BIOSTRATIGRAPHIC AND TAXONOMIC STUDIES
OF SOME
TASMANIAN CAMBRIAN TRILOBITES

by

J. B. Jago, B.Sc.(Hons)(Tas.)
Department of Geology and Mineralogy
University of Adelaide

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SUMMARY

The first detailed taxonomic and biostratigraphic studies of Tasmanian Middle and Upper Cambrian trilobites are contained in this thesis. Agnostid trilobites have been studied in considerably greater detail than polymerid trilobites because they provide the best means of local and intercontinental correlation.

Two, and possibly three, distinct agnostid assemblages are recognized in the Tasmanian Middle Cambrian and early Upper Cambrian sequences. These are (1) an agnostid assemblage in which polymerid trilobites are absent, rare or present as thanatocoenotic fossils, (2) a ptychagnostid-non-nepeid assemblage which could be considered as a variation of assemblage (1), and (3) a nepeid-clavagnostid-peronopsid assemblage which does not contain ptychagnostids. It is proposed that assemblage (1) was essentially an open sea fauna with assemblages (2) and (3) occurring progressively closer to the shore.

Taxonomic studies of newly collected material and some previously collected material has led to the recognition and description of over ninety agnostid species and three non-agnostid species. Five genera and twenty-five species are new. About two-thirds of the agnostid species could not be assigned to any particular species, new or old, because of their poor preservation. Large numbers of polymerid trilobites are listed but not described. The availability of

rubber casts of much Australian and particularly overseas type material has allowed detailed comparison to be made of some Tasmanian species with previously described species. These rubber casts have allowed comprehensive revisions to be made of certain agnostid and non-agnostid genera and species.

The main body of Tasmanian fossiliferous Middle and Upper Cambrian sediments was deposited in the Dundas Trough between the Tyennan Geanticline in Central Tasmania and the Rocky Cape Geanticline in the north-west of the island. Other important depositional areas were to the north-west of the Rocky Cape Geanticline and in the Denison Range area of south-central Tasmania. Extending along the western and northern margins of the Tyennan Geanticline was the Mt. Read Volcanic Arc. In the course of this study sediments containing Middle Cambrian trilobites have been found associated with the Mt. Read Volcanics in the Que River and Queenstown areas. This indicates that the Mt. Read Volcanics are at least partly coeval with the fossiliferous Middle and Upper Cambrian sediments found elsewhere in Tasmania, a point which had long been controversial.

It is proposed, largely on the evidence of agnostid age datings, that throughout much of the Upper Cambrian, the seas in Tasmania retreated progressively southwards. It is confirmed that the Tyennan Movement in the latest Upper Cambrian considerably folded the pre-existing rocks close to the Tyennan Geanticline but had little effect towards the centre of the Dundas Trough. On a continental scale it is proposed that in Middle and Upper Cambrian times Tasmania was the site of a small group of volcanic islands situated off the coast of Gondwanaland.

Previous workers have used the term "Dundas Group" or the term "Dundas Group and correlates" to describe the fossiliferous Middle and Upper Cambrian sediments of Tasmania. However, this study has shown that the use of the term "Dundas Group and correlates" in this sense is invalid, and that the term "Dundas Group" should be restricted to the section between Mt. Razorback and Misery Hill. A new map for the Dundas area is given. This differs considerably from previously published maps. The St. Valentines Peak area has been largely remapped. The first measured section of some of the Cambrian sediments of the Birch Inlet area is presented. Minor stratigraphic corrections have also been made in other areas.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any University nor, to the best of my knowledge and belief, does it contain any material previously published or written by another person, except where due reference is made in the text.

