pygidium was figured by Walcott (1913, pl. 23, fig. 9) as *Hysterolenus?* sp. indet. (USNM 58268).

Dictyites, based on Walcott's (1913, p. 224, pl. 23, figs 5 USNM 58287 and 5a USNM 58288) *Illaenurus dictys,* is said by Kobayashi (1933a, p. 137) to be distinguished from *Tsinania* by the presence of depressed cranidial and pygidial borders. In assessing the holotype cranidium (USNM 58287), it is observed that the anterior part of the cranidium retains shell, the rear half being exfoliated; that the anterior cranidial outline is a little more angulate than that seen on Walcott's (loc. cit., fig. 3) largest illustrated cranidium of *Tsinania canens;* and that the anterior cranidial border is neither better defined nor wider (sag.) than that of early and intermediate holaspides of *T. canens*. The type pygidium (USNM 58288) of *Illaenurus dictys,* an internal mould, is indistinguishable from those of *Tsinania canens*. It certainly has no depressed border, the marginal furrow being completely effaced. Only the degree of angulation of the anterior cranidial outline, and the more divergent preocular sections of the facial suture, therefore, differentiate the species *Dictyites dictys* from *Tsinania canens.*

In spite of the similarities observed between their type species there is a strong case for maintaining the distinction of these taxa. A substantial group of Korean and Australian species exists having decidedly angulate cranidial margins, and relatively long (sag.), wide (tr.) preglabellar areas with distinct, though ill defined, marginal furrows enclosed by widely divergent preocular facial sutures. These cranidia are invariably associated with pygidia, very similar in shape and segmentation to those of *Tsinania canens* (as conceived above), but possessing depressed borders and non-effaced marginal furrows. Into this category fall species such as *Dictyites dictys* (Walcott) *sensu* Kobayashi (1933a), *D. trigonalis* Kobayashi (1933a), *D. dolichocephala* (Kobayashi, 1933a), *D. depressa* (Kobayashi, 1935c), and *D. taianfuensis* (Endo, 1939). The name *Dictyites* is retained for these species, their cranidial characteristics being linked to those of *Tsinania* through *Dictyites dictys* (Walcott) s.s.

Following Kobayashi (1952), the concept of *Tsinania,* as distinct from *Dictyites,* is expanded to include species with widely divergent preocular facial sutures, but rounded and only slightly angulate anterior cranidial margins. These species have wider (sag.) anterior borders than the type species, i.e. they are more depressed, and their associated pygidia also possess definable borders, sometimes depressed, but generally visible only when the shell is exfoliated. Kobayashi's (1952, p. 150-2, pl. 13, figs 1-8) *Tsinania canens* and the Australian species described below have these features.

Because the type species of *Tsinania* and *Dictyites* are so similar, these taxa are regarded below as subgenera, *Tsinania* taking generic priority. They are differentiated on the following characteristics. Cranidia of *Dictyites* have angulate anterior cranidial margins at all growth stages, and have a well developed plectrum on exfoliated surfaces. Borders of both cranidia and pygidia are depressed to varying degrees (the condition of the pygidium of the type species is anomalous), but usually best displayed on exfoliated cranidia. *Tsinania* has angulate anterior cranidial outlines in meraspides and early holaspides, becoming rounded off during holaspid morphogenesis. Its pygidia are triangular during meraspid and early holaspid growth stages, but become rounded posteriorly during late holaspid morphogenesis. The borders of the pygidium of *Tsinania* are much narrower and less well defined than those of *Dictyites,* being almost imperceptible when the full thickness of shell is preserved, narrow and ledge-like on exfoliated material of some species. Meraspid pygidia of both subgenera possess anterolaterally a pair of spines developed from the opisthopleuron to the first pleural segment. These spines are resorbed during holaspid morphogenesis, their loss apparently occurring at different times in different species.

Genus TSINANIA Walcott, 1914
Subgenus TSINANIA Walcott, 1914

Type species: Illaenurus canens Walcott, 1905, p. 96 *nom. nud.;* 1913, p. 222-3, pl. 23, figs 3, 3a-c, from the Chaumitien Limestone of Tsinan, Shantung, China; designated Walcott (1914, p. 43).

Other species: Regardless of synonymy the following species have been referred to *Tsinania,* and are considered to belong to *Tsinania* (*Tsinania*).

Illaenurus ceres Walcott (1905, p. 97 *nom. nud.;* 1913, p. 223, pl. 23, figs 4-4a), from the Chaumitien Limestone of Chaumitien, Shantung, China. *Illaenurus pagoda* Sun (1924, p. 82, pl. V, figs 10a-c), from the Kaolishan Limestone of Taian, Shantung, and the Fengshan Limestone of Chihli, Hopei. *Tsinania longa* Kobayashi (1933a, p. 137, pl. XIV, figs 20-21), from the Yenchou Formation, Wuhutsui Basin, Liaotung, Manchuria. *Tsinania* (?) *humilis* Kobayashi (1933a, p. 137, pl. XIV, figs 18-19; 1952, p. 152, pl. 13, figs 9-11), Yenchou Formation, Wuhutsui Basin, Liaotung, Manchuria. *Tsinania acuta* Sun (1935, p. 55-6, pl. V, fig. 24, text-fig. 7), from the Taoyuan Limestone, Peking, China. *Tsinania peipingense* Sun (1935, p. 55, pl. V, figs 22-23, text-fig. 6), from the Taoyuan Limestone, Peking, China. *Tsinania tingtaohengi* Sun (1935, p. 56-7, pl. V, fig. 16), Upper Wolungshan Formation, Huolu, Hopei, China. *Tsinania canens* var. *shansiensis* Sun (1935, p. 53-4, pl. V, figs 20-21), Upper Licheng Formation, Shanyaocheng, Licheng, Shansi, China. *Tsinania canens* (Walcott), Kobayashi (1913, p. 186, pl. XX, figs 7-9), north of Hualienchai railway station, central Manchuria. *Tsinania canens* (Walcott), Kobayashi (1933a, p. 136, pl. XIV, figs 4-6), from the Yenchou Formation, Wuhutsui Basin, Liaotung, Manchuria. *Tsinania convexa* Resser & Endo (*in* Kobayashi, 1933a *nom. nud.; in* Endo & Resser, 1937, p. 296, pl. 56, figs 19-20), Yenchou Formation, Liaoyang, Manchuria. *Tsinania longicephala* Resser & Endo (*in* Kobayashi, 1933a, p. 133 *nom. nud.; in* Endo & Resser, 1937, p. 296-7, pl. 55, figs 20-27), Yenchou Formation, Paishan, Manchuria. *Tsinania vulgaris* Resser & Endo (*in* Kobayashi, 1933a, p. 133 *nom. nud.; in* Endo & Resser, 1937, p. 295-6, pl. 56, figs 13-18, 21-22), Yenchou Formation, Yentai Colliery, and Liaoyang, Manchuria. *Tsinania canens* (Walcott), Endo

(1939, p. 12, pl. 2, figs 26-27), Kaolishan Formation, Shantung, China. *Tsinania canens* (Walcott), Kobayashi (1952, p. 150-2, pl. 13, figs 1-8, text-fig. 2), Huangluohsien, eastern Jehol, China. *Tsinania (Tsinania)* cf. *pagoda* (Sun, 1924), *T.* (*T.*) *nomas* sp. nov., and *T.* (*T.*) *necopina* sp. nov., are described below from western Queensland.

Tsinania cleora Walcott (1914, p. 43 *nom. nud.;* 1916, p. 227, pl. 36, figs 9, 9a-c; 1924b, pl. 14, fig. 6), from a float boulder at Notch Peak, Utah; and *Tsinania elongata* Walcott (1916, p. 228, pl. 36, figs 10, 10a), from Field, British Columbia, are not congeneric with Asian Tsinaniidae.

Age and Distribution: Fengshanian and equivalents in China (Shantung, Hopei, Shansi, Jehol), Manchuria, North Korea, South Korea; Payntonian in Australia (western Queensland).

TSINANIA (TSINANIA) cf. PAGODA (Sun, 1924)
(Pl. 50, figs 1-2; Text-fig. 65)

cf. 1924 *Illaenurus pagoda* Sun, p. 82, pl. V, figs 10a-c.

Types: Original cotypes are numbered 624-626, Geological Survey of China, Peking (*fide* Sun, 1924).

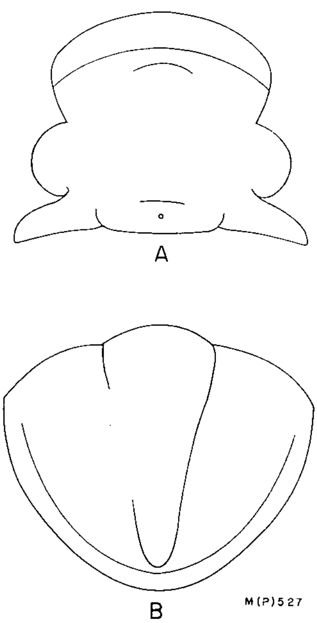

Fig. 65. External testaceous morphology of *Tsinania (Tsinania)* cf. *pagoda* (Sun, 1924); (A) cranidium based on CPC 11966, x5; (B) pygidium based on CPC 11965, x5.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K142 and K143, at 408.5 and 409.5 m from the base of the measured section; Mount Ninmaroo, horizons K165 and K166, at 50 and 52 m from the base of the measured section.

Age: Late Upper Cambrian, early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas.*

Material: Four cranidia and three pygidia, of which specimens CPC 11965 and 11966 are illustrated.

Size: The cranidia range in sagittal length between 5.90 and 6.60 mm; and the pygidia between 5.80 and 6.60 mm (Lp_1).

Comment: The pygidia at hand compare well with Sun's illustrated material of *Illaenurus pagoda.* When shell is preserved only faint traces of borders are visible (cf. Sun, 1924, pl. V, fig. 10b) and the pygidial axis is almost completely effaced. Removal of the shell reveals narrow borders and an axis with nine axial rings and a pleural zone with an indeterminate number of segments. Chinese and Australian pygidia are of the same shape. Relatively narrow (tr.) and elongated posteriorly (sag.), they also resemble in shape late holaspides of *Tsinania* (*T.*)

necopina (above), and those referred by Walcott (1913, pl. 23, figs 3b-c) and Kobayashi (1913, pl. XX, figs 7-9) to *T.* (*T.*) *canens,* by Walcott (1913, pl. 23, fig. 4a) to *T. ceres,* and by Sun (1935, pl. V, fig. 24) to *T. acuta* and (pl. V, figs 22-23) to *T. peipingense.* Kobayashi (1942, p. 299; 1952, p. 150) considers *T. pagoda, T. acuta,* and *T. peipingense* as synonyms of *Tsinania canens* (Walcott).

The associated cranidia, with elongated preglabellar areas (sag.), seem closely comparable to those referred here to *T.* (*T.*) *nomas,* and it is possible that the few fragments available are merely varieties of that species.

TSINANIA (TSINANIA) NOMAS sp. nov.

(Pl. 47, figs 1-7; Text-fig. 66)

?1952 *Tsinania canens* Walcott, 1905; Kobayashi, p. 150-2, pl. 13, figs 1-8, text-fig. 2.

Name: Gk, *nomas,* the wanderer, nomad.

Holotype: CPC 11948, the exfoliated cranidial fragment illustrated in Plate 47, fig. 1.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K138, K139, K140, K142, K143, and K144, at 374, 375, 390, 409, 409.5, and 417 m from the base of the measured section; Mount Ninmaroo, horizons K168, K169, and K170, at 67, 69, and 70 m from the base of the measured section.

Age: Late Upper Cambrian, early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas.*

Material: The species is known from 27 cranidial fragments, 9 librigenae, and 47 pygidia. The type series comprises specimens CPC 11948-54.

Size: Cranidia range in length (sag.) between 2.10 and 12.30 mm, and pygidia (Lp_1) between 2.80 and 13.70 mm.

Diagnosis: A species of *Tsinania* (*Tsinania*) having angulate anterior cranidial margins in meraspides and early holaspides, rounded margins in late holaspides. Meraspid pygidia are subtriangular, holaspides becoming increasingly rounded posteriorly with increase in length (sag.). Testaceous cranidia show a faint anterior border, exfoliated ones a depressed border. Pygidial spines are resorbed between lengths (sag.) 2.80 and 4.25 mm. There are 9-10 axial rings and six pleural segments. Narrow pygidial borders are present.

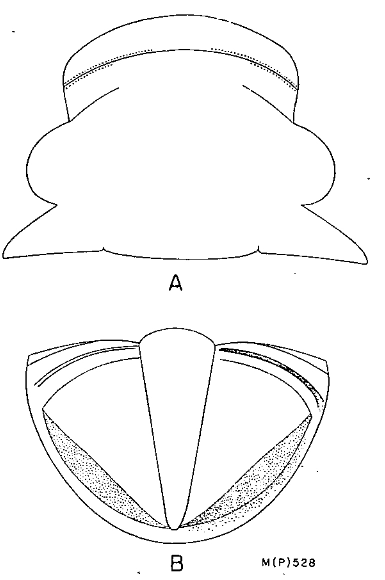

Fig. 66. External testaceous morphology of *Tsinania* (*Tsinania*) *nomas* sp. nov.; (A) cranidium based on CPC 11949, x6.5; (B) pygidium based on CPC 11950, x6.

Differential diagnosis: The specimens figured by Kobayashi (1952, p. 150-2, pl. 13, figs 1-8) from eastern Jehol, northern China, as *Tsinania canens* are, from a study of the photographs, indistinguishable from those described here as *Tsinania*

(*Tsinania*) *nomas*. The cranidium is also similar to those described under *T. canens* (Walcott) by Kobayashi (1933a, pl. XIV, fig. 4; 1935c, pl. VI, fig. 13), from southern Manchuria and South Korea respectively, differing only in the width (tr.) of the preglabellar area. Pygidia of *T.* (*T.*) *nomas* are most similar to that described as *T. canens* from South Korea by Kobayashi (1935c, pl. V, fig. 20).

Description: The cranidial outline of early holaspides is gently angulate anteriorly, but quite evenly rounded in late holaspides. When preserved with shell the glabella, occipital ring and palpebral lobes, glabellar furrows, occipital furrow, and palpebral furrows, are almost effaced, but a trace of the furrow separating the preocular areas from the anterior cranidial border is faintly visible. Exfoliation shows a subparallel-sided glabella, tapering gently forwards, and obtusely rounded anteriorly. Traces of four glabellar lobes and three pairs of furrows are evident from the arrangement of the muscle scars (see Pl. 47, fig. 1). The glabellar flanks are constricted near the junction of the axial furrows and ocular ridges, and again opposite the low bacculae, which are formed anterolateral to the occipital ring.

The occipital furrow is effaced, but a small node, visible on parietal surfaces, marks the position of the occipital ring, which is otherwise also effaced.

On the parietal surface palpebral lobes are seen to be arcuate, moderately long, sited about the midlength of the glabella, and some distance from it. They are connected by faint, duplicated ocular ridges to the anterolateral corners of the glabella. The preocular sections of the facial suture are strongly divergent forwards, and in holaspides the anterolateral cranidial margins lie on a line (exsag.) with the outer margins of the palpebral lobes. They enclose a wide (sag.), flat or gently concave cranidial border, best seen on parietal surfaces, and subtriangular preocular areas becoming confluent in front of the glabella to form a gently convex (sag.) preglabellar field. A plectrum is weakly developed. The postocular facial sutures enclose long (tr.) and narrow (exsag.) posterolateral limbs.

The librigena has a faint, shallow, lateral marginal furrow which curves inwards towards the base of the eye instead of running concentric to the margin of the subocular groove. A similar orientation is seen in the synonymized species *Tsinania canens* (Walcott) *sensu* Kobayashi, 1952. The length of the posterolateral limbs, deduced from the rear margins of the librigena, is striking when compared to the species described here under *Tsinania* (*Dictyites*). The genal spine is broad-based and long. There is no posterior marginal furrow.

Meraspid pygidia, like those of *Dictyites,* are triangular, with anterolateral spines. The triangular shape is retained until a sagittal length of about 4.60 mm, then becomes increasingly rounded; L:W is 60-73%. The marginal spines are lost between sagittal lengths of 2.80 to 4.25 mm. The flat, effaced axis, with fused articulating half-ring, reaches to the posterior marginal furrow, and on exfoliated surfaces is seen to be composed of nine or ten axial rings. Six pleural segments are observed in CPC 11952 (Pl. 47, fig. 5). Individuals preserved with shell are almost featureless apart from faint, narrow (tr.) borders. Pleural articulating facets are identical with those of *Dictyites antidictys* sp. nov. (see below), gently inclined; the pygidium is weakly fulcrate.

When shell is preserved, specimens of *T.* (*T.*) *nomas* are smooth. Extensive exfoliation reveals a punctate surface. Pygidial margins are often lirate, and a fine raised lira runs along the outer margin of the librigena.

TSINANIA (TSINANIA) NECOPINA sp. nov.
(Pl. 48, figs 1-8; Pl. 49, figs 9-10; Text-figs 67A-D)

Name: L., *necopina,* unexpected, referring to the unexpected presence of the upturned wire-like border of the meraspid cranidium.

Holotype: CPC 11955, the largely exfoliated cranidial fragment illustrated in Plate 48, fig. 1.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K138 and K139, at 374 and 375 m from the base of the measured section; and at B510 and B510b, from previous collections; Mount Datson, horizon K175, 40 m from the base of the measured section.

Age: Late Upper Cambrian, early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas*.

Material: Known from the fragments of 12 cranidia, 3 librigenae, and 17 pygidia. The illustrated paradigm comprises specimens CPC 11955-64.

Size: Cranidia range in length (sag.) between 2.05 and 14.30 mm, and pygidia between 2.10 and 21.40 mm (Lp_1).

Diagnosis: In shelly specimens the glabella and palpebral lobes are visibly defined and bacculae and ocular ridges faintly defined. Parietal surfaces are strongly bacculate, and have strongly defined ocular rings and palpebral lobes. All cranidia are characterized by very long (tr.), narrow (sag.), blade-like posterolateral limbs. Meraspides have a thin, addorsally oriented, wire-like cranidial border, holaspides a flat border, reasonably well defined even on the shell. Pygidia are subtriangular throughout morphogenesis. Meraspid spines are not lost until pygidial lengths of 4.05 and 4.10 mm (Lp_1). Shelly pygidia have no discernible borders, but narrow ones are present on exfoliated shields. There are up to 13 axial rings and 11 pleural segments.

Differential diagnosis: Pygidia of *Tsinania* (*T.*) *necopina* are most similar to those previously assigned to *Tsinania canens* (Walcott). Comparable specimens are: the pygidium from the type series of Walcott (1913, pl. 23, fig. 3b), but this has only ten axial rings; the three pygidia figured by Kobayashi (1931, p. 186, pl. XX, figs 7-9), which have a more pointed posterior contour; the three pygidia figured as *Illaenurus pagoda* by Sun (1924, p. 82, pl. V, figs 10a-c); that figured as *Tsinania canens* var. *pagoda* by Kobayashi (1931, p. 186, pl. XX, fig. 10); and that figured as *T. canens* by Kobayashi (1933a, pl. XIV, fig. 5), which are all more pointed posteriorly than the pygidia of *T.* (*T.*) *necopina.* The pygidium figured as *Dicty* (sic) *longicauda* by Kobayashi (1935c, p. 307-8, pl. VI, fig. 15) from South Korea, and that as *Tsinania canens* by Lu (1957, p. 269, pl. 147, fig. 10), are morphologically similar, in shape and segmentation. The only comparable cranidium, that illustrated as *T. canens* by Lu (1957, pl. 147, fig. 9), appears to have shorter (tr.) posterolateral limbs.

Description: Tsinania (*T.*) *necopina* is a large thick-shelled species. Its meraspid cranidia have angulate anterior margins and are particularly characterized by the presence of narrow (sag.), upturned wire-like borders, and abaxially deep marginal furrows. Adaxially these furrows shallow to form a narrow (tr.) platform. The

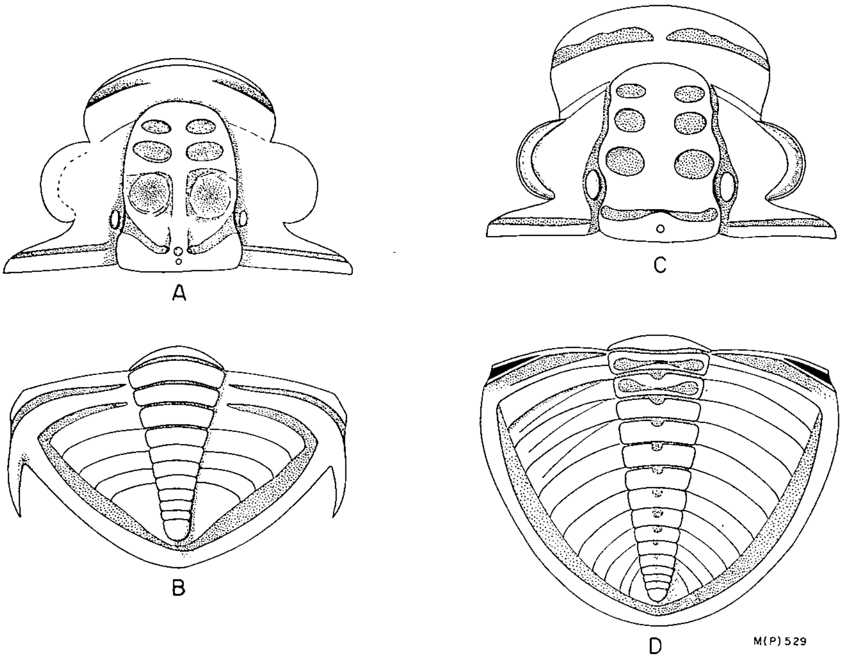

Fig. 67. Parietal morphology of *Tsinania* (*Tsinania*) *necopina* sp. nov.; (A) late meraspid or early holaspid cranidium with raised anterior cranidial border, based on CPC 11956, x5.5; (B) late meraspid or early holaspid pygidium with anterolateral spines, based on CPC 11960, x12; (C) late holaspid cranidium based on CPC 11958, x2.5; (D) late holaspid pygidium based on CPC 11964, x1.8.

glabellar outline is just visible when the shell is preserved. On such specimens it is parallel-sided, and anteriorly obtusely rounded, but when the shell is removed its flanks are seen to be swollen at the level of the preoccipital lobes and tightly constricted at the occipital furrow. Exfoliated cranidia show, from the pattern of the mucle scars, the presence of three pairs of glabellar furrows. Strongly developed bacculae lie opposite the preoccipital glabellar constrictions, apparently within the axial furrows. The occipital furrow is effaced and the position of the occipital ring is marked solely by a faint nuchal node. All exfoliated cranidia display a well preserved system of muscle scars, and a sagittal raised keel, all very reminiscent of certain Asaphidae.

