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DEPARTMENT OF NATIONAL DEVELOPMENT
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

BULLETIN 104

# Oryctocephalidae (Trilobita: Middle Cambrian) of Australia

BY

J. H. SHERGOLD

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# SUMMARY

This Bulletin describes the morphology and relationships of trilobites of the family Oryctocephalidae from the following areas in Australia: northeastern Northern Territory and northwestern Queensland; east-central Northern Territory; and northwestern New South Wales. Seven genera and thirteen species are known to occur. Two genera and nine species are newly described. With the exception of *Tonkinella* s.s., a full suite of oryctocephalid genera is now known.

The known Australian Oryctocephalidae are found to be confined to beds of Middle Cambrian age, the fauna as a whole falling within the *Ptychagnostus gibbus* agnostid zone of Westergaard (1946), the Templetonian Stage. This horizon overlies *Redlichia*-bearing strata of the Ordian Stage in north Australia. In other parts of the world the fauna may appear in strata of equivalent age to the Ordian, e.g. the pre-*Glossopleura* faunas of the Rocky Mountains of Canada and USA, the upper Lena Stage of Tuva, and the Mantouan *Redlichia* Shales of China. In Pennsylvania a representative of the family is present in undisputed Lower Cambrian rocks.

The fauna of the Northern Territory and northwestern New South Wales has little in common with that from northwestern Queensland. Whereas the former can be satisfactorily compared to faunas from the Rocky Mountains, where they are found commonly in the *Bathyuriscus-Elrathina* zone of Rasetti (1951), that from Queensland is mainly new. It contains a genus which occurs in China, indicating some contact between the former seas of north Australia and those of southeast Asia.

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# INTRODUCTION

The trilobite family Oryctocephalidae is of considerable importance in international correlation. Though it originated in the Lower Cambrian, its acme of distribution and morphological variation was achieved in the lower Middle Cambrian. The proliferation was followed everywhere by marked decline, so that a distinct 'oryctocephalid zone' is apparent in many parts of the world. Oryctocephalid trilobites appear at about this stratigraphical level in southeastern Asia, Kashmir, China, Manchuria, Korea, southern, eastern, and northern Siberia, the Rocky Mountains of North America, and the Andean Cordillera of South America. In general terms the acme of the Oryctocephalidae lies at the end of the time span of the redlichiid trilobites and is contemporaneous with the beginnings of the ascendancy of the Paradoxididae. In the areas indicated the Oryctocephalidae are associated with Agnostidae which allow correlation to be made with the non-oryctocephalid, paradoxidid Middle Cambrian of Europe and northeastern North America.

In this Bulletin the occurrence, morphology, and relationships of the Australian representatives of the family Oryctocephalidae are recorded. They are assessed within the knowledge of oryctocephalid faunas from other parts of the world, and part of the scope of the work has been to establish them within the framework of global distribution, both spatial and temporal.

The taxonomic descriptions are based on all the specimens of Oryctocephalidae known to me in the Commonwealth Palaeontological Collection, housed in the Bureau of Mineral Resources. Numbered specimens from this collection are prefixed CPC. Latex rubber casts of type material from North America were also studied, and these, from the U.S. National Museum, Washington, are prefixed USNM. Casts of some of the North American specimens have been refigured for comparative purposes.

The classifications of oryctocephalid trilobites proposed by Moore (1959) and Tchernysheva (1960a) have been succeeded by the more comprehensive classification of Suvorova (1964), on which I have based my descriptions. No attempt is made here to discuss the detailed morphogenesis of the species described because only holaspides and a few late meraspides are available for study. Nevertheless, comment is passed where observations on morphogenetic changes have been recorded. These comments, together with those on any other variation noted, are embraced within the detailed descriptions of the species. Similarly no attempt is made to discuss the phylogenies of the families described because the exact stratigraphical positioning of some of the Australian material is still uncertain.

Much of the literature pertaining to the stratigraphy of that part of the Middle Cambrian in which the oryctocephalid faunas occur is to be found in the Records of the Bureau of Mineral Resources. These are classified as unpublished papers and are not widely distributed. The information set out below has been abstracted from these Records and also from already published accounts, notably those of Whitehouse (1936, 1939) and Öpik (1956, 1960, 1968). The faunal associations indicated are generalized and the determination of many elements temporary pending publications by A. A. Öpik on Australian 'agnostids' and xystridurids and C. G. Gatehouse on the ptychopariids.

A study of the oryctocephalid trilobites of Australia was first undertaken by Dr A. A. Öpik at the beginning of the last decade. Unfortunately his notes and descriptions and nearly all his material were destroyed in a fire which swept through the Bureau of Mineral Resources in 1953. The material was re-collected by Öpik and field geologists working in northern and central Australia and I have been entrusted with its illustration and description.

## ACKNOWLEDGMENTS

I gratefully thank Dr A. A. Öpik for his interest in this work at all stages in its development, for his guidance and for many fruitful discussions. Dr R. A. Robison, U.S. National Museum, Washington, obtained for me latex casts of North American type material, and Dr B. Daily, University of Adelaide, South Australia, sent me casts of further material, together with some of Russian and some of the Argentinian specimens. To them I extend my sincere thanks.

## COMPOSITION OF THE FAUNA

The family Oryctocephalidae Beecher, 1897, originated in the Lower Cambrian, but its representatives became most widely dispersed during Middle Cambrian times. There is no record of the family from rocks of Upper Cambrian age.

The family is well represented in Australia. Seven genera and thirteen species are discussed in this paper; two genera and nine species are newly described. The complete fauna comprises: *Oryctocephalus reynoldsi* Reed, 1899, *O.* cf. *reynoldsi* Reed, 1899, *O. alexandriensis* sp. nov., *O. opiki* sp. nov.; *Oryctocephalites sulcatus* sp. nov., *O. runcinatus* sp. nov., *O. gelasinus* sp. nov.; *Oryctocephalina lancastrioides* sp. nov.; *Sandoveria lobata* gen. nov. et sp. nov.; *Barklyella expansa* gen. nov. et sp. nov.; *Cheiruroides (Cheiruroides) succincta* sp. nov.; and ?*Chienaspis peregrina* (Whitehouse, 1939).

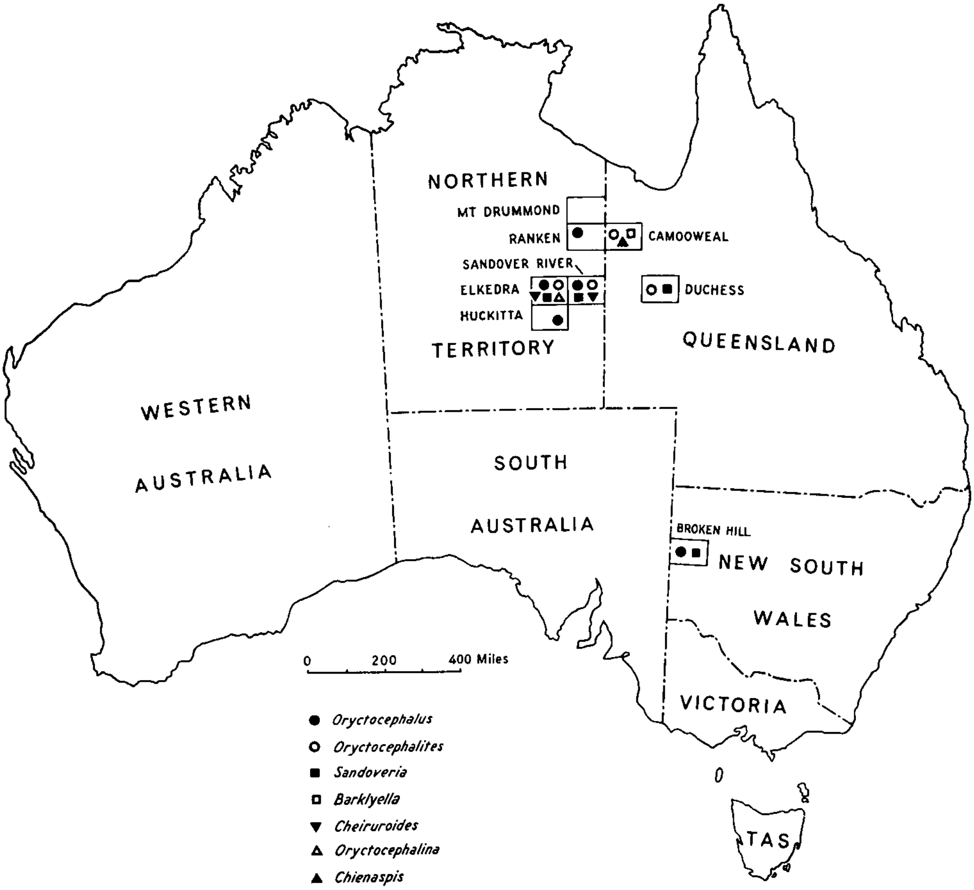
The known Australian oryctocephalid fauna is confined to the lower part of the Middle Cambrian, to the Templetonian Stage, and it is precisely the narrowness of its range which gives the family its importance in correlation, not only of Cambrian faunas within Australia but throughout the rest of the world.

## DISTRIBUTION AND ASSOCIATION

The distribution of the Australian oryctocephalid genera is shown in Text-figure 1. They are described below from three main areas: east-central Northern Territory (Elkedra, Huckitta, and Sandover River 1:250,000 Geological Series Sheets); northeastern Northern Territory and northwestern Queensland (Mount Drummond, Ranken, Camooweal, and Duchess Sheets); and northwestern New South Wales (Broken Hill Sheet).

The oryctocephalid assemblage of east-central Northern Territory, Elkedra area, occurs in the Sandover Beds (Öpik, 1956b, pp. 42-44). It comprises *Oryctocephalus reynoldsi, Oryctocephalites gelasinus, O. runcinatus, Oryctocephalina lancastrioides, Sandoveria lobata,* and *Cheiruroides (C.) succincta.* The fauna is associated with *'Xystridura' browni* (Etheridge), *'X.'* aff. *browni, Xystridura* spp., *Lyriaspis* sp., *Elrathina* sp., *Ptychagnostus* cf. *gibbus, Ptychagnostus* spp., *Peronopsis elkedraensis* (Etheridge), *P. scutalis* (Salter), and *Pagetia significans* (Etheridge) (Öpik, 1956b, p. 43). Correlatives to the south, the Arthur Creek Beds (Smith, 1963, pp. 9-10) of the Huckitta area, contain *Oryctocephalus reynoldsi* with a similar association.

Oryctocephalids occur also in the Middle Cambrian of the Barkly Tableland, which extends northwest to southeast across the Northern Territory-Queensland border in the vicinity of Camooweal. In this region the Wonarah Beds (Öpik, 1956b, p. 40), occurring in the south and southeast of the Alroy Sheet, the northwest of the Avon Downs Sheet, and the southwest of the Ranken Sheet (Randal 1966a, b, c), have been correlated by Öpik (1956b, 1959, 1960) with the



**Text-figure 1. Distribution of oryctocephalid genera in Australia.**

Sandover Beds lying to the south. *Oryctocephalus* has been recorded from the Wonarah Beds by Öpik (1956b, p. 41) and Gatehouse (1966, p. 3), but I have not been able to trace the specimen or specimens concerned. The associated fauna is varied and includes: the trilobites *'Anomocarella'* sp., *Eurostina trigona* (Whitehouse), *'Xystridura' browni, 'X.'* aff. *browni, Xystridura* sp., *Pagetia significans, Peronopsis* cf. *elkedraensis, Lyriaspis* sp., two ptychopariid genera; brachiopoda; gastropoda; hyolithids; and perhaps an archaeocyathid (Randal, 1966b, table 1; 1966c, table 1; Gatehouse 1966, p. 3).

The Burton Beds (Smith & Roberts, 1963, p. 11) (=Alexandria Beds of Öpik, 1956b, p. 40) occur to the north of the Wonarah Beds, at the northwest corner of the Ranken Sheet and the southwest corner of the Mount Drummond Sheet, on Alexandria station. *Oryctocephalus alexandriensis* occurs in these beds, together with *'Xystridura' browni, Xystridura* sp., *Lyriaspis alroyensis* (Etheridge), *Eurostina trigona, Pagetia significans, Peronopsis elkedraensis, Peronopsis* sp., *Kootenia* sp., Dolichometopidae, and phosphatic brachiopods (Gatehouse, 1966, pp. 4-5).

Öpik (1956b, pp. 33-36, fig. 2) regards the Sandover Beds as shelf deposits, and their northerly correlatives, the Wonarah Beds, Burton Beds, and Gum Ridge Formation, as epicontinental deposits. The diversity of the Oryctocephalidae in the Sandover Beds compared with that of the Wonarah and Burton Beds lends support to his argument.

An oryctocephalid fauna occurs in the Beetle Creek Formation of northwest Queensland, towards the eastern margin of the Barkly Tableland. In the Camooweal area, *Oryctocephalites sulcatus* and *Barklyella expansa* have been described from a locality between the Barkly Highway and Thorntonia station. Farther to the south *?Chienaspis peregrina* occurs in the vicinity of the Templeton River. At the southern margin of the Duchess Sheet *Oryctocephalites* cf. *gelasinus* and *Sandoveria* sp. indet. have been recorded. Öpik (1956a, p. 17) has given a generalized account of the Beetle Creek Formation fauna. It includes *Xystridura* spp., *Lyriaspis* spp., *Pagetia* cf. *significans, Peronopsis normata, Kootenia modica* (Whitehouse), *Dinesus ida* Etheridge, *?Eodiscus* sp., *Fuchouia* spp., *Elrathina* spp., and ptychopariid trilobites.

Öpik (1956b, p. 43) has considered that, although the same genera exist, with few exceptions, there are no species in common between the Sandover Beds and their correlatives of the Northern Territory and the Beetle Creek Formation and its correlatives in northwest Queensland. As is evident from the above synthesis, the oryctocephalid faunas of the two areas are quite distinct.

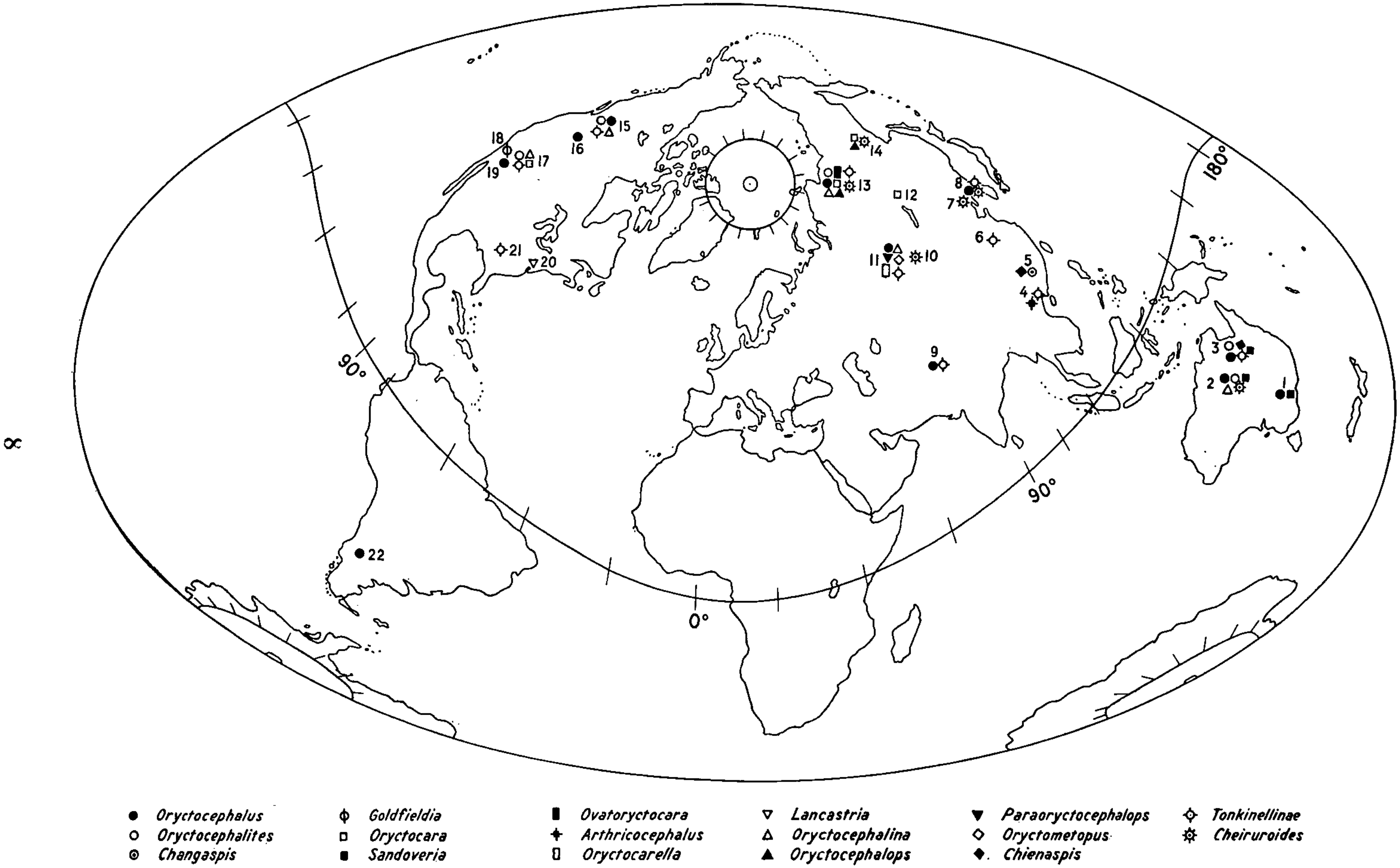
The Middle Cambrian of northwestern New South Wales is not well known. In the Mootwingee Ranges, Broken Hill Sheet, *Oryctocephalus reynoldsi, O.* cf. *reynoldsi, O. opiki,* and *Sandoveria* sp. are associated with species of *Xystridura.* The Oryctocephalidae appear to have more in common with those of the Sandover Beds than with those of the Beetle Creek Formation.

## THE AUSTRALIAN FAUNA IN GLOBAL PERSPECTIVE

To place the Australian oryctocephalid fauna in its true perspective it is necessary to consider the distribution of the family and its range in time throughout the world. The global occurrence of oryctocephalid genera has been plotted on Text-figure 2.

### *Spatial Distribution*

The earliest reference to oryctocephalid trilobites is that of Walcott (1886), who described the type species of *Oryctocephalus, O. primus,* from a Middle Cambrian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◎ Changaspis
ɸ Goldfieldia
□ Oryctocara
■ Sandoveria
▮ Ovatoryctocara
✦ Arthricocephalus
▯ Oryctocarella
▽ Lancastria
△ Oryctocephalina
▲ Oryctocephalops
▼ Paraoryctocephalops
◇ Oryctometopus
◆ Chienaspis
✧ Tonkinellinae
✲ Cheiruroides

limestone outcropping east of Pioche, in Nevada, USA. Faunas were later described by Matthew (1899), Reed (1899), Woodward (1902), and Rasetti (1951) from the Mount Stephen area of British Columbia, Canada. Oryctocephalids from Idaho were considered by Walcott (1908) and Resser (1938a, 1939a, 1939b); from Pennsylvania by Walcott (1912); from the southern Appalachians by Resser (1938b); and from Nevada by Palmer (1954, 1964).

In the USSR oryctocephalid trilobites are known from two important areas: the Siberian Platform and the Sayan Uplands. To the north of the former area Oryctocephalidae have been found on the northern flanks of the Anabar Shield, along the Olenek and Anabar Rivers (Lermontova, 1940; Tchernysheva, 1960b, 1962; Soloviev, 1964; Suvorova, 1964). To the east of the Siberian Platform oryctocephalid faunas occur on the flanks of the Aldan Shield, along tributaries of the River Lena, notably the Maya and Yudoma (Tchernysheva, 1961; Suvorova, 1964). To the south of the Siberian Platform Tchernysheva (1952) has described Oryctocephalidae from the Vitim Plateau. Oryctocephalidae from the Sayan and Kuznets Highlands, lying between Tomsk and Lake Baikal, have been described by Repina (1960), Tomashpolskaya (1960), and Tomashpolskaya & Karpinskii (1962). Representatives of the family found in the Tannu-Ola Range, adjacent to the Mongolian frontier, in southern Tuva, have been described by Pokrovskaya (1959).

The family is distributed throughout eastern and southern Asia in five areas. Korean occurrences have been described by Saito (1934) and Kobayashi (1935, 1961). Resser (*in* Endo & Resser, 1937) considered Manchurian faunas. Lu (1957), Chien (1961), and Chang (1959) have treated those from China, and Mansuy (1915) discussed North Vietnamese representatives. The oryctocephalid faunas of Kashmir were described by Reed (1910, 1934) and Kobayashi (1934).

The family Oryctocephalidae is represented in South America by the occurrence in the Province of Mendoza described by Rusconi (1952).

There is no definite record of the family from northwest Europe.

The global distribution map (Text-fig. 2) shows oryctocephalid faunas to lie on a well defined belt which circles the earth. Creer, Irving, & Runcorn (1954) positioned the Cambrian North Pole in the general area of the Marshall Islands in the Pacific and the South Pole near Saint Helena in the South Atlantic. These determinations were based on British samples, the only material available at that time. Since then Irving (1964, pp. 123, 125-6, text-fig. 6.13) has indicated all the positions of the Cambrian North Pole, plotted from Australian, North American, European, and Asian samples, presently known. A wide scatter is shown. Nevertheless, Irving (op. cit. pp. 204-5, 213, text-fig. 9.46) has estimated a series of Cambrian palaeolatitudes. On the basis of these, oryctocephalid faunas lie almost

**Text-figure 2. Global distribution of the oryctocephalid genera described to date. Areas of occurrence are: 1) Northwestern New South Wales. 2) Elkedra-Huckitta region, central Australia. 3) Barkley Tableland, Queensland and Northern Territory. 4) Tonkin, North Vietnam. 5) Kweichow, China. 6) Shantung, China. 7) Manchuria. 8) North Korea. 9) Kashmir. 10) Tuva, USSR. 11) Sayan Uplands, Siberia. 12) Trans-Baikal, Vitim Plateau, Siberia. 13) Olenek-Anabar Rivers, north Siberian Platform. 14) Maya-Yudoma Rivers, east Siberian Platform. 15) Mount Stephen area, British Columbia. 16) Pend Orielle, Idaho. 17) Wasatch Mountains, Idaho-Utah. 18) Goldfield, Nevada. 19) Pioche, Nevada. 20) Lancaster County, Pennsylvania. 21) Rogersville, Alabama. 22) Mendoza Province, Argentina.**

entirely within the Cambrian latitudes 20°S-20°N. The faunas are thus decidedly tropical.

### *Temporal Distribution*

In this section no attempt is made to discuss the complexities arising from the positioning of the Lower/Middle Cambrian boundary. Its purpose is to give an account of the stratigraphical occurrences of the various representatives of the family Oryctocephalidae as interpreted by the authors indicated, and to discuss the correlation of these occurrences.

The family is most widely distributed in rocks of Middle Cambrian age, although there are reports of Lower Cambrian occurrences.

Most detailed stratigraphical control over early Middle Cambrian faunas has been elucidated by Rasetti (1951) in the Mount Stephen area of British Columbia. Oryctocephalid representatives *(?Oryctocephalina)* occur here in the lower faunal zone, the *Wenkchemia-Stephenaspis* zone, of the Mount Whyte Formation, the lowest Middle Cambrian zone as interpreted by Rasetti. Oryctocephalidae continue to range upwards into the *Bathyuriscus-Elrathina* zone of the upper Stephen Formation.

To the south, Oryctocephalidae occur in the Lakeview Limestone of Pend Orielle, northern Idaho, and in the Spence Shale member of the Ute Formation and *Ptarmigania* Strata of the northern Wasatch Mountains of northeast Utah and adjacent Idaho. The Lakeview Limestone fauna is comparable to that of the Stephen Formation (Resser, 1938a, p. 4) and is equivalent in age to that of the Spence Shale (Resser, 1939a, p. 2). The *Ptarmigania* Strata contain a fauna considered by Resser (1939b, p. 17) to be related to the *Albertella* fauna. Faunally this occurrence must represent lateral equivalents of the Cathedral Formation of British Columbia (Rasetti, 1951). At Pioche, in Nevada, the type species of *Oryctocephalus* occurs in the Pioche Shale associated with *Kochaspis liliana* Walcott and *K. augusta* Walcott, indicating correlation of this lithological unit with the higher part of the Mount Whyte Formation of British Columbia (Rasetti, 1951, p. 93; Palmer, 1954, p. 69). In Alabama, representatives of the Oryctocephalidae occur in the Rogersville Formation, considered by Resser (1938b, p. 20) to lie within the *Ehmania-Elrathia* zones, towards the middle of the Middle Cambrian.

The presence of Oryctocephalidae in the Lower Cambrian of North America rests on the records of Walcott (1912) and Palmer (1964). Walcott described *Lancastria roddyi* from beds of high Lower Cambrian age in Lancaster County, Pennsylvania, where the species is associated with *Paedumias transitans* Walcott. Palmer described the new genus *Goldfieldia* from the Lower Cambrian of western Nevada. These occurrences apart, the North American oryctocephalid fauna is from the lower part of the Middle Cambrian, occurring mostly within the *Wenkchemia-Stephenaspis* to *Bathyuriscus-Elrathina* zones of Rasetti.

Species of *Oryctocephalus* from County Martillo in the Province of Mendoza, Argentina, have been discussed by Rusconi (1952) and Poulsen (1958) and placed within the *Glossopleura* zone. Their range, therefore, falls within that of the oryctocephalid fauna of the Rocky Mountains.

In the north and east of the Siberian Platform, on the Vitim Plateau, and in the Kuznets Altai, oryctocephalids are distributed in the lower part of the Middle Cambrian, in the Amga Stage. In Tuva, however, *Cheiruroides* is present in the highest beds of the Lena (Pokrovskaya, 1959), a Stage which has been variously regarded as of Lower or sometimes Middle Cambrian age. Currently the base of the Middle Cambrian (Amga Stage) is placed by Tchernysheva (1961, p. 34, text-fig. 2) between her zones of *Kootenia* and *Schistocephalus antiquus,* an horizon which appears to lie more or less at the base of the *Paradoxides* Series of Scandinavia — actually at the base of the *Paradoxides pinus* Zone (Westergaard, 1946), the uppermost zone of the *P. oelandicus* Stage (Öpik, 1966, p. 4). The Tuvan occurrence apart, the Russian oryctocephalid fauna extends from the base of the *P. pinus* Zone (high *P. oelandicus* Stage) to higher than the base of the *Ptychagnostus atavus-Tomagnostus fissus* Zone (lower *Paradoxides paradoxissimus* Stage).

Oryctocephalidae occur in the Tangshihian of the Hwangho Basin province of North Korea, southern Manchuria, and northern China (Kobayashi, 1956, p. 345). In North Korea representatives of the family are present in the Masanri Formation of the Chuwa district, in beds overlying shales containing *Bonnia* and *Redlichia* (Shora Formation). The Masanri Formation is placed by Kobayashi (op. cit. p. 353, table 2) across the Mantouan-Fuchouan boundary. In the Neietsu Zone of South Korea oryctocephalids occur in the lowest part of the Machari Formation (*Olenoides* Beds of Neietsu), correlated by Kobayashi with the lowest Taitzuan (middle Fuchouan). If this assignment is correct the oryctocephalid fauna extends into higher stratigraphical levels in South Korea than elsewhere.

In Manchuria *Cheiruroides orientalis* (Resser & Endo) occurs considerably lower, in the Misakian Stage of the Mantouan Series (Lower Cambrian), where it is associated with *Redlichia chinensis* Walcott. Oryctocephalidae occurring in the Balang Shale of Balang, near Duyun, Kweichow, China, are likewise considered to be of Lower Cambrian age (Chien, 1961, p. 111). Because they are again associated with *Redlichia chinensis,* Chien (op. cit.) would equate the Balang Shale with the *Redlichia*-bearing Mantouan of Manchuria. In North Vietnam beds with the oryctocephalid species *Tonkinella flabelliformis* Mansuy (Siao Pin Tchai Series) again overlie *Redlichia*-bearing strata (Saurin, 1956, pp. 397-398).

In southeastern Asia, therefore, the oryctocephalid fauna is found either in association with *Redlichia* or immediately above it. The fauna appears to range well into the paradoxidian Middle Cambrian.

In Australia, in northwestern Queensland (the Undilla Basin), where the Middle Cambrian is most completely represented, Öpik (1956a, pp. 14-20) has outlined a zonal scheme based largely on the succession of Scandinavian agnostid trilobites described by Westergaard (1946). Here Öpik (loc. cit., and 1958, p. 11) considers the basal Middle Cambrian fauna to be characterized by species of *Redlichia.* Shale containing this trilobite was found to be followed by limestone and shale with a *Dinesus-Xystridura* fauna and these by beds containing a succession of agnostids, comparable to that described from Scandinavia, representing the zones *Ptychagnostus gibbus* to *Leiopyge laevigata.*

The oryctocephalid trilobites of the Beetle Creek Formation are an essential part of the *Xystridura* faunal zone, and the range of the Oryctocephalidae in this formation is coincident with the higher range of *Xystridura* itself, falling also within the span of *Ptychagnostus praecurrens* (Öpik, pers. comm.). The oryctocephalid fauna of the Mootwingee Ranges, New South Wales, is again associated with *Xystridura* and overlies beds with *Redlichia* (Öpik, 1961, unpubl. rep.). Similarly, the Sandover Beds of eastern-central Northern Territory, correlated with the Beetle Creek Formation of Queensland, contain the association of Oryctocephalidae and *Xystridura,* overlying beds with *Redlichia* (Öpik, 1956b, p. 41). Near Tennant Creek, in the Gum Ridge Formation, the ranges of *Redlichia* and *Xystridura* overlap (Öpik, 1956b, p. 49).

The oryctocephalid fauna of Australia, considered in toto, lies in a stratigraphical position higher than the acme of *Redlichia,* in a similar position to that of the North Korean and Vietnamese occurrences. Öpik (1958, p. 11) has regarded the *Redlichia*-bearing beds of northern Australia as of lowest Middle Cambrian age. This is 'borne out by associated fossils and by the fact that the *Redlichia* faunas . . . are immediately followed by faunas correlated with the Scandinavian *Ptychagnostus ("Triplagnostus") praecurrens* and *P. ("T") gibbus* zones, which are well above the base of the Middle Cambrian. Consequently the *Redlichia*-bearing beds themselves should be correlated with the greater part of the *Paradoxides oelandicus* Stage of Scandinavia' (loc. cit.). Öpik (1968) has developed this theme and has proposed a new, basal Middle Cambrian Stage, the Ordian, for these *Redlichia*-bearing beds. The new Stage covers an interval between the ollenellan Lower Cambrian and the paradoxidian Middle Cambrian. A Templetonian Stage (Templeton Series of Whitehouse, 1936, restricted) is considered by Öpik to overlie the Ordian in Australia. *Ptychagnostus gibbus* occurs in the highest division of the Templetonian, which contains also the *'Xystridura'* and oryctocephalid faunas.

Öpik (1968) correlates his Ordian Stage with the *Protolenus* zone of the Acado-Baltic Province, the pre-*Glossopleura* zone of the Rocky Mountains, the top of the Lena Stage of Siberia, and much of the *Redlichia*-bearing strata of southern and eastern Asia. The oryctocephalid occurrences of Tuva and China fall into this Stage, as do those from beds below the *Glossopleura* zone of western North America. The proliferation of the Oryctocephalidae, however, occurs in the Templetonian and its equivalents. Australian oryctocephalids are restricted to this interval.

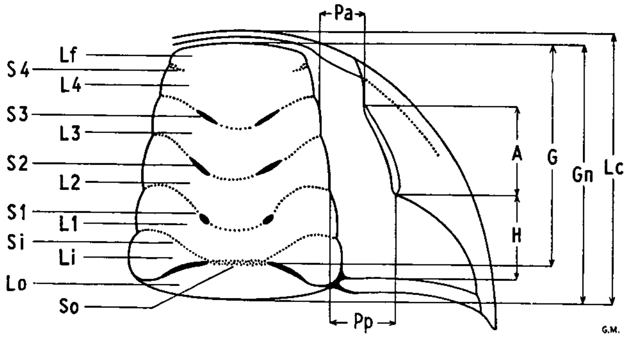
As suggested by Öpik (1956b, p. 43), the fauna of the Sandover Beds is similar in composition to that of the Spence Shale and *Ptarmigania* Strata of Idaho. The possible synonymy of *Ptychagnostus (Triplagnostus) praecurrens* and *Triplagnostus burgessensis* Rasetti (see Öpik, 1956, p. 44) and the presence of *Elrathina* sp. and *Lyriaspis* sp. in the Sandover Beds indicate correlation with the fauna of the *Bathyuriscus-Elrathina* Zone of the Stephen Formation, British Columbia.

The presence in Australia of species of *Oryctocephalites* of the *O. incertus* type offers correlation with the Amga faunas of the Siberian Platform. The Siberian faunas lie in a similar stratigraphical position, with regard to the agnostid time-scale of Westergaard, as does the Australian fauna, i.e. they range no higher than the *Ptychagnostus gibbus* Zone. The occurrence of *?Chienaspis* in Queensland probably indicates some connexion between the seaways of northern Australia and southeast Asia at this time.

To conclude, the family Oryctocephalidae is first represented in undoubted high Lower Cambrian. Ranging through the basal Middle Cambrian Stage it attains maximum diversification and distribution in the highest beds of the *Paradoxides oelandicus* and lowest of the *P. paradoxissimus* Stages (the Templetonian Stage of Australia), i.e. within the *Paradoxides pinus* and *Ptychagnostus gibbus* Zones of Westergaard (1946). By late *Pt. gibbus* time, however, the Oryctocephalidae are largely extinct.

## MORPHOLOGICAL NOMENCLATURE OF THE ORYCTOCEPHALIDAE

Wherever possible the nomenclature established by the authors of the Treatise on Invertebrate Palaeontology, part O, Arthropoda, is utilized; but some modifications and additions have had to be made.



**Text-figure 3. Glabellar notation and parameters measured on an oryctocephalid cephalon. The symbols are explained in the text.**

The symbols L and S are used to denote glabellar lobes and furrows. These are numbered from the rear forwards. Generally four pairs of lobes (L1-L4) and furrows (S1-S4) are interposed between the occipital furrow ($S_0$) and the frontal glabellar lobe ($L_f$) (Text-fig. 3). In the new genus *Sandoveria,* however, an additional pair of lobes and furrows is evident between the occipital furrow and the preoccipital glabellar lobes (L1). The furrows separating the preoccipital lobes from the additional pair of lobes are referred to as intervening furrows ($S_i$), in this procedure following the terminology of Öpik (1963, p. 67, fig. 20), who has described analogous furrows in the genus *Asilluchus* Öpik. The additional lobes abaxially overlap the distal ends of the occipital ring ($L_0$) and are separated from it by deep, posterolaterally directed, apodemal grooves. They are termed here intervening lobes ($L_i$), but may be interpreted as basal preoccipital lobes. The intervening furrows separating them from the true preoccipital lobes are strongest abaxially. Though weaker adaxially, they merge with the occipital furrow mesially.

Structures, exaggerated by the upward crushing of the articulating half rings, are found in the thorax and pygidium of the same genus. Axial rings have anterolateral lobulae, referred to as axial lobulae, analogous to the occipital lobules of other trilobites. The crescentic structures found in the central portion of the axis are referred to as axial semilunar crescents.

### *Definition of Selected Dimensions*

Parameters judged to be of greatest value in oryctocephalid taxonomy are illustrated on Text-figure 3 and defined as follows:

> Lc, Length of cephalon (sagittal); G, Glabellar length (sagittal); Gn, Glabellar length plus length (sagittal) of occipital ring; A, Eye length (exsagittal); H, Distance of eye from the posterior border furrow of the cephalon; Pa, Transverse width across palpebral area from the glabella to the anterior margin of the eye; Pp, Transverse width across the palpebral area from the glabella to the posterior margin of the eye.

The symbols G, Gn, A, and H were originally used by Struve (1958, p.167) for the analysis of dalmanitid trilobites and have been later employed by Henry (1964) and Shergold (1966) working on representatives of the same family.

Selected ratios used in this text are:

> A:G, comparing the eye length with that of the glabella; A:Gn, making a similar comparison but including also the occipital ring; H:A, giving an estimate of the distance of the back of the eye from the border furrow for various eye lengths; Pa:Pp, indicating the relative transverse width of the palpebral areas; Pp:L1, comparing the posterior palpebral width (tr.) with the glabellar width at L1. H:A, A:G and Pp:L1 together give some idea of the relative length of the eye and the distance of its posterior margin from both the glabella and posterior border furrow.

In the pygidium, dimensions measured include the overall length (sag.) and width (tr.) to the spine bases, where spines are present; and the length (sag.) and anterior width (tr.) of the axis. The length of the axis is expressed as a proportion of the total pygidial length.

## CLASSIFICATION

The classification adopted throughout this Bulletin is that of Suvorova (1964). In this the family Oryctocephalidae is divided into five subfamilies. The distribution of genera, revised in the light of this work, is as follows:

Family Oryctocephalidae Beecher, 1897.

Subfamily Oryctocephalinae Beecher, 1897
*Oryctocephalus* Walcott, 1886; *Oryctocephalites* Resser, 1939b; *Changaspis* Chien, 1961; *Goldfieldia* Palmer, 1964.

Subfamily Oryctocarinae Hupé, 1955
*Oryctocara* Walcott, 1908; *Ovatoryctocara* Tchernysheva, 1962; *Oryctocarella* Tomashpolskaya & Karpinskii, 1962; *Arthricocephalus* Bergeron, 1899; *Sandoveria* gen. nov.

Subfamily Lancastriinae Kobayashi, 1935
*Lancastria* Kobayashi, 1935; *Oryctocephalops* Lermontova, 1940; *Paraoryctocephalops* Tomashpolskaya, 1960; *Oryctocephalina* Lermontova, 1940; *Oryctometopus* Tomashpolskaya, 1964; *Chienaspis* Suvorova, 1964.

Subfamily Cheiruroidinae Suvorova, 1964
*Cheiruroides (Cheiruroides*) Kobayashi, 1935; *Cheiruroides (Inicanella)* Lazarenko, 1960; *Paleooryctocephalus* Repina, 1964.

Subfamily Tonkinellinae Reed, 1934
*Tonkinella* Mansuy, 1916; *Barklyella* gen. nov.

# SYSTEMATIC DESCRIPTIONS

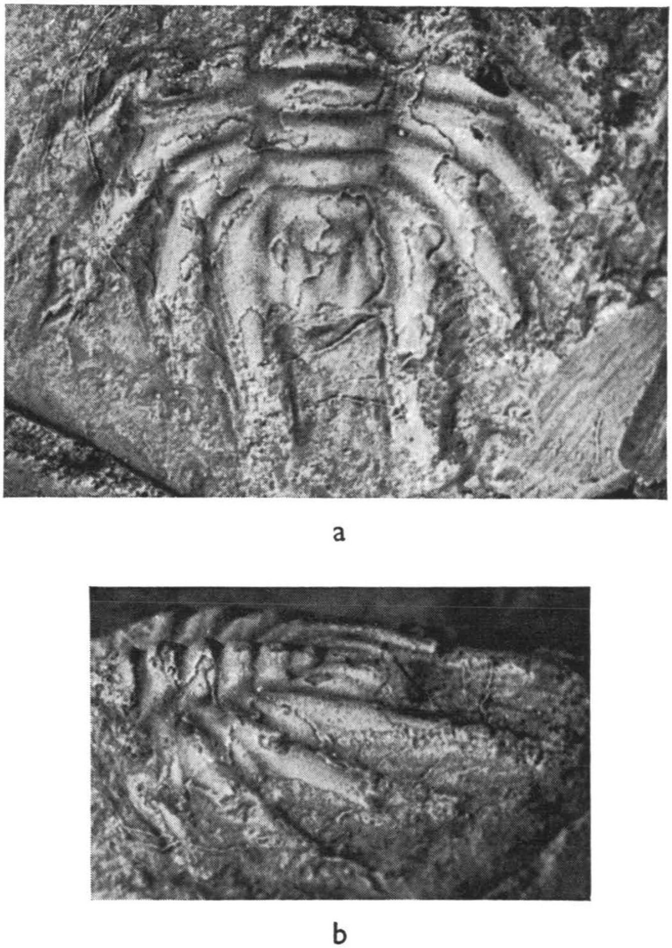
## Family ORYCTOCEPHALIDAE Beecher, 1897

## Subfamily ORYCTOCEPHALINAE Beecher, 1897

### Genus ORYCTOCEPHALUS Walcott, 1886

*Type species. Oryctocephalus primus* Walcott (1886, pp. 210-211, pl. 29, figs 3, 3a), occurring in the Middle Cambrian Pioche Formation, Pioche Shale, Pioche, Nevada, USA.

Walcott originally figured holaspid specimens of a cranidium (fig. 3) and a pygidium (fig. 3a). Interest centres mainly on the pygidium, as the cranidium must be regarded without doubt as the type cephalon of *O. primus,* and hence *Oryctocephalus.* Walcott (p. 211) stated that the pygidium which he referred to *O. primus* has five pleural segments. His illustration on plate 29, figure 3a shows the presence of six pairs of marginal spines, implying the presence of six pleural segments. Palmer (1954, pl. 15, figs 1, 2) has refigured Walcott's material. His illustration (pl. 15, fig. 2) shows the presence of only five pleural segments. Through the courtesy of Professor A. R. Palmer and Dr R. A. Robison I have been able to examine latex casts of Walcott's material. The pygidium is



**Text-figure 4. The pygidium of** *Oryctocephalus primus* **Walcott, 1886. A) USNM 15427, pygidium, dorsal view, X12; figured Walcott, 1886, pl. 29, fig. 3a. B) Same specimen, oblique lateral view, X12.**

illustrated in Text-figure 4. It shows very clearly only five pairs of marginal spines and five pleural segments. Most of the species mentioned below, having a cranidium similar to that described by Walcott for *O. primus,* have pygidia with six pleural segments and six pairs of marginal spines. *Oryctocephalites,* erected by Resser (1936b), has a cranidium of *Oryctocephalus*-type. Its pygidium, essentially similar to that of *Oryctocephalus,* invariably contains, in holaspid morphogenetic stages, five pygidial pleural segments. The problem arising, therefore, is how to interpret the pentameric segmentation of the pygidium attributed to *Oryctocephalus primus.* Moore (1959) has largely evaded the issue by stating, in his generic diagnosis of *Oryctocephalus,* that five or six pleural segments may be present. I would prefer to standardize the issue by restricting to six the number of pairs of pleural furrows characterizing *Oryctocephalus*. I would, therefore, restrict the type of *Oryctocephalus primus* to the cranidium figured by Walcott (1886, pl. 29, fig. 3). The pygidium attributed to *O. primus* (pl. 29, fig. 3a) I would prefer to place in the genus *Oryctocephalites*. Thus all oryctocephalid trilobites with cranidium similar to that of *Oryctocephalus primus* and having six pleural segments in the pygidium of holaspid individuals would be placed in *Oryctocephalus*. Those with five segments are more likely to belong to *Oryctocephalites*.

Rusconi (1952) has erected the subgenus *Oryctocephalus (Vinakainella)*, but its validity is doubted by Poulsen (1958, p. 6), who finds no morphological differences to justify it. Moore (1959, p. 0220) regards *Vinakainella* as synonymous with *Oryctocephalus;* he also considers *Oryctocephalina* Lermontova, 1940, a synonym of *Oryctocephalus,* but justification for the retention of *Oryctocephalina* as a separate entity is set out below under the heading of the subfamily Lancastriinae.

*Other species.* Sixteen species have previously been assigned to the genus *Oryctocephalus* and two further species are newly described below. Not all of these species, however, may belong to the genus. Apart from the type species, the following certainly do:

*Oryctocephalus reynoldsi* Reed (1899, pp. 359-361, text-fig.; the species occurs in Australia and further references are given under the synonymy of the species). Stephen Formation, *Ogygopsis* Shale, Burgess Shale, *Bathyuriscus-Elrathina* Zone, British Columbia, Canada; Sandover Beds and lateral equivalents, Northern Territory and New South Wales, Australia.

*O. reynoldsiformis* Lermontova (1940, p. 136, pl. XLII, figs 2, 2a-e; Tchernysheva, 1962, pp. 16-19, pl. 1, figs 1-8). Amga Stage, North Siberian Platform and Kuznets Alatau, Siberia, USSR.

*O. walcotti* Resser (1938a, p. 9, pl. 1, figs 22, 23; Resser, 1939a, pp. 13-14, pl. 2, figs 15-18). Spence Shale, Lakeview, Pend Orielle, Idaho, USA.

*O. matthewi* Rasetti (1951, p. 195, pl. 26, figs 4, 5). Stephen Formation, *Ogygopsis* Shale, Burgess Shale, *Bathyuriscus-Elrathina* Zone, British Columbia, Canada.

*O. burgessensis* Resser (1938c, p. 37) a new name for the specimen figured as *O. primus* by Kobayashi (1935, p. 147, pl. 15, fig. 1; Rasetti, 1951, pp. 194-5, pl. 26, figs 1-3). Stephen Formation, Burgess Shale, *Bathyuriscus-Elrathina* Zone, British Columbia, Canada.

*O. vicinus* Tchernysheva (1962, pp. 19-20, pl. 2, figs 9-10). Amga Stage, Olenek River, North Siberian Platform, Siberia, USSR.

*O. salteri* Reed (1910, pp. 11-12, pl. 1, figs 16-21). Horizon 9, Parahio Valley, Spiti, Kashmir.

*O. indicus* (Reed, 1910, pp. 9-10, pl. 1, fig. 15; Resser, 1938c, p. 38). Horizon 2, Parahio Valley, Spiti, Kashmir.

*O. walkeri* Matthew (1899, pp. 60-61, pl. 3, fig. 2) 'Shales' (probably Burgess Shale), Stephen Formation, Mount Stephen, British Columbia, Canada.

The following may or may not belong to *Oryctocephalus*. *Oryctocephalus maladensis* Resser, 1939b, and *O. limbatus* Tchernysheva, 1962, are similar in their cephalic characteristics to *Oryctocephalina* and are here temporarily referred to that genus. Both species are known solely from cephala and their absolute classification must await the discovery of the thorax and pygidium. *O. saitoi* Resser, 1938c, *O. kobayashii* Saito, 1934, and *O. orientalis* Saito, 1934, all from the Ssukkol Shales of northwest Korea, also share glabellar characteristics in common with *Oryctocephalina*. A pygidium attributed to *Oryctocephalus orientalis* (see Saito, 1934, pl. 25, fig. 21) is of *Oryctocephalus* type but contains only four pleural segments; it may be an incomplete specimen.

I have been unable to obtain access to the publications of Rusconi. I cannot, therefore, comment on *Oryctocephalus pentacantha* Rusconi, 1952. *O. asperoensis* Rusconi, 1952, has, however, been discussed by Poulsen (1958, p. 6) who regards *O. asperoensis* and *O. spinulosa* Rusconi, 1952, as different developmental stages within the same species and, therefore, as synonyms. I have a latex duplicate of the holotype pygidium of *O. asperoensis,* and confirm its correct generic assignation. Rusconi described his material from the *Glossopleura* zone, County Martillo, Province of Mendoza, Argentina.

Newly described below are *O. alexandriensis* and *O. opiki* from lateral equivalents of the Sandover Beds of the Northern Territory and New South Wales, Australia.

Species of *Oryctocephalus* may be divided into two groups based on the relative lengths that their cephalic, thoracic, and pygidial spines have attained during late holaspid morphogenetic stages. One group is based on *O. reynoldsi* and includes also *O. reynoldsiformis, O. burgessensis, O. walkeri, O. indicus,* and *O. asperoensis*. This group has long genal spines and a very long fourth pair of pygidial spines. The second group is centred on *O. matthewi* and includes also *O. salteri*. It is characterized by short mucronations, those of the pygidium being of nearly equal size. Of the new Australian species *O. opiki* belongs to the first group, while *O. alexandriensis* belongs to the second. The remaining species of *Oryctocephalus* are either imperfectly known or have been described from cranidia alone.

### ORYCTOCEPHALUS REYNOLDSI Reed, 1899

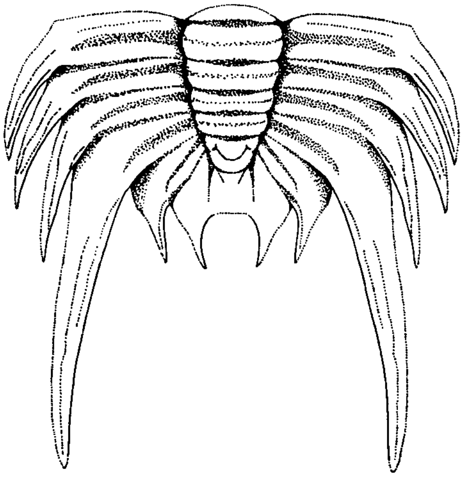
(Pl. 3, figs 2-6; Pl. 4, figs 3-4; Text-fig. 5)

1899 *Oryctocephalus Reynoldsi,* sp. nov., Reed, 1899, pp. 359-361, text-fig. (line drawing).
1902 *Oryctocephalus Reynoldsi,* F. R. Cowper Reed, 1899; Woodward, 1902, p. 540, text-fig. 6.
1908 *Oryctocephalus reynoldsi* Reed; Walcott, pl. 3, fig. 1.
1940 *Oryctocephalus reynoldsi* Reed; Lermontova, 1940, p. 136, text-fig. 94.
1951 *Oryctocephalus reynoldsi* Reed; Rasetti, 1951, p. 193, pl. 29, figs 4, 5.

*Types*. The types (see Rasetti, 1951, p. 193) are from the Stephen Formation, *Ogygopsis* and Burgess Shale lentils, *Bathyuriscus-Elrathina* Zone, Mount Stephen, British Columbia, Canada.

*Material.* The Australian material consists largely of disarticulated cranidia and pygidia, the former being generally well flattened. In the BMR collections there are 14 cranidia, 9 pygidia, and one more or less complete individual in a very poor state of preservation, which can be referred to the species. The cranidia vary in length (sag.) from a minimum of 2.10 mm to approximately 8.00 mm, with the majority of specimens falling within the range 4 to 5 mm. The pygidia range in length from 0.90 to 4.50 mm.

*Occurrence. Oryctocephalus reynoldsi* Reed occurs in the Northern Territory. It is present in Bureau of Mineral Resources collections numbered E6, E16, and N32 from the Elkedra district; H47 and H48 from the Huckitta area; and N33 and N34 from the Sandover River area. In the northeast of the Northern Territory the species occurs in the collection numbered N25b from Alexandria homestead (for further information on localities, see p. 59 ff).