The palpebral lobes, faintly outlined on the shell, are strong and arcuate on the parietal surface. They are large, extend rearwards close to the level of the rear of the preoccipital glabellar lobes, and are placed well away from the glabella. Anteriorly duplicated ocular ridges connect them to the frontal lobe of the glabella. The preocular sections of the facial suture are not strongly divergent, and the anterolateral margins of the cranidium lie well within the outer limits of the palpebral lobes. The facial suture encloses preocular areas which are confluent sagittally to form a preglabellar field of appreciable width (sag.). In holaspides, the marginal furrows are well defined even when shell is preserved, separating the preocular areas and preglabellar field from a wide (sag.), flat or gently concave cranidial border. The postocular facial suture encloses long (tr.), narrow (exsag.) posterolateral limbs bearing sharply defined posterior marginal furrows only on parietal surfaces.

Librigenae of *T.* (*T.*) *necopina* closely resemble those of *T.* (*Dictyites*) *antidictys* sp. nov. but are differentiated by the possession of well defined eye socles. The lateral marginal furrows are merely wide and shallow depressions, and no posterior marginal furrows are visible when shell is preserved. The genal spine is broad-based and stout.

Meraspid pygidia are similar to those of *T.* (*T.*) *nomas* described above, having a subtriangular shape, well defined borders, triangular pleural zone, and anterolateral spines derived from the first opisthopleuron. In *T.* (*T.*) *necopina* these spines are retained to pygidial lengths of 4.10 mm, and the marked triangular shape does not begin to round off until lengths approach 7.00 mm. Thereafter posterior rounding begins to take place so that the largest holaspides are both rounded and elongate. The L:W ratio varies through observed morphogenesis from 54 to 78%. Surface morphology on specimens with shell is not clear — even the first pleural furrow and marginal furrows are largely effaced, and the axis has very little relief. Exfoliated shields show narrow (tr.) borders, and the largest specimen, CPC 11964 (Pl. 49, fig. 10), displays 13 axial rings and 11 pleural segments, together with traces of the caecal network and the imprint of the extent of the doublure. The nature of the articulating half-ring and fulcral devices is as described above for *T.* (*T.*) *nomas*.

Overall the surface of the shell is smooth, save for raised lirae on the genal spines and margins of the pygidium, as in other Tsinaniidae. Exfoliation reveals a densely punctate parietal surface.

Subgenus Dictyites Kobayashi, 1936

pro Dictya Kobayashi, 1933a, p. 137, = *Dicty* Kobayashi, 1935c, p. 307

Type species: Illaenurus dictys Walcott 1905, p. 98 *nom. nud.;* 1913, p. 224, pl. 23, figs 5, 5′, Chaumitien Limestone, Pagoda Hill, near Tsinan, Shantung, China; designated by Kobayashi (1933a, p. 138).

Other species: Regardless of synonymy the following species have been referred to the subgenus *Dictyites: Tsinania* cf. *dictys* (Walcott), Kobayashi (1931, p. 187, pl. XXII, fig. 11), *Tsinania* Zone, Hualienchai, Manchuria. *Dictya dictys* (Walcott), Kobayashi (1933a, p. 138, pl. XIV, figs 7-9), *Tsinania* Zone, Paichiashan, Wuhutsui Basin, Liaotung, southern Manchuria. *Dictya dolichocephala* Kobayashi (1933a, p. 138-9, pl. XIV, fig. 12), locality as above. *Dictya trigonalis* Kobayashi (1933a, p. 139, pl. XIV, figs 10-11, 13-15), *Dictyella* Zone, locality as above. *Dictya trigonalis* Kobayashi (1935c, p. 306, pl. VI, figs 9-12), *Dictya* Zone, Doten and Kasetsu-ji, South Korea. *Dicty* (sic) *longicauda* Kobayashi (1935c, p. 307-8, pl. VI, fig. 15), locality as above. *Dictya depressa* Kobayashi (1935c, p. 307, pl. VI, figs 16-19), locality as above. *Dictya taianfuensis* Endo (1939, p. 11-12, pl. 2, figs 21-23), Kaolishan Limestone, Shantung, China. Described below are *Tsinania* (*Dictyites*) *antidictys* sp. nov., and *Tsinania* (*Dictyites*) cf. *trigonalis* (Kobayashi, 1933a), from western Queensland.

Distribution: China (Shantung), Manchuria (Taitzuho Valley and Liaotung), South Korea, Australia (western Queensland).

Age: Fengshanian in Asia, Payntonian in Australia.

TSINANIA (DICTYITES) ANTIDICTYS sp. nov.
(Pl. 49, figs 1-8; Text-fig. 68)

Name: Specific nomen *dictys* prefixed by Gk *anti,* meaning similar to or like.

Holotype: CPC 11967, an exfoliated and incomplete cranidium, illustrated in Plate 49, fig. 1.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizon K135, 335 m from the base of the measured section.

Age: Late Upper Cambrian, early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas.*

Material: The paradigm consists of 6 cranidia, 6 librigenae, and 40 pygidia preserved as exfoliated and partly exfoliated moulds. Preservation is generally poor and fragmentary. Specimens CPC 11967-74 are illustrated.

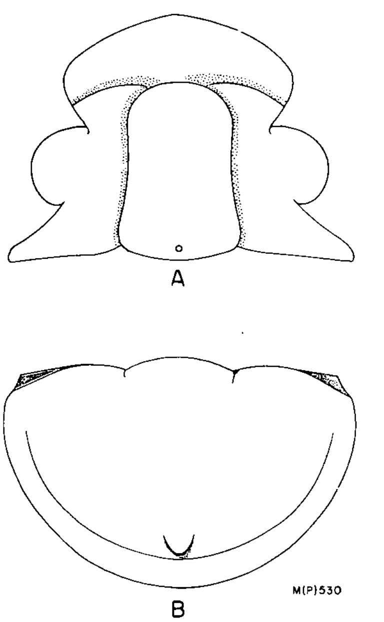

Fig. 68. External testaceous morphology of *Tsinania (Dictyites) antidictys* sp. nov.; (A) cranidium based on CPC 11970, x8; (B) pygidium based on CPC 11974, x6.

Size: Cranidia vary in sagittal length between 3.10 and 6.10 mm; pygidia measure (Lp_1) between 1.70 and 4.10 mm; larger specimens are too fragmentary to assess.

Diagnosis: A species of *Tsinania (Dictyites)* with the following combination of characteristics: gently anterior cranidial margin; smooth, effaced test; proportionately broad (sag.) anterior cranidial border; very faint ocular ridges and effaced bacculae; semicircular pygidium with prominent depressed and striated borders at all morphogenetic stages; pleural furrows and transverse furrows almost completely effaced, rarely visible even on parietal surfaces; as many as eight axial rings could constitute the axis; anterolateral spines resorbed between lengths of 2.50 and 2.70 mm.

Differential diagnosis: Cranidia of *Dictyites dictys* (Walcott) and those of *Dictyites antidictys* sp. nov. cannot be adequately compared as the former species is known only from a single partly exfoliated specimen. Parietal surfaces of the Australian species appear to have well defined preocular areas. The pygidium assigned to *D. dictys* is less transversely rounded and apparently proportionately different from those of *D. antidictys.* It would appear, however, to have similar segmentation.

Dictyites dictys (Walcott) by Kobayashi (1933a, p. 138, pl. XIV, figs 7-9) has considerably greater anterior marginal angularity than either *D. dictys* or *D. antidictys,* and its preglabellar area is considerably longer (sag.). *D. trigonalis* (Kobayashi, 1933a, p. 139, pl. XIV, figs 10-11, 13-15) is well differentiated by the wider depressed borders of both cranidium and pygidium. *D. taianfuensis* (Endo, 1939, p. 11-12, pl. 2, figs 21-23), like *D. dictys* sensu Kobayashi (1933a), has a much longer (sag.) preglabellar area.

Of previously described specimens, only *Tsinania* cf. *dictys* (Walcott) by Kobayashi (1931, p. 187, pl. XXII, fig. 11), an incomplete pygidium, has comparable pygidial shape to that of *Tsinania* (*Dictyites*) *antidictys.*

Description: The species conforms to the concept of the subgenus *Dictyites* set out above in having an angulate anterior cranidial outline throughout the observed morphogenesis (Pl. 49, figs 1, 2, 4). When preserved with shell the glabella is seen to have low relief, to be subparallel-sided, tapering gently forwards, anteriorly obtusely rounded, and visibly constricted about its midpoint. Morphology of the parietal surface (Pl. 49, fig. 1) indicates the presence of three pairs of glabellar furrows, but these are effaced on the shell.

The occipital ring is very narrow (sag.), is separated from the glabella by a faint and shallow occipital furrow, effaced on holaspides, and is in general appearance reminiscent of Asaphacea. It bears a small node mesially which is most often effaced on the shell.

The palpebral lobes are moderately large, arcuate in plan view, and widely spaced (tr.) from the glabella. They occupy 31-35% of the total cranidial length (sag.). Very faint ocular ridges connect the palpebral lobes to the glabella. The preocular sections of the facial suture arch outwards then inwards across the preocular areas, enclosing a broad (sag.), flat cranidial border and narrow (exsag.) triangular preocular areas. On parietal surfaces (Pl. 49, fig. 1) conspicuous furrows delineating the anterior margins of the preocular areas curve sagittally rearwards to enclose a distinct plectrum. The last is separated from the frontal glabellar lobe by a very narrow (sag.) ridge which merges laterally into the preocular areas. A very faint furrow, possibly a paradoublural line, crosses the anterior cranidial border. The postocular facial suture encloses comparatively long, triangular posterolateral limbs, broken away on much of the fragmentary material available.

The librigena has only a single faint and shallow marginal furrow laterally. Even this is effaced before it reaches the genal angles. No posterior marginal furrow is observed, and the genal spine base appears to be confluent with the convexity of the cheek. The genal spine is stout, broad-based, and relatively short.

Pygidia at all morphogenetic stages are transverse and semicircular, evenly rounded posteriorly. The meraspid shape is basically retained into the holaspid stage of development, the L:W ratio varying between 53-67%. Meraspides bear a pair of spines anterolaterally derived from the opisthopleuron of the first pleural segment. During morphogenesis they are resorbed between pygidial lengths of 2.50 and 2.70 mm (Lp_1). The axis is poorly defined even on exfoliated specimens and a maximum of eight axial rings can be determined. It extends rearwards to the marginal furrow, and is evenly tapered. The first pleural segment alone is readily defined. It bears a strong pleural furrow which continues to the anterolateral margin of the pygidium in front of the spine base in meraspides, and tends to become effaced during subsequent morphogenesis. The marginal furrow is a well defined shallow depression separating a depressed pygidial border which is widest (sag.) posteriorly. The articulating half-ring is fused to the axis. The anterolateral articulating facets are extremely narrow bands, and the pygidium in general may be described as weakly fulcrate.

When preserved with shell the surface prosopon is generally smooth, except that the genal spines and extreme pygidial margins are lirate. Exfoliated cranidia show well the musculature of the glabella and the raised sagittal keel which bisects it (Pl. 49, fig. 1).

TSINANIA (DICTYITES) cf. TRIGONALIS (Kobayashi, 1933)
(Pl. 50, figs 3-9; Text-fig. 69)

cf. 1933a *Dictya trigonalis* Kobayashi, p. 139, pl. XIV, figs 10-11, 13-15.

cf. 1935c *Dictya trigonalis* Kobayashi; Kobayashi, p. 306, pl. VI, figs 10, 12, ?figs 9, 11.

? 1935c *Dictya depressa* Kobayashi, p. 307, pl. VI, figs 17-19 (pygidia), ?fig. 16 (gena), *non* fig. 19 (cranidium).

Occurrence: Originally described from southern Manchuria and South Korea, the species also occurs in the 'Chatsworth Limestone', Black Mountain, horizon K142, 409 m from the base of the measured section; Mount Ninmaroo, horizons K168, K169, and K170, at 67, 69, and 70 m from the base of the measured section; Dribbling Bore, horizons K186 and K187, at 29 and 31 m from the base of the measured section; and at B777 collected between K186 and K187 in 1957.

Age: Late Upper Cambrian, Yenchouan in Manchuria, Fengshanian in South Korea, early Payntonian, Assemblage-Zone of *Pseudagnostus quasibilobus* with *Tsinania nomas,* in Australia.

Material: 17 cranidia, 5 librigenae, and 36 pygidia constitute the investigated paradigm, specimens CPC 11975-81 being illustrated.

Size: Cranidia range in sagittal length between 3.10 and 12.80 mm; and pygidia between 2.10 and 11.00 mm (Lp_1).

Differential diagnosis: The Australian species is so close to Kobayashi's *trigonalis* that specific differentiation is considered unwarranted. Strikingly similar are the pygidia (compare Kobayashi, 1933a, pl. XIV, fig. 15, with Pl. 50, figs 7-9 herein). Cranidia are also very similar, Kobayashi's exfoliated holotype (1933a, pl. XIV, fig. 14) comparing well with that illustrated in Plate 50, fig. 3. Australian cranidia perhaps have a somewhat wider (tr.) preglabellar area than those from Manchuria. Cranidia from South Korea cannot be adequately compared owing to their indifferent preservation, but the strongly depressed borders of their pygidia compare well with the Australian specimens. *Dictya depressa,* which is synonymized here with *Tsinania* (*Dictyites*) *trigonalis,* has comparable pygidia, considered incorrectly matched with the cranidium with which Kobayashi (1935c, pl. VI, fig. 19) would have them associated.

Tsinania (*Dictyites*) cf. *trigonalis* differs from illustrated material of *D. trigonalis* Kobayashi in having a wider (tr.) preglabellar area, and this seems to be the only difference. The same characteristic differentiates the species from *D. antidictys* sp. nov.; Wf:Wp for the former is 77-94%, increasing with size, and for the latter 75-80%. The preglabellar area is, however, longer (sag.) than that of

D. dictys (Walcott). The species *D. trigonalis* and *D.* cf. *trigonalis* are readily differentiated from other species on pygidial characteristics, and particularly by their wide depressed borders. Their triangular meraspid shape is retained throughout holaspid morphogenesis, the shield merely becoming longer at the expense of its width.

Description: The following notes are given in lieu of a full description, as Kobayashi (1933a, 1935c) has described many of the features of this species.

The shell is very thick (see Pl. 50, fig. 4) and when preserved the glabella, occipital ring, and palpebral lobes are effaced. Similarly, the lateral marginal furrow of the librigena is restricted to a wide, shallow, mostly effaced depression. Faint furrows delineating preocular areas from the cranidial border are visible; however, on exfoliation of the shell, the glabella is seen to be acutely rounded anteriorly, and the sagittal keel, which is a feature of its parietal morphology, is seen to continue anteriorly and merge into the plectrum so that the preocular areas are separated sagittally. Ocular ridges, as in *Dictyites antidictys,* are very faint. *D.* cf. *trigonalis* is bacculate, the small swellings forming within the axial furrow opposite the preoccipital glabellar lobes. The anterior cranidial border is slightly upturned (addorsally), and the posterolateral limbs are short and triangular.

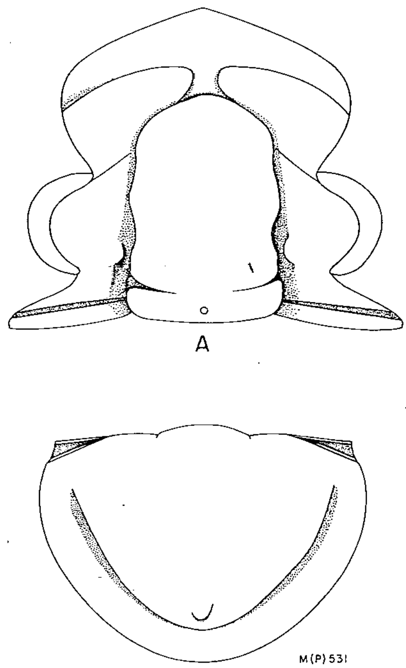

Fig. 69. External testaceous morphology of *Tsinania (Dictyites)* cf. *trigonalis* (Kobayashi, 1933); (A) cranidium based on CPC 11975, x12; (B) pygidium based on CPC 11979, x3.

The meraspid pygidium is very similar to that of *D. antidictys,* merely having a more triangular, rather than transverse semicircular, shape. Like that species, the meraspides bear anterolateral spines developed from the opisthopleuron of the first pleural segment. In *T.* (*D.*) cf. *trigonalis* these spines are resorbed between pygidial lengths 3.60 and 4.80 mm, and so are retained longer than in *D. antidictys.* The triangularity of the pygidium is retained throughout holaspid morphogenesis, overall; for 20 specimens with lengths (sag.) between 2.10 and 11.00 mm, the ratio L:W varies between 58 and 80%. The flat pygidial axis, reaching close to the marginal furrow posteriorly, has traces of 12 rings, but the number of pleural segments cannot be accurately assessed. Some meraspides have thoracic segments attached. These are narrow (exsag.) and elongated into spines. They are bisected equally by transverse pleural furrows, and in appearance are strikingly similar to the first pleural segment of the pygidium.

The surfaces of most cranidia are smooth, but some show a faint granulation. All the pygidia studied are smooth. Exfoliation displays a punctate parietal surface in unweathered specimens. The genal spines and pygidial borders are lirate, as in *T.* (*D.*) *antidictys.*

LEIOSTEGIACEA, FAMILIAE, SUBFAMILIAE, ET GENERA INCERTAE SEDIS

Genus Incertae Sedis 1

(Pl. 46, figs 5-7)

Comment: A few pygidial fragments illustrated in Plate 46 cannot be assigned with confidence to known leiostegiacean genera. They are characterized by wide posterolateral borders and the presence of five, possibly six, pleural segments. They resemble pygidia of *Pagodia* in that the first pleural furrow continues across the anterolateral border to the margin. Interpleural furrows are effaced.

Occurrence: Ninmaroo Formation, Black Mountain, horizons as follows: the specimens illustrated in Plate 46, figs 5-6, CPC 11943-4, are from K147, at 738 m from the base of the measured section, where they occur in a silicified oolite; the specimen in Plate 46, fig. 7, CPC 11945, comes from K149, 780 m from the base of the measured section, and is from a bituminous oolitic and pebbly limestone. Similar fragments, too small to illustrate, occur at K146, at 731 m from the base of the section.

Age: Early Ordovician, Datsonian, Zones of *Oneotodus bicuspatus* with *Drepanodus simplex* and *Cordylodus oklahomensis* with *C. lindstromi.*

Genus Incertae Sedis 2

(Pl. 46, fig. 1)

Comment: A single cranidium, CPC 11946, characterized by leiostegiid unfurrowed glabella, narrow (sag.) occipital ring, small palpebral lobes placed about the glabellar midpoint, long, blade-like posterolateral limbs, and simple cranidial border as in *Leiostegium* (*Leiostegium*). The ocular ridges are prominent.

Occurrence: 'Chatsworth Limestone', Dribbling Bore, horizon K195, 171 m from the base of the measured section.

Age: Early Ordovician, lowest layer referable to the Datsonian Stage, Zone of *Cordylodus proavus.*

Genus Incertae Sedis 3

(Pl. 46, fig. 2)

Comment: A second solitary cranidial fragment, CPC 11947, which has leiostegiacean affinity, is similar to Genus Incertae Sedis 2, but has a granulose surface, and more strongly resembles a pagodiid.

Occurrence: 'Chatsworth Limestone', Dribbling Bore, horizon K195, 171 m from the base of the measured section.

Age: Early Ordovician, as above earliest Datsonian, Zone of *Cordylodus proavus.*

Suborder ASAPHINA Salter, 1864
Superfamily ASAPHACEA Burmeister, 1843
Family ASAPHIDAE Burmeister, 1843
Subfamily ISOTELINAE Angelin, 1854
Genus GOLASAPHUS Shergold, 1972

Type species: Golasaphus momedahensis Shergold 1972, p. 75-80, pl. 10, figs 1-8; pl. 11, figs 1-9, from the Gola Beds, Momedah Creek, Boulia district, western Queensland; by original designation.

Other species: Golasaphus triquetrus sp. nov. and *G. simus* sp. nov. are described below from the pre-Payntonian 'Chatsworth Limestone' of Black Mountain.

Comment: The species described below are placed with some reserve in *Golasaphus.* They differ from the type species in the shapes of their preglabellar areas and the shapes of their pygidia, which possess marginal furrows. Such characteristics are here regarded as of specific value, but others may consider them of subgeneric or even generic categorization. In common with *G. momedahensis,* the new species have similar glabellar shapes, similarly sized and shaped posterolateral limbs, nodes lying in equivalent positions on the glabella, similarly shaped pygidial axes with similar segmentation, and hypostomata nearly identical. To include these species in *Golasaphus* the previously given generic diagnosis must be emended, omitting reference to pygidial shape and the condition of the pygidial marginal furrows.

GOLASAPHUS TRIQUETRUS sp. nov.
(Pl. 56, figs 1-9; Text-fig. 70)

Name: L., *triquetrus,* triangular.

Holotype: CPC 12865, the cranidium preserved with shell, illustrated in Plate 56, fig. 8.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K119 and K121, at 157 and 171.5 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zone of *Pseudagnostus bifax* with *P. denticulatus;* pre-Payntonian A, Assemblage-Zone of *Pseudagnostus clarki maximus* with *P. papilio.*

Material: The available material consists of 8 cranidia and 11 pygidia, specimens CPC 12858-66 being illustrated.

Size: Measurable cranidia vary in sagittal length between 5.00 and 6.60 mm; the pygidia range (Lp_1) between 1.40 and 5.60 mm.

Diagnosis: A species of *Golasaphus* with long, drawn out, triangular preglabellar area enclosed by preocular facial sutures with low angle of divergence forwards; small palpebral lobes situated about the middle of the glabella; a triangular pygidium, drawn out posteriorly, which has wide borders and wide, shallow marginal furrows, and a straight-sided axis tapering rearwards, containing six axial rings.

Differential diagnosis: Golasaphus triquetrus is similar to *G. momedahensis* in its glabellar outline, tapering forwards and acutely rounded anteriorly, in the position of its axial node, and relative proportions of glabella to size of cranidium. The palpebral lobes are similarly situated and the posterolateral limbs of comparable length (tr.), in both species being distally expanded. Pygidia are similar only in the comparable proportionate length of the axis, and its sixfold segmentation.

Although a number of previously described asaphid species have a comparable transversely narrow, sagittally elongate, preglabellar area, in none is it combined with anteriorly tapering glabella and distally expanded posterolateral limbs. The closest combination seems to be that of the early Arenigian species *Plesiomegalaspis* (*Ekeraspis*) *heroides* (Brögger) (see Tjernvik, 1956, p. 244, pl. VIII, fig. 1).