**Text-figure 5. The pygidium of *Oryctocephalus reynoldsi* Reed, 1899, based on specimen CPC 8345, figured Plate 3, figure 4 [X 10].**

*Comments.* The Australian specimens are characterized by a nearly parallel-sided glabella, very similar to that depicted by Reed (1899, p. 359), expanding very gently to the anterior. Ocular ridges are fairly strongly defined even on poorly preserved material and are duplicated on a specimen assigned to this species from the extreme northeast of the Northern Territory (see Pl. 3, fig. 2). Glabellar furrows are represented by isolated pits in small specimens, and deeper, chevron-shaped excavations in late holaspides, as in the specimens figured by Rasetti (1951, p. 29, fig. 5). The pygidia (Text-fig. 5), especially those from the northeast of the Territory, are almost identical with those illustrated by Rasetti (pl. 29, figs 4, 5), being characterized by an extremely long fourth pair of spines whose length (exsag.) considerably exceeds that (sag.) of the pygidium (from the first transverse furrow of the axis, behind the articulating half ring, to the posterior margin). Of the remaining spines, pairs 1-3 are subequal in size and length, and the tips of the sixth pair, when fully excavated, are slightly longer than those of the fifth. Both pleural and interpleural furrows are strongly defined, the pleural furrows cutting obliquely across the pleuron and very nearly contacting the interpleural furrow behind each spine base. The sixth pair of pleural furrows runs backwards as a continuation of the axial furrows to the posterior margin of the pygidium. There is a faint indication of suturing along the line of fusion of the pleurae of the sixth segment, immediately behind the axis.

The characteristics described above are to a large extent found also in *Oryctocephalus reynoldsiformis* Lermontova. The main difference between this species and *O. reynoldsi* appears to lie in the greater anterior expansion of the glabella in the former. As the Australian species is in the bulk of its characteristics most similar to *O. reynoldsi* it is here classed with that species.

TABLE 1. Parameters relating to the size and position of the eyes in *Oryctocephalus reynoldsi* and *O.* cf. *reynoldsi.*

| *O. reynoldsi* | Lc mm | H:A% | A:Gn% | Pa:Pp% | Pp:L1% |
|---|---|---|---|---|---|
| CPC 8365 | 2.50 | 22.73 | 47.83 | 63.17 | 82.60 |
| CPC 8363 | 4.25 | 25.00 | 38.56 | 62.50 | 93.03 |
| CPC 8361 | 4.40 | 18.66 | 44.30 | 76.17 | 87.08 |
| CPC 8343 | 4.95 | 23.61 | 43.51 | 75.86 | 80.11 |
| CPC 8362 | 7.05 | 22.90 | 45.17 | 73.64 | 98.09 |
| CPC 8364 | 8.00 | 20.49 | — | 75.21 | 93.01 |
| *O.* cf. *reynoldsi* | | | | | |
| CPC 8342 | 4.30 | 30.49 | 40.75 | 80.76 | 97.88 |
| CPC 8341 | 9.80 | 37.68 | 40.36 | 79.00 | 82.41 |

## ORYCTOCEPHALUS cf. REYNOLDSI Reed, 1899

(Pl. 2, fig. 8; Pl. 3, fig. 1)

*Material.* Two cranidia, CPC 8342, an internal mould with cephalic length (sag.) of 4.30 mm, and CPC 8341, an external mould with a length of 9.80 mm.

*Occurrence.* The two specimens are associated with *Oryctocephalus opiki* sp. nov. in the Middle Cambrian of the Mootwingee Ranges, 6 miles northwest of Mount Wright, northwest New South Wales (see p. 61).

*Comments.* In the shape and structure of the glabella the two specimens from New South Wales are entirely compatible with those specimens from the Northern Territory here referred to *O. reynoldsi.* In other respects there are subtle differences. The ocular furrows are fainter, similar to the condition observed in

*O. opiki* sp. nov. The eyes, though placed at a comparable distance from the glabella, appear to be shorter (see Table 1, ratio H:A), and consequently the distance (H) from the back of the eye to the posterior border furrow is longer. It has not been found possible to differentiate two distinct pygidia among the Mootwingee material; all those present in the collection, though of basically *reynoldsi*-type, are referred to *O. opiki.* It would appear that on pygidial characteristics *O.* cf. *reynoldsi* is close to *O. opiki.* Glabellar characteristics, however, suggest close relationship with *O. reynoldsi.*

### ORYCTOCEPHALUS OPIKI sp. nov.

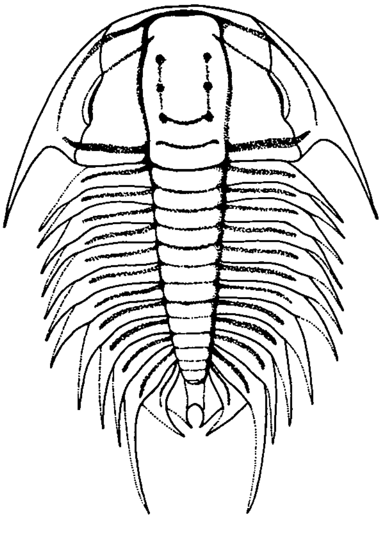
(Pl. 1, figs 1-5; Pl. 2, figs 1-7; Text-figs 6, 7)

*Name.* The species is named in honour of Dr A. A. Öpik, in recognition of his contribution to our knowledge of the Cambrian trilobite faunas of Australia.

*Holotype.* The holotype (here designated) is the internal mould of a complete dorsal carapace, CPC 8348, illustrated on Plate 1, figure 1, and by Text-figure 6.

*Occurrence.* The type and other material described and figured here was collected by Dr Öpik from the Middle Cambrian of the Mootwingee Ranges, 6 miles northwest of Mount Wright, in northwestern New South Wales (see p. 61).

*Material.* The material studied includes 11 cranidia varying in length (sag.) between 1.25 and 5.35 mm; 15 pygidia varying in length (sag.) from 1.20 to



**Text-figure 6. A reconstruction of *Oryctocephalus opiki* sp. nov. based on the holotype CPC 8348 [X 6].**

4.20 mm; 5 more or less complete dorsal shields with a maximum length (sag.) approaching 9.20 mm; and the ventral surface of a single cranidium showing the fused rostral-hypostomal plate and with attached librigenae. All the specimens are preserved as moulds in buff or pale brown, white, yellow, or pinkish weathering siltstone. Most are flattened but otherwise undistorted.

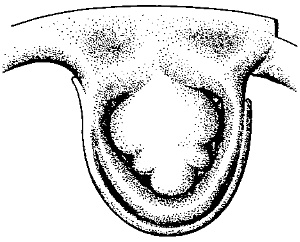
*Diagnosis.* A species of *Oryctocephalus* having the following combination of characteristics: cranidial outline subquadrate; glabellar outline subovate, barrel-shaped; long genal spines; weakly defined ocular ridges; long thoracic and pygidial spines as in *O. reynoldsi;* weak interpleural furrows in the pygidium.

*Description.* The cephalic outline is semicircular, being approximately twice as wide (tr.) as long (sag.), excluding the genal spines; it is evenly rounded anteriorly. The cranidial outline is subquadrate.

The glabella has a subovate or barrel-shaped outline. The axial furrows which define it are parallel at the level of L1, thence expanding slightly forwards to the level of L3. From this point they taper gently inwards to the anterolateral corners of the glabella. The frontal lobe is obtusely rounded anteriorly, often with a faint sagittal depression. S1 pits are transversely elongated, connected across the sagittal line (tr.) by a wide (sag.) and shallow furrow which arches to the posterior. S2 pits are ovoid, equal in depth to the S1 pits, isolated. S3 pits are somewhat less deep, also isolated. All three pairs of pits fail to connect with the axial furrows. A fourth pair, S4, is occasionally present, situated on the flanks of the frontal lobe near the confluence of the axial furrows, the anterolateral marginal furrow of the cephalon, and the ocular ridges. S4, when present, connect with the axial furrows.

The occipital ring is very nearly as wide sagittally as the preoccipital glabellar lobes and transversely of equal width. The occipital furrow is mesially shallow, arching posteriorly, abaxially much more deeply furrowed and arching to the anterior. It does not reach the axial furrows laterally, the occipital ring and the preoccipital lobes being abaxially fused.

The cephalic border is widest anterolaterally, narrowest anteriorly, where its width (sag.) is reduced by the anterior protrusion of the frontal glabellar lobe. At



**Text-figure 7. The hypostome of *Oryctocephalus opiki* sp. nov. based on specimen CPC 8351, figured Plate 1, figure 4 [X 5.5].**

this point it has a width (sag.) of between 0.1 and 0.2 percent of the total cephalic length (sag.). Anteriorly the border is slightly upraised and separated from the glabella by a deep preglabellar furrow.

The palpebral lobes are narrow (tr.) and slightly inclined to the sagittal line, extending from approximately the middle of L1 to approximately the middle of L3. The ocular ridges are very faint, save where they are exaggerated by oblique compression. They are straight or very gently curved, intersecting the axial furrows at the level of S4 at angles between 55° and 65°. The preocular fixigenal area is rather wide, subtriangular in shape, and moderately convex (exsag.). The preocular section of the facial suture is deflected outwards slightly from the sagittal line in its passage across the preocular fixigenae but curves gently inwards across the anterolateral border. The postocular section of the facial suture is deflected sharply posterolaterally to cut the posterior cephalic border at an angle of about 30°. The width (tr.) of the palpebral area, between the back of the eye and the glabella (parameter Pp), averages (13 specimens) 86 percent of the glabellar width (tr.) at L1; the width anteriorly (Pa) is approximately 60-80 percent of the posterior width (Pp). Values of A:Gn, H:A, Pa:Pp and Pp:L1 are listed in Table 2. The librigenae are narrow (tr.) with wide borders. The genal spines are stout and long, reaching to the third or fourth segments of the thoracic axis.

The hypostome (Text-fig. 7), anteriorly fused to the rostral plate, is separated from the anterior cranidial margin by a marginal suture which extends around the anterior cephalic periphery between the anterolateral connective sutures. The latter are well defined lines (Pl. 1, fig. 4), not cracks on the ventral doublure, and represent the ventral expression of the preocular sections of the facial suture. The connective sutures appear to have been non-functional during ecdysis. The lateral and posterior margins are gently rounded, the posterolateral corners rounded off, the structure as a whole having a decidedly ovoid outline. A narrow marginal rim runs concentric to the posterior and lateral margins but becomes thickened and more convex anterolaterally, where it merges into the upraised anterolateral shoulders. A shallow marginal furrow extends around the posterior half of the hypostome, separating the marginal rim from a convex, horseshoe-shaped posterior and posterolateral border. The border furrow is shallow posterolaterally but deepens adjacent to the anterolateral shoulders. The median body is strongly convex, pear-shaped, without a transverse bisecting furrow. The maculae are represented by well defined ovoid patches towards the posterolateral margins of the median body. The anterior wings, reduced to short prongs extending addorsally below the level of the rostral-hypostomal plate, are shown on the left hand side of the specimen figured on Plate 2, figure 4 and Text-figure 7. Lateral notches as such are not developed. A shallow depression lies on the rostral-hypostomal plate sagittally and similar depressions anterolaterally flank the shoulders.

The thorax is composed of seven segments. Each pleuron is equally wide (tr.) as far as its geniculation and is obliquely transversed by a wide (exsag.), shallow pleural furrow. The free thoracic spines are stout, almost half as long as the width (tr.) of the respective pleuron. The axis is moderately convex (tr.), widest (tr.) at about the third ring, thence tapering gradually rearwards.

The pygidium, excluding the free spines, has a subquadrate outline and is only marginally wider than long. Six pleural segments are indicated by wide and shallow pleural furrows which terminate distally very close to the posterior margin of the pleuron; interpleural furrows are present but weak. There are six pairs of fringe spines: pairs 1-3 are broad-based, stout and of equal length, being approximately one-half to two-thirds the width of each respective pleural segment; the fourth pair is broad-based and gently curved adaxially, longer than the total pygidial length (sag.); the fifth pair is very short, the ends of each spine lying well to the anterior of those of the fourth pair but to the posterior of the ends of the third pair, sometimes distally curved towards the sagittal line; the sixth pair is short, though longer than the fifth, frequently with incurved distal extremities. The axis is conical, evenly tapering to the posterior and approximately three-quarters the length (sag.) of the pygidium. It is composed of five rings plus a blunt terminal piece not always differentiated from the fifth ring; each ring is separated by a well defined transverse furrow.

TABLE 2. Parameters relating to the size and position of the eyes in *Oryctocephalus opiki*.

| *O. opiki* | Lc mm | H:A% | A:Gn% | Pa:Pp% | Pp:L1% |
|---|---|---|---|---|---|
| CPC 8353 | 2.75 | 29.41 | 41.87 | 66.67 | 94.39 |
| CPC 8354 | 3.55 | 27.97 | 47.68 | 73.33 | 88.61 |
| CPC 8349 | 3.60 | 33.01 | 36.20 | 68.37 | 71.36 |
| CPC 8350 | 3.60 | 28.00 | 41.67 | 73.05 | 83.51 |
| CPC 8348 | 3.65 | 34.46 | 40.03 | 79.00 | 74.91 |
| CPC 8358 | 3.90 | 26.36 | 43.00 | 75.28 | 98.54 |
| CPC 8360 | 4.40 | 25.71 | 42.61 | 69.20 | 85.94 |
| CPC 8359 | 5.35 | 27.31 | 41.50 | 73.86 | 82.50 |
| CPC 8357 | 7.00 | 25.00 | 42.38 | 66.74 | 86.50 |

*Relationships*. *Oryctocephalus opiki* may be differentiated from *O. primus* Walcott, *O. orientalis* Saito, *O. salteri* Reed, and *O. matthewi* Rasetti on account of its longer genal spines and heterogeneous pygidial spines, the fourth pair being very long and the fifth very short. In these characteristics it is related to *O. reynoldsi* Reed, *O. walcotti* Resser, *O. indicus* Reed, *O. walkeri* Matthew, *O. burgessensis* Resser, and *O. reynoldsiformis* Lermontova. For comparative purposes *O. indicus* and *O. walkeri* are imperfectly known, but comparison can be made with the remaining species. Of these our species differs from *O. burgessensis* in that the glabella expands to a lesser extent anteriorly and the eyes are somewhat larger, extending farther towards the posterior border furrow. The pygidial spines are shorter and stouter, especially the fifth and sixth pairs. *O. opiki* differs from *O. reynoldsi* in that the glabellar pits S2 and S3 are not transversely connected. The mesial spinules shown by Reed (1899, p. 359) on the axial rings of the thorax are absent in *O. opiki*. The pygidia of *O. opiki, O. reynoldsi, O. reynoldsiformis,* and *O. walcotti* are all very similar. In the latter two species, however, the interpleural furrows are stronger, and in the cranidium the ocular ridges are more prominent, especially in *O. walcotti,* and the preocular areas possibly wider (exsag.). While the posterior palpebral areas of *O. walcotti* are roughly equal to those of *O. opiki* (about 75 percent of the preoccipital glabellar width(tr.) ) those of *O. reynoldsiformis* are wider than the glabellar dimension.

Two species are known only from cranidia: *O. kobayashii* Saito and *O. vicinus* Tchernysheva. These differ from *O. opiki* in the following respects: *O. kobayashii* has an anterior cranidial contour which is straight rather than rounded, giving rise to wide triangular preocular areas and a very narrow anterior border: *O. vicinus* has a strongly waisted glabella at the level of the preoccipital glabellar lobes.

### ORYCTOCEPHALUS ALEXANDRIENSIS sp. nov.

(Pl. 4, figs 1-2; Text-fig. 8)

1956 *Oryctocephalus* sp.; Öpik, 1956, p. 40.
1966 *Oryctocephalus* Walcott, 1886; Gatehouse, 1966, pp. 4, 5.

*Name.* The species is named from its type locality (N24 in the Index) on Alexandria station, in the Northern Territory.

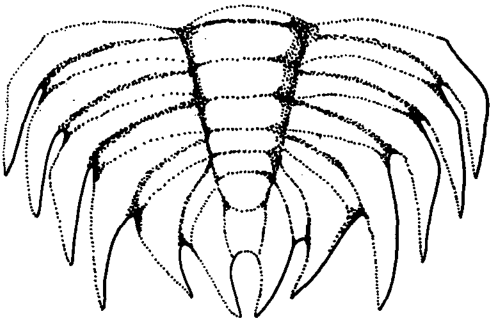
*Holotype* (here designated). The pygidium, CPC 8366, illustrated on Plate 4, figure 1.

*Occurrence.* The species occurs in the Burton Beds (Smith & Roberts, 1963, p. 11; Gatehouse, 1966, p. 4), of lower Middle Cambrian age, at the 'Old Well' (Öpik, 1956b, p. 40), Alexandria station, northeastern Northern Territory (N24).

*Material.* The species is represented by three pygidia, preserved in full relief with vestiges of their shell in a grey-brown siliceous mudstone. At the time of writing cephala are unknown. The pygidia range in length (sag.) between 1.70 and 3.60 mm.

*Diagnosis.* A species of *Oryctocephalus,* of the *O. matthewi* species group, with the following characteristics: relatively long (sag.) pygidial axis, exceeding 80 percent of the total pygidial length (sag.); fringe spines of subequal length, the fourth pair being stouter but not appreciably longer than the others, derived entirely from the anterior pleural bands; very narrow posterior pleural bands, the pleural furrows cutting towards the lateral margins behind the spine bases; weak interpleural furrows; sixth pair of posterior pleural bands completely fused behind the axis.

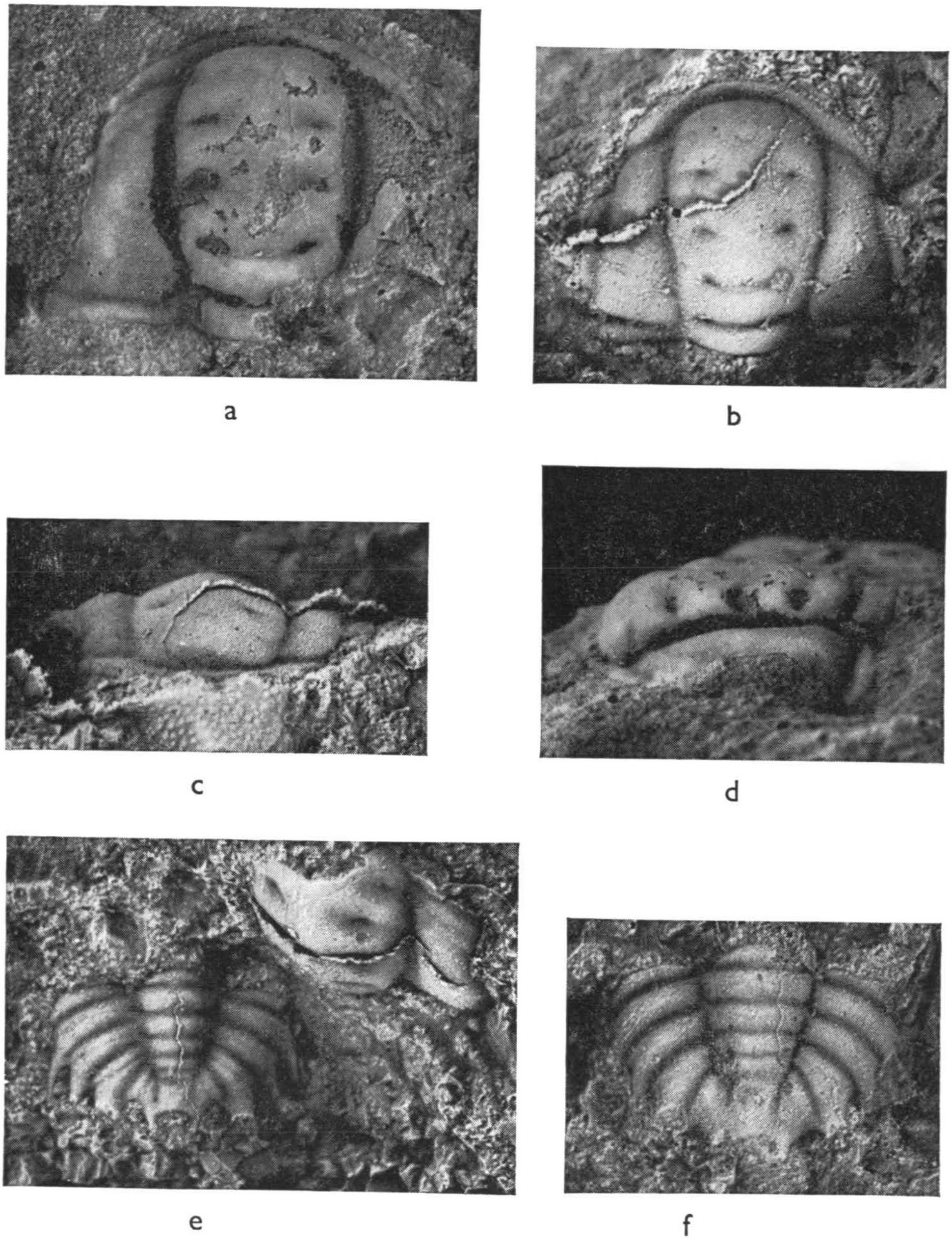
*Description.* The axis is conical, evenly tapering to the posterior, attaining a length equivalent to 82-84 percent of the total pygidial length; the anterior width (tr.) at the first ring is equivalent to 33-36 percent of the total pygidial width (tr.). It is composed of five rings, all clearly delimited by strong transverse furrows, and a rounded terminal piece. There are six pleural segments with even gentle convexity (tr.), without marked geniculation. Strong pleural furrows, running parallel to weak interpleural furrows, divide each segment into a wide anterior and very narrow posterior band. The fringe spines are of subequal length; spine pairs 1-3 are equal in length, with marked geniculations evident on their anterior margins near their points of issue from the furrowed pleural zone; the fourth pair is stouter than the remainder, but only slightly longer; the fifth pair is more delicate than pairs 1-3 but very nearly as long; the sixth pair is marginally shorter; the distal extremities of the fifth and sixth pairs of spines curve adaxially. The spines are derived in entirety from the anterior pleural bands, the pleural furrows cutting towards the lateral margins behind the spine bases (Text-fig. 8). The spines are hollow and have a rounded cross-section (see Pl. 4, fig. 1). The sixth pair of posterior pleural bands is completely fused behind the axis. The posterior margin of pygidium is convex forwards.



**Text-figure 8. The pygidium of *Oryctocephalus alexandriensis* sp. nov. based on the holotype CPC 8366, figured Plate 4, figure 1 [X 15].**

*Relationships*. The absence of an enlarged fourth pair of pygidial spines differentiates *O. alexandriensis* from members of the *Oryctocephalus reynoldsi* species group but allies it to those of the *O. matthewi* group.

*O. alexandriensis* may be most satisfactorily related to *O. salteri* Reed, in which the spines are of similar lengths and proportions (Reed, 1910, pl. 1, figs 17, 18, 21). It differs from this species, however, in its relatively longer (sag.) pygidial axis and narrower posterior pleural bands. *O. alexandriensis* is also comparable to *O. matthewi* (see Rasetti, 1951, pl. 26, figs 4, 5). The pleural furrows of both species confine the width (exsag.) of the posterior pleural bands to very narrow strips, and in both restrict the spines to the anterior pleural bands. The marginal spines are, however, considerably shorter in *O. matthewi*. The lengths of these spines in *O. alexandriensis* are similar to those observed on the specimen figured by Rasetti (op. cit., pl. 26, fig. 2) as *O. burgessensis*, but this latter is a small holaspid and the comparison should not be taken too far.



**Text-figure 9.** *Oryctocephalites typicalis* Resser, 1939. A) USNM 98528c, cranidium, dorsal view, X12, figured Resser, 1939b, pl. 3, fig. 3. B) USNM 98528b, cranidium, dorsal view, X12, figured Resser, 1939b, pl. 3, fig. 2. C) Same specimen, anterior view, X12. D) USNM 98528c, as for Fig. A, lateral view, X12. E) USNM 98528f, pygidium with associated cranidium, X12, figured Resser, 1939b, pl. 3, fig. 6. F) USNM 98528d, pygidium, dorsal view, X12, figured Resser, 1939b, pl. 3, fig. 4.

### Genus ORYCTOCEPHALITES Resser, 1939

*Type species. Oryctocephalites typicalis* Resser, 1939b, p. 45, pl. 3, figs 1-6, from the *Ptarmigania* Strata, northern Wasatch Mountains, Idaho, USA.

*Other species.* Only two other species of *Oryctocephalites* have previously been described as such, but a third may exist:

*Oryctocephalites resseri* Rasetti, 1951, p. 196, pl. 15, fig. 9. Mount Whyte Formation, *Plagiura-Kochaspis* Zone, British Columbia, Canada;

*O. incertus* Tchernysheva, 1960b, p. 219, pl. 51, fig. 7; Tchernysheva, 1962, pp. 26-27, pl. 3, figs 7-10. Amga Stage, Olenek River, North Siberian Platform, Siberia, USSR.

*?Oryctocephalites* sp. (syn. *Oryctocephalus primus* (pars), Walcott, 1886, p. 211, pl. 29, fig. 3a; Palmer, 1954, pp. 68-9, pl. 15, fig 2). Pioche Formation, Pioche Shale, Pioche, Nevada, USA.

Described below are the three new species *Oryctocephalites runcinatus, O. sulcatus,* and *O. gelasinus* from the Sandover Beds of the Northern Territory and the Beetle Creek Formation of northwest Queensland.