Description: The glabella, together with the fused occipital ring, occupies 70% of the total cranidial length (sag.). It tapers unevenly forwards, having a slight constriction opposite the palpebral areas, and is acutely rounded anteriorly. A glabellar node lies sagittally a short distance in front of the largely effaced occipital furrow, towards the rear of the glabella. From this node a low keel runs along the sagittal line to the front of the glabella, where it becomes depressed into a faint sulcus (Pl. 56, fig. 7). When shell is preserved glabellar furrows are effaced. Exfoliation reveals the pattern of muscle scars illustrated in Plate 56, fig. 7, which indicates traces of four pairs of glabellar furrows, and an occipital furrow.

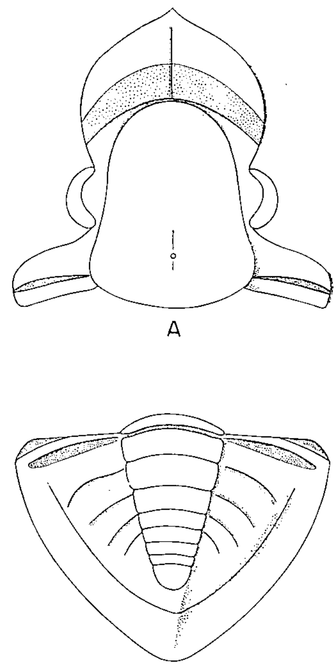

Fig. 70. ***Golasaphus triquetrus* sp. nov.; (A) cranidial reconstruction based on CPC 12865, x8; (B) pygidial reconstruction based on CPC 12862, x6.**

Palpebral furrows are also effaced and the palpebral lobes appear confluent with the palpebral areas on testaceous specimens. The palpebral lobes are small (exsag.), situated opposite the midlength of the glabella, and occupying 32-43% of the parameter Gn. The palpebral areas are much restricted, as the palpebral lobes contact the axial furrows at both ends.

The preocular sections of the facial suture diverge forwards sigmoidally at low angles, enclosing an ogival preglabellar area, transversely narrow but sagittally elongate. The cranidial border rises gently from the anterior marginal furrow, itself developed from the broadly concave preglabellar field. The field is separated from the preglabellar furrow by gently convex triangular ridges, probably representing paradoublural lines. All structures are interrupted along the sagittal line by the presence of a continuation of the glabellar keel, which runs to the anterior margin of the cranidium (Pl. 56, figs 6-7). The postocular sections of the facial suture are slightly sigmoidal, enclosing long (tr.) distally expanded posterolateral limbs bearing shallow posterior marginal furrows.

The pygidia are triangular, markedly so in late holaspides, a little more subtriangular in early ones, with length to width ratios varying between 64 and 84% and increasing progressively with increase in pygidial length (sag.). The axis is straight-sided, tapering gently rearwards, and continues as a post-axial ridge for a short distance across the posterior border. It is composed of six axial rings, and has a narrow (sag.) band-like articulating half-ring fused to it anteriorly. Only three pleural segments are defined; the first by strong pleural furrows, the remainder becoming progressively further effaced rearwards. The first pleural furrow runs transversely across the anterolateral borders to the margins. Marginal furrows are broad and shallow, and are merely the break in convexity between the pleural zone and the borders. The latter are wide, especially posteriorly. Articulating facets are narrow, moderately inclined, and sited at the anterolateral extremities well away from the axial furrows.

Golasaphus triquetrus has a smooth external test on all preserved specimens. The ventral doublure of the pygidium is lirate. Degrees of exfoliation reveal punctate parietal surfaces of both cranidia and pygidia.

GOLASAPHUS SIMUS sp. nov.
(Pl. 55, figs 1-8; Text-fig. 71)

Name: L., *simus,* flat or pug-nosed, referring to the short (sag.) preglabellar area.

Holotype: CPC 12867a, a cranidial fragment illustrated in Plate 55, fig. 1. Its counterpart mould, CPC 12867b, is illustrated in the same plate as fig. 2.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K118, K119, K120, K121, at 156, 157, 158.6, 164.5, 171.5, and 175 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zone of *Pseudagnostus bifax* with *P. denticulatus;* pre-Payntonian A, Assemblage-Zone of *P. clarki maximus* with *P. papilio.*

Material: Three cranidia, one librigena, two hypostomata, and 22 pygidia, of which CPC 12867a-73 are figured.

Size: The single measurable cranidium has a length (sag.) of 6.40 mm; pygidia vary between 3.40 and 5.20 mm (Lp_1).

Diagnosis: A *Golasaphus* species with acutely rounded frontal glabellar lobe, short (sag.) preglabellar area, less than 20% of the total cranidial length, preocular facial sutures diverging at about 90°, small palpebral lobes anteriorly sited, distally tapering posterolateral limbs; pygidia are subtriangular, posteriorly rounded, with proportionately short (sag.) axes, broad borders, and shallow marginal furrows.

Differential diagnosis: Golasaphus simus appears in some respects to bridge the gap between *Golasaphus* and *Atopasaphus.* The wide (tr.) preglabellar area and small eyes are reminiscent of the latter, but the shape of the glabella, the hypostoma, the shape of the pygidium, and the nature of its axis and borders are more reminiscent of *Golasaphus,* especially *G. triquetrus,* with which it is associated. The pygidial shape is intermediate between *G. momedahensis* and *G. triquetrus.*

Description: The cranidial outline is anteriorly gently arched, pointed sagittally. The glabella, with occipital ring, occupying 84% of the cranidial length (sag.), is anteriorly acutely rounded, laterally constricted opposite the palpebral areas. There is a gentle anterior taper, which is less pronounced than in *Golasaphus triquetrus*. No details are known of the glabellar furrowing or occipital ring.

The preocular facial sutures are sigmoidal and diverge anterolaterally at approximately 90°. They enclose a very narrow (sag.) preglabellar area, no more than 20% of the total cranidial length (sag.). The preglabellar area comprises a fairly distinct cranidial border separated from convex triangular ridges which flank the anterolateral corners of the glabella, by a shallow and wide (sag.) marginal furrow. This is confluent with the preglabellar furrow sagittally. A hint of a sagittal carina is present on the latex replica of the external mould of the holotype (Pl. 55, fig. 2). Nothing is known of the posterolateral limbs.

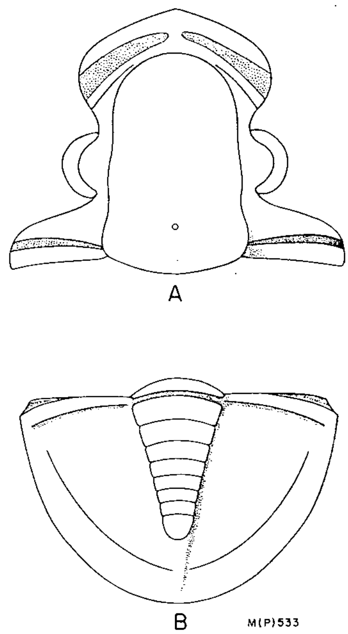

Fig. 71. *Golasaphus simus* **sp. nov.; (A) reconstructed cranidium based on CPC 12867b, x5.5; (B) pygidium based on CPC 12868, x6.**

The palpebral lobes are short (exsag.) and situated slightly in front of the midlength of the glabella. They are close to the glabella, reaching the axial furrows both anteriorly and posteriorly. The lobes are effaced when shell is preserved, but are visible as narrow crescents on exfoliated specimens.

The hypostoma of *G. simus* is similar in all respects to that of early holaspides of *G. momedahensis*. Its borders are perhaps slightly narrower (tr.) but no other differences can be discerned.

Pygidia are subtriangular, posteriorly rounded, with length (sag.) 62-75% of the width (tr.). The pygidial axis is conical, straight-sided, tapering rearwards, and is composed of six rings, an indistinct terminal piece, and a very narrow (sag.) articulating half-ring. A post-axial ridge carries the line of the axis to the posterior margin. Pleural segments are indistinct, especially when shell is preserved, but exfoliated material shows weak traces of four pleural segments. Only the first pleural furrow is at all well defined. Marginal furrows are wide and shallow, as in *Atopasaphus stenocanthus*. The borders are wide and flat, especially posteriorly, where they occupy up to 30% of the total pygidial length (sag.).

Genus ASAPHELLUS Callaway, 1877

Type species: Asaphus (Isotelus?) homfrayi Salter, 1866a, p. 311, pl. VIII, figs 11-14; 1866B: 165-6, pl. 24, figs 6-12, from the Tremadoc Series at Garth, North Wales: indicated by Callaway (1877, p. 664).

?ASAPHELLUS sp.
(Pl. 57, figs 6-8)

Occurrence: Ninmaroo Formation, Black Mountain, horizons K150, K151, at 971 and 101 m from the base of the measured section.

Age: Early Ordovician, Warendian, Zone of *Cordylodus rotundatus* with *C. angulatus.*

Material: Fragments of two cranidia and a single pygidium, of which specimens CPC 12876-12877 are illustrated.

Size: All the material is incomplete, and no overall measurement of size can be given. The specimen figured in Plate 57, fig. 7, has a glabellar plus occipital length (sag.) of 5.00 mm.

Comment: The illustrated cranidium is placed questionably in *Asaphellus,* because the angle of divergence of its preocular facial sutures is greater than in other assigned species. Characteristics in favour of classification with that genus are: the small palpebral lobes, wide (exsag.) distally tapering posterolateral limbs, and rectangular glabella, slightly waisted adjacent to the palpebral areas. The front of the cranidium is unfortunately broken away.

The cranidium of *?Asaphellus* sp. is associated with a rather featureless pygidium (Pl. 57, fig. 8) with very wide (tr.) and shallow concave borders, almost similar to the pygidium of *Asaphellus.*

If the cranidium and pygidium so illustrated are combined, *?Asaphellus* sp. becomes most similar to the specimens described as *Asaphellus homfrayi* (Salter) by Lake (1942, p. 321-6, pl. XLV, figs 1-9; pl. XLVI, fig. 1) from the Shineton Shale of Shineton Brook, Salop. Only the structure of the preglabellar area distinguishes the cranidium of *?Asaphellus* sp. from that of *Niobides armatus* Harrington & Leanza (1957, p. 182, fig. 90, 91.2a-d) from the Arenig Series of Argentina. Pygidia of the two species, however, are quite distinct.

Subfamily NIOBINAE Jaanusson, 1959
Genus NIOBELLA Reed, 1931

Type species: Niobe homfrayi Salter, 1866a, p. 314, pl. VI, figs 5-8; 1866b, p. 143-4, pl. 20, figs 3-12, from the Lower Tremadoc Series of North Wales; designated by Reed (1931).

?NIOBELLA sp.
(Pl. 57, figs 1-3)

Occurrence: 'Chatsworth Limestone', Dribbling Bore, horizon K195, at 171 m from the base of the measured section.

Age: Early Ordovician, Datsonian, Zone of *Cordylodus proavus.*

Material: 11 pygidial fragments; specimens CPC 12878-80 are illustrated.

Comments: The asaphacean pygidia have a semicircular shape, with transverse or slightly indented posterior margins, broad shallow borders, six axial rings, and five pleural segments. Removal of the shell displays prominent geniculation traversed by pleural furrows which tend to deepen distally and exaggerate the extremities of the pleural segments, as in *Niobe.*

Pygidia of *Niobella homfrayi smithi* Stubblefield (1933, p. 368-370, pl. XXXIV, figs 2-4; Lake, 1946, p. 333, pl. XLVI, figs 2-3) have similar wide shallow borders, and similar semicircular shape, the outline posteriorly transverse. This species, however, has eight or nine axial and pleural segments, whereas *?Niobella* sp. has six. Of species of *Niobe, N. emarginula* Angelin (1851, p. 15, pl. 11, fig. 3; Tjernvik, 1956, p. 226-8, pl. IV, figs 14-17, text-fig. 36C) from the early Arenigian of Västergötland, is most similar because the distal swellings of the pleural segments are less well emphasized than normal in the genus.

Subfamily SYMPHYSURININAE Kobayashi, 1955
Genus SYMPHYSURINA Ulrich *in* Walcott, 1924

Type species: Symphysurina woosteri Ulrich *in* Walcott (1924a, p. 38, fig. 8; Walcott, 1925, p. 115, pl. 21, figs 1-11), from the Oneota Dolomite, Trempealeau, Wisconsin; designated by Walcott (1925, p. 109).

?SYMPHYSURINA sp.
(Pl. 57, fig. 4)

Occurrence: 'Chatsworth Limestone', Dribbling Bore, horizon K195, at 171 m from the base of the measured section.

Age: Early Ordovician, Datsonian, Zone of *Cordylodus proavus.*

Material: A single fragment of a librigena, CPC 12881.

Comment: An elongate transversely triangular librigena, with long curved laterally directed genal spine drawn from the entire margin, and long postocular facial suture indicating articulation with a long and very narrow (exsag.) posterolateral limb, is morphologically comparable with genae assigned to some species of *Symphysurina.* In particular, comparison may be made with *S. bubops* Winston & Nicholls (1967, p. 87, pl. 12, fig. 17) from the Wilberns Formation of Texas, and *S. uncaspicata* Hintze (1952, p. 233, pl. II, figs 2 and 4) from Zone B, Ibex, Millard County, Utah. Whether these librigenae are correctly referred to *Symphysurina* is questionable, as the type species, *S. woosteri,* has a more normal asaphoid structure with short genal spines projected rearwards from a distinct genal angle (see Walcott, 1925, pl. 21, figs 3, 5-7). It should be noted, however, that some species of *Symphysurina* lack genal spines altogether, and these are associated with cranidia readily comparable with *S. woosteri.*

Subfamily INCERTAE SEDIS
Genus ATOPASAPHUS Shergold, 1972

Type species: Atopasaphus petasatus Shergold, 1972, p. 81-82, pl. 9, fig. 5, from the Gola Beds of Momedah Creek, Boulia area, western Queensland, by original designation.

Comments: The species described below differs from previously described material in having a narrower (tr.) preglabellar area. All specimens from Black Mountain are, however, considerably larger. Whereas the cranidial length of the sole specimen of *A. petasatus* from the Gola Beds is only 4.40 mm, the smallest specimen of *A. stenocanthus* from Black Mountain is 6.40 mm, and others range to lengths of 14.40 mm.

ATOPASAPHUS STENOCANTHUS sp. nov.
(Pl. 54, figs 1-6; Text-fig. 72)

Name: Compounded from Gk, *stenos,* narrow, and *kanthos,* border.

Holotype: CPC 12886, a large cranidium preserved with shell, illustrated in Plate 54, fig. 6.

Occurrence: 'Chatsworth Limestone', Black Mountain, horizons K107, K108, K109, K111, K114, and K116, at 68, 73, 80, 112, 128.5, and 138 m from the base of the measured section.

Age: Late Upper Cambrian, pre-Payntonian B, Assemblage-Zones of *Pseudagnostus clarki patulus* with *Caznaia squamosa, Pseudagnostus clarki prolatus* with *Caznaia sectatrix,* and *Pseudagnostus bifax* with *P. denticulatus.*

Material: The species is known from fragments of 7 cranidia, a librigena, and 7 pygidia. The illustrated paradigm comprises specimens CPC 12882-6.

Size: The smallest cranidium has a length (sag.) of 11.40 mm and the largest 14.40 mm; pygidial lengths (sag.) (Lp_1) range between 4.20 and 14.70 mm.

Diagnosis: *Atopasaphus* with short preglabellar area (sag.), obtusely rounded frontal glabellar lobe, bacculae, distally tapered posterolateral limbs, preocular facial sutures diverging anteriorly at angles up to 110°; broadly semicircular pygidium with nearly effaced axis, wide flat borders, and wide shallow marginal furrows.

Differential diagnosis: Atopasaphus stenocanthus differs from the type, *A. petasatus,* in having less widely divergent preocular facial sutures, shorter (sag.) preglabellar area, and slightly more obtusely rounded frontal glabellar lobe. Both species have similarly shaped glabellae and posterolateral limbs, and have similarly sized palpebral lobes similarly situated with respect to the glabella.

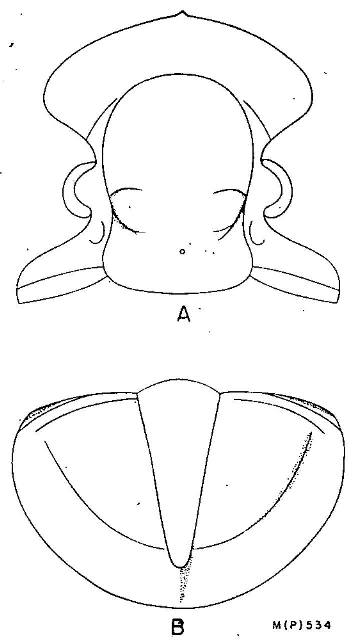

Fig. 72. *Atopasaphus stenocanthus* **sp. nov.; (A) reconstructed cranidium based on CPC 12886, x2.5; (B) pygidium based on CPC 12882, x7.**

Description: The glabella is not well defined. When the shell is preserved the axial furrows are almost effaced laterally, and bacculae are incorporated into the glabella. Anteriorly the glabella is obtusely rounded, and almost as wide (tr.) as the occipital ring. It is markedly constricted laterally opposite the palpebral lobes and only traces of the glabellar furrows run adaxially rearwards from a point opposite the rear of these lobes. The bacculae lie opposite the glabellar furrows slightly behind the palpebral lobes. The general shape of the glabella is 'isoteloid', but its axial node, which appears to lie well forward, prevents classification within Isotelinae. The glabella with occipital ring occupies about 78% of the total cranidial length in late holaspides.

The palpebral lobes are not readily visible on testaceous material, and are poorly defined even on exfoliated shields. They are moderately large, sited about the midlength of the glabella, occupying approximately 22% of the parameter Gn. The palpebral areas are narrow (tr.), the palpebral lobes contacting the axial furrows.

The preocular sections of the facial suture diverge linearly at 110° antero-laterally — they curve adaxially on reaching the cranidial border. The preglabellar area is short (sag.), and composed of a simple gently concave (sag.) depression. No border or marginal furrow is obviously developed, but the paradoublural lines are faintly visible adjacent to the anterolateral corners of the glabella. A faint carina bisects the preglabellar area sagittally. The postocular sections of the facial suture are gently sigmoidal and enclose distally tapering posterolateral limbs.

The librigena matched with the cranidial fragments, but not illustrated, is almost featureless, save for a very shallow concavity which represents the lateral marginal furrow. The spine is broad, probably indicating a stout spine.

Associated pygidia are semicircular, with length (sag.) 63-68% of their width (tr.). Characteristically, when shell is preserved, the axis is almost effaced and the shield surface featureless, apart from the low swelling of the pleura and gentle concavity of the marginal furrows. Exfoliated material shows up to seven axial rings and four pleural segments, all with very weak furrows. The articulating half-ring is a simple bar, very narrow (sag.). Posteriorly the axis passes into a post-axial ridge which reaches nearly to the posterior margin. The pygidial borders are wide and flat, posteriorly 30% of the total pygidial length (sag.). Exfoliated specimens show a correspondingly very wide doublure.

Asaphid hypostoma undet.
(Pl. 57, fig. 5)

Occurrence: 'Chatsworth Limestone', Dribbling Bore, horizon K195, from the base of the measured section.

Age: Early Ordovician, Datsonian, Zone of *Cordylodus proavus*.

Material: Two incomplete hypostomata, one of which, CPC 12887, is illustrated.

Comment: The asaphid hypostoma illustrated, CPC 12887, has broad (tr.) lateral borders, and a narrow (sag.) anteriorly indented posterior one. The median body is elongate (sag.), triangular, and is confluent sagittally with the posterior lobe. The maculae slope posteriorly adaxially, their lines continuing anterolaterally to define the lateral extent of the median body. Anterolateral prolongations from the posterior lobe become confluent distally with the lateral borders. The anterior margin of the hypostome, and the nature of the anterolateral wings, is not known. The borders are strongly lirate.

This hypostoma should possibly be united with the pygidia described above as *Niobella?* sp.

Of previously described hypostomata, the one illustrated here is most similar to that of *Plesiomegalaspis,* and especially that of *P. estonica* Tjernvik (1956, pl. VI, figs 4, 12, 13). The relationships of the median body and posterior lobe to maculae are quite similar, but they are readily distinguished by the wider lateral borders of the Australian specimen, and its gently curved posterior margin. The hypostoma of *Asaphellus homfrayi* (Salter) (see Lake, 1942, pl. XLV, fig. 1), though it has similar borders and median body, has transversely inclined maculae.

Superfamily CERATOPYGACEA Linnarsson, 1869

Family CERATOPYGIDAE Linnarsson, 1869

Genus ONYCHOPYGE Harrington, 1938

Type species: Onychopyge riojana Harrington (1938, p. 179, pl. 5, fig. 20; Harrington & Leanza, 1957, p. 187-8, figs 95, 96.2a-c) from the Lower Tremadoc Series of La Rioja, Argentina, by original designation.

Other species: Onychopyge argentina Harrington & Leanza (1957, p. 189, figs 96.1a-d), Lower Tremadoc, Salta and Jujuy, Argentina. *Onychopyge longispina* Harrington & Leanza (1957, p. 189, fig. 96.4), Lower Tremadoc, Salta, Argentina. *Onychopyge plagiacantha* Harrington & Leanza (1957, p. 189, fig. 96.3), Lower Tremadoc, La Rioja, Argentina. *Onychopyge sculptura* Robison & Pantoja-Alor (1968, p. 784, pl. 100, figs 1-7, 10), Tiñu Formation, Nochixtlán, Mexico. Described below is *Onychopyge assula* from the Datsonian of western Queensland.

Distribution: South America (Argentina), Central America (Mexico), Australia (western Queensland).

ONYCHOPYGE ASSULA sp. nov.

(Pl. 46, figs 3-4)

Name: L., *assula,* noun in apposition, a shaving, chip or fragment, all that we have of the species.

Holotype: CPC 12889, a pygidium preserved with shell, illustrated in Plate 46, fig. 4.

Occurrence: 'Chatsworth Limestone', Dribbling Bore, horizon K195, at 171 m from the base of the measured section.

Age: Early Ordovician, Datsonian, Zone of *Cordylodus proavus.*

Material: Fragments of one cranidium, CPC 12888, and one pygidium, CPC 12889.

Diagnosis: Onychopyge with large semicircular palpebral lobes extending from the preoccipital glabellar lobe to a point anterior to the median lateral glabellar pits.

The pygidium is transverse, with marked borders, especially posterolaterally, long prominent post-axial ridge, four (possibly five) axial rings, but only two pleural segments.

Differential diagnosis: Onychopyge assula differs from Argentinian material in which the cranidium is known in having well developed pit-like glabellar furrows; the preoccipital ones bifurcate. In this respect it is comparable with *O. sculptura* from Mexico, but differs by its slightly shorter palpebral lobes, which extend in *O. sculptura* to the occipital furrows, although this difference may be due solely to morphogenesis. The pygidium is more transverse than in any previously described species, and has fewer axial, but a similar number of pleural, segments. The posterolateral borders are more strongly separated from the pleural zone in *O. assula* than in *O. sculptura* and *O. plagiacantha* and the posterior margin (although broken) appears to have been less angular.

Description: The single cranidial fragment embraces a portion of the glabella and the palpebral lobe and palpebral area. Two pairs of glabellar furrows are visible. The preoccipital ones are overdeepened pits, adaxially bifurcated, opening abaxially into the axial furrows. The median lateral furrows are merely elongate pits remote from the axial furrows. The palpebral lobes are long (exsag.) and semicircular. They extend from a little in front of the median lateral glabellar pits rearwards to the middle of the preoccipital glabellar lobes. They are of even width at all points and posteriorly are separated from the glabella by gently convex (tr.) bacculae. The palpebral areas are wide (tr.), gently convex (tr.). The surface of the cranidial fragment is sculptured overall with a pattern of raised lirae.

The pygidium is transverse, with prominent axis and post-axial ridge. Four axial segments are preserved, together with an indistinct terminal piece which runs posteriorly into a prominent raised post-axial ridge. Only the first pleural segment is well defined, with a wide shallow pleural furrow and upraised anterior propleural and posterior opisthopleural margins, which continue across the anterolateral borders into spine bases. A second pleural segment is poorly developed, fading distally. Posterolateral borders are well developed and there is a strong break of convexity between them and the pleura. The posterior margins, although broken, appear to have been angulate rearwards, as in other species of *Onychopyge*. Raised lirae adorn the posterolateral borders.

REFERENCES

ANGELIN, N. P., 1851—PALAEONTOLOGICA SCANDINAVICA: Academiae Regiae Scientarium Suecanae (Holmiae); *Pars I.* CRUSTACEA FORMATIONIS TRANSITIONIS. 1-24 pls 1-24.

ANGELIN, N. P., 1854—Idem; *Pars II.* i-ix, 21-92, pls 25-41.

BELL, W. C., & ELLINWOOD, H. L., 1962—Upper Franconian and Lower Trempealeauan Cambrian trilobites and brachiopods, Wilberns Formation, central Texas. *J. Paleont.*, 36 (3), 385-423, pls 51-64.

BELL, W. C., FENIAK, O. W., & KURTZ, V. E., 1952—Trilobites of the Franconia Formation, southeast Minnesota. *J. Paleont.*, 26 (2), 175-98, pls 29-38.

BERG, R. R., & ROSS, R. J., Jr, 1959—Trilobites from the Peerless and Manitou Formations, Colorado. *J. Paleont.*, 33 (1), 106-19, pls 21-22.

BILLINGS, E., 1860—On some new species of fossils from the limestone near Point Lévi opposite Quebec. *Proc. canad. Nat. Geol.*, 5, 301-24, 30 figs.

BILLINGS, E., 1861-1865—PALAEOZOIC FOSSILS, Vol. 1, containing descriptions and figures of new or little known species of organic remains from the Silurian rocks. *Geol. Surv. Canada,* 1-426, figs 1-401.

BRÖGGER, W. C., 1882—DIE SILURISCHEN ETAGEN 2 UND 3 IM KRISTIANIAGEBIET UND AUF EKER, IHRE GLIEDERUNG, FOSSILIEN, SCHICHTENSTÖRUNGEN UND KONTAKTMETAMORFOSEN. *Univ.-Programm. (Christiania)*, 1-376, pls 1-12.

BROWN, G. A., 1961—Stratigraphy, structure and sedimentary petrology of some Lower Palaeozoic limestones from the Boulia area, western Queensland. *M.Sc. Thesis, Univ. Melbourne* (unpubl.).

CALLAWAY, C., 1877—On a new area of Upper Cambrian rocks in south Shropshire, with a description of a new fauna. *Quart. J. geol. Soc. Lond.*, 33, 652-71, pl. 24.

CASEY, J. N., 1959—New names in Queensland stratigraphy (Part 5). *Aust. Oil Gas J.*, 5, 31-6.

CASEY, J. N., 1968—Boulia, Qld—1:250 000 Geological Series. *Bur. Miner. Resour. Aust. explan. Notes* SF/54-10.

CASEY, J. N., & GILBERT-TOMLINSON, Joyce, 1956—Cambrian geology of the Huckitta-Marqua region, Northern Territory. *In* El Sistema cambrico, su Paleogeografia y el Problema de su Base, 2, 55-74. *20th int. geol. Cong., Mexico.*

CASEY, J. N., REYNOLDS, M. A., DOW, D. B., PRITCHARD, P. W., VINE, R. R., & PATEN, R. J., 1960—The geology of the Boulia area, western Queensland. *Bur. Miner. Resour. Aust. Rec.* 1960/12 (unpubl.).

CHEETHAM, A. H., & HAZEL, J. E., 1969—Binary (presence-absence) similarity coefficients. *J. Paleont.*, 43(5), 1130-6.

CHIEN, Yi-Yuan, 1961—Cambrian trilobites from Sandu and Duyun, southern Kweichow. *Acta paleont. sinica,* 9 (2), 91-129 (Chinese), 130-9 (English), 5 pls.

CLARK, T. H., 1923—A group of new species of *Agnostus* from Lévis, Quebec. *Canad. Field Nat.*, 37 (7), 121-125.

CLARK, T. H., 1924—The paleontology of the Beekmantown Series at Lévis, Quebec. *Bull. Amer. Paleont.*, 10 (41), 1/134, 9 pls.

DAVIES, P. J., & TILL, R., 1968—Stained dry cellulose peels of ancient and recent impregnated carbonate sediments. *J. sediment. Petrol.*, 38, 234-7.

DRUCE, E. C., & JONES, P. J., 1971—Cambro-Ordovician conodonts from the Burke River Structural Belt, Queensland. *Bur. Miner. Resour. Aust. Bull.* 110, 1-158, pls 1-20.

ENDO, R., 1931—The Cambrian Period. *In* Iwanami Lecture Series, section on Geology, Palaeontology, Mineralogy and Petrology. 1-94 (Chinese).

ENDO, R., 1937—See ENDO, R., & RESSER, C. E., 1937.

ENDO, R., 1939—Cambrian Fossils from Shantung. *Jubilee Publ. Comm. Prof. Yabe's 60th Birthday,* 1-18, pls 1-2.

ENDO, R., 1944—Restudies on the Cambrian formations and fossils of southern Manchukuo. *Cent. nat. Mus. Manchukuo Bull.* 7, 1-100, pls 1-10.

ENDO, R., & RESSER, C. E., 1937—The Sinian and Cambrian Formations and fossils of southern Manchukuo. *Manch. sci. Mus. Bull.* 1, 1-474, pls 14-73.

FOLK, R. L., 1959—Practical petrographic classification of limestones. *Bull. Amer. Ass. Petrol. Geol.*, 43, 1-38.

FREDERICKSON, E. A., 1949—Trilobite faunas of the Upper Cambrian Honey Creek Formation. *J. Paleont.*, 23 (4), 341-63, pls 68-72.

GILBERT-TOMLINSON, Joyce, 1956—See CASEY, J. N., & GILBERT-TOMLINSON, Joyce, 1956.

GILBERT-TOMLINSON, Joyce, 1963—Cambrian fossils from Phillips-Sunray Black Mountain No 1 well, Boulia area, Queensland. *In* GREEN, D. C., et al., 1963.

GILBERT-TOMLINSON, Joyce, 1969—See HILL, D., et al., 1969.

GILL, E. D., 1949—*Prosopon,* a term used to replace the biologically erroneous term *Ornament. J. Paleont.*, 23 (5), 572.

GRANT, R. E., 1962—Trilobite distribution, Upper Franconia Formation (Upper Cambrian), south-eastern Minnesota. *J. Paleont.*, 36 (5), 965-98, pl. 139.

GRANT, R. E., 1965—Faunas and stratigraphy of the Snowy Range Formation (Upper Cambrian) in southwestern Montana and northwestern Wyoming. *Geol. Soc. Amer. Mem.* 96, ix + 1-171, pls 5-15.

GREEN, D. C., HAMLING, D. D., & KYRANIS, N., 1963—Phillips-Sunray stratigraphical drilling, Boulia area, ATP 54P, Queensland, well completion report: Black Mountain No. 1, Canary No. 1, Beentree No. 1, Elizabeth Springs No. 1. *Phillips Petroleum Co.* (unpubl.).

HALL, A. V., 1969—Avoiding informational distortion in automatic grouping programs. *System. Zool.*, 18 (1969), 318-29.

HALL, J., 1863—Preliminary notice of the fauna of the Potsdam Sandstone; with remarks upon the previously known species of fossils and descriptions of some new ones, from the sandstone of the Upper Mississippi Valley. *N.Y. State Cab. nat. Hist., 16th ann. Rep.*, App. D, Contributions to Palaeontology, 119-84, pls Va-XI.

HALL, J., 1867—As above, reprinted in: *Trans. Albany Inst.*, 5, 93-195, pls I-VI.

HALL, J., & WHITFIELD, R. P., 1877—Palaeontology, part II. *In* KING, C., 1877—*Report of the geological exploration of the fortieth parallel.* IV. *Prof. Pap. Engineer Dept, U.S. Army,* 18, 198-302, pls I-VIII.

HARRINGTON, H. J., 1937—On some Ordovician fossils from northern Argentina. *Geol. Mag.*, 74, 97-124, pls V-VI.

HARRINGTON, H. J., 1938—Sobre las faunas del Ordoviciano inferior del norte argentino. *Rev. Mus. de La Plata (Buenos Aires), n.s.* 1, *Paleont.*, 4, 109-289, pls I-XIV.

HARRINGTON, H. J., 1959—General description of Trilobita. *In* MOORE, R. C., (ed.), 1959, 038-0117.

HARRINGTON, H. J., & LEANZA, A. F., 1957—Ordovician trilobites of Argentina. *Univ. Kansas, Dep. Geol. spec. Publ.* 1, 276 pp, 104 figs.

HARRINGTON, H. J., MOORE, R. C., & STUBBLEFIELD, C. J., 1959—Morphological terms applied to Trilobita. *In* MOORE, R. C., (ed.), 1959, 0117-0126.

HAZEL, J. E., 1970—Binary coefficients and clustering in biostratigraphy. *Bull. geol. Soc. Amer.*, 81, 3237-52.

HAZEL, J. E., 1971—Ostracode biostratigraphy of the Yorktown Formation (upper Miocene and lower Pliocene) of Virginia and North Carolina. *U.S. geol. Surv. prof. Pap.* 704, 1-13.

HENNINGSMOEN, G., 1957—The trilobite family Olenidae. *Norske Videnskapsakad. (Oslo), mat.-naturv. Kl., Skr.*, 1, 303 pp, 31 pls.

HILL, D., PLAYFORD, G., & WOODS, J. T., (eds), 1969—ORDOVICIAN AND SILURIAN FOSSILS OF QUEENSLAND. *Qld palaeontogr. Soc., Brisbane,* 18 pp, 15 pls.

HILL, D., PLAYFORD, G., & WOODS, J. T., (eds), 1971—CAMBRIAN FOSSILS OF QUEENSLAND. *Ibid.*, 32 pp, 15 pls.

HINTZE, L. F., 1952—Lower Ordovician trilobites from western Utah and eastern Nevada. *Utah geol. Min. Surv. Bull.*, 48, vi + 1-249, pls 1-28.

HOLLAND, C. H., (ed.), 1971—THE LOWER PALAEOZOIC ROCKS OF THE WORLD, Vol. 1. THE CAMBRIAN OF THE NEW WORLD. *N.Y., Wiley-Interscience,* 456 pp.

HOWELL, B. F., 1935—Cambrian and Ordovician trilobites from Hérault, southern France. *J. Paleont.*, 9 (3), 222-38, pls 22-23.

HUNT, A. S., 1967—Growth, variation, and instar development of an agnostid trilobite. *J. Paleont.*, 41 (1), 203-8, pl. 22.

HUPE, P., 1952—Contribution à l'étude du Cambrien inférieur et du Précambrien III de l'Anti-Atlas marocain. *Notes mém. Serv. géol. Maroc.*, 103, 41-402, pls 1-24.

HUPE, P., 1953—Classification des trilobites. *Ann. Paléont.*, 39, 61-168, figs 1-92.

HUPE, P., 1955—Classification des trilobites. *Ibid.*, 41, 93-325, figs 93-247.

IVSHIN, N. K., 1960—See KHALFIN, L. L., 1960.

JAANUSSON, V., 1959—See MOORE, R. C., 1959.

JAEKEL, O., 1909—Über die Agnostiden. *Z. dtsch. geol. Ges.*, 61, 380-401.

JONES, P. J., SHERGOLD, J. H., & DRUCE, E. C., 1971—Late Cambrian and early Ordovician stages in western Queensland. *J. geol. Soc. Aust.*, 18 (1), 1-32.

KAULBACK, J. A., & VEEVERS, J. J., 1969—The Cambrian and Ordovician geology of the southern part of the Bonaparte Gulf Basin, and the Cambrian and Devonian geology of the outliers, Western Australia. *Bur. Miner. Resour. Aust. Rep.* 109, 1-55, 4 App.

KHALFIN, L. L., (ed.), 1955—ATLAS OF GUIDE FORMS OF FOSSIL FAUNA AND FLORA OF WESTERN SIBERIA. *W. Sib. geol. Office, USSR*, 502 pp. (Russian).

KHALFIN, L. L., (ed.), 1960—Palaeozoic biostratigraphy of the Sayan Altay mining region. Part 1, Lower Palaeozoic, Cambrian System. *SNIIGGIMS*, 19, 11-253, 33 pls (Russian).

KING, W. B. R., 1937—Cambrian trilobites from Iran (Persia). *Palaeont. indica, n.s.* 22, 5, 1-22, pls I-II.

KOBAYASHI, T., 1931—Studies on the stratigraphy and palaeontology of the Cambro-Ordovician formation of Hualienchai and Niuhsintai, south Manchuria. *Jap. J. Geol. Geogr.*, 8 (3), 131-89, pls XVI-XXII.

KOBAYASHI, T., 1933a—Upper Cambrian of the Wuhutsui Basin, Liaotung, with special reference to the limit of the Chaumitien (or Upper Cambrian) of eastern Asia, and its subdivision. *Ibid.*, 11(1-2), 55-155, pls IX-XV.

KOBAYASHI, T., 1933b—Faunal study of the Wanwanian (basal Ordovician) Series with special notes on the Ribeiridae and the ellesmeroceratoids. *J. Fac. Sci. Imp. Univ. Tokyo*, (2) 3 (7), 249-328, pls I-X.

KOBAYASHI, T., 1934a—The Cambro-Ordovician formations and faunas of South Chosen. Palaeontology, pt I. Middle Ordovician faunas. *Ibid.*, (2), 3(8), 329-519, pls I-XLIV.

KOBAYASHI, T., 1934b—*Idem.* Palaeontology, pt II. Lower Ordovician faunas. *Ibid.*, (2), 3(9), 521-85, pls I-VIII.

KOBAYASHI, T., 1935a—The *Briscoia* fauna of the late Upper Cambrian in Alaska with descriptions of a few Upper Cambrian trilobites from Montana and Nevada. *Jap. J. Geol. Geogr.*, 12(3-4), 39-57, pls 8-10.

KOBAYASHI, T., 1935b—On the *Kainella* fauna of the basal Ordovician age found in Argentina. *Ibid.*, 12(3-4), 59-67, pl. XI.

KOBAYASHI, T., 1935c—The Cambro-Ordovician formations and faunas of South Chosen. Palaeontology, pt III. Cambrian faunas of South Chosen with special study on the Cambrian trilobite genera and families. *J. Fac. Sci. Imp. Univ. Tokyo*, (2), 4(2), 49-344, pls I-XXIV.

KOBAYASHI, T., 1936—Notes on nomenclature of some Cambro-Ordovician genera. *J. geol. Soc. Japan*, 43(519), 922.

KOBAYASHI, T., 1937—The Cambro-Ordovician shelly faunas of South America. *J. Fac. Sci. Imp. Univ. Tokyo*, (2), 4(4), 369-522, pls I-VIII.

KOBAYASHI, T., 1938—Upper Cambrian fossils from British Columbia with a discussion on the isolated occurrence of the so-called '*Olenus*' Beds of Mt Jubilee. *Jap. J. Geol. Geogr.*, 15(3-4), 149-92, pls XV-XVI.

KOBAYASHI, T., 1939—Supplementary notes on the Agnostida. *J. geol. Soc. Japan*, 46(554), 577-80.

KOBAYASHI, T., 1942—Miscellaneous notes on the Cambro-Ordovician geology and palaeontology, No. VIII. The Rakuroan complex of the Shansi Basin and its surroundings. *Jap. J. Geol. Geogr.*, 18(4), 283-306.

KOBAYASHI, T., 1943—Cambrian faunas of Siberia. *J. Fac. Sci. Imp. Univ. Tokyo*, (2), 6(12), 271-334, pls I-II.

KOBAYASHI, T., 1951—Miscellaneous notes on the Cambro-Ordovician geology and palaeontology, No. XXIII. On the late Upper Cambrian (Fengshanian) fauna in eastern Jehol. *Trans. Proc. palaeont. Soc. Japan*, n.s., 3, 75-80, pl. 7.

KOBAYASHI, T., 1952—Miscellaneous notes on the Cambro-Ordovician geology and palaeontology, No. XXIV. On *Mansuyia* and the Tsinaniidae. *Ibid.*, n.s., 5, 145-54, pl. 13.

KOBAYASHI, T., 1953—On the Kainellidae. *Jap. J. Geol. Geogr.*, 23(1), 37-61, pls 1-4.

KOBAYASHI, T., 1955—The Ordovician fossils of the McKay Group in British Columbia, western Canada, with a note on the early Ordovician palaeogeography. *J. Fac. Sci. Univ. Tokyo*, (2) 9 (3), 355-493, pls I-IX.

KOBAYASHI, T., 1956—On the Kaolishaniinae. *Jap. J. Geol. Geogr.*, 27(1), 9-20, pl. II.

KOBAYASHI, T., 1957—Upper Cambrian fossils from Peninsular Thailand. *J. Fac. Sci. Univ. Tokyo*, (2), 10(3), 367-82, pls IV-V.

KOBAYASHI, T., 1960a—The Cambro-Ordovician formations and faunas of South Korea, part VI. Palaeontology, V. *Ibid.*, (2), 12(2), 217-75, pls 12-14.

KOBAYASHI, T., 1960b—Idem, part VII. Palaeontology, VI. *Ibid.*, (2), 12(2), 329-420, pls 19-21.

KOBAYASHI, T., 1962—Idem, part IX. Palaeontology, VIII. The Machari fauna. *Ibid.*, (2), 14(1), 1-152, pls 1-12.

KOBAYASHI, T., 1966a—Idem, part X. Stratigraphy of the Chosen Group in Korea and south Manchuria, and its relation to the Cambro-Ordovician formations of other areas. Section A, The Chosen Group of South Korea. *Ibid.*, (2), 16(1), 1-84.

KOBAYASHI, T., 1966b—Idem, Section B, The Chosen Group of North Korea and northeast China. *Ibid.*, (2), 16(2), 209-311.

KOBAYASHI, T., 1967—Idem, Section C, The Cambrian of eastern Asia and other parts of the continent. *Ibid.*, (2), 16(3), 381-534.

LAKE, P., 1906—Monograph of the British Cambrian trilobites, part 1. *Palaeontogr. Soc. Lond., Monogr.*, 60 (1906), 1-28, pls 1-2.

LAKE, P., 1907—*Idem*, part 2. *Ibid.*, 61 (1907), 29-48, pls 3-4.

LAKE, P., 1942—*Idem*, part 13. *Ibid.*, 96 (1942), 307-332, pls 44-46.

LAKE, P., 1946—*Idem*, Part 14. *Ibid.*, 99 (1946), 333-350, pl. 47, addenda and errata.

LAZARENKO, N. P., 1966—Biostratigraphy and some new trilobites from the Upper Cambrian of the Olenek Uplift and Kharaulakh Mountain. *Research work Inst. Geol. Arctic, Learned Paps Palaeont. Biostrat.*, 2, 33-78, 8 pls (Russian).

LERMONTOVA, E. V., 1940—Arthropoda. *In* VOLOGDIN, A. G., 1940—ATLAS OF THE LEADING FORMS OF FOSSIL FAUNAS IN THE USSR. Vol. 1, CAMBRIAN. 1-194, pls 1-49 (Russian).

LERMONTOVA, E. V., 1951—Upper Cambrian trilobites and brachiopods from Boshche-Kul (N.E. Kazakhstan). *VSEGEI (Moscow)*, 1-49, pls I-VI (Russian).

LOCHMAN, Christina, 1956—The evolution of some upper Cambrian and Lower Ordovician trilobite families. *J. Paleont.*, 30(3), 445-62, pl. 47.

LOCHMAN, Christina, 1964—Upper Cambrian faunas from the sub-surface Deadwood Formation, Williston Basin, Montana. *J. Paleont.*, 38(1), 33-60, pls 9-15.

LOCHMAN, Christina, & HU, Chung-Hung, 1959—A *Ptychaspis* faunule from the Bear River Range, southeastern Idaho. *J. Paleont.*, 33(3), 404-427, pls 57-60.

LOCHMAN-BALK, Christina, 1959—See MOORE, R. C., 1959.

LONGACRE, Susan Ann, 1970—Trilobites of the Upper Cambrian ptychaspid biomere, Wilberns Formation, central Texas. *Paleont. Soc. Mem.*, 4, *J. Paleont.*, 44(1), *suppl.*, 1-70, pls 1-6.

LU, Yen-Hao, (*inter alia*), 1957—Trilobita. *In* CHUNG-KUO PIAO CHUN HUA SHIH (Index fossils of China, part 3). *Inst. Palaeont., Acad. Sinica*, 249-98, pls 137-155 (Chinese).

LU, Yen-Hao, CHANG, W. T., CHU, Chao-ling, CHIEN, Yi-yuan, & HSIANG, Lee-wen, 1965—CHINESE FOSSILS OF ALL GROUPS. TRILOBITA. Vol. 1,362 pp, pls 1-66; vol. 2, pp 363-766, pls 67-135. *Science Publication Co., Peking.*

MANSUY, H., 1915—Faunes cambriennes du Haut-Tonkin. *Serv. géol. Indoch. Mém.* 4, *fasc.* II, 1-35, pls 1-3.

MANSUY, H., 1916—Faunes cambriennes de l'extrême-orient méridional. *Serv. géol. Indoch. Mém.* 5, *fasc.* I, 1-48, pls 1-7.

MELO, J. F., & BUZAS, M. A., 1968—An application of cluster analysis as a method of determining biofacies. *J. Paleont.*, 42(3), 747-58.

MOORE, R. C., (ed.) 1959—TREATISE ON INVERTEBRATE PALEONTOLOGY. Part O, ARTHROPODA, 1, ii-xix, 01-0560. *Geol. Soc. Amer. & Kansas Univ. Press.*

NOLAN, T. B., MERRIAM, C. W., & WILLIAMS, J. S., 1956—The stratigraphic section in the vicinity of Eureka, Nevada. *U.S. geol. Surv. prof. Pap.* 276, 1-77.