The species of *Oryctocephalites* described below are more closely related to *O. incertus* than to the type species, *O. typicalis.* I have had the opportunity to study latex moulds and plaster casts of Resser's original material (USNM 98528 a-f). The major differences between the Russian and American species lie in the convexity of the cranidium as a whole and the degree of anterior curvature to the cranidial outline. The convexity of the cranidium influences any measurement which may be made to assess the size and position of the eyes and the appearance of the glabellar furrows. In *O. typicalis* (Text-fig. 9) a strong convexity (tr. and sag.) imparts to the glabella a swollen appearance; the glabellar furrows stand apart from the axial furrows; the palpebral areas appear narrow (tr.) and there is strong anterior cranidial curvature. In *O. incertus* the diagnostic characteristics have been described from material varyingly flattened. The glabella is proportionately longer (sag.) and less convex, the glabellar furrows are deeper and closer to the axial furrows, the anterior cranidial curvature is reduced, and the palpebral areas are considerably wider (tr.). Some of the observed differences are undoubtedly the result of preservation, which may thus obscure the true relationships between the two species. The Australian material is preserved in a similar manner to that of the Russian species, which probably accounts for the apparent close relationships between the taxa. The species recognized differ in the prominence of the ocular ridges and the width (tr.) of the palpebral areas. The pygidia of all species attributed to *Oryctocephalites* are very similar.

### ORYCTOCEPHALITES RUNCINATUS sp. nov.

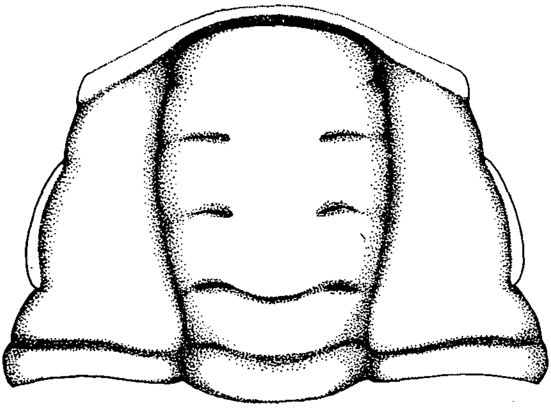
(Pl. 6, figs 3-8; Pl. 7, figs 1-4; Text-fig. 10)

1956 *Oryctocephalites* cf. *typicalis* Resser (pars); Öpik 1956b, p. 43.

*Name. Runcinatus,* L., planed off, smooth; referring to the smoothed-out ocular ridges of the genae.

*Holotype.* The holotype (here designated) is the internal mould of a cranidium, CPC 8368, figured here on Plate 6, figure 3.

*Occurrence.* The holotype and other specimens were collected from pebbles, of Middle Cambrian age, from the floodplain of the Sandover River at Stokes Bore, Stokes Creek, 18.5 miles west-southwest of Georgina Downs homestead, Northern Territory (collecting station N35).



**Text-figure 10. The cranidium of *Oryctocephalites runcinatus* sp. nov. based on the holotype CPC 8368, figured Plate 6, fig. 3 [X 14].**

A varied oryctocephalid fauna, the 'Argadargada fauna' of Öpik (1954, p. 14), has been obtained from loose pebbles at a number of collecting points on the Elkedra and Sandover River Geological Sheets. Öpik (1956b, pp. 42-3) reports that these pebbles have been traced to outcrop in the Elkedra district. Certainly a comparable fauna exists in situ at locality N32. *Oryctocephalites runcinatus* has been identified from collections made at N32, N33, N35, and N36. It is confined to the Middle Cambrian, Templetonian, *Xystridura* fauna, of the Elkedra-Argadargada region of the Northern Territory.

*Material.* One cephalo-thorax with disarticulated librigenae, ten cranidia, and three pygidia are attributed to the species. All are preserved as moulds and are flattened to varying degrees. The material at hand consists largely of holaspides.

One poorly preserved meraspid cranidium (CPC 8377) has an estimated cranidial length (sag.) of 1.60 mm. The holaspid cranidia range in length between 3.00 and 4.50 mm. The pygidia range in length (sag.) between 1.35 and 2.40 mm.

*Diagnosis.* A species of the *Oryctocephalites incertus* group with very poorly defined ocular ridges and a posterior palpebral width (tr.) equivalent to only 75 percent of the preoccipital glabellar width (tr.).

*Description.* The cranidium is evenly arched forwards. The glabella is subrectangular, the containing axial furrows expanding very slightly outwards at the level of S2, where the maximum width (tr.) of the glabella is obtained, and are drawn in at the level of L1, where the minimum width (tr.) is observed. It is anteriorly gently rounded and extends forwards to displace the curve of the anterior cranidial border. There are three well defined pairs of glabellar furrows which do not reach the axial furrows abaxially, and a faintly indicated, marginal, fourth pair which does reach them. S1 are short, deep, arched gently forwards, and are joined by a strong and deep transverse connecting furrow which curves gently backwards mesially. S2 are a little less deep than S1 but have a similar configuration; they are equally long but sagittally disconnected. S3 are as S2 but a little straighter. S4 are typically obscure. The glabellar lobes are rectangular or subrectangular and are of approximately equal width (exsag.).

The occipital ring is transversely wider than L1 but sagittally only about two-thirds as wide; it is not raised above the general level of the glabellar side lobes. The occipital furrow is deepest abaxially and has a shallow sagittal section which curves posteriorly; abaxially it just reaches the axial furrows.

The cranidial border is narrow (sag. and exsag.) but is widest at the anterolateral corners of the glabella. The eyes are of moderate length, extending from the level of the anterior of L1 to the anterior of L3, attaining a length equivalent to 41-53 percent of the glabella (plus occipital ring). They are separated from the posterior border furrow by an area of fixigena equivalent to 28-40 percent of the total eye length. The palpebral lobes are strongly defined by rather shallow palpebral furrrows. The ocular ridges are very weakly defined. The posterior palpebral width (tr.) varies between 68 and 85 percent (mean 76 percent) of the preoccipital width (tr.). The posterior border furrow is deep and wide (exsag.). Short, broad-based intergenal spines may be present at the posterolateral margins of the cranidium (see Pl. 6, figs 3, 4, 6). The hypostome is unknown.

Four thoracic segments are preserved on specimen CPC 8370 (Pl. 6, fig. 5). They show obliquely directed pleural furrows and short, delicate pleural spines which belong largely to the anterior pleural bands.

The pygidium is small and spinose. The axis is relatively short, occupying 70 percent of the total pygidial length (sag.) and anteriorly (at the first ring) 30 percent of the maximum width (tr.). It contains five axial rings, tapering evenly to the posterior, and a poorly defined terminal piece delimited posteriorly by a triangular depression whose flanks are themselves defined by the adaxial ends of the fifth pair of pleural furrows. Five pleural segments bear strongly indicated pleural furrows which curve gradually backwards and outwards across the convexity of the pleural field so that the fifth pair lies parallel to the course of the axial furrows projected posteriorly. The pleural furrows are directed to the margins of the pygidium behind the segmental spine bases. The interpleural furrows are weak. Five pairs of delicate, long free spines originate from the anterior pleural bands: spine pairs one to three are of equal length; pair four is a little longer and stouter; pair five is short, with incurved distal ends. There is no border or marginal furrow, the pleurae passing directly into the spine bases.

TABLE 3. Parameters and proportions relating to size and position of eyes in species of *Oryctocephalites runcinatus* sp. nov.

| | Lc mm | H:A% | A:Gn% | Pa:Pp% | Pp:L1% |
|---|---|---|---|---|---|
| CPC 8377 | 1.60 | 28.58 | 41.59 | 68.66 | 68.36 |
| CPC 8378 | 3.00 | 29.88 | 42.99 | 60.98 | 73.87 |
| CPC 8373 | 3.40 | 33.35 | 42.67 | 65.45 | 75.70 |
| CPC 8371 | 3.60 | — | — | 71.99 | 75.75 |
| CPC 8368 | 3.85 | 30.77 | 47.07 | 70.10 | 73.16 |
| CPC 8379 | 3.90 | 29.75 | 44.00 | 56.76 | 85.45 |
| CPC 8369 | 3.90 | 31.39 | 52.83 | 73.41 | 75.18 |
| CPC 8372 | 3.90 | 35.38 | 43.62 | 63.40 | 82.96 |
| CPC 8380 | 4.00 | 39.52 | 45.09 | 63.96 | 77.16 |
| CPC 8370 | 4.50 | 40.00 | 40.99 | 62.04 | 74.44 |

*Relationships. Oryctocephalites runcinatus* sp. nov. is preserved in a similar manner to *O. incertus* Tchernysheva, 1960, from the Siberian Platform. The two species have much in common and are closely related. *O. runcinatus,* however, may be readily differentiated by the absence or extreme weakness of its ocular ridges. The three specimens of *O. incertus* figured by Tchernysheva (1962, pl. 3, figs 7-9) show the posterior palpebral width (tr.) to be equal to the preoccipital glabellar width (tr.) (i.e. Pp:L1 is 100 percent). In *O. runcinatus* this dimension occupies only 75 percent of the glabellar width (ranging between 68 and 85 percent, mean 76 percent, Table 3). *O. incertus* and *O. runcinatus* share a common cranidial outline, equally arched in front; the axial furrows are similarly divergent and the glabellar furrows similarly incised and orientated. The eyes of *O. incertus* may be proportionately slightly longer (exsag.) than those of *O. runcinatus.*

Comparison of *O. runcinatus* with *O. typicalis* Resser, 1939b, is complicated by the fact that the latter is preserved in full relief whereas the former is largely flattened. As a result the shape of the glabella (Text-fig. 9) in *O. typicalis* is decidedly more oval and the eyes appear closer to the glabella. The general arrangement of the glabellar furrows is similar, however, and the essential characteristics of the pygidium are comparable.

*Oryctocephalites resseri* Rasetti (1951, p. 196, pl. 15, fig. 9) appears to have glabellar pits rather than the furrows seen in *O. runcinatus* at S2 and S3. Very strong ocular ridges are indicated in this species. In the nature of its glabellar pitting *O. resseri* is closer to *Oryctocephalus* than to *Oryctocephalites.*

### ORYCTOCEPHALITES SULCATUS sp. nov.

(Pl. 8, figs 1-13; Pl. 9, figs 1-7; Text-figs 11A, B, C)

*Name. Sulcatus,* L., furrowed, referring to the presence of glabellar furrows rather than pits.

*Holotype.* The holotype (here designated) is the internal mould of a cranidium, CPC 8386, figured here on Plate 8, figure 7.

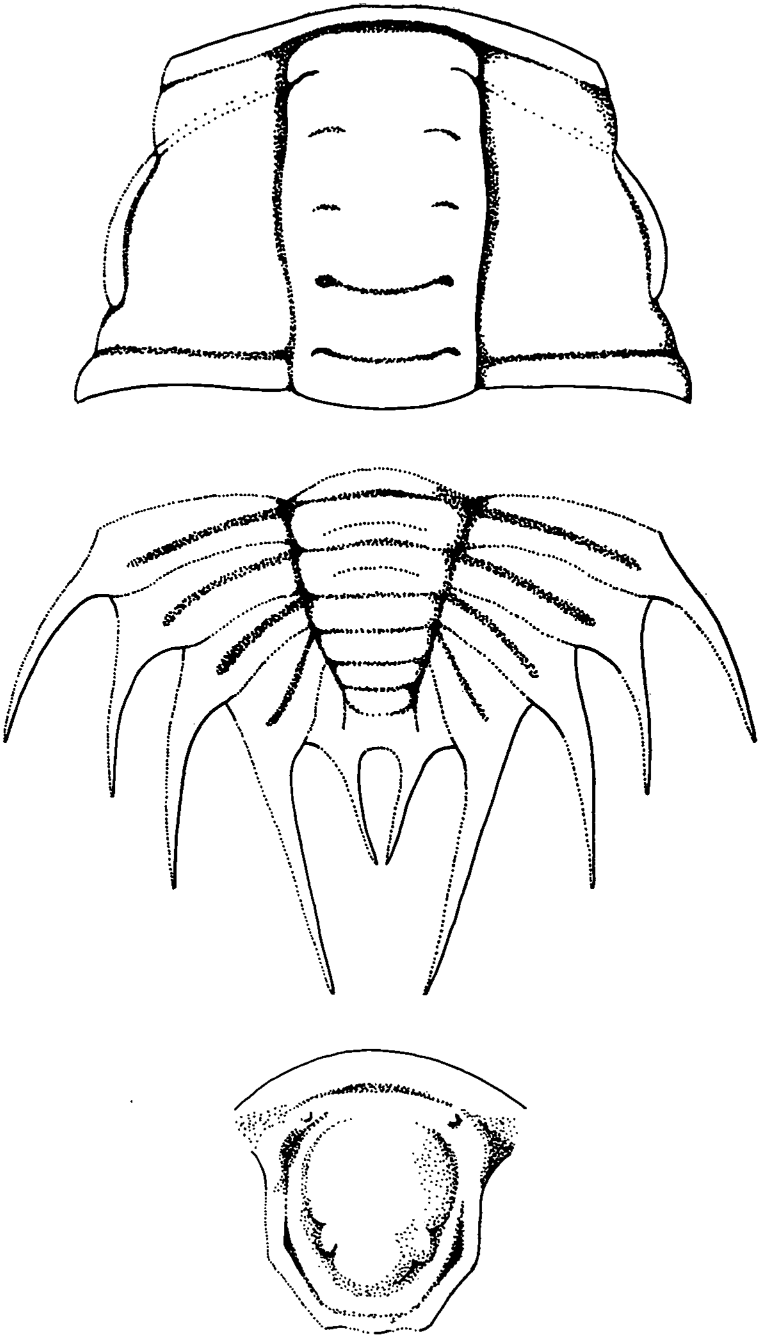
*Occurrence.* All the available material, the holotype included, was obtained from locality M267, Dingo Creek, between the Barkly Highway and Thorntonia station, northwestern Queensland. The rock matrix is a fine-grained dolomitic sandstone with chert patches, weathering white or pale yellow. It has been referred, on account of its *Xystridura*-oryctocephalid fauna, to the Middle Cambrian Beetle Creek Formation (Öpik, pers. comm.).

*Material.* The material consists mainly of disarticulated cranidia with infrequent pygidia and hypostomata. Fifteen cranidia ranging in length (sag.) from 0.90 to 5.20 mm, three pygidia with lengths between 1.80 and 2.20 mm, and two hypostomata are referred to this species.

*Diagnosis.* A species of the *Oryctocephalites incertus* group with gently arched anterior cranidial outline; glabellar furrows S2 and S3 sloping gently backwards abaxially, lightly incised, being distinct furrows rather than pits; posterior palpebral areas less wide than the preoccipital glabellar width (tr.).

*Description.* The cranidium is anteriorly even or gently arched. The overall outline of the glabella is subrectangular. The axial furrows on flattened material expand outwards quite markedly at the level of L2 and L3 and are drawn in equally markedly at L1 and L4. The glabella is situated with regard to the anterior border and margin of the cephalon as in *O. incertus* and *O. runcinatus.* There are three pairs of well defined glabellar side furrows. S1 are pits joined transversely by a deeply incised connecting furrow which arches slightly backwards (sag.). S2 are distinct furrows rather than pits, being linear or gently arched forwards, abaxially with posterior slope; not reaching the axial furrows. S3 are long, shallow, linear or very gently curved forwards, abaxially directed to the posterior, often just reaching the axial furrows. S2 and S3 are sagittally discontinuous. S4 are present on most specimens, being short and linear, as deep or deeper than S3, sloping into the axial furrows off the flanks of the glabella. The glabellar lobes are of approximately equal width (exsag.).

The occipital ring is low, transversely as wide and convex as the preoccipital lobes, sagittally about two-thirds as wide. The occipital furrow is well defined and



**Text-figure 11.** *Oryctocephalites sulcatus* **sp. nov. A) Cranidium based on the holotype CPC 8386, figured Plate 8, figure 7 [X 21]. B) Pygidium based on specimen CPC 8389, figured on Plate 9, figure 7 [X 13]. C) Hypostome based on specimen CPC 8388, figured Plate 8, figure 11 [X 15].**

narrow (sag.), with a similar curvature to that of the S1 connecting furrow; the abaxial apodemal grooves are sinuous and deeper than the mesial section of the furrow, reaching in some instances, but not becoming confluent with, the axial furrows.

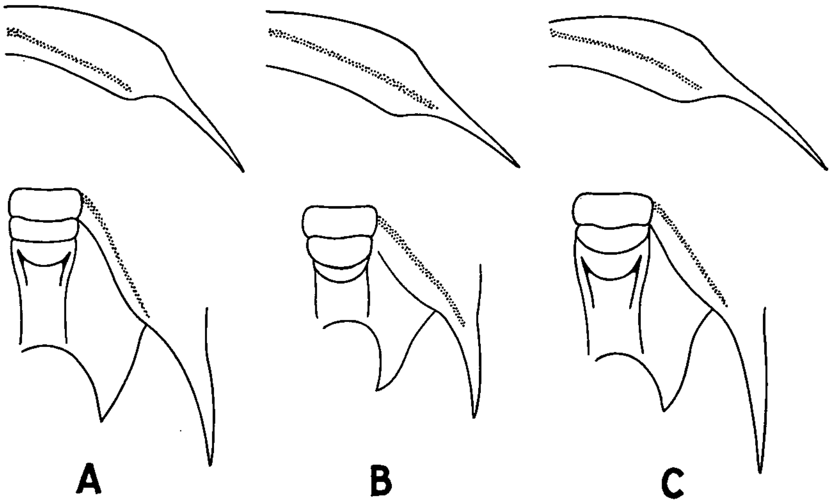
The cranidial border and border furrows are as in other species of *Oryctocephalites*. The preocular ridges are rather prominent. They are linear and intersect the axial furrows at angles between 61° and 70°. The preocular areas are subrectangular. The palpebral lobes are strongly defined and the palpebral furrows, though shallow, are also well defined. The palpebral lobes extend from the anterior of L1 to the anterior of L3 and occupy 35-45 percent of the total glabellar length (sag. plus occipital ring). A distance 26-40 percent of the total eye length (exsag.) separates the back of the eye from the posterior border furrow. The posterior palpebral area is less wide (tr.) than L1, the parameter Pp ranging between 72-98 percent (mean 88 percent) of L1. The posterior cranidial margin is straight rather than curved or sinuous.

The hypostome (Text-fig. 11C) has a subquadrate outline, anteriorly strongly curved. The posterolateral corners are truncate, the posterior margin sinuous, indented on each side of the sagittal line. The median body is ovoid to pear-shaped, as in *Oryctocephalus opiki* sp. nov., bounded by a shallow border furrow and posteriorly by a convex border roll. The latter is fringed posteriorly by a narrow marginal rim which merges into the border roll at the lateral margins of the median body. Anterolaterally the border passes into low shoulders which in turn pass anteriorly into the frontal portion of the median body. A shallow furrow lies anterior to the median body and possibly represents the line of fusion of the hypostome and rostral plate. Anterior wings and lateral notches cannot be satisfactorily evaluated on the material at hand. The maculae are indistinct patches situated near the posterolateral margins of the median body. Two further tubercles or raised patches lie on each shoulder, on either side of the sagittal line, but are only observed in certain conditions of illumination.

The pygidium is very nearly identical with that of *Oryctocephalites runcinatus* but has a slightly longer axis (sag.), representing 80-86 percent of the total pygidial length (sag.) and somewhat wider posterior pleural bands. The pygidium illustrated on Plate 9, figure 7, has extremely long and delicate spines.

*Morphogenetic variation*. The specimens of cranidia illustrated on Plates 8 and 9 are considered to form a morphogenetic series. Figures 1-6 on Plate 8 are interpreted as meraspides. They are noted for their narrow cylindrical glabellae, which frequently have preoccipital furrows cutting transversely across them from axial furrow to axial furrow. As the cranidium increases in size the ends of this preoccipital furrow migrate further and further from the axial furrows, cf. Plate 9, figure 4. There may be some difference in the position of the eyes on the cheeks, as indicated from the proportions given on Table 4 under the headings H:A and Pp:L1.

*Relationships*. Like *Oryctocephalites runcinatus* sp. nov., *O. sulcatus* sp. nov. is closely comparable to *O. incertus* Tchernysheva. The Australian species may be



**Text-figure 12.** Diagrammatical interpretation of the position and courses of the pleural furrows in species of *Oryctocephalites*. A) *O. runcinatus* sp. nov. B) *O. gelasinus* sp. nov. C) *O. sulcatus* sp. nov.

differentiated by: a less anteriorly arched cranidial outline; less deeply incised S2 and S3 furrows; eyes situated a little farther from the posterior border furrow; less wide (tr.) posterior palpebral areas; wider (exsag.) posterior pleural bands in the pygidium and less strongly defined interpleural furrows. The two species have similar glabellar outlines and ocular ridges of equivalent strength.

*O. sulcatus* differs from *O. runcinatus* in having wider (tr.) palpebral areas (Table 4); stronger ocular ridges; wider posterior pleural bands in the pygidium, and longer anterior lateral furrows in the glabella.

TABLE 4. Parameters and proportions relating to the size and position of the eyes in *Oryctocephalites sulcatus* sp. nov.

| | Lc mm | H:A% | A:Gn% | Pa:Pp% | Pp:L1% |
|---|---|---|---|---|---|
| CPC 8391 | 1.75 | 34.92 | 41.31 | 65.04 | 91.79 |
| CPC 8382 | 1.85 | 29.17 | 42.32 | 69.63 | 94.61 |
| CPC 8384 | 1.90 | 26.19 | 44.68 | 72.88 | 92.19 |
| CPC 8386 | 2.45 | 30.88 | 43.87 | 68.53 | 96.42 |
| CPC 8437 | 2.60 | 33.19 | 44.90 | 77.07 | 89.89 |
| CPC 8396 | 2.70 | 32.10 | 39.75 | 69.04 | 85.65 |
| CPC 8440 | 2.75 | 38.85 | 38.58 | 68.32 | 96.01 |
| CPC 8392 | 3.30 | 35.95 | 40.05 | 73.52 | 83.45 |
| CPC 8383 | 3.40 | 32.00 | 41.67 | 72.66 | 72.63 |
| CPC 8395 | 3.80 | 36.37 | 40.68 | 75.56 | 76.93 |
| CPC 8381 | 4.40 | 39.33 | 35.48 | 74.56 | 88.51 |
| CPC 8394 | 4.00 | 40.25 | 42.63 | 67.79 | 97.52 |
| CPC 8393 | 5.15 | 37.43 | 38.50 | 61.28 | 83.08 |

The nature of the glabellar furrowing and wide palpebral areas differentiates *O. sulcatus* from *O. typicalis* Resser. No satisfactory comparison can be made with *O. resseri* Rasetti.

### ORYCTOCEPHALITES GELASINUS sp. nov.

(Pl. 5, figs 1-7, 9-10; Pl. 6, figs 1-2; Text-fig. 13)

1956 *Oryctocephalites* cf. *typicalis* Resser (pars); Öpik 1956b, p. 43.

*Name. Gelasinus,* L., a dimple, referring to the shape of the median lateral glabellar pits.

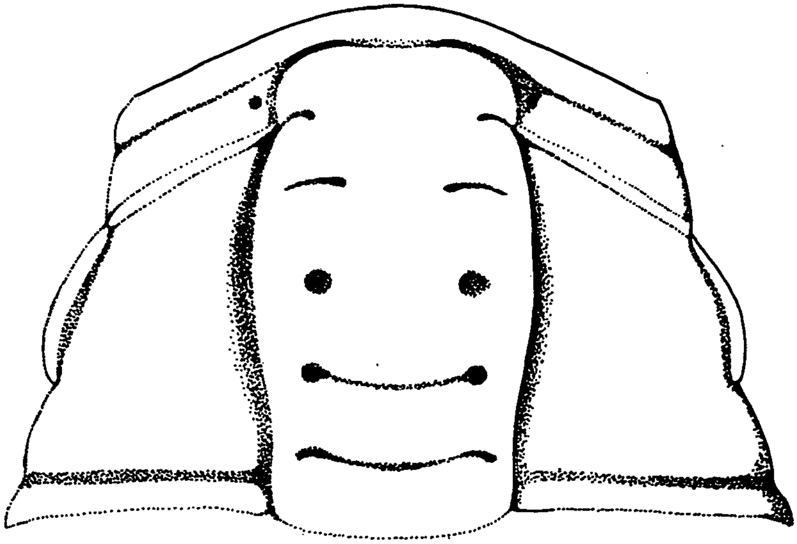
*Holotype.* The holotype (here designated) is a somewhat flattened but otherwise entire cranidium, CPC 8406, figured here Plate 5, figure 10.

*Occurrence.* The holotype was collected from pebbles on the floodplain of the Sandover River at Stokes Bore, Stokes Creek, 18.5 miles west-southwest of Georgina Downs homestead, Northern Territory (BMR collection N35). The species occurs quite commonly in these pebbles, and has been obtained from collecting points N33, N35, and N36, in the Argadargada area. It occurs also in collection N32 obtained from the Sandover River some 45 miles south-southeast of Elkedra.

*Material.* The material includes three complete or nearly complete stage 5 meraspides ranging in cephalic length (sag.) from 1.40-1.75 mm; fourteen isolated cranidia ranging in length (sag.) from 2.30 to 7.50 mm; and three disarticulated pygidia ranging in length from 3.00 to 4.00 mm.

*Diagnosis.* A species assigned to *Oryctocephalites* with characteristics intermediate between that genus and *Oryctocephalus.* S2 are represented by pits as in species of *Oryctocephalus;* S3 by short ovoid pits or furrows as in *Oryctocephalites.* Other characteristics include narrow but fairly prominent ocular ridges; pygidium with proportionately long (sag.) axis; long pleural furrows extending into the bases of the free spines; spines of subequal length; and a completely fused postaxial area, without trace of suturing.