ÖPIK, A. A., 1956—Cambrian geology of Queensland. *In* El Sistema cambrico, su Paleogeografia y el Problema du su Base, 2, 1-24. *20th int. geol. Cong. Mexico.*

ÖPIK, A. A., 1960—Cambrian and Ordovician geology [of Queensland]. *J. geol. Soc. Aust.*, 7, 91-103.

ÖPIK, A. A., 1961a—Alimentary caeca of agnostids and other trilobites. *Palaeontology*, 3(4), 410-38, pls 68-70.

ÖPIK, A. A., 1961b—The geology and palaeontology of the headwaters of the Burke River, Queensland. *Bur. Miner. Resour. Aust. Bull.* 53, 5-249, pls 1-24.

ÖPIK, A. A., 1963—Early Upper Cambrian fossils from Queensland. *Ibid.*, 64, 5-133, pls 1-9.

ÖPIK, A. A., 1967a—The Mindyallan fauna of northwestern Queensland. *Ibid.*, 74, vol. 1, 1-404; vol. 2, 1-166, pls 1-67.

ÖPIK, A. A., 1967b—The Ordian Stage of the Cambrian and its Australian Metadoxididae. *Ibid.*, 92, 133-170, pls 19-20.

ÖPIK, A. A., 1969—Appendix 3. The Cambrian and Ordovician sequence, Cambridge Gulf area. *In* KAULBACK, J. A., & VEEVERS, J. J., 1969.

ÖPIK, A. A., 1970—Nepeid trilobites of the Middle Cambrian of northern Australia. *Bur. Miner. Resour. Aust. Bull.* 113, i-iv, 1-48, pls 1-17.

ÖPIK, A. A., 1971—*Redlichia* of the Ordian (Cambrian) of northern Australia and New South Wales. *Ibid.*, 114, 1-66, pls 1-14.

OWEN, D. D., 1852—REPORT OF THE GEOLOGICAL SURVEY OF WISCONSIN, IOWA AND MINNESOTA AND INCIDENTALLY OF A PORTION OF NEBRASKA TERRITORY. Vol. 1, xxxviii, 39-638; vol. 2, maps and pls 1-15. *Lippincott, Grambo & Co., Philadelphia.*

PALMER, A. R., 1954—The faunas of the Riley Formation in central Texas. *J. Paleont.*, 28(6), 709-86, pls 76-92.

PALMER, A. R., 1955—Upper Cambrian Agnostidae of the Eureka district, Nevada. *J. Paleont.*, 29(1), 86-101, pls 19-20.

PALMER, A. R., 1956—See NOLAN, T. B., et al., 1956.

PALMER, A. R., 1960a—Trilobites of the Upper Cambrian Dunderberg Shale, Eureka district, Nevada. *U.S. geol. Surv. prof. Pap.* 334-C, 1-109, pls 1-11.

PALMER, A. R., 1960b—Some aspects of the early Upper Cambrian stratigraphy of White Pine County, Nevada and vicinity. *In* Guidebook of the geology of east-central Nevada 1960, 53-8. *Intermontane Assoc. Petrol. Geol., 11th Ann. Field Conf.*

PALMER, A. R., 1962—*Glyptagnostus* and associated trilobites in the United States. *U.S. geol. Surv. prof. Pap.* 374-F, 1-49, pls 1-6.

PALMER, A. R., 1965—Trilobites of the late Cambrian pterocephaliid biomere in the Great Basin, United States. *Ibid.*, 493, 1-105, pls 1-23.

PALMER, A. R., 1968—Cambrian trilobites of east-central Alaska. *Ibid.*, 559-B, 1-115, pls 1-13.

PALMER, A. R., 1969—Cambrian trilobite distributions in North America and their bearing on Cambrian palaeography of Newfoundland. *In* North Atlantic—geology and continental drift. *Amer. Ass. Petrol. Geol., Mem.* 12, 139-44.

PALMER, A. R., 1971a—The Cambrian of the Great Basin and adjacent areas, western United States. *In* HOLLAND, C. H. (ed.), 1-78.

PALMER, A. R., 1971b—The Cambrian of the Appalachian and eastern New England regions, eastern United States. *In Ibid.*, 169-217.

POKROVSKAYA, N. V., 1963—See VASILENKO, V. K., 1963.

POULSEN, C., 1946—Notes on the Cambro-Ordovician fossils collected by the Oxford University Ellesmereland Expedition 1934-5. *Quart. J. geol. Soc. Lond.*, 102, 299-337, pls XIX-XXIV.

POULSEN, C., 1948—*Grinnelaspis*, new name replacing *Actinopeltis* Poulsen 1946. *J. Paleont.*, 22(1), 107.

RAASCH, G. O., 1952—Revision of Croixian Dikelocephalidae. *Trans. Ill. St. Acad. Sci.*, 44, 137-151.

RASETTI, F., 1944—Upper Cambrian trilobites from the Lévis conglomerate. *J. Paleont.*, 18(3), 229-58, pls 36-39.

RASETTI, F., 1954—Early Ordovician trilobites from Quebec and Newfoundland. *J. Paleont.*, 28(5), 581-7, pls 60-61.

RASETTI, F., 1959a—Trempealeauan trilobites from the Conococheague, Frederick and Grove Limestones of the central Appalachians. *J. Paleont.*, 33(3), 375-98, pls 51-55.

RASETTI, F., 1959b—See MOORE, R. C., 1959.

RASETTI, F., 1961—Dresbachian and Franconian trilobites of the Conococheague and Frederick Limestones of the central Appalachians. *J. Paleont.*, 35(1), 104-24, pls 21-25.

RASETTI, F., 1965—Upper Cambrian trilobite faunas of northeastern Tennessee. *Smithson. misc. Coll.*, 148(3), 1-127, pls 1-21.

RAYMOND, P. E., 1913—Revision of the species which have been referred to the genus *Bathyurus*. *Vict. Mem. Mus. Bull.* 1, 51-69, pl. VIII.

RAYMOND, P. E., 1924—New Upper Cambrian and Lower Ordovician trilobites from Vermont. *Proc. Boston Soc. nat. Hist.*, 37(4), 389-466, pls 12-14.

RAYMOND, P. E., 1925—New Upper Cambrian and early Ordovician trilobites from Vermont. *Vt St. Geol., 14th Biennial Rep.* (1923-24), 137-203, pls 12-14.

RAYMOND, P. E., 1937—Upper Cambrian and Lower Ordovician Trilobita and Ostracoda from Vermont. *Bull. geol. Soc. Amer.*, 48, 1079-146, 4 pls.

REED, F. R. C., 1931—A review of the British species of Asaphidae. *Ann. Mag. nat. Hist.*, (10) 7, 441-72.

RESSER, C. E., 1942a—Fifth contribution to the nomenclature of Cambrian fossils. *Smithson. misc. Coll.*, 101(15), 1-58.

RESSER, C. E., 1942b—New Upper Cambrian trilobites. *Ibid.*, 103(5), 1-136, 21 pls.

RESSER, C. E., & ENDO, R., 1931—See ENDO, R., 1931.

RESSER, C. E., & ENDO, R., 1933—See KOBAYASHI, T., 1933a.

RESSER, C. E., & ENDO, R., 1937—See ENDO, R., & RESSER, C. E., 1937.

ROBISON, R. A., & PANTOJA-ALOR, J., 1968—Tremadocian trilobites from the Nochixtlán region, Oaxaca, Mexico. *J. Paleont.*, 42(3), 767-800, pls 97-104.

ROSS, R. J., Jr, 1951—Stratigraphy of the Garden City Formation in northeastern Utah, and its trilobite faunas. *Peabody Mus. nat. Hist., Yale Univ., Bull.* 6, vi + 1-161, pls 1-36.

ROSS, R. J., Jr, 1958—Trilobites in a pillow-lava of the Ordovician Valmy Formation, Nevada. *J. Paleont.*, 32(3), 559-70, pls 83-84.

ROWELL, A. J., & MCBRIDE, D. J., 1972a—A quantitative study of Trempealeauean (latest Cambrian) trilobite faunal provinces in North America. *6th ann. Mtg S.-central Sect. geol. Soc. Amer.*, 292-3 (Abstr.).

ROWELL, A. J., & MCBRIDE, D. J., 1972b—Faunal variation in the *Elvinia* Zone of North America—a numerical approach. *24th Sess. int. geol. Congr. Montreal, 7, Paleontology*, 246-253.

ROSOVA, A. V., 1960—Upper Cambrian trilobites from Salair (Tolstochikhinsk Suite). *Acad. Sci. USSR, Sib. Div., Inst. Geol. Geophys.*, 5, 1-116, pls I-VIII (Russian).

ROSOVA, A. V., 1963—Biostratigraphical scheme for the upper parts of the Middle Cambrian and for the Upper Cambrian of the northwestern part of the Siberian Platform and the index trilobites. *Ibid.*, 9, 3-19, 2 pls (Russian).

ROSOVA, A. V., 1968—Biostratigraphy and trilobites of the Upper Cambrian and Lower Ordovician of the northwest Siberian Platform. *Ibid.*, 36, 3-196, pls I-XVII (Russian).

RUSHTON, A. W. A., 1971—See TAYLOR, K., & RUSHTON, A. W. A., 1971.

RUZICKA, R., 1931—Supplément à la faune des couches à *Euloma* du gisement métallifère près de Holoubkov (à Ouzky). *Zvlastni otisk z. věstniku státniho geol. úst. Csl. Repub. (Praha), Ročnik* 7, 1-9 (Czech), 10-20 (French), 1 pl.

SALTER, J. W., 1864a—A monograph of the British trilobites. *Palaeontogr. Soc. Lond., Monogr.*, 1-80, pls 1-6.

SALTER, J. W., 1864b—Figures and descriptions illustrative of British organic remains. *Mem. geol. Surv. U.K., Dec.* 11, 11 pp, 1 pl.

SALTER, J. W., 1866a—On the fossils of north Wales. Appendix *in* RAMSAY, A. C.—The geology of north Wales. *Geol. Surv. G.B. Mem.* 3, 331-611, pls 1-26.

SALTER, J. W., 1866b—A monograph of the British trilobites. *Palaeontogr. Soc. Lond. Monogr.*, 129-76, pls 15-25.

SDZUY, K., 1955—Die Fauna der Leimnitz-Schiefer (Tremadoc). *Abh. Senck. naturf. Ges.*, 492, 1-74, pls 1-8.

SDZUY, K., 1958—Fossilien aus dem Tremadoc der Montagne Noire. *Senck. leth.*, 39 (3-4), 255-88, pls 1-3.

SHAW, A. B., 1951—Paleontology of northwestern Vermont, 1. New Late Cambrian trilobites. *J. Paleont.*, 25(1), 97-114, pls 21-24.

SHAW, A. B., 1952—Idem, II. Fauna of the Upper Cambrian Rockledge Conglomerate near St Albans. *J. Paleont.*, 26(3), 458-83, pl. 57.

SHAW, A. B., 1955—Idem, IV. A new trilobite genus. *J. Paleont.*, 29(1), 187.

SHAW, F. C., & ORMISTON, A. R., 1964—The eye socle of trilobites. *J. Paleont.*, 38(5), 1001-2.

SHERGOLD, J. H., 1971—Résumé of data on the base of the Ordovician in central and northern Australia. *In* Colloque ordovicien-silurien, Brest, Septembre 1971. *BRGM Mem.* 73, 391-402.

SHERGOLD, J. H., 1972—Late Upper Cambrian trilobites from the Gola Beds, western Queensland. *Bur. Miner. Resour. Aust. Bull.* 112, 1-126, pls 1-19.

SHERGOLD, J. H., 1973—A new conocoryphid trilobite from the Middle Cambrian of western Queensland. *Bur. Miner. Resour. Aust. Bull.* 126, 19-26, pls 10-12.

SIVOV, A. G., 1955—See KHALFIN, L. L., 1955.

SMITH, K. G., 1972—Stratigraphy of the Georgina Basin. *Bur. Miner. Resour. Aust. Bull.* 111, 156 pp.

STUBBLEFIELD, C. J., 1933—Notes on the fossils. *In* SMITH, S., 1933. On the occurrence of Tremadoc Shales in the Tortworth Inlier (Gloucestershire). *Quart. J. geol. Soc. Lond.*, 89(4), 357-77, pl. 34.

SUN, Yun-Chu, 1924—Contribution to the Cambrian faunas of China. *Palaeont. sinica,* (B) 1, *Fasc.* 4, 1-109, pls I-V.

SUN, Yun-Chu, 1935—The Upper Cambrian trilobite faunas of north China. *Palaeont. sinica,* (B) 2, *Fasc.* 2, 1-69, pls I-VI.

SUN, Yun-Chu, 1939—On the occurrence of Fengshanian (the late Upper Cambrian) trilobite faunas in W. Yunnan. *40th Anniv. Paps Nat. Univ. Peking, 1939,* 29-34, pl. 1; reprinted June 1947 in *Contrib. geol. Inst. Nat. Univ. Peking,* 27, 29-34, pl. 1.

TAYLOR, K., & RUSHTON, A. W. A., 1971—The pre-Westphalian geology of the Warwickshire Coalfield. *Geol. Surv. U.K., Bull.* 35, 152 pp., 12 pls.

TJERNVIK, T. E., 1956—On the early Ordovician of Sweden: stratigraphy and fauna. *Geol. Inst. Univ. Uppsala Bull.* 36, 107-284, pls 1-11.

TROEDSSON, G. T., 1937—On the Cambro-Ordovician faunas of western Quruq Tagh, eastern Tien-shan. *In* Report of the scientific expedition to the northwestern provinces of China under the leadership of Dr Sven Hedin. The Sino-Swedish Expedition Publ. 4. V. Invertebrate Palaeontology 1. *Palaeont. sinica, n.s.* (B) 2 (*whole ser.* 106), 1-74, pls 1-10.

TULLBERG, S. A., 1880—*Agnostus*-arterna i de Kambriska aflagringarne vid Andrarum. *Sver. geol. Undersök.*, (C) 42, 1-37, 2 pls.

ULRICH, E. O., 1924—See WALCOTT, C. D., 1924a.

ULRICH, E. O., & RESSER, C. E., 1930—The Cambrian of the Upper Mississippi Valley. Pt 1, Trilobita; Dikelocephalinae and Osceolinae. *Milwaukee Publ. Mus. Bull.* 12(1), 1-122, pls 1-23.

ULRICH, E. O., & RESSER, C. E., 1933—Idem., Pt 2, Trilobita; Saukiinae. *Ibid.*, 12(2), 123-306, pls 24-45.

VASILENKO, V. K., (ed.) 1963—Decisions of the interdepartmental council for the preparation of unified stratigraphical schemes for the Yakutian ASSR. *Governmental geol. Comm. USSR.* (Russian).

WALCOTT, C. D., 1884—Palaeontology of the Eureka district. *U.S. geol. Surv. Monogr.* 8, xiii + 1-298, pls 1-24 (maps).

WALCOTT, C. D., 1905—Cambrian faunas of China. *Proc. U.S. nat. Mus.*, 29, 1-106.

WALCOTT, C. D., 1906—Cambrian faunas of China. *Proc. U.S. nat. Mus.*, 30, 563-95.

WALCOTT, C. D., 1911—Cambrian geology and paleontology II. No. 4. Cambrian faunas of China. *Smithson. misc. Coll.*, 57(4), 69-108, pls 14-17.

WALCOTT, C. D., 1913—The Cambrian faunas of China. *In* RESEARCH IN CHINA, 3, 3-276, pls 1-24. *Carnegie Inst. Publ.* 54.

WALCOTT, C. D., 1914a—Cambrian geology and paleontology, II. No. 13. *Dikelocephalus* and other genera of Dikelocephalinae. *Smithson. misc. Coll.*, 57(13), 345-412, pls 60-70.

WALCOTT, C. D., 1914b—Idem, III. No. 1, The Cambrian faunas of eastern Asia. *Ibid.*, 64(1), 1-75, pls 1-3.

WALCOTT, C. D., 1916—Idem, III, No. 3. Cambrian trilobites. *Ibid.*, 64(3), 157-256, pls 24-38.

WALCOTT, C. D., 1924a—Idem, V. No. 1 Geological formations of Beaverfoot-Brisco-Stanford Range, British Columbia, Canada. *Ibid.*, 75(1), 1-51, pls 1-8.

WALCOTT, C. D., 1924b—Idem, V. No. 2. Cambrian and Lower Ozarkian trilobites. *Ibid.*, 75(2), 53-60, pls 9-14.

WALCOTT, C. D., 1925—Idem, V. No. 3. Cambrian and Ozarkian trilobites. *Ibid.*, 75(3), 61-146, pls 15-24.

WALCOTT, C. D., & RESSER, C. E., 1924—Trilobites from the Ozarkian sandstones of the island of Novaya-Zemlya. *In Report of the scientific results of the Norwegian expedition to Novaya-Zemlya 1921*, No. 24, 3-14, pls I-II. *Soc. Arts Sci. Kristiania.*

WESTERGAARD, A. H., 1909—Studier öfver Dictyograptusskiffern och dess gränslager. *Medd. Lunds geol. Fältkubb.*, (B) 4, 3-79, pls I-V (also published in *Lunds Univ. Aarsskr., n. f., Afd* 2, *Bd* 5(3), and *Kongl. Fysiograf. Sällskapets Handl., n. f., Bd* 20(3)).

WESTERGAARD, A. H., 1922—Sveriges Olenidskiffer. *Sver. geol. Undersök., Avh.* (C) 18, 1-205, 6 pls.

WESTERGAARD, A. H., 1939—On Swedish Cambrian Asaphidae. *Sver. geol. Undersök.*, (C) 421, *Aarsb.* 33(1), 3-16, pls 1-3.

WESTERGAARD, A. H., 1944—Borrningar genom Skaanes Alunskiffer 1941-2. *Sver. geol. Undersök.*, (C) 459, *Aarsb.* 38(1), 3-37 (Swedish), 38-45 (English), pls 1-3.

WESTERGAARD, A. H., 1947—Supplementary notes on the Upper Cambrian trilobites of Sweden. *Sver. geol. Undersök.*, (C) 489, *Aarsb.* 41(8), 3-34, pls 1-3.

WHITEHOUSE, F. W., 1936—The Cambrian faunas of northeastern Australia. Part 1, Stratigraphical outline. Part 2, Trilobita (Miomera). *Mem. Qld Mus.*, 11, 59-112, pls 8-10.

WHITEHOUSE, F. W., 1939—Idem, Part 3, The polymerid trilobites. *Ibid.*, 21(3), 179-282, pls 19-25.

WHITTINGTON, H. B., 1959—See MOORE, R. C., 1959.

WHITTINGTON, H. B., 1965—Trilobites of the Ordovician Table Head Formation, western Newfoundland. *Bull. Mus. comp. Zool., Harvard Univ.*, 132(4), 275-442, pls 1-68.

WILSON, J. L., 1954—Late Cambrian and early Ordovician trilobites from the Marathon Uplift, Texas. *J. Paleont.*, 28(3), 249-85, pls 24-27.

WINSTON, D., & NICHOLLS, H., 1967—Late Cambrian and early Ordovician faunas from the Wilberns Formation of the central Texas. *J. Paleont.*, 41(1), 66-96, pls 9-13.

WOLFART, R., 1970—Fauna, Stratigraphie und Paläogeographie des Ordoviziums in Afghanistan. *Beih. geol. Jb.*, 89, 1-125, pls 1-17.

APPENDIX A

INDEX OF SECTIONS AND LOCALITIES

All sections and localities discussed in this paper are to be found on the Boulia 1:250 000 Geological Series Sheet SF/54-10. The rock determinations were made by Mr B. Radke (BMR) by examination of stained acetate peels of polished surfaces (after the methods of Davies & Till, 1968).

BLACK MOUNTAIN

The trilobites described are from horizons collected by the author during 1967 and 1969 on the line of section shown in Text-figure 3. All horizons examined at that time were prefixed with the letter K. They are located on a measured section, the measurements given below with respect to its base.

K103: 1.65 m from the base of the measured section. 'Chatsworth Limestone', a layer 7.5-15 cm thick of light purplish to olive grey coarse-grained bituminous biosparite (shelly calcarenite), grain supported, with fine sparite settling out on upper surfaces of trilobite and pelmatozoan fragments. This limestone appears to be well washed and contains little mud, and there are few signs of the continued abrasion of fragments. Dip 32°/270.

Fauna: *Pseudagnostus clarki patulus, P. elix, P.* sp. A; *Caznaia squamosa, Euloma (Plecteuloma) strix, Hapsidocare chydaeum, Koldinioidia* cf. *cylindrica, Sigmakainella primaeva, Wuhuia* cf. *W. dryope.*

K104: 6 m, 'Chatsworth Limestone', a 15 cm layer, as above, with same dip.

Fauna: *Pseudagnostus clarki patulus, P. elix, P.* sp. A; *Caznaia squamosa, Euloma (Plecteuloma) strix, Hapsidocare chydaeum, Koldinioidia* cf. *cylindrica, Sigmakainella primaeva,* Idahoiid gen. undet.

K105: 7.3 m, 'Chatsworth Limestone', as above, same dip.

Fauna: *Pseudagnostus clarki patulus, P. coronatus, P.* sp. A; *Caznaia squamosa, Euloma (Plecteuloma) strix, Hapsidocare chydaeum, Koldinioidia* cf. *cylindrica, Sigmakainella primaeva.*

K106: 50.6 m, 'Chatsworth Limestone', a 15 cm layer of very coarse biosparite (shelly calcarenite), grain supported, containing infiltered sand and silt grade sediment, and trilobite and pelmatozoan fragments showing few signs of continued abrasion. Fauna: *Pseudagnostus clarki patulus, P.* sp. B, *P. coronatus; Caznaia squamosa, Ceronocare* sp., *Euloma (Plecteuloma) strix, Hapsidocare chydaeum, Koldinioidia* cf. *cylindrica, Mendosina* sp., *Pagodia (Pagodia)* sp., *Sigmakainella primaeva.*

K107: 68.3 m, 'Chatsworth Limestone', a layer 7.5 cm thick splitting into two leaves and increasing in thickness to 15 cm, of light to medium grey biopelsparite containing abundant fine peloids, and trilobite fragments with geopetal structures. Dip 19°/250.

Fauna: *Pseudagnostus clarki patulus; Caznaia squamosa, C. sectatrix, Atopasaphus stenocanthus, Koldinioidia* cf. *cylindrica, Prosaukia* sp. A.

K108: 73 m, 'Chatsworth Limestone', a 7.5 cm layer of light to medium grey biopelsparite with grumeleuse fabric, trilobite fragments with geopetal structures, and patchily silicified matrix (the bioclasts remain unsilicified).