*Description.* The anterior cranidial outline is a gentle even curve, not appreciably bowed forwards. The anterior border is rather wide (sag. and exsag.). The glabella expands forwards, is widest (tr.) at S2 and drawn in at L1 and L4. Anteriorly there is a slight sagittal depression in the contour of the frontal lobe, more pronounced in this species than in others attributed to the genus. S1 are represented by pits joined transversely by a deeply impressed connecting furrow, arching gently backwards. S2 are isolated pits or subcircular dimples, remote from the axial furrows. S3 are short isolated furrows curved gently forwards, or elongated pits impressed to a similar depth as S2. S4 are typically present, represented by short furrows, obliquely directed to the posterior and contacting the axial furrows. The glabellar lobes are of approximately equal width (exsag.).



**Text-figure 13. The cranidium of *Oryctocephalites gelasinus* sp. nov. based on the holotype CPC 8406, figured Plate 5, figure 10 [X 12].**

The occipital ring has the same transverse width as L1 and almost the same sagittal width. The occipital furrow is deepened abaxially into elongated pits but remains well defined and deep sagittally; it does not reach the axial furrows.

The eyes extend from mid L1 to mid L3 and occupy between 37 and 52 percent of the total glabellar length (sag., plus the occipital ring). They are separated from the posterior border furrow by an area of fixigena representing between 25 and 40 percent of the eye length. The ocular ridges are rather prominent, simple, narrow, and only very gently curved. They intersect the axial furrows at angles between 58° and 67°. The preocular area is subrectangular. The posterior palpebral areas are less wide (tr.) than L1, Pp occupying 67 to 94 percent (mean 81 percent) of the preoccipital glabellar width (tr.). The palpebral furrows are well defined; the palpebral lobes have prominent relief. The posterior margins of the cranidium are linear, transverse proximally (nearest the sagittal line), curving sharply into intergenal spines distally (prominent in meraspides, see Plate 5, figures 3, 7).

The librigenae have been observed only in meraspid carapaces. They are very narrow, without marked border furrows, and are extended into short, rather stout genal spines, reaching backwards to approximately the second thoracic axial ring.

The thorax (observed only in meraspides) has a cylindrical axis which, at each segment, is as wide (tr.) as the corresponding pleuron (excluding the spine). The pleural segments bear wide, deep pleural furrows running nearly parallel with the margins of the segment and passing distally into the bases of the pleural spines. The pleural spines are short and stout, derived equally from the anterior and posterior pleural bands.

The hypostome is unknown.

The pygidium is small and spinose. The axis, tapering evenly to the posterior, occupies 83 to 90 percent of the total pygidial length (sag.) and anteriorly (at the first ring) 30 to 35 percent of the maximum width (tr.). It contains five rings, separated by well defined transverse furrows, and a terminal piece which slopes backwards into the postaxial area. There are five pleural segments with strong pleural furrows directed somewhat obliquely and running into the spine bases (Text-fig. 12B). The posterior pleural bands are nearly as wide (exsag.) as the anterior bands. The interpleural furrows are strong but there is no trace of the fused fifth pair, even proximally, in the postaxial area. The pleural spines are relatively long and are all of similar length and size, the fourth pair being only slightly longer than the first three and the fifth only slightly shorter than pairs one to three. Meraspid pygidia have short spines all of approximately equal length.

TABLE 5. Parameters and proportions relating to the size and position of the eyes in *Oryctocephalites gelasinus* sp. nov.

| *O. gelasinus* | Lc mm | H:A% | A:Gn% | Pa:Pp% | Pp:L1% |
|---|---|---|---|---|---|
| CPC 8397 | 1.37 | 26.03 | 51.96 | 78.52 | 79.86 |
| CPC 8398 | 1.55 | 27.49 | 46.62 | 73.47 | 73.13 |
| CPC 8399 | 1.75 | 29.72 | 49.72 | 65.09 | 83.71 |
| CPC 8408 | 2.30 | 29.56 | 42.72 | 85.21 | 94.28 |
| CPC 8400 | 2.45 | 30.00 | 45.31 | 64.35 | 78.23 |
| CPC 8409 | 2.35 | — | — | 66.68 | 80.23 |
| CPC 8402 | — | 38.55 | — | 63.85 | 84.28 |
| CPC 8403 | 3.00 | 39.56 | 44.17 | 77.21 | 84.48 |
| CPC 8401 | 3.00 | 25.37 | 47.47 | 67.41 | 86.16 |
| CPC 8410 | 3.35 | — | — | 62.50 | 87.02 |
| CPC 8411 | 3.90 | 32.94 | — | 67.04 | 72.38 |
| CPC 8406 | 6.15 | 34.17 | 40.76 | 66.85 | 77.71 |
| CPC 8405 | 7.50 | 32.91 | 43.62 | 65.73 | 67.74 |
| Mean | | 34.76 | 44.71 | 74.53 | 81.29 |
| *O.* cf. *gelasinus* | | | | | |
| CPC 8404 | 5.44 | 44.14 | 37.45 | 70.30 | 94.84 |

*Relationships. Oryctocephalites gelasinus* sp. nov. is readily distinguished from the species *O. incertus* Tchernysheva, *O. runcinatus* sp. nov. and *O. sulcatus* sp. nov., and from *O. typicalis* Resser on account of its S2 pits. In this characteristic, however, it is comparable to *O. resseri* Rasetti. It further differs from the above-mentioned species in that the pygidium lacks trace of segmentation in the postaxial area and the pleural furrows are long and extend into the spine bases. They bisect the pleuron almost equally rather than cutting towards the margin behind the spine base to restrict the width of the posterior pleural band as it does in *O. incertus* and *O. typicalis.* While the S2 pits ally *O. gelasinus* with *O. resseri,* these species differ in the nature of the S3 furrowing. In the latter these are also represented by pits.

### ORYCTOCEPHALITES cf. GELASINUS sp. nov.

(Pl. 5, fig. 8)

A single cranidium (CPC 8404) comparable to *Oryctocephalites gelasinus* sp. nov. has been obtained from locality D135 in northwestern Queensland. The section exposed at this locality is considered by Öpik (*in* Carter & Öpik, 1963, p. 22) to be the lateral equivalent of part of the Beetle Creek Formation of the Undilla Basin.

The specimen is comparable to *O. gelasinus* in its general cranidial and glabellar shapes. S2 are represented by overdeepened pits and S3 by short curved furrows impressed to a similar depth. The ocular ridges are of equivalent prominence. Differences are observed largely in the characteristics connected with the size of the eyes. These are situated farther forward than in the specimens assigned to this species from the Northern Territory — H:A is 44 percent — and compared to the total glabellar length they are slightly smaller; A:Gn is 37 percent (Table 5). The ratio of anterior and posterior palpebral widths is comparable to the mean value obtained for *O. gelasinus,* but Pp:L1 is 95 percent and Pa:Pp is 70 percent. The cranidial surface of the Queensland specimen is granulose, unlike the smooth surfaces of the specimens classified as *O. gelasinus.* Further material is required before this specimen can be adequately interpreted.

## Subfamily ORYCTOCARINAE Hupé, 1955

### Genus SANDOVERIA nov.

*Name.* The name of this new genus is derived from that of the Sandover River of the Northern Territory. The majority of the specimens studied were derived from localities on the Sandover River 1:250,000 Geological Series Sheet.

*Type species. Sandoveria lobata* gen. nov. et sp. nov., the only species yet assigned to the genus.

*Diagnosis*. *Sandoveria* gen. nov. is distinct from other Oryctocarinae by having seven thoracic segments in holaspid morphogenetic stages in combination with the following set of diagnostic characteristics: intervening furrows set between the preoccipital glabellar furrows, S1, and the true occipital furrows; intervening lobes sited abaxially between the first glabellar lobes, L1, and the occipital ring; flattened thoracic and pygidial axial lobulae confluent with their respective pleural segments; semilunar crescentic axial rings in both thorax and pygidium; and a glabella tapering to the anterior.

*Relationships*. Suvorova (1964, p. 235) has included the following genera within the subfamily Oryctocarinae: *Oryctocara* Walcott, 1908, *Ovatoryctocara* Tchernysheva, 1962, *Oryctocarella* Tomashpolskaya & Karpinskii, 1962, and *Arthricocephalus* Bergeron, 1899. *Sandoveria* differs from all of these genera in the points set out in the diagnosis, but some account of similarities and general relationships is given below.

*Sandoveria* apart, the oryctocarinid genera possess a narrow (tr.) glabella and thoracic axis, with cylindrical shape. In *Sandoveria* the glabella is broad-based and tapers anteriorly, and the glabella and thoracic axis combined together have a spindle-shaped appearance. Weak glabellar furrows connecting with the axial furrows are probably present in species of all genera. Similarly all possess a granulation of the test as in *Sandoveria.*

In *Oryctocara geikiei* Walcott, 1908, the type species, and in *O. lata* Tchernysheva, 1952, there are eleven thoracic segments and seven pleural segments in the pygidium. In most respects these species have a high degree of correspondence. In *O. granulata* Tchernysheva, 1962, there are indications, from the notched outline of the glabella, of weak furrows connecting the axial furrows and glabellar pits. Similar weak furrows are observed also in *Ovatoryctocara ovata* Tchernysheva, 1960, but these never possess the curvature described below in *Sandoveria lobata. Ovatoryctocara ovata* has only four thoracic segments, but ten pairs of pleurae in the pygidium, which has a considerably more ovate outline than in other Oryctocarinae.

*Arthricocephalus* is similar to *Oryctocara* in its general form, but there are fewer thoracic segments. In *Arthricocephalus chauveaui* Bergeron, 1899, there are eight thoracic segments and six pairs of pygidial pleurae. The glabellar furrows are shown (Bergeron, 1899, p. 515, text-fig. 9) to be transversely continuous across the glabella and to reach the axial furrows. Chien (1961, p. 117) states that there are nine thoracic segments and five pairs of pygidial pleurae in *A. duyunensis* Chien, but his figures (op. cit. pl. 2, figs 7, 8) show the presence of only eight thoracic segments. The glabellar furrows in this species are transversely continuous but terminate before reaching the axial furrows in pits. The single species which has been referred to *Oryctocarella, O. sibirica* (Tomashpolskaya, 1960), has identical segmentation to *Arthricocephalus chauveaui,* and Suvorova (1964, p. 235) has considered the two genera to be possible synonyms (compare the figures of Tomashpolskaya, 1960, pl. 23, fig. 5, and Tomashpolskaya & Karpinskii, 1962, text-figs 1-6, with the text-figure of Bergeron, 1899).

### SANDOVERIA LOBATA gen. nov. et sp. nov.

(Pl. 10, figs 1-11; Text-figs 14, 15)

?1956 *Oryctocara* aff. *geikiei* (Walcott); Öpik, 1956b; p. 43.

*Name. Lobata,* L., lobate, swollen; referring to the convexity of the glabellar lobes and axial lobulae.

*Holotype.* The holotype (here designated) is the internal mould (with counterpart) of a nearly complete dorsal carapace, CPC 8412, illustrated here Plate 10, figures 1-4.

*Occurrence.* The holotype is from the Middle Cambrian Sandover Beds of the Argadargada district of the Northern Territory. It was collected from loose pebbles in the floodplain of the Sandover River at the 'Turn off to Stokes Bore', 9.5 miles southwest of Georgina Downs homestead (collecting station N34). Additional material has been identified in collections N33 and N35 from the same area and from collection N32, which lies some distance to the west, 45 miles south-southeast of Elkedra station.

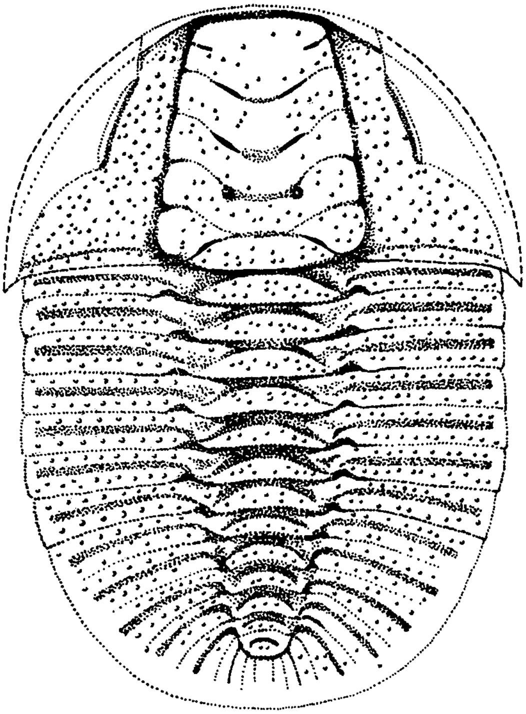
A single specimen which is definitely referable to the genus *Sandoveria* was obtained from lateral equivalents of the Sandover Beds in the Mootwingee Ranges of northwest New South Wales (CPC 8419). Preservation unfortunately forbids direct comparison with the material from the Northern Territory. A second single specimen was obtained from locality D135 in northwest Queensland. This specimen (CPC 8418) is unique in representing an enrolled individual. Unfortunately the preservation is so poor that all attempts to photograph the specimen have failed. Though enrolled the specimen has been drastically flattened so that very little comparative information can be gleaned from it. Though it belongs to the new genus *Sandoveria* its species is indeterminable.

*Material.* The material consists of five nearly complete articulated carapaces, including one meraspid with librigenae preserved; three isolated cranidia; and nine isolated pygidia. As indicated above there is one enrolled specimen of undetermined species.

Both meraspid and holaspid morphogenetic stages are represented in the collections. The smallest nearly complete individual (CPC 8414) is a stage 5 meraspid with an estimated overall length (sag.) of 3.50 mm. The largest complete specimen (CPC 8412), the holotype, has an overall length (sag.) of 6.00 mm (cephalic length 2.40 mm, thoracic length 2.20 mm, and pygidial length 1.40 mm). The largest disarticulated cranidium (CPC 8417) has a length of 3.05 mm and the length of the largest pygidium (CPC 8413) is 2.00 mm.

Selected proportions and measurements are given in Table 6.

*Diagnosis.* A species of *Sandoveria* gen. nov. with all the attributes listed under the generic diagnosis.



**Text-figure 14. A reconstruction of *Sandoveria lobata* gen. et sp. nov. based on the holotype CPC 8412, illustrated Plate 10, figures 1-4 [X 15].**

*Description.* The cephalic outline is broadly semicircular, evenly rounded, without trace of posterolateral genal spines or projections. A narrow upraised rim represents the border. It runs concentric to the margin of the cephalon and is not interrupted by the forward extension of the glabella as it is in *Oryctocara geikiei* Walcott, but is similar to the situation as observed in *Ovatoryctocara ovata* Tchernysheva. With the exception of the various furrows, the entire dorsal surface is granulose, the individual granules being distributed randomly on the glabella, genae, and pygidial and thoracic margins, but arranged in approximate transverse rows along the pleural segments and the axis of both thorax and pygidium.

The glabellar outline is broadly pear-shaped, with the maximum width (tr.) across L1 and the minimum width (tr.) across the frontal lobe. The axial furrows are gently curved and converge anteriorly at angles ranging between 12° and 26°. All the available material has to some extent been flattened so that lobar convexity cannot be accurately assessed. In addition to the normal style of oryctocarinid glabellar pitting *Sandoveria lobata* sp. nov. shows traces of furrows connecting the pits and the axial furrows. For each pair of pits there are corresponding notches along the glabellar margins where these furrows enter the axial furrows, but the confluences in each case lie somewhat in front of a transverse line joining the appropriate pairs of pits (Text-fig. 14).

S1 are represented adaxially by small, but deep, ovoid pits of *Oryctocephalus* type, frequently connected by a shallow, posteriorly curved, transverse furrow. The abaxial courses of S1 are faintly indicated by weak depressions curving strongly to the anterior, deepening adjacent to the axial furrows and joining them some way to the anterior of a transverse line connecting the S1 pits and projected to the axial furrows (Text-fig. 14). S2 are adaxially somewhat elongated ovoid pits or short grooves, posteriorly inclined to the sagittal line; their connexions to the axial furrows are invariably weakly defined but the confluence is indicated by a notching of the glabellar margin in some specimens. S3 are short grooves, similarly posteriorly directed towards the sagittal line; connected by quite clearly visible furrows to the axial furrows; strongly curved to the anterior as S1. A fourth pair of furrows is weakly impressed anterior to S3 on some specimens.

Diagnostic of *Sandoveria lobata* is the presence of intervening lobes (Text-fig. 3) lying immediately posterior to the preoccipital lobes (L1) and separated from them by well defined intervening furrows (Si) (terminology after Öpik, 1963, p. 67, text-fig. 20, *Asilluchus nanus* Öpik). The intervening furrows curve strongly to the anterior, coursing inwards and posteriorly, at their adaxial extremities joining the true occipital furrow (So), a slight depression forming sagittally at this confluence. The depression is separated (sag.) from the transverse connecting furrow of S1 by a low but slightly convex (sag.) transverse roll at the base of the median longitudinal field.

The intervening lobes are teardrop-shaped, rather strongly convex, widest distally, narrowing and pinching out adaxially, apparently sagging abaxially across the ends of the true occipital lobe. The latter is transversely wide but sagittally narrow, broadly disc-shaped, about $\frac{2}{3}$ the width (exsag.) of the occipital lobulae. The occipital furrow is shallow sagittally, deepened into elongated apodemal pits abaxially which are represented by short grooves sloping abaxially obliquely backwards, faintly connected to the axial furrows by weak lines which define also the posterior margins of the intervening lobes.

The facial suture, as in other Oryctocarinae, from the back of the eyes to the anterior border encloses narrow (tr.) subrectangular palpebral and prepalpebral areas. From the back of the eyes to the posterior border furrows the facial sutures describe shallow arcs cutting the posterior cephalic margins at angles of approximately 45°. The posterior border furrows are shallow and wide (exsag.). The preglabellar furrow is shallow and narrow (sag.). The anterior border is a narrow (sag.) upraised rim, not displaced forwards by the anterior margin of the glabella.

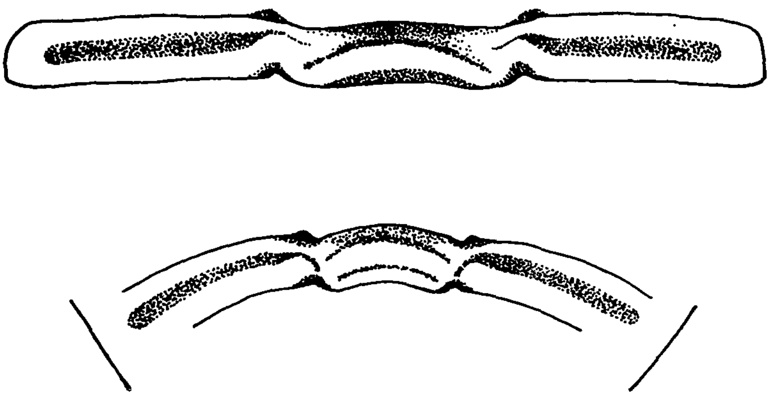
The eyes extend from the confluence of S1 to the confluence of S3 with the axial furrows, their length ranging between 40 and 52 percent of the total glabellar length (sag., plus the occipital ring). Between the back of the eyes and the posterior border furrows lies an area of fixigena equivalent to 47-64 percent of the total eye length (exsag.) (see Table 6), this distance apparently increasing during morphogenesis. The palpebral lobes are narrow (tr.) and slightly upraised above the palpebral areas. The palpebral width (tr.) remains relatively constant during morphogenesis, the anterior palpebral width (tr.) ranging between 50 and

70 percent of the posterior width (tr.). The latter dimension varies between 29 and 47 percent of the preoccipital glabellar width (tr.) and appears to decrease during morphogenesis, indicating an adaxial shift in the posterior position of the eyes with respect to the glabella.

The nature of the hypostome is unknown.

The thorax is composed of seven segments in holaspid morphogenetic stages. The pleural segments are simple, distally blade-like, but parallel-sided, divided by wide (exsag.), but shallow, pleural furrows. Anterior and posterior bands each bear a line of granulations. Strong apodemal pits notch the adaxial posterior margins of each segment at its junction with the poorly defined axial furrows. All pleural segments are of even width (exsag.), approximately one-quarter the transverse width. The axis decreases in width (tr.) evenly as far as the fifth segment thence decreases more rapidly to the posterior; it is slightly wider (tr.) for each segment than the corresponding pleuron.

The thoracic axial furrows are extremely weak, so that the pleurae merge adaxially into the axial rings. Each axial ring is characterized by the presence of a central semilunar crescent which appears to represent the ring as it is normally seen in other Oryctocephalids. This crescentic structure is flanked by shallow furrows curving from the apodemal pit on one side of the axis to that on the other, the furrows of each flank being divided by a crescentic depression lying in a sagittal position (Pl. 10, fig. 4; Text-fig. 15). The triangular areas formed on each side of the semilunar crescent are devoid of granules and pass abaxially without break into the anterior bands of the thoracic pleurae. These areas are gently convex and are reminiscent of pads or cushions. They probably represent flattened lobulae analogous to those associated with the occipital ring in other trilobites, e.g. certain Proetidae. In this paper they are termed axial lobulae. The axial lobulae are further emphasized by the adaxial terminations of the pleural



**Text-figure 15. Thoracic and pygidial segments of *Sandoveria lobata* gen. et sp. nov. A) Fifth thoracic segment. B) Second pygidial segment. X 22**

furrows, which curve into this area towards the apodemal pits. In the pygidium the pleural furrows merge into the apodemal pits. The definition of both axial semilunar crescents and axial lobulae must be largely influenced by the nature of the articulating mechanism of the ventral surface, which on flattening may be thrust through the thin dorsal shell. The presence of the mesial axial depression and the course taken by the adaxial ends of the pleural furrows indicates, however, that analogous structures must also exist on non-flattened material.

The pygidium is semicircular in outline, is wider (tr.) than long (sag.), and has an entire margin with an undifferentiated, narrow border. The axis in holaspid morphogenetic stages is composed of five well defined rings, an ill defined sixth, and a terminal piece. The axial lobulae of the thorax are found also in the pygidium, the oblique furrows flanking the axial crescents imparting to each pygidial ring a duplicated appearance, especially as these furrows tend to be as deep and as clearly defined as the transverse furrows separating the rings. The axis is relatively short (sag.), occupying 59-68 percent of the total pygidial length, and narrow (tr.), anteriorly 24-28 percent of the total pygidial width. Holaspides are characterized by six pleural segments with low convexity (tr.). Interpleural furrows are strong and wide (exsag.); those of segments one to three are evenly arched with the pleural convexity, those to the posterior swept backwards to a greater extent, the sixth lying almost parallel (exsag.) to the sagittal line. Between the sixth pair of pleural furrows an undifferentiated area is enclosed behind the axial termination.

TABLE 6. Parameters and proportions relating to the size and position of the eyes on *Sandoveria lobata* gen. et sp. nov.

| *S. lobata:* | Lc mm | H:A% | A:Gn% | Pa:Pp% | Pp:L1% |
|---|---|---|---|---|---|
| CPC 8414 | 1.45 | 47.57 | 47.43 | 68.06 | 45.57 |
| CPC 8415 | 1.45 | 49.25 | 47.19 | 59.46 | 43.27 |
| CPC 8419 | 1.60 | 59.75 | 51.87 | 66.94 | 46.65 |
| CPC 8416 | 2.00 | 51.64 | 46.77 | 70.69 | 40.84 |
| CPC 8412 | 2.40 | 64.21 | 47.97 | 49.57 | 32.66 |
| CPC 8417 | 3.05 | 54.00 | 39.66 | 68.85 | 28.98 |

## Subfamily LANCASTRIINAE Kobayashi, 1935

The subfamily Lancastriinae is certainly represented in Australia. Unhappily determination of trilobites so classified requires for examination individuals showing the complete thorax, the cranidium, and the relationships of the pygidial structures to those of the thorax. Such material is scarce, that presently at hand and that used by Whitehouse (1939) being either imperfectly preserved or consisting of disarticulated cranidia or incomplete pygo-thoraces. The following material is currently available for consideration.

Two specimens were figured by Whitehouse (1939) which may be fairly confidently referred to the Lancastriinae. They are the pygidium figured as *Paradoxides peregrinus* (Whitehouse, 1939, pp. 194-196, pl. 20, fig. 6) and the cranidium figured as *Oryctocephalus discus* (op. cit., pp. 252-253, pl. 25, fig. 15). Öpik (1956a, p. 17) has suggested that together the cranidium and the pygidium may represent a species of *Lancastria* Kobayashi. I agree that the two specimens probably represent a single species and that this is representative of a lancastriinid genus. After examination of latex casts of *Lancastria roddyi*, the type species of *Lancastria,* however, I would be inclined to consider Whitehouse's specimens as comparable to the species *Chienaspis micropyge* (Chien, 1961). The subject is considered more fully below.

In addition to Whitehouse's material there are seven specimens in the Commonwealth Palaeontological Collection, CPC 8421-8427, from the Northern Territory. The available material is discussed at length below.

*Subfamilial Diagnosis.* Oryctocephalidae with strong ocular ridges; thorax multiannular, with long pleural spines; pygidium with few segments (up to two) or represented by a variety of plate-like terminations (Text-fig. 16).

*Range of subfamily.* Lower to Middle Cambrian.

*Distribution.* North America, USSR, China, and Australia.

*Comments.* Suvorova (1964, p. 245) has listed the genera which she considers to constitute the subfamily Lancastriinae: *Lancastria* Kobayashi, 1935; *Oryctocephalops* Lermontova, 1940; *Paraoryctocephalops* Tomashpolskaya, 1960; *Oryctometopus* Tomashpolskaya, 1964 (*in* Suvorova, 1964); and *Chienaspis* Suvorova, 1964.

To these I would add *Oryctocephalina* Lermontova, 1940, a genus considered as synonymous with *Oryctocephalus* by Moore (1959) and Tchernysheva (1962, p. 22). This genus, known previously only from its cranidium, can be reinterpreted from the Australian material, from which the thorax is now known.

## Genus LANCASTRIA Kobayashi, 1935

*Type species. Olenopsis roddyi* Walcott, 1912, from the Lower Cambrian of Lancaster County, Pennsylvania, U.S.A.

### LANCASTRIA RODDYI (Walcott, 1912)

(Pl. 11, fig. 4, plaster cast)

1912 *Olenopsis roddyi;* Walcott, 1912, pp. 244-246, pl. 36, fig. 1.
1935 *Lancastria roddyi;* Kobayashi, 1935, p. 129.
1938 *Lancastria roddyi* (Walcott); Resser & Howell, 1938, pl. 10, fig. 3.
1959 *Lancastria roddyi* (Walcott); Moore, 1959, p. 0220, text-fig. 162.4.

*Type.* The somewhat distorted internal mould of a complete dorsal carapace, USNM 58363. The horizon and locality are as for the type species. The species is known from this single specimen.

*Comments.* The main characteristics of this American species are considered here to facilitate discussion of the affinities of the Australian representatives of the Lancastriinae. Its essentials are as follows: the cephalic outline is broadly semicircular, with stout genal spines. The subquadrate glabella (owing to preservation) has three pairs of grooves instead of the pitting typical of *Oryctocephalus* or the furrowing of *Oryctocephalops*. S1 are transversely connected across the glabella, but do not reach the axial furrows. S2 and S3 are grooves which again do no reach the axial furrows. S4 are linear and transverse, being represented by grooves which contact the axial furrows. There are strong ocular ridges. The eyes are small, with rather strongly curved palpebral lobes. Long thoracic pleural spines indicate the presence of nineteen thoracic segments which bear strong pleural and interpleural furrows. The pygidium is represented by a plate with an ill defined segmentation visible as a weak suture immediately posterior to the thoracic axis. The axial portion of the plate shows very weak traces of transverse furrowing. There is no pygidium in the strict sense of the term.

### Genus ORYCTOCEPHALINA Lermontova, 1940

*Type species. Oryctocephalina reticulata* Lermontova, 1940, occurring in the Middle Cambrian Amga Stage of the north Siberian Platform and the Kuznets Alatau (Batenev Range) of the USSR.

*Comments. Oryctocephalina* was considered synonymous with *Oryctocephalus* by Moore (1959, p. 0220) and by Tchernysheva (1962, p. 22). The genus has been reinstated by Kobayashi (1961, p. 224) and by Suvorova (1964, p. 234). The latter has classified it with the Oryctocephalinae.

*Species. Oryctocephalina* is considered to accommodate the following species:

*Oryctocephalina reticulata* Lermontova (1940, p. 137, pl. XLII, fig. 3, *non* figs 3a, 3b; Tchernysheva* *in* Khalfina (ed.) 1960, p. 199, pl. Sm-XXIII, fig. 4, ?fig. 2; Tchernysheva, 1962, pp. 20-22, pl. 2, figs 1-8). North Siberian Platform (Olenek River area) and the Kuznets Alatau (Batenev Range), Siberia, USSR.

*Oryctocephalina maladensis* (Resser) (syn. *Oryctocephalus maladensis* Resser, 1939b, p. 45, pl. 3, figs 8, 9, *non* fig. 7). Langston Limestone, Wasatch Mountains, Idaho, U.S.A.

*Oryctocephalina limbata* (Tchernysheva) (syn. *Oryctocephalus limbatus* Tchernysheva, 1962, pp. 22-24, pl. 2, figs 11, 12). North Siberian Platform (Olenek River area), Siberia, USSR.

*Oryctocephalina* sp. (syn. *Oryctocephalus* sp. indet. *No. 1,* Rasetti, 1951, p. 193, pl. 9, fig. 24). Mount Whyte Formation, *Wenkchemia-Stephenaspis* Zone, Mount Stephen, British Columbia, Canada.

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* As there are no indications to the contrary, Tchernysheva is presumed to be responsible for the section on Oryctocephalids in this treatise.

*Oryctocephalina lancastrioides* sp. nov. (below Pl. 11, figs 1-3, 5; Pl. 12, figs 1-4). Sandover Beds, Northern Territory, Central Australia.

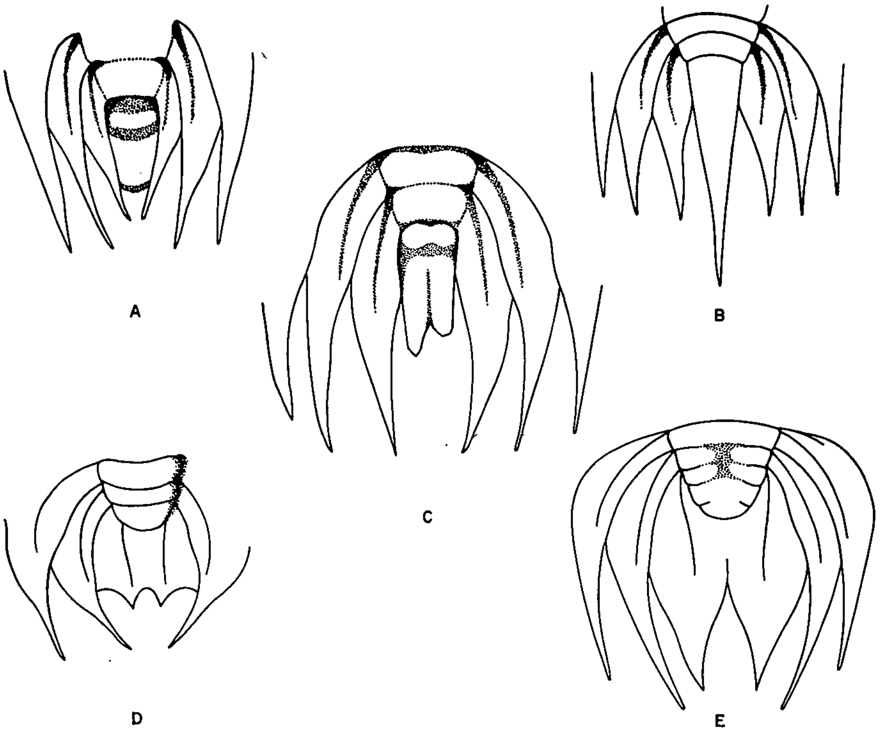
*Diagnosis.* A full diagnosis of *Oryctocephalina,* which has not previously been given, is as follows.

Diagnostic features of the cephalon lie in the nature of the axial furrows bounding the glabella. These are sinuous; drawn in (notched) at the levels mid L1, mid L2, mid L3 and mid L4 and expanded slightly outwards at the corresponding furrows. The ocular ridges are strongly defined and often duplicated. The eyes are proportionately small. The palpebral lobes are strongly curved; and the anterior palpebral areas nearly as wide (tr.) as the posterior palpebral areas. The thorax is multiannular with probably seventeen segments (although this number is not definitely established), each with strongly spined pleurae. There is no sharp line of demarcation between thorax and pygidium and it is difficult to assess where one ends and the other begins. The terminal, postaxial segment is here considered to constitute the pygidium. This is proximally fused but has free distal endings; it bears strong pleural furrows.

*Relationships. Oryctocephalina* is most closely related to *Lancastria.* Although the number of thoracic segments is not definitely established there are at least seventeen in *Oryctocephalina lancastrioides* sp. nov. (see below). In *Lancastria roddyi* (Walcott) there are nineteen thoracic segments. In both genera the pygidium is confined to a single postaxial segment. They are differentiated, however, in the nature of this segment, which in *L. roddyi* is represented by a fused plate and in *O. lancastrioides* by a pair of pleurae, similar to those of the thorax, which are only proximally fused. The glabellar segmentation in *L. roddyi* is certainly affected by compression but it seems likely that the lobes were originally separated by pits rather than by furrows and in this respect would be comparable to the situation in *Oryctocephalina.*

It is in the pitted nature of the glabella segmentation that cranidia of *Oryctocephalina* may be distinguished from those of *Oryctocephalops, Oryctometopus, Paraoryctocephalops, Chienaspis,* and *Cheiruroides,* for in these genera there are well defined glabellar furrows. It is because of the presence of glabellar pits that *Oryctocephalina* has previously been confused with *Oryctocephalus* and classified with the Oryctocephalinae.

*Oryctocephalina* has more thoracic segments than *Oryctocephalops* (with 12 segments), *Chienaspis* (14), and *Cheiruroides* (12-15), but fewer than *Lancastria* (19). The postaxial pygidial segment of *Oryctocephalina* is similar in structure to that of *Oryctocephalops,* but the free distal ends of the pleural spines are longer and the line of fusion (sag.) between the pleurae is still faintly visible, at least distally. In *Oryctocephalops* the postaxial pleurae are sagittally completely fused (according to the reconstruction of Suvorova, 1964, p. 248, text-fig. 73). In *Chienaspis* the pygidium 'is very small, extending posteriorly into a long and slender spine' (Chien, 1961, p. 119). In this respect it differs from other lancastriinid genera though it is possible that this structure has been derived from the pygidial plate observed in *Lancastria.* (The postaxial segmentation of lancastriinid genera is compared in Text-fig. 16.)



**Text-figure 16. A comparison of the pygidial terminations of lancastriinid genera. A)** *Lancastria roddyi* **(Walcott, 1912) based on the holotype, USNM 58363. B)** *Chienaspis micropyge* **(Chien, 1961) after Chien, 1961, text-fig. 1. C)** *?Chienaspis peregrina* **(Whitehouse, 1939) redrawn from Whitehouse, pl. 20, fig. 6. D)** *Oryctocephalops frischenfeldi* **Lermontova, 1940, drawn from Suvorova, 1964, p. 248, text-fig. 73. E)** *Oryctocephalina lancastrioides* **sp. nov. based on specimen CPC 8424.**

## ORYCTOCEPHALINA LANCASTRIOIDES sp. nov.

(Pl. 11, figs 1-3, 5; Pl. 12, figs 1-4; Text-fig. 17)

*Name.* Compounded from the generic nomen *Lancastria* (after Lancaster County, Pennsylvania, U.S.A.) and the suffix-*oides,* Gk, similar or comparable. The name refers to the similarity of the thorax of this species to that in *Lancastria roddyi.*

*Holotype.* The holotype (here designated) is the nearly complete internal mould of a dorsal exoskeleton on which have been impressed the outlines of the ventral cephalic doublure and hypostome, CPC 8421, figured here Plate 11, figures 1, 5; Plate 12, figure 4.

*Occurrence.* The holotype was collected from a small outlier of Middle Cambrian Sandover Beds, 4.5 miles northeast of Supplejack Bore, Elkedra station, Northern Territory (collection NT32). Additional material has been obtained from whitish or pale yellow, thickly bedded siltstone outcropping adjacent to the creek crossing 37 miles west of the 'Ooratippra turn off', Elkedra (BMR collection N32).

*Material.* The material consists of the nearly complete specimen designated above as the holotype, CPC 8421; four disarticulated cranidia, CPC 8422, 8423, 8425, 8426; and two incomplete pygo-thoraces, CPC 8424, 8427. On the available material cranidial lengths range between 2.75 and 7.25 mm.

*Diagnosis.* The diagnosis and following description are compounded from all the available material.

The cranidium has a relatively narrow (tr.) glabella defined by sinuous axial furrows. The palpebral lobes are rather strongly curved, resulting in the near equivalence of the widths (tr.) of the anterior and posterior palpebral areas. The ocular ridges are prominent and duplicated; the preocular areas wide and subrectangular. There are at least seventeen thoracic segments, with stout pleural spines, and a single postaxial pygidial segment with pleurae proximally fused, distally free-ending, similar to the thoracic pleurae.

*Description.* The cephalon is broadly semicircular in outline, with stout genal spines extending backwards to the level of the sixth axial transverse connecting furrow of the thorax. A finely granulose surface is faintly discernible on the latex casts of some specimens.

The glabella, about one-third as wide (tr.) as the maximum cranidial width (tr.), is long and narrow (tr.), subquadrate in general outline but slightly wider (tr.) at the base. The confining axial furrows are sinuous, curving gently inwards at mid L1, mid L2, mid L3, and mid L4, and gently outwards at the levels of the respective furrows, the resultant notching of the axial furrows being related to an ancestral pattern of glabellar furrowing (some trace of this may be vaguely discerned on the cranidium CPC 8422, pl. 11, fig. 2). The original furrows would appear to have curved inwards and backwards from the notches along the axial furrows adjacent to the middle of each preceding lobe to terminate at the apodemal pits. The glabellar pits S1, S2, S3 are small oval dimples. S4 are short linear grooves, directed slightly posteriorly to the axial furrows. All pits are remote from the axial furrows, including S4. S1 pits are faintly connected by a transverse furrow.

The occipital furrow curves very gently backwards in its mesial section to terminate laterally in groove-like pits which do not reach the axial furrows. The occipital ring is transversely as wide as L1, half as wide sagittally. It is divided into poorly defined lateral lobes in some specimens by exsagittal furrows running directly backwards from the terminal apodemal pits of the occipital furrow.

In the holotype the ventral doublure has been impressed on to the dorsal surface of the cephalon. This widens towards the genal spines and is narrowest anterolaterally. The outline of the hypostome is similarly impressed and seems to be comparable to that of *Oryctocephalus,* but no structures are clearly visible

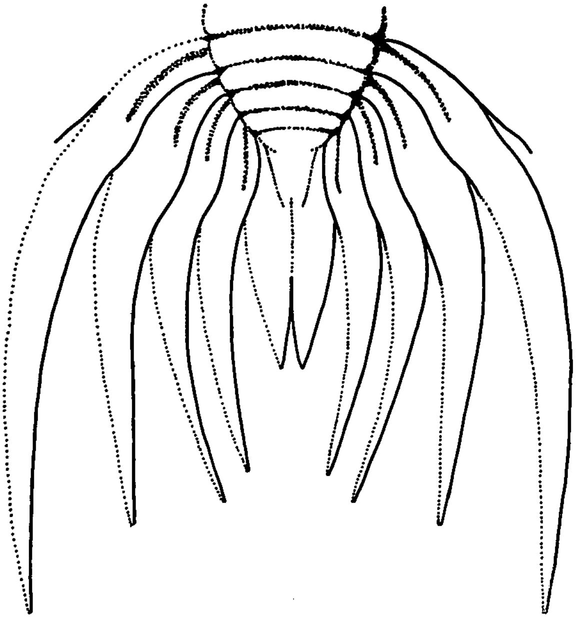
The palpebral lobes are prominent; the palpebral furrows shallow. The ocular ridges are strongly defined, duplicated by a very faint dividing line running mesially along the centres of the ridges. Several olenid trilobites also possess this characteristic. The anterior palpebral width (tr.), on the specimens measured, is between 82 and 93 percent of the posterior width. The latter is 75-90 percent (tr.) of the glabellar width at L1. The eyes are moderately long, attaining 39-54 percent of the glabellar length (plus the occipital ring) and are separated from the posterior border furrows by areas of fixigena amounting to 20-40 percent of the total eye length. The postocular sections of the facial suture reach posterolaterally nearly to the genal spines. The posterior cranidial margins are linear, oblique posterolaterally; the posterior border furrows run parallel to the posterior margins.

Seventeen thoracic segments can be counted on the holotype. The thoracic axis is almost spindle-shaped, tapering gently backwards; it is widest (tr.) at rings 3-6; as wide (tr.) as the furrowed parts of the thoracic pleurae. The outlines of the articulating half rings are frequently impressed on the dorsal surface. The pleurae have strong interpleural furrows and even stronger pleural furrows cutting obliquely across each pleuron posteriorly towards the spine base, gradually reducing the width (exsag.) of the posterior pleural bands. The interpleural furrows curve anteriorly at their distal ends, thence curve outwards and slightly backwards. The pleural spines are wide-based and stout, as long as the width (tr.) of the furrowed part of the pleuron, extending outwards and backwards so that the periphery of the exoskeleton assumes an oval outline.

The pygidium (Text-fig. 17) is difficult to differentiate from the thorax. It is composed of two axial rings, together with a terminal piece, and a single pair of pleurae. The axial rings are node-like, being mesially interrupted. The pleural segment is similar to those of the thoracic segments but the pleurae are wider (exsag.), lanceolate, and terminate in more massive, but shorter, spines. Sagittally, where the pleurae come together behind the axis a line of fusion is visible distally but is obliterated proximally. The pleurae bear well defined pleural furrows which extend into the bases of the spines.

*Relationships. Oryctocephalina lancastrioides* sp. nov. has cephalic features in common with *O. reticulata* Lermontova, 1940. As the thorax and pygidium of the latter are not known the Australian species has been named differently. It is distinguished by its wider (tr.) palpebral areas, smaller eyes and less well developed transverse glabellar furrowing from *O. maladensis* (Resser, 1939).

The cephalon of *O. lancastrioides* sp. nov. and *Lancastria roddyi* (Walcott, 1912) have a similar overall shape, strong ocular ridges, and relatively strongly curved palpebral lobes. *L. roddyi,* however, has a greater number of thoracic segments and its pygidium is restricted to a small oval plate with rounded posterior margin. It is not pointed or falciform as shown by Hupé (1953, p. 77, text-fig. 55).



**Text-figure 17. A reconstruction of the posterior thoracic segments and pygidial termination of *Oryctocephalina lancastrioides* sp. nov. based on specimen CPC 8424, illustrated Plate 12, Figs 1, 2 [X 11].**

In its pygidial structures *Oryctocephalina lancastrioides* may be compared to *Oryctocephalops frischenfeldi* Lermontova (1940, p. 137, pl. XLII, figs 1a-c; Tchernysheva, 1962, pp. 44-46, pl. 3, figs 13-14; Suvorova, 1964, pp. 247-252, text-fig. 73, pl. 28, figs 1-11, pl. 29, figs 1-7). In the latter there is no trace of fusion at the coalescence of the postaxial pleurae and the spines of this segment are considerably shorter. Two pleural segments are ascribed to *O. frischenfeldi,* but as in *Oryctocephalina* the definition of a pygidium in the strict sense of the term is largely subjective.

### Genus CHIENASPIS Suvorova, 1964

*Type species. Changaspis micropyge* Chien, 1961, p. 98 (Chinese), 118-119 (English), text-fig. 1 (p. 98), pl. 2, figs 11-13; from the Balang Shale, Balang, 15 km east of Duyun, Kweichow, China.

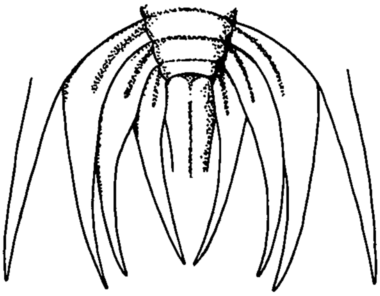
### ?CHIENASPIS PEREGRINA (Whitehouse, 1939), new combination

(Text-fig. 18)

1939 *Paradoxides peregrinus* Whitehouse, 1939, pp. 194-196, pl. 20, fig. 6.
1939 *Oryctocephalus discus* Whitehouse, 1939, pp. 252-253, pl. 25, fig. 15.
1956 *Paradoxides peregrinus* Whitehouse; Öpik, 1956a; p. 17.

*Holotype.* The holotype (designated the holotype of *Paradoxides peregrinus* by

Whitehouse, 1939, p. 196) is the pygidium with attached thoracic segments figured by Whitehouse, pl. 20, fig. 6. This specimen, F3316, is in the collections of the Department of Geology, University of Queensland. Whitehouse (p. 194) gives the horizon and locality as Middle Cambrian, *Dinesus* Stage, Templeton River, Queensland, but there is apparently some confusion over the exact locality (p. 194, footnote 15).



**Text-figure 18. A reconstruction of the posterior thoracic segments and pygidial termination of** *?Chienaspis peregrina* **(Whitehouse, 1939) based on the holotype, Qld Univ. Coll. F3316, figured Whitehouse, 1939, pl. 20, fig. 6 [X 5].**

*Comments.* I have referred Whitehouse's specimens to *Chienaspis* because of the pygidial similarities between *Paradoxides peregrinus* and *Chienaspis micropyge* (Chien). *Chienaspis* is the only oryctocephalid genus in which there is a post-axial terminal spine similar to that described by Whitehouse. The assignment is, however, questionable, for the type specimen shows what appears to be a line of suturing along the length of the spine (or what remains of it) and it may represent two fused pleurae. As the distal extremity is broken off the exact nature of the termination cannot be assessed.

The cranidium figured by Whitehouse as *Oryctocephalus discus* and the pygidium discussed above have been considered by Öpik (1956a, p. 17) to represent a single species of *Lancastria.* The cranidium is certainly that of an oryctocephalid trilobite. The presence of distinct and long furrows rather than pits, the strong ocular ridges, and the subquadrate glabella suggest classification with either *Oryctocephalops* or *Chienaspis.* In view of the characteristics shown by the pygidium Öpik's suggestion is followed and the cranidium and pygidium are considered together, but as a species of *Chienaspis* and not *Lancastria.*

## Subfamily CHEIRUROIDINAE Suvorova, 1964

The subfamily Cheiruroidinae is only sparsely represented in the collections studied: only two cranidia referable to it are known to date. Both are placed in the subgenus *Cheiruroides* (*Cheiruroides*) Kobayashi, 1935.

*Diagnosis.* 'Glabella with slotted furrows. Palpebral lobes of medium size. Ocular ridges clearly defined. Posterior branches of the facial sutures of medium length, slightly diverging. Genal angles rounded. Genal spines absent. 10-14 thoracic segments with blunted pleural tips. Pygidium very small with only a small number of segments, one or a few more. Pygidial margins entire, without spines.' (Suvorova, 1964, p. 256, trans. F. Kousal.)

*Range.* Middle Cambrian. In Tuva, in Manchuria, and in North Korea the subfamily is represented in beds which have been assigned to the Lower Cambrian. In the last two areas occurrences are associated with *Redlichia.* Öpik (1968) would regard these beds as representing his Ordian Stage, which he considers to be of basal Middle Cambrian age.

*Distribution.* Australia, Manchuria, North Korea, USSR (Tuva; north and east of the Siberian platform; eastern Sayan Uplands, R. Uyar; Kuznets Altai, Sukhie Solontsy).

*Comments.* Suvorova (1964, p. 257) has included in the Cheiruroidinae *Cheiruroides (Cheiruroides)* Kobayashi, 1935, and *Cheiruroides (Inicanella)* Lazarenko, 1960. *Paleooryctocephalus* Repina (1964, pp. 308-309, pl. 48, fig. 11) should probably also be classified with the Cheiruroidinae. It has a similar glabellar outline to that of *Cheiruroides (Inicanella)*; the eyes are of similar size and are similarly placed on the genae. The glabellar furrows are, however, adaxially pitted and only S1 connects with the axial furrows. There is no transverse furrow connecting the S1 pits.

### Genus CHEIRUROIDES Kobayashi, 1935

### Subgenus CHEIRUROIDES Kobayashi, 1935

*Type species. Atops orientalis* Resser & Endo, 1937, from the Middle Cambrian (sensu Öpik, 1968), *Redlichia* Shales, Misaki, Misakiyama, Manchuria.

*Other species and their distribution*

*Cheiruroides (Cheiruroides) primigenia* (Saito, 1934, pp. 232-233, pl. 25, figs 26-29). Middle Cambrian (sensu Öpik, 1968), lower *Redlichia* Shales, various localities, northwest Korea.

*C. (C.) maslovi* Pokrovskaya, 1959, pp. 126-129, pl. 9, figs 10-12. Lena Stage (transition to Middle Cambrian sensu Pokrovskaya, 1959; Middle Cambrian sensu Öpik, 1968), eastern Tannu-Ola mountain range, upper reaches of the Shivelik-Khem River, Tuva, USSR.

*C. (C.) arctica* Tchernysheva, 1962, pp. 48-51, pl. 6, figs 1-8. Middle Cambrian, Amga Stage, middle reaches of the Olenek River, North Siberian Platform, USSR.

*C. (C.) fortis* Suvorova, 1964, pp. 262-263, pl. 30, fig. 16. Middle Cambrian, Amga Stage, middle reaches of the Olenek River, North Siberian Platform, USSR.

*C. (C.) succincta* sp. nov. (Pl. 7, figs 5-7). Middle Cambrian, Sandover Beds, Northern Territory, Australia.

### CHEIRUROIDES (CHEIRUROIDES) SUCCINCTA sp. nov.

(Pl. 7, figs 5-7)

*Name. Succincta,* L., short, brief, concise; referring to the brevity of the glabellar furrows S2 and S3.

*Holotype.* The holotype (here designated) is the cranidial internal mould CPC 8428, figured Plate 7, figures 5, 6.

*Occurrence.* Middle Cambrian Sandover Beds, locality NT63, 30 miles due south of Elkedra station, Northern Territory.

*Material.* The species is described from two cranidia found in Bureau of Mineral Resources collections N33 and NT63. The holotype, CPC 8428, is preserved as an internal mould in leached, iron-stained, friable shale. It has a cranidial length (sag.) of approximately 2.65 mm. The second specimen, CPC 8429, is preserved with its shell in a compact orange or yellow-brown weathered siltstone. This specimen attains an estimated length of 2.35 mm.

*Diagnosis.* A species of *Cheiruroides* (*Cheiruroides*) with small eyes; obtusely rounded frontal lobe; axial furrows expanding outwards at L2 and L3, drawn in at L1 and S3; posterior cranidial margin posteriorly curved; short glabellar furrows not confluent with the axial furrows; weak ocular ridges.

*Description.* The cranidial outline is anteriorly rounded. The anterior border is narrow (sag.), upturned; the glabella does not appreciably break the course of the border rim. The surface of the shell is smooth.