Fauna: *Pseudagnostus clarki patulus?, P.* sp. C; *Atopasaphus stenocanthus, Atratebia nexosa, Caznaia sectatrix, Hapsidocare grossum, Koldinioidia* cf. *cylindrica, Pagodia (Lotosoides) turbinata, Prosaukia* sp. A; Brachiopoda undet.

K109: 80.5 m, 'Chatsworth Limestone', a 7.5 cm layer of olive grey weathered bioclastic crystalline limestone containing disseminated fine quartz sand and imbricated trilobite fragments. Fossil fragments have sparry infillings.

Fauna: *Pseudagnostus clarki patulus?; Atopasaphus stenocanthus, Atratebia nexosa, Caznaia sectatrix, Hapsidocare grossum, Koldinioidia* cf. *cylindrica, Prosaukia* sp. A; Brachiopoda undet.

K110: 91 m, 'Chatsworth Limestone', a medium grey brownish weathering bioclastic crystalline limestone with scattered fine quartz grains throughout.

Fauna: *Atratebia nexosa, Hapsidocare grossum, Pagodia (Oreadella)* cf. *buda.*

K111: 108.5 m, 'Chatsworth Limestone', 5-7.5 cm layer of medium grey biomicrite grading into pelsparite with partly silicified matrix. Fossil fragments have spary infillings. Dip 25°/250.

Fauna: *Pseudagnostus clarki prolatus; Atopasaphus stenocanthus, Atratebia nexosa, Caznaia sectatrix, Ceronocare pandum, Duplora clara, Koldinioidia* cf. *cylindrica, Pagodia (Lotosoides) calcarata, P. (L.) turbinata, Prosaukia* sp. A, *?Richardsonella* sp., *Sigmakainella translira;* Brachiopoda undet.

K112: 121 m, 'Chatsworth Limestone', a 15-23 cm layer of medium grey biomicrite with partly silicified matrix, containing granular mud clasts, and trilobite fragments with spary infillings.

Fauna: *Pseudagnostus clarki prolatus; Atratebia nexosa, Caznaia sectatrix, Ceronocare pandum, Koldinioidia* cf. *cylindrica, Lorrettina macrops, Prosaukia* sp. A, *Sigmakainella translira;* Brachiopoda undet.

K113: 129 m, 'Chatsworth Limestone', light grey, yellow, or brownish weathering biomicrite containing very fine quartz sand, and occasional patches of grain-supported biosparite. Spar cavities underlie trilobite fragments. Dip 35°/250.

Fauna: *Caznaia sectatrix, Ceronocare pandum, Duplora clara, Sigmakainella translira;* Brachiopoda undet.

K114: 130.5 m, 'Chatsworth Limestone', light grey biomicrite with occasional patches of fine sand. The bioclasts are zoned and strongly oriented. Geopetal structures are common.

Fauna: *Atopasaphus stenocanthus, Ceronocare pandum, Lophosaukia torquata, Lorrettina macrops, Sigmakainella translira;* Brachiopoda undet.; sponge spicules; echinodermal debris.

K115: 134-140 m, 'Chatsworth Limestone', rubble-covered slope, chert fragments over unexposed limestone. The sampled specimen is a biopelmicrite with areas of silicification, containing few bioclastic fragments, and very fine peloids with grumeleuse fabric.

Fauna: *Pseudagnostus bifax; Duplora clara, Lophosaukia torquata, Pagodia (Lotosoides) turbinata.*

K116: 140 m, 'Chatsworth Limestone', light grey grain-supported biopelsparite with infiltered peloids, patches of silicification, and lineated trilobite debris.

Fauna: *Connagnostus conspectus, Geragnostus (Strictagnostus) chronius, Pseudagnostus bifax, P. clavus; Atopasaphus stenocanthus, Atratebia nexosa, Ceronocare pandum, Duplora clara, Hapsidocare grossum, Lophosaukia acuta, L. torquata, Lorrettina macrops, Pagodia (Lotosoides) calcarata, P. (L.) turbinata, Sigmakainella translira;* Brachiopoda undet.

K117: 151 m, 'Chatsworth Limestone', (1) light grey biomicrite, with scattered fine sand and patches of silicification, containing much trilobite debris, (2) very coarse grain-supported biosparite containing trilobite and pelmatozoan fragments, silicification within allochems.

Fauna: *Connagnostus conspectus, Geragnostus (Strictagnostus) chronius, Pseudagnostus bifax, P. denticulatus; Ceronocare pandum, Hapsidocare grossum, Lophosaukia acuta, L. torquata, Lorrettina macrops, Sigmakainella translira.*

K118: 156 m, 'Chatsworth Limestone', a 10 cm layer of light grey biosparite containing dominantly trilobite debris and pelmatozoans. The allochems are heavily silicified, the silica irregularly spreading into the cement. Dip 28°/270.

Fauna: *Lotagnostus (Trilobagnostus) irretitus, Pseudagnostus bifax, P. clavus, P. denticulatus; Golasaphus simus, Hapsidocare grossum?, Lophosaukia torquata, Lorrettina macrops, Parakoldinioidia bigranulosa.*

K119: 157 m, 'Chatsworth Limestone', pale grey biosparite with imbricated trilobite and pelmatozoan fragments in approximately equal volume.

Fauna: *Connagnostus conspectus, Lotagnostus (Trilobagnostus) irretitus, Geragnostus (Micragnostus)* cf. *acrolebes, Pseudagnostus bifax, P. denticulatus; Golasaphus simus, G. triquetrus, Lorrettina macrops, ?Sigmakainella trispinosa.*

K120: 158.5-164.6 m, 'Chatsworth Limestone', erratic blocks of grain-supported biosparite, a well silicified trilobite pelmatozoan coquina.

Fauna: *Atopasaphus simus, Lophosaukia torquata,* mansuyiinid indet.

K121: 171.6 m, 'Chatsworth Limestone', from a 46 cm layer of grain-supported trilobite pelmatozoan biosparite.

Fauna: *Lotagnostus (Trilobagnostus) irretitus, Pseudagnostus clarki maximus, P. clavus, P. papilio; Atratebia nexosa?, Golasaphus simus, G. triquetrus, Maladioidella* cf. *chinchiaensis, Palacorona* sp. indet., *?Protopeltura* sp., *?Sigmakainella trispinosa.*

K122: 174.9 m, 'Chatsworth Limestone', a 13 cm layer of light to medium grey trilobite pelmatozoan grain-supported biosparite with infiltered peloids overlying biomicrite (wackestone). Dip 26°/255.

Fauna: *Pseudagnostus clarki maximus; Golasaphus simus, Palacorona* sp. indet., *?Mansuyites* sp. indet.; Brachiopoda undet.

K123: 185 m, 'Chatsworth Limestone', light grey trilobite biomicrite containing 20-30% of silt-sized quartz, and some spar fillings below convex fragments. The sample is from a layer 75 cm thick with several leaves.

Fauna: *Geragnostus (Strictagnostus) chronius, Pseudagnostus clarki maximus, P. papilio; Maladioidella* cf. *chinchiaensis, Mansuyites* sp. indet., *Sigmakainella longilira, ?S. trispinosa.*

K124: 199.6 m, 'Chatsworth Limestone', a 15 cm layer of dark grey trilobite biomicrite of silt grade, with geopetal structures, and thin biosparite laminae.

Fauna: *Pseudagnostus clarki maximus, P. papilio; Lophosaukia* sp. A, *Mansuyites* sp. indet., *Palacorona* sp. indet.

K125: 202.4 m, 'Chatsworth Limestone', a 15 cm layer of purple weathering laminated micrite.

Fauna: *Pseudagnostus clarki maximus; Lophosaukia* sp. A, *Mansuyites* sp. indet.

K126: 231.7 m, 'Chatsworth Limestone', medium to dark grey trilobite biomicrite (wackestone) with large homogeneous micrite clasts, and high silica content.

Fauna: *Pseudagnostus clarki maximus; Lophosaukia* sp. A, *Palacorona* sp. indet.

K127: 234.7 m, 'Chatsworth Limestone', a 10 cm layer of medium grey silicified micrite with patches and laminae of trilobite pelmatozoan biosparite with geopetal structures.

Fauna: Indeterminate trilobite fragments.

K128: 239.6 m, 'Chatsworth Limestone', a thin layer 2.5 cm thick, of medium grey or brownish silicified and recrystallized micrite with few bioclasts. The silicification is due to the presence of homogeneous fine-grained authigenic quartz.

Fauna: *Pseudagnostus clarki maximus; Palacorona* sp., *Prosaukia* sp. indet., *Sinosaukia impages.*

K129: 249.3 m, 'Chatsworth Limestone', massive layer of medium grey or brownish trilobite biomicrite with grumeleuse structure, containing thin laminae of trilobite pelmatozoan biosparite. Some dolomitization is evident.

Fauna: Indeterminate trilobite fragments; undet. Brachiopoda.

K130: 272 m, 'Chatsworth Limestone', a 10 cm layer of medium grey biosparite with infiltering fine calcarenite and large mud clasts, overlying bioclastic micrite.

Fauna: *Pseudagnostus clarki maximus; Mansuyia* cf. *orientalis, ?Prosaukia cornigra, Sinosaukia impages.*

K131: 309.3 m, 'Chatsworth Limestone', at the foot of the second escarpment face, a 15-30 cm layer of medium grey grain-supported brachiopod trilobite biopelsparite containing silt-size peloids, and authigenic quartz, and having geopetal structures. Dip 30°/255.

Fauna: *Geragnostus (Strictagnostus) chronius; Mansuyia* cf. *orientalis, ?Prosaukia cornigra, Sinosaukia impages, ?Wanwanaspis* sp. indet.; Brachiopoda undet.

K132: 312.4 m, 'Chatsworth Limestone', a 15 cm layer of pale grey intraclastic biomicrite. The clasts are elongate, aligned, and of granular size. They have underlying spar crystals too narrow for geopetals. Bioclasts are mainly trilobite fragments. Minor silicification in zones.

Fauna: Indeterminate saukiid fragments.

K133: 324.6 m, 'Chatsworth Limestone', a 25 cm layer of pale grey well silicified trilobite pelmatozoan brachiopod biomicrite with elongate aligned mud clasts.

Fauna: *Mansuyia* cf. *orientalis, Sinosaukia impages.*

K134: 329.2 m, 'Chatsworth Limestone', medium grey or purplish weathering grain-supported trilobite pelmatozoan brachiopod biosparite with elongate mud clasts.

Fauna: *Mansuyia* cf. *orientalis, Sinosaukia impages.*

K135: 335.3 m, 'Chatsworth Limestone', a 15 cm layer of medium grey brownish or purplish weathering trilobite biopelsparite, partially silicified, with aligned trilobite fragments.

Fauna: *Mansuyia* cf. *orientalis, Sinosaukia impages, Tsinania (Dictyites) antidictys.*

K136: 347.8 m, 'Chatsworth Limestone', from the top of a massive layer of pale grey current-bedded biosparite (trilobite coquina).

Fauna: *Geragnostus (Strictagnostus)* sp.; *Anderssonella beauchampi, Koldinioidia payntonensis, Mansuyia* cf. *orientalis.*

K137: 365.8 m, 'Chatsworth Limestone', medium grey, olive grey, or purplish grey trilobite pelmatozoan biomicrite, grain-supported in places, containing mud laths, patches of spar and silicification.

Fauna: *Anderssonella beauchampi, Galerosaukia* sp., *Wanwanaspis* cf. *semicircularis, W.* sp.

K138: 373.7 m, 'Chatsworth Limestone', greenish grey or purplish grey trilobite pelmatozoan biosparite alternating with biomicrite. High degree of dolomitization.

Fauna: *Pseudagnostus orbiculatus, P. quasibilobus; Anderssonella beauchampi, Haniwa mucronata, Koldinioidia payntonensis, ?Prosaukia absona, Ptychaspis (Asioptychaspis) delta, Sinosaukia* sp. indet., *Tsinania (Tsinania) necopina, T. (T.) nomas, Wanwanaspis pygidion.*

K139: 375 m, 'Chatsworth Limestone', pale grey or white fine sandy trilobite pelmatozoan biosparite with laminated dolomitization.

Fauna: *Geragnostus (Micragnostus)* cf. *intermedius, Pseudagnostus orbiculatus, P. quasibilobus; Anderssonella beauchampi, Haniwa mucronata, Lophosaukia* sp. C, *Mansuyia* cf. *tani, ?Prosaukia absona, Koldinioidia payntonensis, Tsinania (Tsinania) necopina, T. (T.) nomas, Wanwanaspis pygidion.*

K140: 390.4 m, 'Chatsworth Limestone', olive grey fine-grained biopelsparite, with random dolomitization. Little bioclastic material.

Fauna: *Tsinania (Tsinania) nomas.*

K141: 395.6 m, 'Chatsworth Limestone', fine sandy biosparite with disseminated dolomitization, containing large non-dolomitized laminated micrite (calcisiltite) clasts. Fauna: *Galerosaukia galerita;* undet. Brachiopoda.

K142: 408.7 m, 'Chatsworth Limestone', brownish grey well sorted biopelsparite, with broken but lineated bioclasts, trilobites and pelmatozoans, and fine sand.

Fauna: *Tsinania (Tsinania) nomas, T. (T.)* cf. *pagoda, T. (Dictyites)* cf. *trigonalis.*

K143: 409.6 m, 'Chatsworth Limestone', pale grey sandy pelsparite, with disseminated dolomite in certain laminae.

Fauna: *Anderssonella eweyi, Tsinania (Tsinania) nomas, T. (T.)* cf. *pagoda;* Brachiopoda undet.

K144: 417.2 m, 'Chatsworth Limestone', pale white or grey biosparite with fine peloids and geopetal structures. Trilobite and pelmatozoan fragments are segregated in alternate laminae.

Fauna: *Anderssonella eweyi, Tsinania (Tsinania) nomas;* undet. Brachiopoda.

K145: 460.8 m, Ninmaroo Formation, variegated limestone/dolomite member, just behind summit of Black Mountain, chert fragments overlying dark grey slightly dolomitized micrite.

Fauna: *?Calvinella solitaria;* ribeirioids undet.

K146: 730.5 m, Ninmaroo Formation, variegated limestone/dolomite member, pale grey pebbly vuggy oosparite with occasional grapestone clasts. Dark micrite binding selected surfaces is thought to be of algal origin.

Fauna: *Leiostegium (Leiostegium) floodi;* ribeirioids undet.; echinodermal debris.

K147: 737.3 m, Ninmaroo Formation, variegated limestone/dolomite member, silicified oosparite.

Fauna: Leiostegiacean genus incertae sedis 1; echinodermal debris.

K148: 770.8 m, Ninmaroo Formation, variegated limestone/dolomite member, grey silicified micrite.

Fauna: Indeterminate trilobite fragments.

K149: 779.3 m, Ninmaroo Formation, variegated limestone/dolomite member, pink and grey biosparite with micrite clasts containing well rounded shell fragments and scattered ooliths. Bioclasts have thin micrite coatings which may be of algal origin. The hand specimen appears to be a bituminous pebble conglomerate.

Fauna: Leiostegiacean genus incertae sedis 1.

K150: 970.8 m, Ninmaroo Formation, encrinite member, thin chert biscuit on the upper surface of a coarse biosparite.

Fauna: ?*Asaphellus* sp. indet.; echinodermal debris.

K151: 1049 m, Ninmaroo Formation, encrinite member, pale grey deeply weathered brachiopod pelmatozoan biosparite, containing peloids and recrystallized micrite clasts, on occasion quite large.

Fauna: ?*Asaphellus* sp. indet.; Brachiopoda (various) undet.; echinodermal debris.

The following horizons were collected from the 'Chatsworth Limestone' of Black Mountain by the Georgina Basin Party (BMR) in 1957. They are unlocated as to the present line of section. The rock samples have not been examined petrographically, hand specimen descriptions being given.

B507: The four horizons below prefixed B507 are said to be from an interval of section 15-37 m above the base of the Black Mountain section. Their stratigraphical order from the base is given as 507a′, 507a″, 507b, and 507c. The indicated dip is 10°/270. All four faunas indicate a position on the measured section between K116 and K118.

B507a′: Coarse crystalline calcarenite.

Fauna: *Pseudagnostus bifax; Ceronocare* cf. *pandum, Duplora clara, Parakoldinioidia bigranulosa, Sigmakainella translira.*

B507a″: Pale grey calcarenite with silica blebs.

Fauna: *Pseudagnostus bifax; Ceronocare* cf. *pandum, Hapsidocare grossum, Lophosaukia torquata, Parakoldinioidia bigranulosa, Sigmakainella translira.*

B507b: Pyritic calcilutite, silicified matrix, bituminous smell.

Fauna: *Pseudagnostus bifax; Mendosina* sp.

B507c: Pale greenish or whitish grey calcarenite with streaks of calcareous mud, surface silicification.

Fauna: *Duplora clara, Lophosaukia torquata, Lorrettina macrops, Pagodia (Lotosoides) calcarata.*

B509: An unlocated sample from the Black Mountain section consisting of a piece of laminated chert 2.5 m thick.

Fauna: *Pseudagnostus papilio; Duplora clara, Koldinioidia* sp., *Lorrettina macrops.* This is a Gola Beds faunal association which indicates that B509 lies higher than 172 m on the measured section.

B510: Four horizons are grouped under this member from the higher part of the Black Mountain section.

B510: Pale grey or white medium-grained sandy or dolomitic very shelly calcarenite.

Fauna: *Pseudagnostus orbiculatus, P. quasibilobus; Haniwa mucronata, Kildinioidia payntonensis, ?Prosaukia absona, Sinosaukia* sp. indet., *Tsinania (Tsinania) necopina.*

This fauna indicates a position close to K138-K139.

B510a: Medium to dark grey sandy calcarenite.

Fauna: Saukiid librigena undet.

Fauna unplaced.

B510a-b: Purplish grey brownish weathering dolomitic limestone.

Fauna: Indet. saukiid fragments, pagodiid indet.; brachiopoda undet.

Position uncertain.

B510b: Pale grey or yellow brown dolomitic and shelly calcarenite.

Fauna: *Pseudagnostus orbiculatus, P. quasibilobus; Galerosaukia ptyxis, Haniwa mucronata, Tsinania (Tsinania) necopina.*

MOUNT NINMAROO

Trilobites were collected from horizons on the line of section shown on Text-figure 3.

K161: 6.7 m, 'Chatsworth Limestone', pale to medium grey and olive grey fine-grained dolomitized trilobite pelmatozoan biopelsparite containing micrite clasts. The sample is from a bed 3 m thick. Dip 30°/285.

Fauna: *Anderssonella eweyi, Mansuyia* cf. *tani.*

K162: 18.3 m, 'Chatsworth Limestone', from a 75 cm unit of pale olive grey sandy biopelsparite containing large imbricated micrite clasts, trilobite and pelmatozoan fragments, all showing little evidence of long transport.

Fauna: Indeterminate trilobite fragments; Brachiopoda undet.

K163: 20 m, 'Chatsworth Limestone', from a 4 m unit consisting of an alternation of thin 'marl' and substantially thicker calcarenite. The examined sample is a fine-grained recrystallized patchily dolomitized and partly silicified biopelsparite.

Fauna: *Anderssonella eweyi, Wanwanaspis pygidion,* saukiid indet.; Brachiopoda undet.

K164: 45.7 m, 'Chatsworth Limestone', medium grey fine-grained sandy pelsparite whose bedding is defined by zones of compaction.

Fauna: Indeterminate saukiid fragments.

K165: 50.3 m, 'Chatsworth Limestone', medium grey fine-grained sandy pelsparite with occasional trilobite fragments.

Fauna: *Galerosaukia ptyxis, Tsinania (Tsinania)* cf. *pagoda, Wanwanaspis pygidion;* Brachiopoda undet.

K166: 52.4 m, 'Chatsworth Limestone', purplish grey intraclastic biopelsparite; well rounded and recrystallized bio- and pelsparite clasts in a dolomitized bioclastic matrix.

Fauna: *Tsinania (Tsinania)* cf. *pagoda,* mansuyiinid indet.

K167: 59.5 m, 'Chatsworth Limestone', medium to dark trilobite biopelsparite. The sample is from an alternation of 'marl' and limestone 6 m thick.

Fauna: *Galerosaukia ptyxis,* tsinaniid indet.

K168: 67.4 m, 'Chatsworth Limestone', pale grey, yellowish or purplish grey weathering sandy biopelsparite with imbricated trilobite fragments. This horizon is from the base of a unit 3 m thick.

Fauna: *Pseudagnostus orbiculatus, P. quasibilobus; Galerosaukia ptyxis, Quadraticephalus* cf. *teres, Tsinania (Tsinania) nomas, T. (Dictyites)* cf. *trigonalis, Wanwanaspis* cf. *semicircularis;* Brachiopoda undet.

K169: 68.6 m, 'Chatsworth Limestone', biopelsparite with fine-grained sandstone laminae and imbricated trilobite fragments. Disseminated dolomitization within the sandier laminae.

Fauna: *Pseudagnostus orbiculatus, P. quasibilobus; Galerosaukia ptyxis, Quadraticephalus* cf. *teres, Tsinania (Tsinania) nomas, T. (Dictyites)* cf. *trigonalis;* Brachiopoda undet.

K170: 70 m, 'Chatsworth Limestone', medium to dark grey purple weathering sandy trilobite pelmatozoan biopelsparite with pellets. Dolomitized.

Fauna: *Galerosaukia ptyxis, Quadraticephalus* cf. *teres, Tsinania (Tsinania) nomas, T. (Dictyites)* cf. *trigonalis.*

On the Mount Ninmaroo section no further trilobites were recovered from the interval 82-760.7 m. Trilobite faunas above that level, of early Ordovician (Warendian) age, are not described in this Bulletin.

MOUNT DATSON

Text-figure 6 shows the line of section from which trilobites were collected at Mount Datson.

K174: 10.7 m, 'Chatsworth Limestone', a 15 cm layer of medium grey well sorted trilobite biopelsparite containing thin laminae of sandy dolomite. Dip 30°/280.

Fauna: Indeterminate saukiid fragments.

K175: 39.6 m, 'Chatsworth Limestone', medium to dark grey sandy dolomitic pelmatozoan trilobite pelsparite from a 75 cm layer.

Fauna: *Koldinioidia payntonensis, Lophosaukia* sp. D, *Palacorona torosa, Tsinania (Tsinania) necopina;* Brachiopoda undet.

K176: 140.2 m, 'Chatsworth Limestone', pale grey partly silicified trilobite pelmatozoan brachiopod biopelsparite with sandy matrix, containing micrite clasts showing little abrasion, and imbricated trilobite fragments.

Fauna: *Pagodia (Datsonia) subterior.*

K177: 161.5 m, 'Chatsworth Limestone', a 30 cm layer of intraclastic biorudite (calcirudite): intraclasts are of dolomitized sandy biopelsparite with trilobite and pelmatozoan fragments which indicate very high energy conditions.