The glabella is obtusely rounded anteriorly, moderately convex (tr. and sag.). The axial furrows curve outwards at L2 and L3, inwards at L1 and S3. S1 are abaxially grooved and connected by a backwards-arching transverse furrow which does not reach the axial furrows.

S2 are represented by short linear transverse grooves, deepened adaxially, but not reaching the axial furrows. S3 are as S2 but slightly longer, reaching nearly to the axial furrows. S4 are very faint. The glabellar lobes L1 are one-third as wide (exsag.) as L2; L2 are equally as wide (exsag.) as L3.

The occipital ring is narrow (sag.), one-half as wide (exsag.) as L1 but of equal transverse width. The occipital furrow is also narrow (sag.), adaxially deepened and reaching the axial furrows on the specimens at hand — but this may be the result of preservation.

The fixigenae are convex (tr.) with strongly curved posterior margins. The posterior borders are narrow (exsag.); the posterior border furrows deep and narrow (exsag.). The palpebral lobes are poorly preserved, but the eyes appear to have been small, extending from mid L2 to the anterior of L3 (CPC 8428) or from S1 to mid L3 (CPC 8429). The palpebral areas are narrow (tr.), distorted on CPC 8429. On CPC 8428 the anterior palpebral width (tr.) is approximately 68 percent of the posterior width, and the latter attains 80 percent of the preoccipital glabellar width (tr.). The distance between the back of the eyes and the posterior border furrows amounts to an estimated 70 percent of the total eye length (exsag.). The ocular ridges are extremely poorly defined.
*Relationship.* The less pronounced glabellar furrows and the brevity of S1 in particular distinguish *Cheiruroides* (*Cheiruroides*) *succincta* sp. nov. from *C.* (*C.*) *primigenia* (Saito, 1934). The posterior cranidial margins of the latter are less strongly curved. The eyes, however, are of similar size and are placed similarly on the genae.

*C.* (*C.*) *orientalis* (Resser & Endo, 1937) differs in its glabellar shape, which is subquadrate, very nearly parallel-sided, rather than ovoid and inflated. It has longer glabellar furrows, with S1 connecting with the axial furrows.

*C.* (*C.*) *arctica* Tchernysheva, 1962, has a similar glabellar shape and furrows of similar orientation to those of *C.* (*C.*) *succincta,* but all the furrows are confluent with the axial furrows. In addition *C.* (*C.*) *arctica* displays prominent ocular ridges. *C.* (*C.*) *fortis* Suvorova, 1964, is characterized by a very strong convexity (tr. and sag.). All the glabellar furrows reach the axial furrows and S1 has an exceptionally strong mesial curvature to the posterior.

*C.* (*C.*) *maslovi* Pokrovskaya, 1959, has a similar glabellar shape to that of *C.* (*C.*) *succincta,* but again the furrows are longer and S1 reaches the axial furrows.

## Subfamily TONKINELLINAE Reed, 1934

According to Suvorova (1964), whose classification is followed here, the Tonkinellinae embrace only the single genus *Tonkinella* Mansuy, 1916. Although there is no direct evidence for the occurrence of this widespread genus in the collections studied, there is a small collection of cranidia from Dingo Creek, Queensland, which is regarded as representing the subfamily in Australia. The characteristics of these are in the main distinct from those of *Tonkinella,* but the shape of the glabella indicates a fairly close relationship. As these specimens cannot satisfactorily be accommodated within existing oryctocephalid genera a new one, *Barklyella,* has been erected for them. The new genus is based solely on cranidial characteristics and it may be found, when the pygidium is eventually known, that *Barklyella* should be classified elsewhere. The new genus appears to occur only in northwest Queensland.

The Tonkinellinae have been diagnosed by Hupé (1955, p. 112) and Suvorova (1964, p. 245). The subfamily is known only from the Middle Cambrian, but at this level has an extremely wide distribution. Species of *Tonkinella* have been reported from North Vietnam, China, North Korea, Kashmir, USSR (Sayan uplands, Baikal mining area, Vitim Plateau (according to Suvorova, 1964, p. 245), north Siberian Platform), USA (Idaho, Alabama), and Canada. The new genus *Barklyella* occurs in Australia.

### Genus BARKLYELLA nov.

*Type species. Barklyella expansa* gen. nov. et sp. nov., Middle Cambrian Beetle Creek Formation, *Dinesus-Xystridura* fauna, Dingo Creek, northwest Queensland.

*Name.* The genus is named from the topographical region known as the Barkly Tableland, which extends from Queensland in the vicinity of Camooweal northwestwards into the Northern Territory.

*Diagnosis.* Tonkinellinae with characteristics intermediate between *Tonkinella* and *Oryctocephalites.* The glabella expands forwards as in *Tonkinella* but is narrower (tr.). S2 are represented by ovoid pits or short grooves; S3 by grooves, pitted at their inner ends, running obliquely in a posterolateral direction and joining the axial furrows. The ocular ridges are prominent, intersecting the axial furrows at low angles. The posterior palpebral areas are proportionately wide (tr.).

*Relationships.* As indicated in the diagnosis *Barklyella* occupies a morphological position intermediate between *Tonkinella* and *Oryctocephalites.* It has the narrow (tr.) glabella, rapidly expanding forwards, characteristic of *Tonkinella,* but is differentiated from this genus by its strongly developed ocular ridges, inclined sharply posterolaterally. It possesses a pattern of glabellar furrowing similar to that of *Oryctocephalites* in that there are preoccipital (S1) pits joined by a posteriorly curved transverse furrow (which may or may not reach the axial furrows) and ovoid median lateral (S2) pits or short grooves isolated from the axial furrows. The S3 furrows are somewhat different from those of *Oryctocephalites,* being well developed grooves or furrows sloping abaxially in a posterior direction and contacting the axial furrows.

### BARKLYELLA EXPANSA sp. nov.

(Pl. 4, figs 5-9)

*Name. Expansa,* L., expanded; referring to the anteriorly expanded glabella.

*Holotype.* The holotype (here designated) is the nearly complete cranidial internal mould, CPC 8433, figured on Plate 4, figure 7.

*Occurrence.* All the known material is from the single locality in Dingo Creek (M267), northwest Queensland. It is from the Beetle Creek Formation.

*Material.* Seven cranidia, all preserved as internal moulds, CPC 8430-8436, are referred to this species. The pygidium is unknown. Three of the cranidia are meraspides. They range in length (sag.) from approximately 0.90 to 1.95 mm. The four holaspid cranidia range in length (sag.) from 2.55 to 4.05 mm.

*Diagnosis.* A species of *Barklyella* gen. nov. with the following combination of characteristics: granular test; preoccipital glabellar furrows not confluent with axial furrows in holaspid morphogenetic stages; axial furrows drawn in at L1 and S3, expanded slightly outwards at S2 and considerably so at the lateral margins of the frontal lobe; ocular ridges intersecting the axial furrows at angles of approximately 55°.

*Description.* The cranidial outline arches forwards with anterior and anterolateral borders as in *Oryctocephalites* spp. The glabella has an anteriorly rounded frontal lobe, with often a sagittal depression in its anterior contour. It is subconical in shape, expanding forwards, defined by axial furrows drawn in at L1 and S3, curving outwards at L2 and L3. S1 are represented by pits connected by a shallow, transverse furrow arching mesially backwards. S2 are pits or short ovoid grooves, isolated from the axial furrows. S3 are short grooves or furrows sloping abaxially backwards, pitted adaxially, confluent with the axial furrows. S4 are short, faintly discernible, lying approximately half-way along the length of the frontal lobe, sloping posteriorly with its convexity to the axial furrows.

The occipital ring is wider (tr.) than L1, and about one-third as wide (sag.). The occipital furrow is abaxially pitted, not reaching the axial furrows.

The eyes extend from S1 to the anterior one-third of L3 and occupy about 45 percent of the glabellar length (Gn). They are subcrescentic in plan, with prominent palpebral lobes and furrows. They are separated from the posterior border furrow by an area of fixigena amounting to about 30 percent of the total eye length (exsag.). The ocular ridges are prominent, intersecting the axial furrows at angles up to 55° near the level of S4. The preocular areas are rectangular and rather wide (exsag.). The anterior palpebral width (tr.) is about two-thirds the posterior width, which itself is as wide as the preoccipital glabellar width (tr.), Pp:L1, 90-100 percent. The posterior margins of the cranidium are linear or very gently curved forwards; short intergenal spines may be present.

The surface of moulds is granulose, especially in meraspides.

*Relationships. Barklyella expansa* gen. nov. et sp. nov. is related to species of *Tonkinella* in its anteriorly expanded glabella. Among these comparison may be made with that cranidium figured by Tchernysheva (1962, pl. 3, fig. 1) as *Tonkinella valida.* This has a comparable anterior cranidial outline, similarly placed eyes, and ocular ridges of like prominence and orientation. It differs in its completely transverse preoccipital furrow, which joins the axial furrows (although a comparable furrow is observed in meraspid stages of *Barklyella expansa*), proportionately narrower (tr.) glabella, and axial furrows curving inwards at L2 and L3 rather than expanding outwards, although this characteristic may depend largely on preservation.

# INDEX OF LOCALITIES

As Öpik (1961, p. 179) has remarked, the term locality has several meanings, which are apparent from the descriptions given below. Information has been largely extracted from the personal filing cards of A. A. Öpik (mentioned in Öpik, loc. cit., p. 179). For each locality the 1:250,000 Geological Series Sheet, geographical co-ordinates, rock types, and stratigraphical unit are given, and the contained oryctocephalid fauna listed.

D135 Duchess Sheet F54/6. Latitude 21° 57′S, longitude 139° 58′E. A low scrubby rise 0.5 mile west of No. 33 Bore (Noranside), west of Ibis Creek. The number refers to a collecting site rather than to a definite position. Middle Cambrian, Beetle Creek Formation, consisting of siliceous shale with chert layers and sandy interbeds (for further details see Öpik *in* Carter & Öpik, 1963, p. 22).

*Oryctocephalites* cf. *gelasinus* sp. nov. and *Sandoveria* gen. nov. sp. indet.

E6 Elkedra Sheet SF53/7. Latitude 21° 44′S, longitude 135° 46′E. Australian National Grid Reference 3725, 2863. Middle Cambrian, Sandover Beds. An exposure in thin-bedded white micaceous siltstone on Bullock Creek, 1 mile north-northeast of its confluence with the Sandover River, 7.5 miles east-northeast of No. 12 Bore. Undulating topography rising to 1300 feet with low heavily dissected hills.

*Oryctocephalus reynoldsi* Reed, 1899.

E16 Elkedra Sheet SF53/7. Latitude 21° 36′S, longitude 135° 26′E. Australian National Grid Reference 3350, 3030. Middle Cambrian, Sandover Beds. White-buff well bedded 'slabby' moderately indurated siltstone in a small incised creek bed, east of the main limestone outcrop, immediately west of Cherry Creek, 0.7 mile northeast of Amaroo No. 1 Bore.

*Oryctocephalus reynoldsi* Reed, 1899.

H47 Huckitta Sheet SF53/11. Latitude 22° 36.5′S, longitude 135° 55.5′E, Middle Cambrian, Arthur Creek Beds (Smith, 1963, pp. 9-10). Laminated yellow-brown siltstone projects through scree material on the north slope of a rise on the Imopunga Ridge, 26 miles west-southwest of Lucy Creek homestead, 1.2 miles south of Arthur Creek.

*Oryctocephalus reynoldsi* Reed, 1899.

H48 Huckitta Sheet SF53/11. Approximately the same reference as for H47. Middle Cambrian, Arthur Creek Beds. Low and discontinuous outcrops of finely laminated yellow-brown siltstone, 80 yards north of the foot of Imopunga Ridge.

*Oryctocephalus reynoldsi* Reed, 1899.

M267 Camooweal Sheet E54/13. Latitude 19° 55.5′S, longitude 138° 59′E, Middle Cambrian, Beetle Creek Formation. Fossils were collected from a sequence of shale with chert layers in Dingo Creek, near the track crossing from Yelvertoft Dip to Paradise Creek mining fields, and from loose material on the bank of the creek.

*Oryctocephalites sulcatus* sp. nov.; *Barklyella expansa* gen. nov. et sp. nov.

N24 The exact location is uncertain. The number refers to the 'Old Well' of Brown (1895, p. 24), Öpik (1956b, p. 40), and Smith & Roberts (1963, p. 11). Brown gives the locality as 5 miles north of Alexandria homestead; while Öpik (op. cit.) places it 7 miles to the northwest. The unofficial reference card system of Öpik quotes the locality as being approximately 10 miles north to northeast from Alexandria, travelling along tracks and fences. The well is shown on no map of the area and aerial photographs were not available to Öpik at the time of his collecting there. The well must lie near the junction of the Ranken and Mount Drummond Sheets, immediately north of Alexandria homestead. The well was noted by Etheridge (1896, p. 13), who gave a geographical reference pertaining to the homestead, which is actually some distance from it to the south. The reference of Whitehouse (1939, p. 270) is that of the homestead. The well, sited on sandy, scrubby, lateritic desert, was bored to 200 feet. Below 120 feet sandstone assessed as Precambrian was encountered. The Cambrian consists of shaly micaceous siliceous to calcareous bluish siltstone with chert layers, and soft brown siltstone.

*Oryctocephalus alexandriensis* sp. nov.

N25 Ranken Sheet SF53/16. Middle Cambrian, Burton Beds (Smith & Roberts, 1963, p. 11), consisting of brown silicified shale fragments, found ex situ up to 3 miles northwest of Alexandria homestead, north of the Playford River, on the track to Brunette Downs.

*Oryctocephalus reynoldsi* Reed, 1899.

N32 Elkedra Sheet SF53/7. Latitude 21° 43′S, longitude 135° 43′E. Australian National Grid Reference 3590, 2870. Middle Cambrian, Sandover Beds. Exposures in white or buff laminated siltstone weathering yellow-brown, at the creek crossing, Argamara Creek, 34.9 miles west of the Ooratippra turn-off.

*Oryctocephalus reynoldsi* Reed, 1899, *Oryctocephalites runcinatus* sp. nov., *Oryctocephalites gelasinus* sp. nov., *Sandoveria lobata* gen. nov. et sp. nov., and *Oryctocephalina lancastrioides* sp. nov.

N33 Sandover River Sheet SF53/8. Latitude 21° 31′S, longitude 136° 51.5′E. Middle Cambrian, Sandover Beds, ex situ pebbles collected from the flood plain of the Sandover River, 6.3 miles west of Argadargada waterhole. Predominant rock types are yellow-brown or buff siltstone, and reddish to purple-hearted siliceous siltstone. The derivation of the pebbles is discussed in the text (p. 29).

*Oryctocephalus reynoldsi* Reed, 1899, *Oryctocephalites gelasinus* sp. nov., *Oryctocephalites runcinatus* sp. nov., *Sandoveria lobata* gen. nov. et. sp. nov., *Cheiruroides (Cheiruroides) succincta* sp. nov.

N34 Sandover River Sheet SF53/8. Latitude 21° 11′S, longitude 137° 31.5′E. Middle Cambrian, Sandover Beds, ex situ pebbles as for N33, collected at the turn-off to Stokes Bore, 9.5 miles from Georgina Downs, along the track to Argadargada. The dominant rock is a yellow-brown siltstone.

*Oryctocephalus reynoldsi* Reed, 1899, *Sandoveria lobata* gen. nov. et sp. nov.

N35 Sandover River Sheet SF53/8. Latitude 21° 12′S, longitude 137° 23.2′E. Middle Cambrian, Sandover Beds, ex situ pebbles as for N33, collected at Stokes Bore, 18.5 miles southwest of Georgina Downs on Stokes Creek. Rock as in N34.

*Oryctocephalites gelasinus* sp. nov., *Oryctocephalites runcinatus* sp. nov., *Sandoveria lobata* gen. nov. et sp. nov.

N36 Sandover River Sheet SF53/8. Latitude 21° 28′S, longitude 137° 04.2′E. Middle Cambrian, Sandover Beds, ex situ pebbles as for N33, collected at Bore No. 18, 30.5 miles east-northeast of Argadargada homestead. Rocks as in N33-N35.

*Oryctocephalites gelasinus* sp. nov., *Oryctocephalites runcinatus* sp. nov.

NT32 Elkedra Sheet SF53/7. Latitude 21° 23′S, longitude 135° 36′E. Middle Cambrian, Sandover Beds. An outlier (Australian National Grid Reference approximately 3490, 3290) of horizontal white and yellow shale with thin limestone bands resting unconformably on steeply dipping Precambrian strata. Outcrop poor, 4.5 miles northeast of Supplejack Bore (Elkedra station).

*Oryctocephalina lancastrioides* sp. nov.

NT63 Elkedra Sheet SF53/7. Locality 516 of MacKay & Jones (1956, pl. 2). Latitude 21° 40′S, longitude 135° 45′E. Middle Cambrian, Sandover Beds. A small outcrop in a gully 3.4 miles north of Cherry Creek Bore and 30 miles south of Elkedra station. White iron-stained friable siltstone dips 10° southeastwards.

*Cheiruroides (Cheiruroides) succincta* sp. nov.

Unnumbered locality: This refers to material from New South Wales which has no Bureau of Mineral Resources collection number. The material is from the unpublished Broken Hill Sheet. The locality lies in the Mootwingee Ranges, 6 miles northwest of Mount Wright: Latitude 31° 12′S, longitude 142° 20′E. Shale with *Oryctocephalus opiki* sp. nov., *O.* cf. *reynoldsi* Reed, 1899, and *Sandoveria lobata* gen. nov. et sp. nov. overlies marl and limestone with *Redlichia* spp. The history of previous investigation in this small Cambro-Ordovician area and the succession is given in Warner & Harrison (1961), Fletcher (1964), and Öpik (1961, unpublished report, and 1968).

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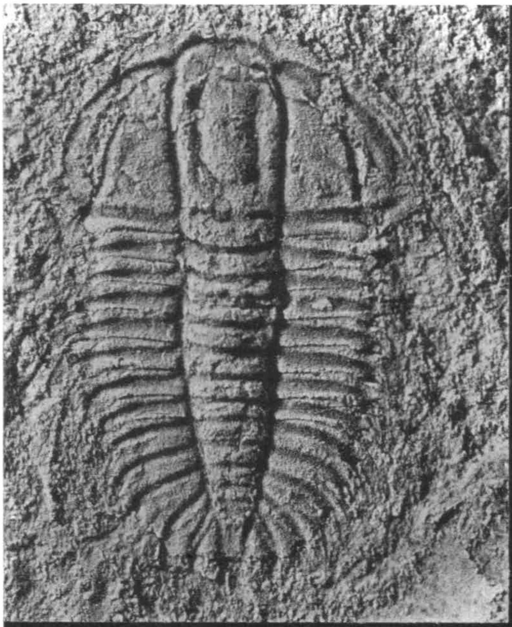
## PLATE 1

*Oryctocephalus opiki* sp. nov.

All specimens from the Mootwingee Ranges, northwestern New South Wales.

| | | |
|---|---|---|
| fig. 1. | CPC 8348; | **holotype;** the internal mould of a complete dorsal exoskeleton, X8. |
| fig. 2. | CPC 8349; | latex cast taken from the external mould of a complete dorsal exoskeleton, X4. |
| fig. 3. | CPC 8350; | latex cast taken from the external mould of a nearly complete dorsal exoskeleton, X6. |
| fig. 4. | CPC 8351; | the internal mould of a complete hypostome and the ventral surfaces of the complete librigenae showing their relationships to the hypostome, X4. |
| fig. 5. | CPC 8348; | **holotype;** latex cast taken from the external mould of fig. 1., X6. |



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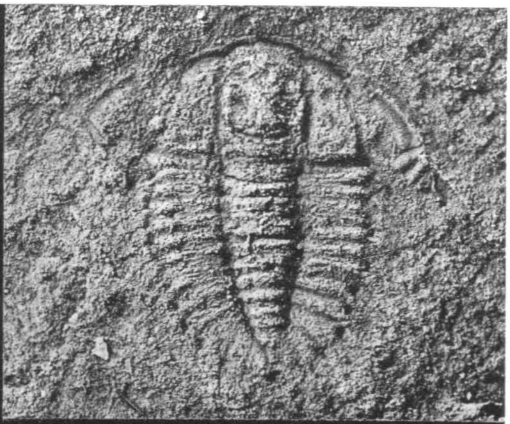

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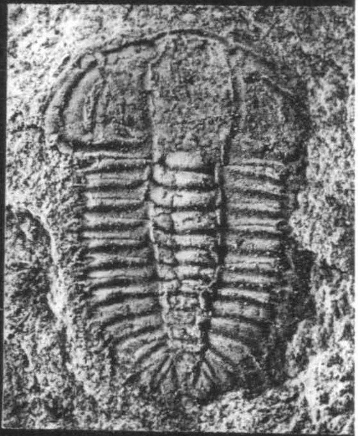

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## PLATE 2

All specimens from the Mootwingee Ranges, northwestern New South Wales.

figs 1-6. *Oryctocephalus opiki* sp. nov.

fig. 1. CPC 8352; latex cast taken from the external mould of a small cranidium, X8.

fig. 2. CPC 8353; internal mould of a cranidium, X8.

fig. 3. CPC 8354; internal mould of a cranidium, X8.

fig. 4. CPC 8351; internal mould of the hypostome, Pl. 1, fig. 4, X8, showing on the left hand side the short, prong-like anterior wing.

fig. 5. CPC 8355; internal mould of a pygidium, X8.

fig. 6. CPC 8356; internal mould of a pygidium, X8.

*Oryctocephalus* cf. *opiki* sp. nov.

fig. 7. CPC 8357; latex cast from the external mould of a cranidium, X8.

*Oryctocephalus* cf. *reynoldsi* Reed, 1899

fig. 8. CPC 8341; latex cast taken from the external mould of a large cranidium, X6.


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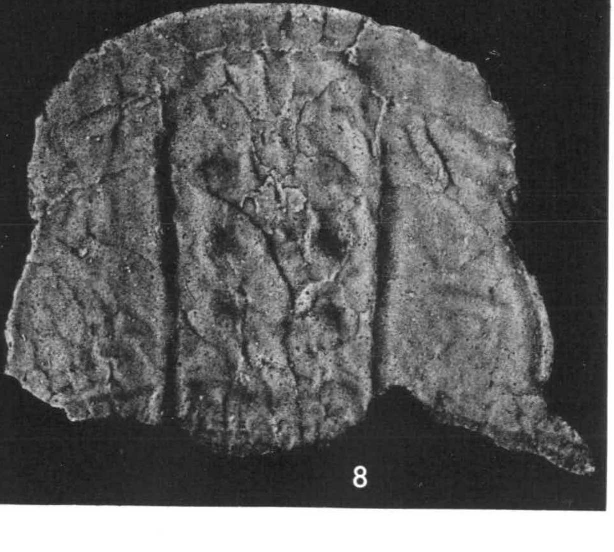
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## PLATE 3

*Oryctocephalus reynoldsi* Reed, 1899

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| fig. 1. | CPC 8342; latex cast taken from the external mould of a cranidium, X8; Mootwingee Ranges, northwestern New South Wales. |
| fig. 2. | CPC 8343; internal mould of a cranidium, X8, showing duplicated ocular ridges; locality N25. |
| fig. 3. | CPC 8344; latex cast taken from the external mould of a pygidial fragment, X8; locality N32. |
| fig. 4. | CPC 8345; internal mould of a pygidium, X6; locality N25. |
| fig. 5. | CPC 8346; internal mould of a pygidium, X8; locality N34. |
| fig. 6. | CPC 8346; latex cast taken from the external mould of fig. 5; locality as above. |

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## PLATE 4

*Oryctocephalus alexandriensis* sp. nov.

fig. 1. CPC 8366; **holotype;** latex cast taken from the external mould of a pygidium, X12, showing the delicate hollow spines in relief; the associated trilobite is a fragment of *Pagetia;* locality N24.

fig. 2. CPC 8367; internal mould of a pygidium, X12; locality as above.

*Oryctocephalus reynoldsi* Reed, 1899

fig. 3. CPC 8347; internal mould of small ?holaspid pygidium, X9, showing very long and delicate spines; locality N33.

fig. 4. CPC 8347; latex cast taken from the external mould of fig. 3, X8; locality as above.

*Barklyella expansa* gen. nov. et sp. nov.

All specimens from locality M267, Dingo Creek, Camooweal Sheet, northwestern Queensland.

fig. 5. CPC 8430; internal mould of a meraspid cranidium, X9.

fig. 6. CPC 8432; internal mould of a meraspid cranidium, X9, showing the preoccipital furrow completely transverse and intersecting the axial furrows as in species of *Tonkinella.*

fig. 7. CPC 8433; **holotype;** internal mould of a cranidium, X12, showing the preoccipital furrow not intersecting the axial furrows.

fig. 8. CPC 8435; internal mould of a cranidium, X12.

fig. 9. CPC 8436; internal mould of a cranidium, X12, showing prominent ocular ridges.