Fauna: Indeterminate trilobite fragments.

K178: 166.2 m, 'Chatsworth Limestone', yellow brown or white leached sandy biosparite.

Fauna *Lophosaukia* sp. D, *Mictosaukia perplexa, Pagodia (Datsonia) subterior, Quadraticephalus* cf. *teres, Wanwanaspis* cf. *semicircularis;* Brachiopoda undet.

K179: 166.8 m, 'Chatsworth Limestone', brownish grey sandy dolomitized (finely disseminated) biopelsparite.
Fauna: Indeterminate trilobite fragments; undet. Brachiopoda.

K180: 185 m, 'Chatsworth Limestone', brownish grey sandy biosparite.
Fauna: *Mictosaukia perplexa.*

K181: 196.7 m, 'Chatsworth Limestone', white leached or purple weathered cross-laminated slightly dolomitized sandy biosparite.
Fauna: *Mictosaukia perplexa;* Brachiopoda undet.

K182: 326 m, Ninmaroo Formation, variegated limestone/dolomite member, yellow-brown and grey pebbly dolomitic biosparite.
Fauna: Undetermined trilobite fragment; Brachiopoda undet.

An interval of dolomite and dolomitic limestone 82 m thick succeeding horizon K182 has yielded no trilobites. No further trilobite faunas were collected until the base of the laminated dolomite member was encountered at 653.6 m from the base of the section. These trilobites, of Warendian age, are not described in this Bulletin.

DRIBBLING BORE

The collected section begins in the core of an anticlinal structure immediately to the west of the fault that bisects the Dribbling Bore structure, and 2.4 km due west of the bore (Text-fig. 6). It continues down-dip to the northwest until the outcrop becomes obscured by superficial deposits.

K185: 0 m, at the base of the section, 'Chatsworth Limestone', medium to dark grey calcite-veined vuggy biomicrite. Some bioclasts overlie geopetal structures, others are silicified. The micrite is possibly algal bound.
Fauna: *Lophosaukia* sp. B; Brachiopoda undet.

K186: 29 m, 'Chatsworth Limestone', medium grey poorly sorted mud supported trilobite pelmatozoan biomicrite, possibly algal bound.
Fauna: *Lophosaukia* sp. B, *Pagodia (Datsonia) subterior, Palacorona torosa, ?Prosaukia nema, Tsinania (Dictyites)* cf. *trigonalis.*

K187: 30.8 m, 'Chatsworth Limestone', medium to dark grey biopelsparite grading into biomicrite, containing geopetal structures.
Fauna: *Pseudagnostus orbiculatus; Lophosaukia* sp. B, *Palacorona torosa, Tsinania (Dictyites)* cf. *trigonalis;* Brachiopoda undet.

K188: 32 m, 'Chatsworth Limestone', pale grey or yellowish grey intraclastic biopelsparite; the clasts are pelmicrite. Pellets are compacted on the upper surfaces of mud clasts and fossil fragments.
Fauna: *Pagodia (Datsonia) subterior.*

K189: 45.7 m, 'Chatsworth Limestone', medium grey intraclastic pelsparite, in which the clasts are biopelmicrite.
Fauna: *Lophosaukia* sp. B, *Maladioidella* sp.; Brachiopoda undet.

K190: 66.2 m, 'Chatsworth Limestone', grey-brown laminated very sandy pelsparite with few bioclasts. The sample is dolomitized along the sandier laminae.
Fauna: Mansuyiinid indet.; Brachiopoda undet.

K191: 102.5 m, 'Chatsworth Limestone', brownish grey intraclastic biosparite overlying trilobite pelmatozoan biopelsparite. The clasts are laminated pelsparites.
Fauna: *Pagodia (Datsonia) subterior,* Saukiidae indet.

K192: 105.6 m, 'Chatsworth Limestone', pale greenish grey laminated biopelsparite with zones of micrite and biosparite, well sorted within laminae.
Fauna: *Mictosaukia perplexa, Pagodia (Datsonia) subterior.*

K193: 140.3 m, 'Chatsworth Limestone' pale grey biolithite: algal micrite binding bioclasts.
Fauna: Indeterminate trilobite fragments.

K194: 158.3 m, 'Chatsworth Limestone', pale grey or yellowish intraclastic biopelsparite: large and often well rounded clasts are composed of micrite and biopelsparite.
Fauna: Indeterminate trilobite fragments.

K195: 171 m, 'Chatsworth Limestone', purplish or brownish grey dolomitized intraclastic biopelsparite.
Fauna: *?Niobella* sp., *Onychopyge assula, ?Symphysurina* sp., leiostegiacean genera incertae sedis 1 and 2; *Cordylodus proavus, Protoconodontus notchpeakensis.*

After a brief interval without outcrop this section is resumed in unfossiliferous calcareous dolomite, massively bedded, and partly obscured by superficial deposits. The dolomite outcrop is more than 190 m thick.

K196: This horizon was collected from the limestone pediment to the east of the fault-line bisecting Dribbling Bore (Text-fig. 6). Medium to dark grey and yellow-brown mottled fine-grained to aphanitic splintery calcilutite crops out here and at most other places on the pediment. The polished sample is a laminated dolomite with thin lenses of pelsparite.
Fauna: *Palacorona torosa,* undet. leiostegiacean; undet. brachiopoda.

Of the samples collected from Dribbling Bore by the Georgina Basin Party (BMR) in 1957, numbered B776-B778, only B777 has a determinable trilobite fauna. B776 is a collection of surface silicified brachiopods not determined here.

B777: This sample was obtained from a point 2.4 km due west of the northernmost mud springs on Granton Pastoral Property. It is located on the measured line of section between 29 and 30.8 m from its base. The limestone is a sandy patchily silicified selectively dolomitized biopelsparite with geopetal structures.
Fauna: *Lophosaukia* sp. B, *Pagodia (Datsonia) subterior, Palacorona torosa, Tsinania (Dictyites)* cf. *trigonalis;* Brachiopoda undet.

APPENDIX B

REGISTER OF FIGURED SPECIMENS

Taxon	*CPC No.*	*Type*	*Plate*	*Fig.*	*Table*	*Loc.*	*Formation*
Lotagnostus (*Trilobagnostus*)	11518	Holotype	14	1		K121	'Chatsworth'
irretitus sp. nov.	11519	Paratype	14	2		K121	'Chatsworth'
	11520	Paratype	14	3		K121	'Chatsworth'
	11521	Paratype	14	4		K118	'Chatsworth'
	11522	Paratype	14	5		K119	'Chatsworth'
	11523	Paratype	14	6		K121	'Chatsworth'
Pseudagnostus clarki	11524	Holotype	1	1	1A	K106	'Chatsworth'
patulus subsp. nov.	11525	Paratype	1	2	1A	K106	'Chatsworth'
	11526	Paratype	1	3	1A	K104	'Chatsworth'
	11527	Paratype	1	4	2A	K107	'Chatsworth'
	11528	Paratype	1	5		K105	'Chatsworth'
	11529	Paratype	1	6	2A	K106	'Chatsworth'
	11530	Paratype	2	2	2A	K107	'Chatsworth'
	11531	Paratype	2	1	2A	K103	'Chatsworth'
Pseudagnostus clarki	11532	Holotype	3	5	1B	K111	'Chatsworth'
prolatus subsp. nov.	11533	Paratype	3	4	1B	K111	'Chatsworth'
	11534	Paratype	3	3	1B	K111	'Chatsworth'
	11535	Paratype	3	2/6	1B	K111	'Chatsworth'
	11536	Paratype	3	1	1B	K111	'Chatsworth'
	11537	Paratype	4	1	2B	K111	'Chatsworth'
	11538	Paratype	4	2	2B	K111	'Chatsworth'
	11539	Paratype	4	3	2B	K111	'Chatsworth'
	11540	Paratype	4	4	2B	K111	'Chatsworth'
	11541	Paratype	4	5	2B	K111	'Chatsworth'
	11542	Paratype	4	6	2B	K111	'Chatsworth'
Pseudagnostus clarki	11543				2A	K105	'Chatsworth'
patulus subsp. nov.	11544				2A	K107	'Chatsworth'
	11545				2A	K107	'Chatsworth'
	11546				2A	K105	'Chatsworth'
	11547				2A	K106	'Chatsworth'
	11548				2A	K106	'Chatsworth'
	11549				2A	K106	'Chatsworth'
	11550				2A	K103	'Chatsworth'
	11551				2A	K107	'Chatsworth'
	11552				2A	K105	'Chatsworth'
	11553				1A	K106	'Chatsworth'
	11554				1A	K106	'Chatsworth'
	11555				1A	K104	'Chatsworth'
	11556				1A	K107	'Chatsworth'
	11557				1A	K107	'Chatsworth'
	11558				1A	K105	'Chatsworth'
Pseudagnostus clarki	11559				1B	K111	'Chatsworth'
prolatus subsp. nov.	11560				1B	K111	'Chatsworth'
	11561				1B	K111	'Chatsworth'
	11562				1B	K111	'Chatsworth'
	11563				1B	K111	'Chatsworth'
	11564				1B	K111	'Chatsworth'
	11565				1B	K111	'Chatsworth'
	11566				1B	K111	'Chatsworth'
	11567				1B	K111	'Chatsworth'
	11568				1B	K111	'Chatsworth'

Taxon	CPC No.	Type	Plate	Fig.	Table	Loc.	Formation
	11569				2B	K111	'Chatsworth'
	11570				2B	K111	'Chatsworth'
	11571				2B	K111	'Chatsworth'
	11572				2B	K111	'Chatsworth'
	11573				2B	K111	'Chatsworth'
	11574				2B	K111	'Chatsworth'
	11575				2B	K111	'Chatsworth'
	11576				2B	K111	'Chatsworth'
	11577				2B	K111	'Chatsworth'
	11578				2B	K111	'Chatsworth'
	11579				2B	K111	'Chatsworth'
	11580				2B	K111	'Chatsworth'
Pseudagnostus clarki maximus subsp. nov.	11581				1C	K124	'Chatsworth'
	11582				1C	K121	'Chatsworth'
	11583				1C	K124	'Chatsworth'
	11584				1C	K128	'Chatsworth'
	11585				1C	K121	'Chatsworth'
	11586				1C	K121	'Chatsworth'
	11587	Holotype	5	1	1C	K121	'Chatsworth'
	11588				2C	K122	'Chatsworth'
	11589				2C	K124	'Chatsworth'
	11590	Paratype	5	2	2C	K121	'Chatsworth'
Pseudagnostus orbiculatus sp. nov.	11591	Holotype	12	9		K187	'Chatsworth'
	11592	Paratype	12	8		K138	'Chatsworth'
	11593	Paratype	12	10		B510	'Chatsworth'
	11594	Paratype	12	11		K138	'Chatsworth'
	11595	Paratype	12	12		B510b	'Chatsworth'
Pseudagnostus bifax sp. nov.	11596	Holotype	9	1	3	K116	'Chatsworth'
	11597	Paratype	9	2	3	K116	'Chatsworth'
	11598	Paratype	9	3	3	K116	'Chatsworth'
	11599	Paratype	9	4	3	K117	'Chatsworth'
	11600	Paratype	9	5	3	K117	'Chatsworth'
	11601	Paratype	9	6	3	K118	'Chatsworth'
	11602	Paratype	9	7	3	K118	'Chatsworth'
	11603				3	K117	'Chatsworth'
	11604				3	K117	'Chatsworth'
	11605				3	K117	'Chatsworth'
	11606				3	K118	'Chatsworth'
	11607				3	K117	'Chatsworth'
	11608				3	K117	'Chatsworth'
	11609				3	K117	'Chatsworth'
	11610				3	K117	'Chatsworth'
	11611				3	K116	'Chatsworth'
	11612				3	K117	'Chatsworth'
	11613				3	K117	'Chatsworth'
	11614				3	K116	'Chatsworth'
	11615				3	K117	'Chatsworth'
	11616				3	K117	'Chatsworth'
	11617				3	K117	'Chatsworth'
	11618				3	K116	'Chatsworth'
	11619				3	K117	'Chatsworth'
	11620				3	K116	'Chatsworth'
	11621				3	K117	'Chatsworth'
	11622				3	K117	'Chatsworth'
	11623				3	K117	'Chatsworth'
	11624				3	K117	'Chatsworth'
	11625				3	K117	'Chatsworth'

Taxon	CPC No.	Type	Plate	Fig.	Table	Loc.	Formation
	11626				3	K116	'Chatsworth'
	11627				3	K117	'Chatsworth'
	11628				3	K117	'Chatsworth'
	11629				3	K116	'Chatsworth'
	11630				3	K117	'Chatsworth'
	11631				3	K117	'Chatsworth'
	11632				3	K117	'Chatsworth'
	11633				3	K115	'Chatsworth'
	11634				3	K116	'Chatsworth'
	11635				3	K117	'Chatsworth'
	11636				3	K117	'Chatsworth'
	11637				3	K117	'Chatsworth'
	11638				3	K117	'Chatsworth'
	11639				4	K117	'Chatsworth'
	11640				4	K116	'Chatsworth'
	11641				4	K116	'Chatsworth'
	11642				4	K117	'Chatsworth'
	11643				4	K117	'Chatsworth'
	11644				4	K117	'Chatsworth'
	11645				4	K117	'Chatsworth'
	11646				4	K117	'Chatsworth'
	11647				4	K116	'Chatsworth'
	11648				4	K118	'Chatsworth'
	11649	Paratype	10	4	4	K116	'Chatsworth'
	11650				4	K117	'Chatsworth'
	11651				4	K117	'Chatsworth'
	11652				4	K117	'Chatsworth'
	11653				4	K118	'Chatsworth'
	11654				4	K117	'Chatsworth'
	11655				4	K117	'Chatsworth'
	11656	Paratype	10	3	4	K116	'Chatsworth'
	11657				4	K117	'Chatsworth'
	11658				4	K117	'Chatsworth'
	11659				4	K117	'Chatsworth'
	11660				4	K117	'Chatsworth'
	11661				4	K116	'Chatsworth'
	11662	Paratype	10	1	4	K116	'Chatsworth'
	11663				4	K117	'Chatsworth'
	11664				4	K117	'Chatsworth'
	11665				4	K117	'Chatsworth'
	11666				4	K117	'Chatsworth'
	11667	Paratype	10	2	4	K117	'Chatsworth'
	11668	Paratype	10	5	4	K117	'Chatsworth'
Pseudagnostus papilio Shergold, 1972	11669	Hypotype	11	1	5A	K121	'Chatsworth'
	11670	Hypotype	11	2	5A	K121	'Chatsworth'
	11671	Hypotype	11	3	5A	K121	'Chatsworth'
	11672	Hypotype	11	4	5A	K123	'Chatsworth'
	11673	Hypotype	11	5	5A	K124	'Chatsworth'
	11674	Hypotype	11	6	5C	K121	'Chatsworth'
	11675	Hypotype	11	7	5C	K121	'Chatsworth'
	11676	Hypotype	11	7	5C	K121	'Chatsworth'
	11677				5A	K121	'Chatsworth'
	11678				5C	K121	'Chatsworth'
	11679				5C	K121	'Chatsworth'
	11680				5B	B750	Gola Beds
	11681				5B	B750	Gola Beds
	11682				5B	B750	Gola Beds
	11683				5B	B750	Gola Beds
	11684				5B	B750	Gola Beds

Taxon	*CPC No.*	*Type*	*Plate*	*Fig.*	*Table*	*Loc.*	*Formation*
	11685				5B	B750	Gola Beds
	11686				5D	K102	Gola Beds
	11687				5D	K102	Gola Beds
Pseudagnostus elix sp. nov.	11688	Holotype	2	3		K103	'Chatsworth'
	11689	Paratype	2	6		K103	'Chatsworth'
	11690	Paratype	2	7		K103	'Chatsworth'
	11691	Paratype	2	4		K103	'Chatsworth'
Pseudagnostus coronatus sp. nov.	11692	Holotype	6	2		K106	'Chatsworth'
	11693	Paratype	6	3		K106	'Chatsworth'
	11694	Paratype	6	4		K106	'Chatsworth'
	11695	Paratype	6	1		K106	'Chatsworth'
	11696	Paratype	6	5		K105	'Chatsworth'
	11697	Paratype	6	6		K106	'Chatsworth'
Pseudagnostus clavus Shergold, 1972	11698	Hypotype	8	10		K121	'Chatsworth'
	11699	Hypotype	8	9		K121	'Chatsworth'
	11700	Hypotype	8	11		K121	'Chatsworth'
	11701	Hypotype	8	12		K121	'Chatsworth'
	11702	Hypotype	8	8		K121	'Chatsworth'
	11703	Hypotype	8	7		K121	'Chatsworth'
	11704	Hypotype	8	6		K116	'Chatsworth'
Pseudagnostus denticulatus sp. nov.	11705	Holotype	8	1		K118	'Chatsworth'
	11706	Paratype	8	2		K118	'Chatsworth'
	11707	Paratype	8	3		K118	'Chatsworth'
	11708	Paratype	8	4		K118	'Chatsworth'
	11709	Paratype	8	5		K118	'Chatsworth'
Pseudagnostus sp. A	11710		7	1		K103	'Chatsworth'
	11711		7	2		K104	'Chatsworth'
Pseudagnostus sp. B	11712		7	3		K106	'Chatsworth'
	11713		7	4		K106	'Chatsworth'
Pseudagnostus sp. C	11714		7	5		K111	'Chatsworth'
	11715		7	6		K111	'Chatsworth'
	11716		7	7		K111	'Chatsworth'
Pseudagnostus quasibilobus sp. nov.	11717	Holotype	12	1		K138	'Chatsworth'
	11718	Paratype	12	2		K139	'Chatsworth'
	11719	Paratype	12	3		K510b	'Chatsworth'
	11720	Paratype	12	4		K139	'Chatsworth'
	11721	Paratype	12	7		K169	'Chatsworth'
	11722	Paratype	12	6		K138	'Chatsworth'
	11723	Paratype	12	5		K138	'Chatsworth'
Geragnostus (Micragnostus) cf. *acrolebes* Shergold, 1972	11724		13	9		K119	'Chatsworth'
	11725		13	10		B507a″	'Chatsworth'
	11726		13	11		K119	'Chatsworth'
Geragnostus (Micragnostus) cf. *intermedius* Palmer, 1968	11727		13	7		K139	'Chatsworth'
	11728a		13	12		K139	'Chatsworth'
	11728b		13	8		K139	'Chatsworth'
Geragnostus (Strictagnostus) chronius sp. nov.	11729a	Paratype	13	1		K117	'Chatsworth'
	11729b	Paratype	13	2		K117	'Chatsworth'
	11730	Paratype	13	3		K123	'Chatsworth'
	11731	Paratype	13	4		K131	'Chatsworth'
	11732	Holotype	13	5		K117	'Chatsworth'
	11733	Paratype	13	6		K116	'Chatsworth'

Taxon	CPC No.	Type	Plate	Fig.	Table	Loc.	Formation
Connagnostus conspectus sp. nov.	11734	Holotype	13	13		K119	'Chatsworth'
	11735	Paratype	13	14		K119	'Chatsworth'
	11736	Paratype	13	15		K117	'Chatsworth'
?Prosaukia nema sp. nov.	11737	Holotype	15	7		K186	'Chatsworth'
?Prosaukia absona sp. nov.	11738	Holotype	15	2		K138	'Chatsworth'
	11739	Paratype	15	1		K138	'Chatsworth'
	11740	Paratype	15	3		B510	'Chatsworth'
	11741	Paratype	15	4		K139	'Chatsworth'
Prosaukia sp. A	11742		15	5/6		K112	'Chatsworth'
?Prosaukia cornigra sp. nov.	11743	Holotype	16	6		K130	'Chatsworth'
	11744	Paratype	16	5		K130	'Chatsworth'
	11745	Paratype	16	2		K130	'Chatsworth'
	11746	Paratype	16	1		K130	'Chatsworth'
	11747	Paratype	16	3/4		K130	'Chatsworth'
Prosaukia sp. indet.	11748	Noted in text				K128	'Chatsworth'
Anderssonella beauchampi sp. nov.	11749	Holotype	20	1		K139	'Chatsworth'
	11750	Paratype	20	2		K139	'Chatsworth'
	11751	Paratype	20	3		K139	'Chatsworth'
	11752	Paratype	20	4		K139	'Chatsworth'
Anderssonella eweyi sp. nov.	11753	Paratype	20	6		K143	'Chatsworth'
Anderssonella beauchampi sp. nov.	11754	Paratype	20	5		K139	'Chatsworth'
	11755a	Paratype	21	1		K139	'Chatsworth'
	11755b	Paratype	21	2		K139	'Chatsworth'
Anderssonella eweyi sp. nov.	11756	Holotype	21	5		K143	'Chatsworth'
	11757	Paratype	21	6		K144	'Chatsworth'
Galerosaukia galerita sp. nov.	11758	Holotype	22	1		K141	'Chatsworth'
	11759	Paratype	22	2		K141	'Chatsworth'
	11760a	Paratype	22	4		K141	'Chatsworth'
	11760b	Paratype	22	3		K141	'Chatsworth'
	11761	Paratype	22	5		K141	'Chatsworth'
Galerosaukia ptyxis sp. nov.	11762	Holotype	22	8		K168	'Chatsworth'
	11763	Paratype	22	9		K169	'Chatsworth'
	11764	Paratype	22	7		K168	'Chatsworth'
	11765	Paratype	22	6		K168	'Chatsworth'
	11766	Paratype	21	3		K143	'Chatsworth'
	11767	Paratype	21	4		K143	'Chatsworth'
Galerosaukia sp.	11768		21	7		K137	'Chatsworth'
	11769		21	8		K137	'Chatsworth'
	11770		21	9		K137	'Chatsworth'
Sinosaukia impages sp. nov.	11771a	Holotype	17	1		K130	'Chatsworth'
	11771b	Holotype	17	2		K130	'Chatsworth'
	11772	Paratype	17	3		K128	'Chatsworth'
	11773	Paratype	17	4		K131	'Chatsworth'
	11774	Paratype	17	5		K135	'Chatsworth'
	11775	Paratype	17	6		K130	'Chatsworth'
	11776	Paratype	17	7		K131	'Chatsworth'