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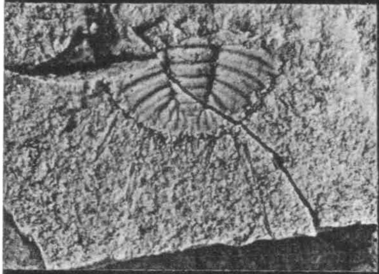

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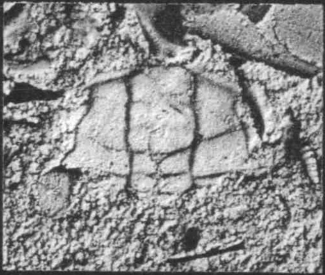

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# PLATE 5

*Oryctocephalites gelasinus* sp. nov.

fig. 1. CPC 8397; internal mould of a complete dorsal exoskeleton of a stage 5 meraspid, X9; locality N35.

fig. 2. CPC 8398; latex cast taken from the external mould of a cephalo-thorax of a stage 5 meraspid, X9; locality N33.

fig. 3. CPC 8399; internal mould of a complete dorsal exoskeleton of a stage 5 meraspid, X9, showing pygidial and thoracic spines; locality N35.

fig. 4. CPC 8400; latex cast taken from the external mould of an incomplete cranidium, X12; locality N35.

fig. 5. CPC 8401; internal mould of a cranidium, X12; locality N32.

fig. 6. CPC 8402; internal mould of an incomplete cranidium, X12; locality N35.

fig. 7. CPC 8403; latex cast taken from the external mould of a cranidium, X12, showing well preserved intergenal spines; locality N35.

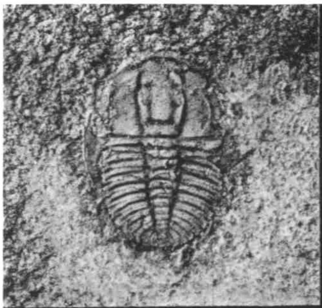
*Oryctocephalites* cf. *gelasinus* sp. nov.

fig. 8. CPC 8404; internal mould of a cranidium, X6; locality D135.

*Oryctocephalites gelasinus* sp. nov.

fig. 9. CPC 8405; internal mould of a cranidium, X6; locality N35.

fig. 10. CPC 8406; **holotype;** internal mould of a cranidium, X6; locality N35.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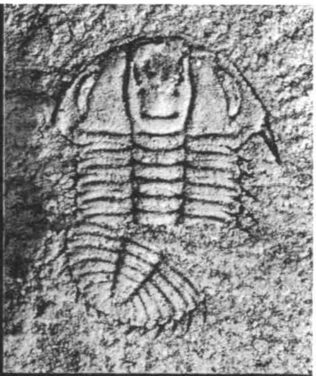
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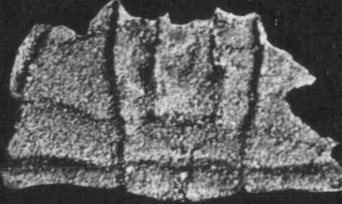
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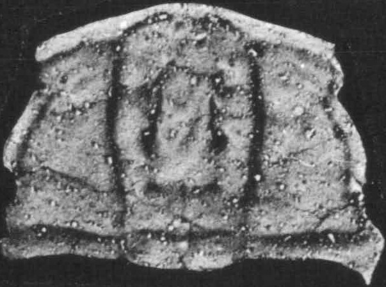
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## PLATE 6

*Oryctocephalites gelasinus* sp. nov.

figs 1, 2. CPC 8407; associated cranidium and pygidium, external and internal moulds, X8; locality N32.

*Oryctocephalites runcinatus* sp. nov.

fig. 3. CPC 8368; **holotype;** internal mould of a cranidium, X12; locality N35.

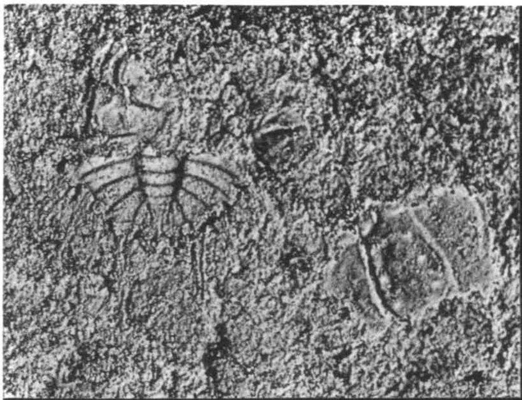
fig. 4. CPC 8369; internal mould of a cranidium, X12, showing intergenal spine and fine surface granulation; locality N33.

fig. 5. CPC 8370; latex cast taken from the external mould of a cephalo-thorax, X6, showing genal and thoracic spines; locality N32.

fig. 6. CPC 8371; internal mould of a cranidium, X12; locality N36.

fig. 7. CPC 8372; internal mould of a cranidium, X12; locality N33.

fig. 8. CPC 8373; internal mould of a cranidium, X12; locality N36.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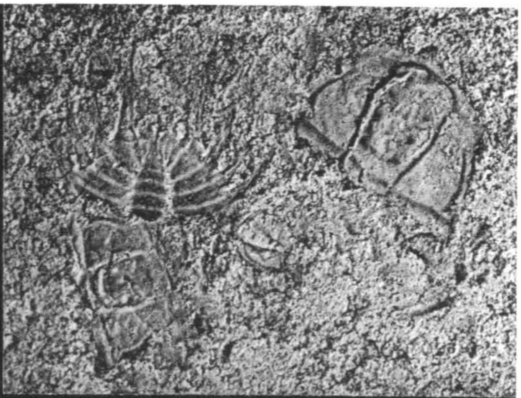
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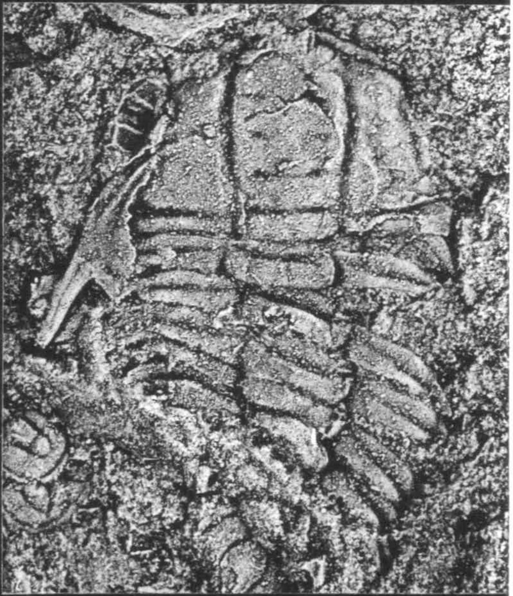
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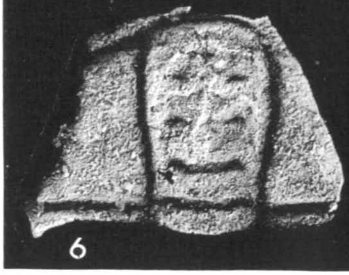
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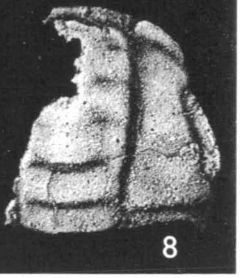
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# PLATE 7

*Oryctocephalites runcinatus* sp. nov.

fig. 1. CPC 8370; internal mould of a cephalo-thorax, X6; locality N32.

fig. 2. CPC 8374; internal mould of a pygidium with two thoracic segments, X8; locality N35.

fig. 3. CPC 8375; internal mould of a pygidium, X8, showing long delicate spines; locality N35.

fig. 4. CPC 8376; internal mould of a pygidium, X8; locality N33.

*Cheiruroides (Cheiruroides) succincta* sp. nov.

fig. 5. CPC 8428; **holotype;** internal mould of a cranidium, X15; locality NT63.

fig. 6. CPC 8428; **holotype;** anterior view of fig. 5; locality NT63.

fig. 7. CPC 8429; latex cast taken from the external mould of an incomplete cranidium, X15; locality N33.

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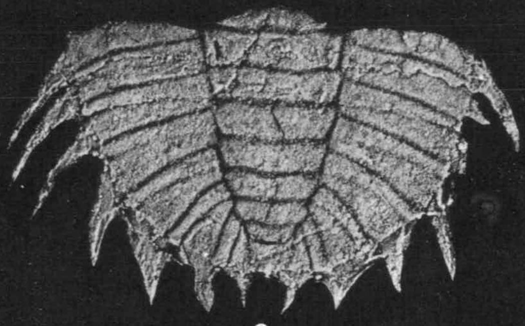

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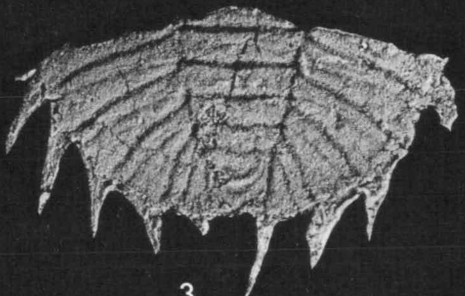

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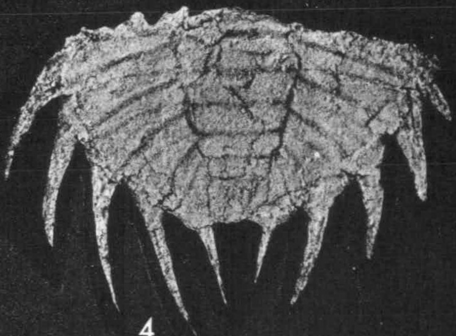

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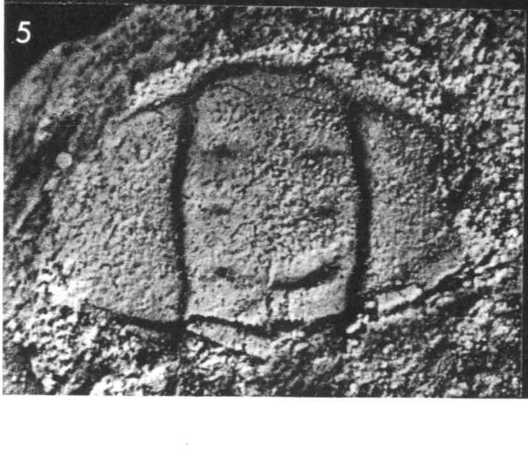

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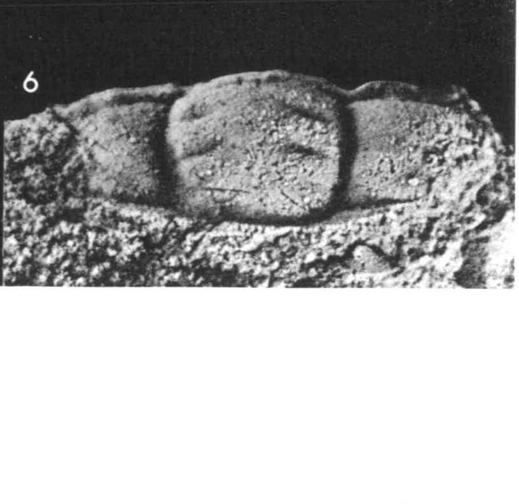

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## PLATE 8

*Oryctocephalites sulcatus* sp. nov.

All specimens from locality M267, Dingo Creek, Camooweal Sheet, northwest Queensland.

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|---|---|
| fig. 1. | CPC 8390; internal mould of a meraspid cranidium, X9. |
| fig. 2. | CPC 8385; internal mould of a meraspid cranidium, X9. |
| fig. 3. | CPC 8384; internal mould of a meraspid cranidium, X9. |
| fig. 4. | CPC 8439; internal mould of a meraspid cranidium, X8. |
| fig. 5. | CPC 8391; internal mould of a meraspid cranidium, X9. |
| fig. 6. | CPC 8382; internal mould of a meraspid cranidium, X9. |
| fig. 7. | CPC 8386; **holotype;** internal mould of a cranidium, X9. |
| fig. 8. | CPC 8437; internal mould of a cranidium, X9. |
| fig. 9. | CPC 8396; internal mould of a cranidium, X9. |
| fig. 10. | CPC 8440; internal mould of a cranidium, X8. |
| fig. 11. | CPC 8388; internal mould of a hypostome, X9, showing sagittal depression immediately behind anterior border. |
| fig. 12. | CPC 8383; internal mould of a cranidium, X9. |
| fig. 13. | CPC 8394; internal mould of a cranidium, X9. |


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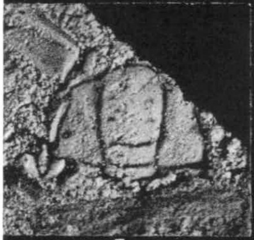
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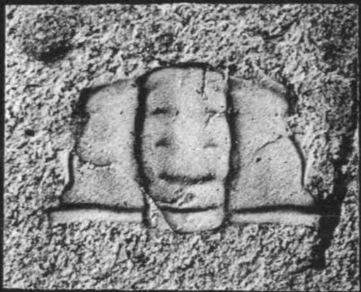
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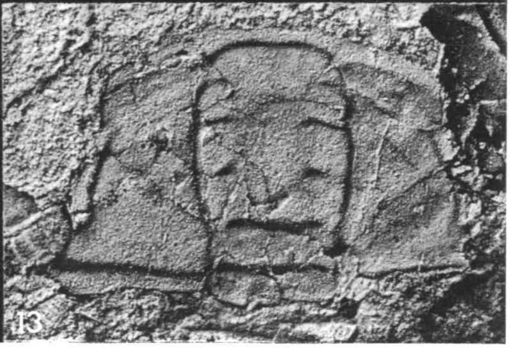
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## PLATE 9

*Oryctocephalites sulcatus* sp. nov.

All specimens from locality M267, Dingo Creek, Camooweal Sheet, northwest Queensland.

| | | |
|---|---|---|
| fig. 1. | CPC 8395; | internal mould of a cranidium, X9, crushed specimen. |
| fig. 2. | CPC 8381; | internal mould of a cranidium, X9, crushed specimen. |
| fig. 3. | CPC 8392; | internal mould of a cranidium, X9. |
| fig. 4. | CPC 8393; | internal mould of the largest cranidium observed, X9. |
| fig. 5. | CPC 8387; | internal mould of a pygidium, X9. |
| fig. 6. | CPC 8438; | internal mould of a pygidium, X9. |
| fig. 7. | CPC 8389; | latex cast from the external mould of a pygidium, X15, showing very long and delicate spines. A species of *Pagetia* is in association. |


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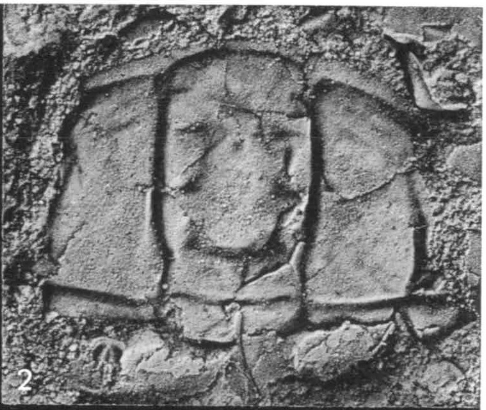
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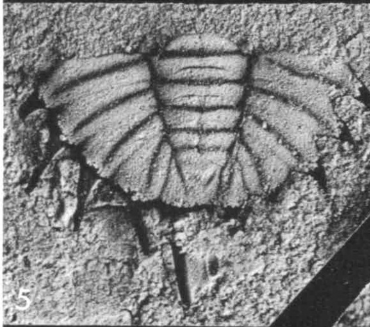
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## PLATE 10

*Sandoveria lobata* gen. nov. et sp. nov.

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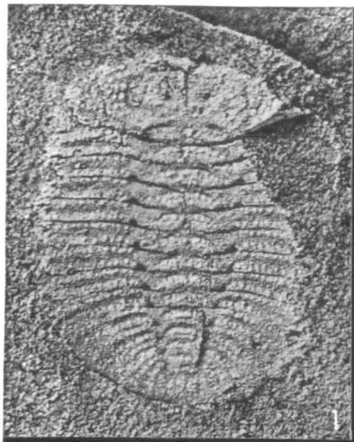
|---|---|---|
| fig. 1. | CPC 8412; | **holotype;** internal mould of a nearly complete dorsal exoskeleton, X9; locality N34. |
| fig. 2. | CPC 8412; | **holotype;** latex cast taken from the external mould of fig. 1., X9; locality as above. |
| fig. 3. | CPC 8412; | **holotype;** enlargement of latex cast of fixigena showing cephalic surface granulation, X18; locality as above. |
| fig. 4. | CPC 8412; | **holotype;** enlargement of latex cast of thoracic segments, X18, showing the nature of the axial lobulae, crescentic axial structures and pleural furrows; locality as above. |
| fig. 5. | CPC 8413; | internal mould of a pygidium, X9; locality N32. |
| fig. 6. | CPC 8413; | latex cast taken from the external mould of fig. 5., X9; locality as above. |
| fig. 7. | CPC 8414; | latex cast taken from the external mould of a nearly complete stage 5 meraspid, X9, showing dissociated basal glabellar intervening lobes; locality N35. |
| fig. 8. | CPC 8414; | internal mould of fig. 7, X9; locality as above. |
| fig. 9. | CPC 8415; | latex cast taken from the external mould of a meraspid cranidium, X12; locality N32. |
| fig. 10. | CPC 8416; | latex cast taken from the external mould of a cranidium, X12; locality as above. |
| fig. 11. | CPC 8417; | latex cast taken from the external mould of a cranidium, X12; locality as above. |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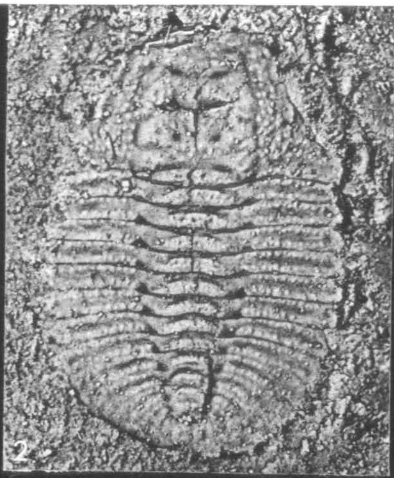
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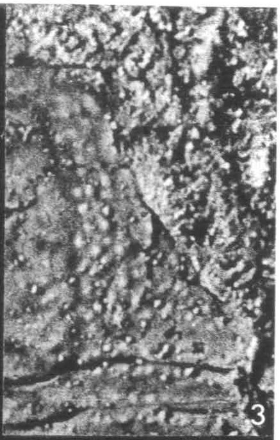
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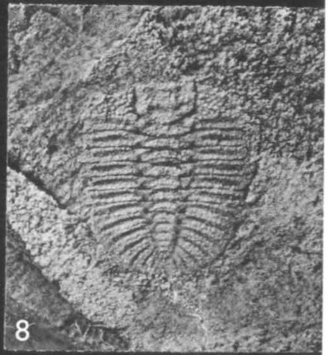
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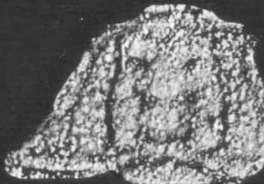
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## PLATE 11

*Oryctocephalina lancastrioides* sp. nov.

fig. 1. CPC 8421; **holotype;** internal mould of a nearly complete dorsal exoskeleton, X3, showing the relationships of cephalon and thorax and the nature of the thoracic mucronations; locality NT32.

fig. 2. CPC 8422; internal mould of a cranidium, X8, showing notched glabellar outline; locality N32.

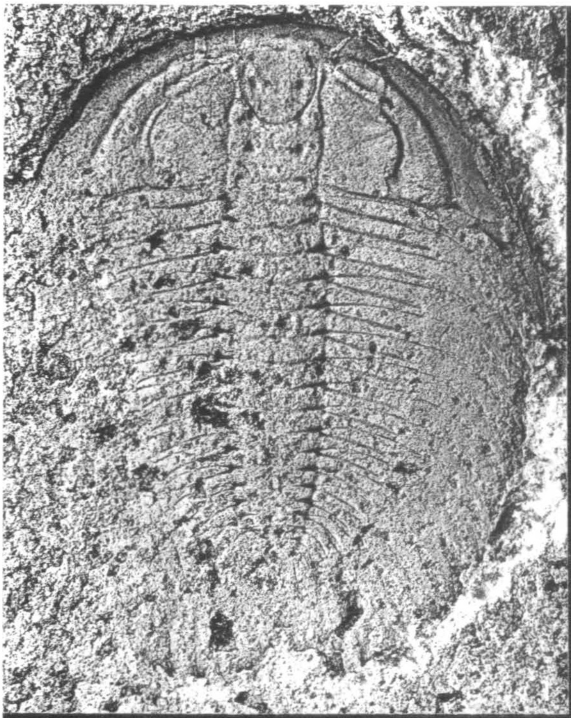
fig. 3. CPC 8423; latex cast taken from the external mould of a cranidium, X8; locality as above.

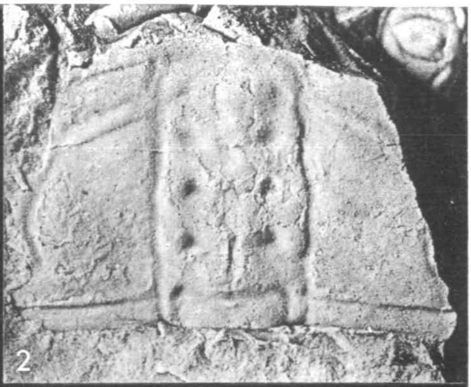
*Lancastria roddyi* (Walcott, 1912)

fig. 4. Plaster cast of **holotype**, USNM 58363, X4, illustrated for comparison with *Oryctocephalina lancastrioides* sp. nov.

*Oryctocephalina lancastrioides* sp. nov.

fig. 5. CPC 8421; **holotype;** impression of hypostome on dorsal surface of cranidium, X9.5; locality NT32, as for fig. 1.





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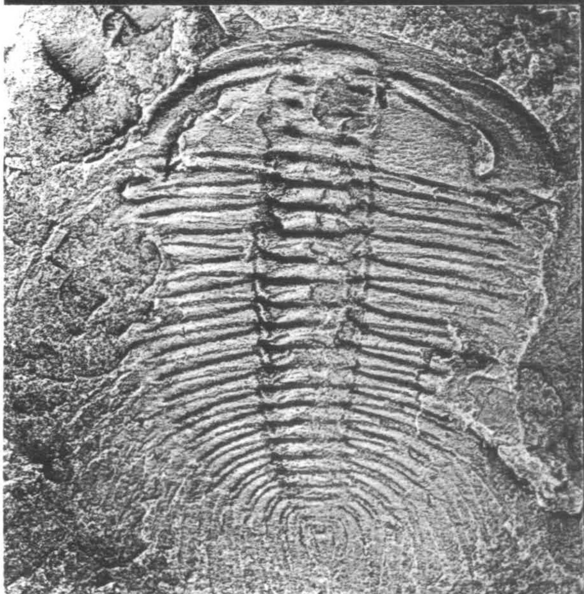

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## PLATE 12

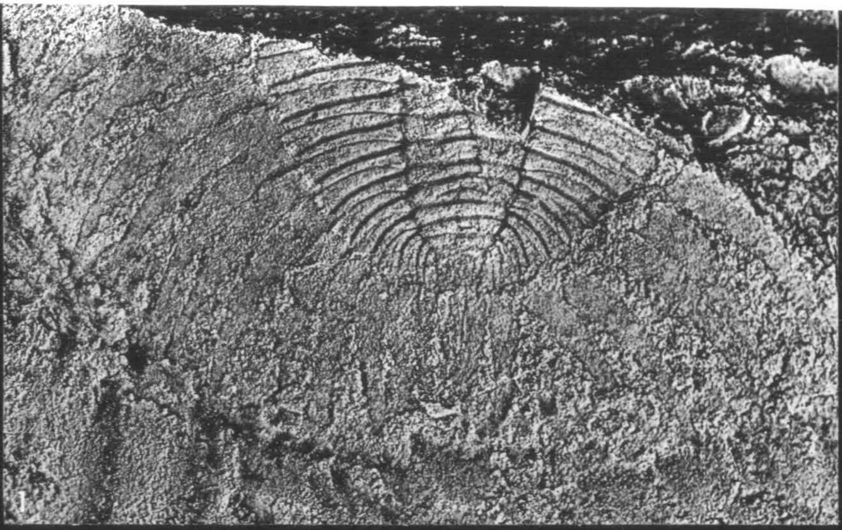
*Oryctocephalina lancastrioides* sp. nov.

fig. 1. CPC 8424; internal mould of thoracic segments and pygidial termination, X6; locality N32.

fig. 2. CPC 8424; latex cast taken from the external mould of fig. 1, X3.5; locality N32.

fig. 3. CPC 8425; internal mould of a cranidium, X6; locality N32.

fig. 4. CPC 8421; **holotype;** enlargement of right librigena, X9.5, showing the course of the facial suture and the genal spine; locality NT32.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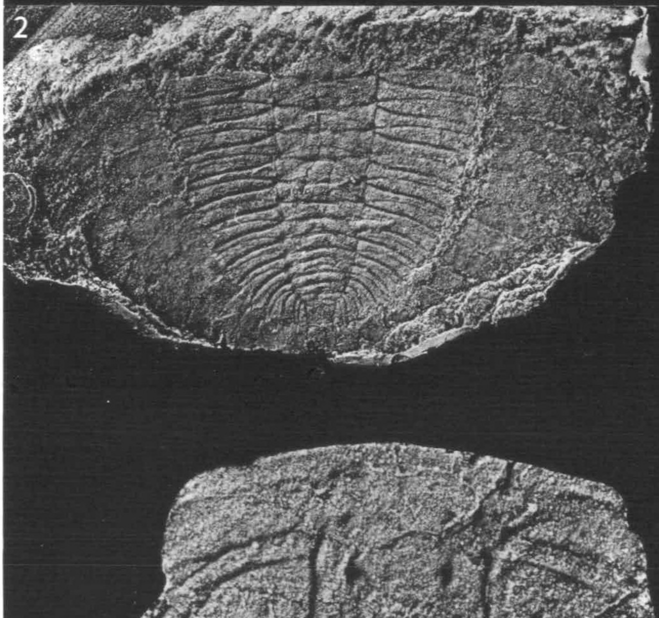
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