Taxon	CPC No.	Type	Plate	Fig.	Table	Loc.	Formation
Sinosaukia sp. indet.	11777		17	8		K138	'Chatsworth'
	11778		17	9		B510	'Chatsworth'
Lophosaukia torquata Shergold, 1972	11779	Hypotype	18	1–3		B507a″	'Chatsworth'
	11780	Hypotype	18	4		K117	'Chatsworth'
	11781	Hypotype	18	5		K117	'Chatsworth'
	11782	Hypotype	18	6		K117	'Chatsworth'
Lophosaukia acuta sp. nov.	11783	Holotype	18	7–9		K116	'Chatsworth'
Lophosaukia sp. D	11784		19	1		K175	'Chatsworth'
Lophosaukia sp. C	11785		19	7		K139	'Chatsworth'
Lophosaukia sp. A	11786		19	2		K124	'Chatsworth'
	11787		19	6		K124	'Chatsworth'
Lophosaukia sp. B	11788		19	3		B777	'Chatsworth'
	11789		19	4		K187	'Chatsworth'
	11790		19	5		K189	'Chatsworth'
?*Calvinella solitaria* sp. nov.	11791	Holotype	23	1		K145	L. Ninmaroo
	11792	Paratype	23	2		K145	L. Ninmaroo
	11793	Paratype	23	3		K145	L. Ninmaroo
	11794	Paratype	23	4		K145	L. Ninmaroo
	11795	Paratype	23	5–6		K145	L. Ninmaroo
	11796	Paratype	23	7		K145	L. Ninmaroo
Mictosaukia perplexa sp. nov.	11797	Paratype	24	1		K180	'Chatsworth'
	11798	Paratype	24	2–8		K178	'Chatsworth'
	11799	Paratype	24	3		K178	'Chatsworth'
	11800	Paratype	24	4		K178	'Chatsworth'
	11801	Paratype	24	5		K178	'Chatsworth'
	11802	Paratype	24	6		K192	'Chatsworth'
	11803	Paratype	24	7		K178	'Chatsworth'
Lophosaukia sp. D	11804		24	10		K178	'Chatsworth'
Mictosaukia perplexa sp. nov.	11805	Holotype	24	9		K178	'Chatsworth'
Caznaia squamosa sp. nov.	11806	Holotype	25	1		K106	'Chatsworth'
	11807	Paratype	25	2		K106	'Chatsworth'
	11808	Paratype	25	3		K106	'Chatsworth'
	11809	Paratype	25	4–5		K106	'Chatsworth'
	11810	Paratype	25	6		K106	'Chatsworth'
	11811	Paratype	26	1		K106	'Chatsworth'
	11812	Paratype	26	2		K107	'Chatsworth'
	11813	Paratype	26	3		K107	'Chatsworth'
	11814	Paratype	26	4		K103	'Chatsworth'
	11815	Paratype	26	5		K106	'Chatsworth'
	11816	Paratype	26	6		K107	'Chatsworth'
Caznaia sectatrix sp. nov.	11817	Paratype	27	2		K109	'Chatsworth'
	11818	Paratype	27	3		K111	'Chatsworth'
	11819	Paratype	27	4		K111	'Chatsworth'
	11820	Paratype	27	5		K111	'Chatsworth'
	11821	Paratype	27	6		K111	'Chatsworth'
	11822	Paratype	26	7		K109	'Chatsworth'
	11823	Holotype	27	1		K111	'Chatsworth'

Taxon	CPC No.	Type	Plate	Fig.	Table	Loc.	Formation
Ptychaspis (Asioptychaspis)	11824	Paratype	29	1		K138	'Chatsworth'
delta sp. nov.	11825a	Holotype	29	2		K138	'Chatsworth'
	11825b	Holotype	29	3		K138	'Chatsworth'
	11826	Paratype	29	4		K138	'Chatsworth'
Quadraticephalus cf. *teres*	11827a		28	1		K169	'Chatsworth'
Resser & Endo, 1937	11827b		28	2		K169	'Chatsworth'
	11828		28	3		K178	'Chatsworth'
	11829		28	4		K178	'Chatsworth'
	11830		28	5		K168	'Chatsworth'
	11831		28	6		K168	'Chatsworth'
	11832		28	7		K168	'Chatsworth'
	11833		28	8		K168	'Chatsworth'
	11834		28	9		K168	'Chatsworth'
Euloma (Plecteuloma) strix	11835	Holotype	30	1–2		K103	'Chatsworth'
sp. nov.	11836	Paratype	30	3		K106	'Chatsworth'
	11837	Paratype	30	4		K106	'Chatsworth'
	11838	Paratype	30	5		K105	'Chatsworth'
	11839	Paratype	30	6		K106	'Chatsworth'
	11840	Paratype	30	7		K106	'Chatsworth'
	11841	Paratype	30	8		K103	'Chatsworth'
Duplora clara Shergold, 1972	11842	Hypotype	30	11		K111	'Chatsworth'
	11843	Hypotype	30	10		K111	'Chatsworth'
	11844	Hypotype	30	9		K111	'Chatsworth'
Sigmakainella translira	11845	Hypotype	32	1		K112	'Chatsworth'
Shergold, 1972	11846	Hypotype	32	2		K113	'Chatsworth'
	11847	Hypotype	32	3		B507a''	'Chatsworth'
	11848	Hypotype	32	4		B507a'	'Chatsworth'
Sigmakainella primaeva sp. nov.	11849	Holotype	31	1		K106	'Chatsworth'
	11850	Paratype	31	2		K106	'Chatsworth'
	11851	Paratype	31	3		K106	'Chatsworth'
	11852	Paratype	31	4		K103	'Chatsworth'
?Sigmakainella trispinosa	11853a	Holotype	32	6		K121	'Chatsworth'
sp. nov.	11853b	Holotype	32	5		K121	'Chatsworth'
?Richardsonella sp.	11854		31	5–6		K106	'Chatsworth'
Sigmakainella longilira Shergold, 1972	11855	Hypotype	33	1		K123	'Chatsworth'
Haniwa mucronata sp. nov.	11856	Paratype	33	2		K138	'Chatsworth'
	11857	Paratype	33	3		B510b	'Chatsworth'
	11858	Paratype	33	4		K138	'Chatsworth'
	11859	Paratype	33	5		B510b	'Chatsworth'
	11860	Paratype	33	6		B510b	'Chatsworth'
	11861	Paratype	33	7		K138	'Chatsworth'
	11862	Holotype	34	1		K138	'Chatsworth'
	11863	Paratype	34	2		K138	'Chatsworth'
	11864	Paratype	34	3		K138	'Chatsworth'
	11865	Paratype	34	4		K139	'Chatsworth'
	11866	Paratype	34	5		K138	'Chatsworth'
	11867a	Paratype	34	6		K138	'Chatsworth'
	11867b	Paratype	34	7		K138	'Chatsworth'
Atratebia nexosa sp. nov.	11868a	Holotype	35	1		B507b	'Chatsworth'
	11868b	Paratype	35	2		B507b	'Chatsworth'
	11869	Paratype	35	4		K109	'Chatsworth'
	11870	Paratype	35	6		K109	'Chatsworth'
	11871	Paratype	35	5		B507b	'Chatsworth'
	11872	Paratype	35	3		K109	'Chatsworth'

Taxon	*CPC No.*	*Type*	*Plate*	*Fig.*	*Table*	*Loc.*	*Formation*
Pagodia (*Pagodia*) sp.	11873		36	3		K106	'Chatsworth'
Pagodia (*Oreadella*) cf. *buda*	11874		36	1		K110	'Chatsworth'
(Resser & Endo, 1933)	11875		36	2		K110	'Chatsworth'
Pagodia (*Lotosoides*) *turbinata*	11876	Paratype	36	4–5		K111	'Chatsworth'
sp. nov.	11877	Paratype	36	6		K115	'Chatsworth'
	11878	Holotype	36	7		K116	'Chatsworth'
Pagodia (*Lotosoides*)	11879	Holotype	37	1–2		K111	'Chatsworth'
calcarata sp. nov.	11880	Paratype	37	3		B507c	'Chatsworth'
	11881	Paratype	37	4		K111	'Chatsworth'
	11882	Paratype	37	5A		K111	'Chatsworth'
	11883	Paratype	37	5B		K111	'Chatsworth'
	11884	Paratype	37	6		K111	'Chatsworth'
Pagodia (*Datsonia*) *subterior*	11885	Holotype	29	5		B777	'Chatsworth'
sp. nov.	11886	Paratype	29	6		B777	'Chatsworth'
	11887	Paratype	29	7		B777	'Chatsworth'
	11888	Paratype	29	9		K186	'Chatsworth'
	11889	Paratype	29	10		B777	'Chatsworth'
	11890	Paratype	29	8		K191	'Chatsworth'
Mansuyia cf. *orientalis*	11891		38	1		K136	'Chatsworth'
Sun, 1924	11892		38	2		K136	'Chatsworth'
	11893		38	3		K136	'Chatsworth'
	11894		38	6		K133	'Chatsworth'
	11895		38	7		K133	'Chatsworth'
	11896		39	2		K136	'Chatsworth'
	11897		38	5		K136	'Chatsworth'
	11898		38	4		K136	'Chatsworth'
	11899a		38	11		K133	'Chatsworth'
	11899b		38	10		K133	'Chatsworth'
	11900		38	9		K130	'Chatsworth'
	11901		38	8		K136	'Chatsworth'
	11902		39	1		K136	'Chatsworth'
Mansuyia cf. *tani* Sun, 1935	11903		39	4		K139	'Chatsworth'
	11904		39	7		B510b	'Chatsworth'
	11905		39	3		K139	'Chatsworth'
	11906a		39	6		B510	'Chatsworth'
	11906b		39	5		B510	'Chatsworth'
Hapsidocare chydaeum sp. nov.	11907	Holotype	40	1–3		K105	'Chatsworth
	11908	Paratype	40	5–6		K103	'Chatsworth'
	11909	Paratype	40	4		K106	'Chatsworth'
	11910	Paratype	40	2		K103	'Chatsworth'
	11911	Paratype	41	1		K103	'Chatsworth'
	11912	Paratype	41	2		K106	'Chatsworth'
	11913	Paratype	41	3		K106	'Chatsworth'
Hapsidocare grossum sp. nov.	11914	Holotype	42	1		K117	'Chatsworth'
	11915	Paratype	41	7		K109	'Chatsworth'
	11916	Paratype	41	4		K109	'Chatsworth'
	11917	Paratype	41	5		K108	'Chatsworth'
	11918	Paratype	42	2		K109	'Chatsworth'
	11919	Paratype	42	5		K116	'Chatsworth'
	11920a	Paratype	42	4		K109	'Chatsworth'
	11920b	Paratype	41	6		K109	'Chatsworth'
	11921	Paratype	42	3		K116	'Chatsworth'

Taxon	CPC No.	Type	Plate	Fig.	Table	Loc.	Formation
Palacorona torosa sp. nov.	11922	Holotype	44	3		B777	'Chatsworth'
	11923	Paratype	44	5		B777	'Chatsworth'
	11924	Paratype	44	6		K186	'Chatsworth'
	11925	Paratype	44	2		K187	'Chatsworth'
	11926	Paratype	44	4		K186	'Chatsworth'
	11927	Paratype	44	1		K196	'Chatsworth'
Palacorona sp. indet.	11928		45	1		K121	'Chatsworth'
Ceronocare pandum sp. nov.	11929	Holotype	43	1		K111	'Chatsworth'
	11930	Paratype	43	2		K111	'Chatsworth'
	11931a	Paratype	43	3		K112	'Chatsworth'
	11931b	Paratype	43	5		K112	'Chatsworth'
	11932	Paratype	43	4		K112	'Chatsworth'
	11933	Paratype	43	6		K111	'Chatsworth'
	11934	Paratype	43	7		K116	'Chatsworth'
	11935	Paratype	42	6		K117	'Chatsworth'
Ceronocare sp.	11936		43	8		K106	'Chatsworth'
Parakoldinioidia bigranulosa sp. nov.	11937	Holotype	45	2		B507a″	'Chatsworth'
	11938	Paratype	45	3		K118	'Chatsworth'
	11939	Paratype	45	5		B507a″	'Chatsworth'
	11940	Paratype	45	4		B507a″	'Chatsworth'
Leiostegium (*Leiostegium*) *floodi* sp. nov.	11941	Holotype	45	7–8		K146	L. Ninmaroo
	11942	Paratype	45	6		K146	L. Ninmaroo
Leiostegiacean undet. 1	11943		46	5		K147	L. Ninmaroo
	11944		46	6		K147	L. Ninmaroo
	11945		46	7		K149	L. Ninmaroo
Leiostegiacean undet. 2	11946		46	1		K195	'Chatsworth'
Leiostegiacean undet. 3	11947		46	2		K195	'Chatsworth'
Tsinania (*Tsinania*) *nomas* sp. nov.	11948	Holotype	47	1		K138	'Chatsworth'
	11949	Paratype	47	2		K142	'Chatsworth'
	11950	Paratype	47	3		K138	'Chatsworth'
	11951	Paratype	47	4		K143	'Chatsworth'
	11952	Paratype	47	5		K138	'Chatsworth'
	11953	Paratype	47	6		K142	'Chatsworth'
	11954	Paratype	47	7		K140	'Chatsworth'
Tsinania (*Tsinania*) *necopina* sp. nov.	11955	Holotype	48	1		K138	'Chatsworth'
	11956	Paratype	48	2		K138	'Chatsworth'
	11957	Paratype	48	3		B510b	'Chatsworth'
	11958	Paratype	48	4		B510b	'Chatsworth'
	11959	Paratype	48	5		K138	'Chatsworth'
	11960	Paratype	48	6		K138	'Chatsworth'
	11961	Paratype	48	7		K139	'Chatsworth'
	11962	Paratype	48	8		B510b	'Chatsworth'
	11963	Paratype	49	9		K138	'Chatsworth'
	11964	Paratype	49	10		K138	'Chatsworth'
Tsinania (*Tsinania*) cf. *pagoda* Sun, 1924	11965		50	1		K166	'Chatsworth'
	11966		50	2		K143	'Chatsworth'
Tsinania (*Dictyites*) *antidictys* sp. nov.	11967	Holotype	49	1		K135	'Chatsworth'
	11968	Paratype	49	2		K135	'Chatsworth'
	11969	Paratype	49	3		K135	'Chatsworth'

Taxon	*CPC No.*	*Type*	*Plate*	*Fig.*	*Table*	*Loc.*	*Formation*
	11970	Paratype	49	4		K135	'Chatsworth'
	11971	Paratype	49	5		K135	'Chatsworth'
	11972	Paratype	49	6		K135	'Chatsworth'
	11973	Paratype	49	7		K135	'Chatsworth'
	11974	Paratype	49	8		K135	'Chatsworth'
Tsinania (*Dictyites*) cf.	11975		50	3		K169	'Chatsworth'
trigonalis	11976		50	4		B777	'Chatsworth'
(Kobayashi, 1933)	11977		50	5		K168	'Chatsworth'
	11978		50	6		B777	'Chatsworth'
	11979		50	7		K186	'Chatsworth'
	11980		50	8		K187	'Chatsworth'
	11981		50	9		K169	'Chatsworth'
Wanwanaspis cf. *semicircularis*	11982		52	1		K178	'Chatsworth'
(Kobayashi, 1933)	11983		52	2		K178	'Chatsworth'
	11984		52	3		K168	'Chatsworth'
	11985		52	4		K137	'Chatsworth'
?*Wanwanaspis* sp. indet.	11986		52	5		K131	'Chatsworth'
Wanwanaspis pygidion sp. nov.	11987	Holotype	52	6		K138	'Chatsworth'
	11988	Paratype	52	7		K138	'Chatsworth'
Lorrettina macrops	11989	Hypotype	53	1		K117	'Chatsworth'
Shergold, 1972	11990	Hypotype	53	2		K118	'Chatsworth'
	11991	Hypotype	53	5–3		K116	'Chatsworth'
	11992	Hypotype	53	4		K116	'Chatsworth'
	11993	Hypotype	53	6		K117	'Chatsworth'
	11994	Hypotype	53	7		K117	'Chatsworth'
	11995	Hypotype	53	8		K118	'Chatsworth'
Maladioidella sp.	11996		51	3		K189	'Chatsworth'
Maladioidella cf. *chinchiaensis*	11997		51	4		K121	'Chatsworth'
Endo, 1937	11998		51	5		K121	'Chatsworth'
	11999		51	6		K121	'Chatsworth'
?*Protopeltura* sp.	12000		46	8–9		K121	'Chatsworth'
	12855		46	10		K121	'Chatsworth'
Wuhuia cf. *dryope* (Walcott, 1905)	12856		52	8–9		K103	'Chatsworth'
Idahoiid gen. et sp. undet.	12857		34	8		K105	'Chatsworth'
Golasaphus triquetrus sp. nov.	12858	Paratype	56	1		K121	'Chatsworth'
	12859	Paratype	56	2		K121	'Chatsworth'
	12860	Paratype	56	3		K121	'Chatsworth'
	12861	Paratype	56	4		K121	'Chatsworth'
	12862	Paratype	56	5		K121	'Chatsworth'
	12863	Paratype	56	6		K121	'Chatsworth'
	12864	Paratype	56	7		K121	'Chatsworth'
	12865	Holotype	56	8		K121	'Chatsworth'
	12866	Paratype	56	9		K121	'Chatsworth'
Golasaphus simus sp. nov.	12867a	Holotype	55	1		K121	'Chatsworth'
	12867b	Holotype	55	2		K121	'Chatsworth'
	12868	Paratype	55	3		K119	'Chatsworth'
	12869	Paratype	55	4		K119	'Chatsworth'

Taxon	*CPC No.*	*Type*	*Plate*	*Fig.*	*Table*	*Loc.*	*Formation*
	12870	Paratype	55	5		K119	'Chatsworth'
	12871	Paratype	55	6		K119	'Chatsworth'
	12872	Paratype	55	7		K121	'Chatsworth'
	12873	Paratype	55	8		K119	'Chatsworth'
Mendosina sp.	12874		51	2		K106	'Chatsworth'
	12875		51	1		B507b	'Chatsworth'
?Asaphellus sp.	12876		57	6–7		K151	Ninmaroo
	12877		57	8		K151	Ninmaroo
?Niobella sp.	12878		57	1		K195	'Chatsworth'
	12879		57	2		K195	'Chatsworth'
	12880		57	3		K195	'Chatsworth'
?Symphysurina sp.	12881		57	4		K195	'Chatsworth'
Atopasaphus stenocanthus	12882	Paratype	54	1		K116	'Chatsworth'
sp. nov.	12883	Paratype	54	2		K116	'Chatsworth'
	12884	Paratype	54	3		K111	'Chatsworth'
	12885	Paratype	54	4–5		K109	'Chatsworth'
	12886	Holotype	54	6		K116	'Chatsworth'
Asaphacean hypostoma undet.	12887		57	5		K195	'Chatsworth'
Onychopyge assula sp. nov.	12888	Paratype	46	3		K195	'Chatsworth'
	12889	Holotype	46	4		K195	'Chatsworth'
Koldinioidia cf. *cylindrica*	12890		58	1		K104	'Chatsworth'
	12891		58	2		K106	'Chatsworth'
	12892		58	3		K103	'Chatsworth'
	12893		58	4		K103	'Chatsworth'
Koldinioidia payntonensis	12894	Paratype	58	5		K139	'Chatsworth'
sp. nov.	12895	Paratype	58	6		K139	'Chatsworth'
	12896	Holotype	58	7		B510	'Chatsworth'
	12897	Paratype	58	8		K139	'Chatsworth'
	12898	Paratype	58	9		K138	'Chatsworth'
	12899	Paratype	58	10		K138	'Chatsworth'

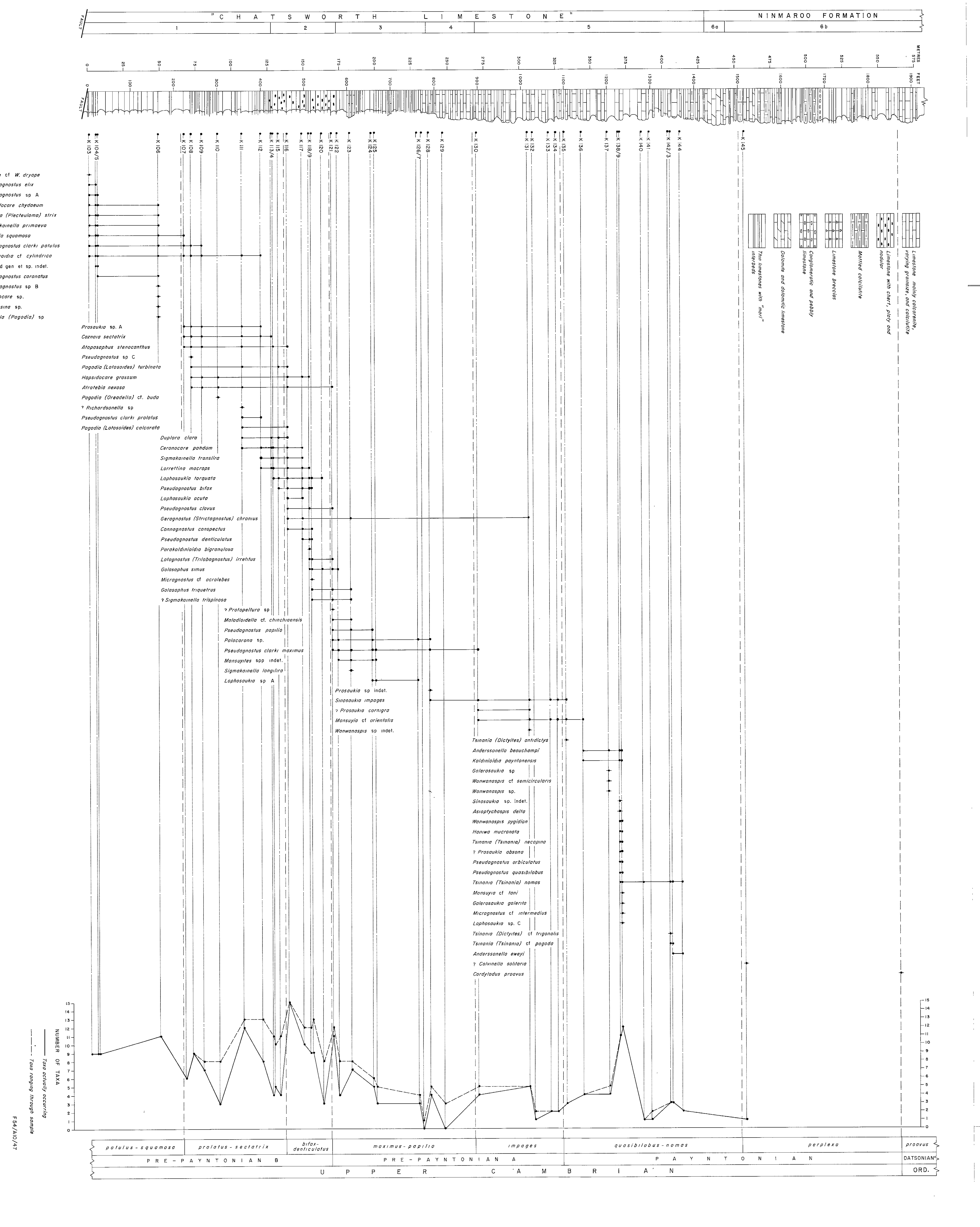

Fig. 4. Stratigraphical analysis of the Black Mountain: rocks, formations, fossils, faunal diversities, and ages. The lithological section is much simplified and its units are discussed in the text.