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Mr. M.R. Banks, Geology Department, University of Tasmania kindly arranged the loan of the extensive trilobite collections from the University of Tasmania; he also answered promptly my frequent requests for information. Mr. J.G. Symons, Mr. M.J. Clarke, and Mr. J. Noldart of the Tasmanian Mines Department arranged the loan of specimens from the Tasmanian Mines Department collections. Mr. J.H. Buckley generously donated specimens from his extensive personal collections of Christmas Hills trilobites; he also kindly provided me with accommodation on several occasions. Professor D. Hill kindly allowed me to take rubber casts of Dr. F. Whitehouse's trilobite collection which is housed at the University of Queensland. Dr. N. Lazarenko provided a magnificent photograph of <u>Schmalenseeia spinulosa</u> Lazarenko from Siberia. Dr. K.D. Corbett gave the writer valuable information about the geology of the Denison Range Area.

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GENERAL INTRODUCTION

This research project deals with the study of some stratigraphic, biostratigraphic and palaeontological aspects of the Middle and Upper Cambrian sedimentary rocks of Tasmania. There is only incidental mention of their tectonic setting and conditions of sedimentation. These aspects have been reviewed in some detail by Banks (1956, 1962a, 1965) and Solomon (1965) and are outside the scope of this thesis.

In the past twenty-five years, Middle and Upper Cambrian fossils have been found at numerous localities in Tasmania. No Lower Cambrian fossils are known from Tasmania. Trilobites make up most of the faunas with dendroids, hydroids, inarticulate brachiopods, gastropods, hyolithids and sponge spicules also being recorded. Numerous lists of generic and sometimes specific names have been given by previous workers (e.g., Öpik, 1951a, 1951b, 1951c; Elliston, 1954; Banks, 1956, 1962a; Blissett, 1962; Burns, 1964). However, prior to this research project being undertaken, no detailed palaeontological or biostratigraphical work had been attempted on these faunas except for two papers on the hydroids and dendroids (Thomas and Henderson, 1945; Quilty, 1971).

The principal method of correlating Cambrian sequences throughout the world has been by use of trilobites. It has been shown in recent years (e.g., Öpik, 1961b, 1963; Robison, 1964b) that certain species of agnostid trilobites had a short time range and a world-wide distribution during the Middle and Upper Cambrian, thus making them excellent index fossils for this period of time. Agnostid trilobites are known from many of the Cambrian fossil localities in Tasmania. I have concentrated on the study of them in this project because of their value in local and intercontinental correlations.

All Tasmanian Cambrian trilobites are distorted. However, at many localities the preservation is quite good and certainly adequate enough to allow the erection of new genera and species. Throughout this study I had at my disposal extensive collections of rubber casts of both polymerid and agnostid trilobites, (including much type material), from different parts of the world. These were from the collection of Dr. B. Daily. They included most of the Swedish specimens described and figured by Westergård (1946), almost all of the material described from Queensland by Whitehouse (1936, 1939), some of the specimens described by Snajdr (1958) from Czechoslovakia as well as some of the material described from Argentina by C. Poulsen (1960) and Rusconi. A substantial amount of North American material was also available. A catalogue of these specimens, which are referred to in this thesis, is given in Appendix 2.

These casts have proved absolutely invaluable for comparative purposes. In my opinion the method used here of comparing material under study with type material or casts of the type material should be used where possible. This is substantiated by the fact that photographs of specimens reproduced in journals invariably lose some of the detail that can be seen on the specimen or even on the original photograph. A further point is that a specimen may exhibit details not noticed by the original worker. The availability of the casts of this type material allowed me to make detailed revisions of certain species and genera.

Prior to the start of this work, extensive collections of Tasmanian Cambrian trilobites were available in the collections of the University of Tasmania and the Tasmanian Mines Department. However, these collections were inadequate for various reasons. I made three extended field trips to Tasmania in the 1967-68, 1968-69, and 1969-70 field seasons in order to systematically collect fossils from as many localities and sections as possible. The only important localities not visited by me were those along the Huskisson River and in the Denison Range-Adamsfield areas. The stratigraphic information given below on these areas comes largely from the existing literature, as well as from extended conversations with Mr. A.H. Blissett and Dr. K.D. Corbett, who have a detailed knowledge of the Huskisson River and Denison Range areas, respectively. Localities are specified in this thesis either in terms of latitude and longitude or in terms of the Tasmanian grid system.

This thesis is divided into two major sections. The first section deals with stratigraphy and biostratigraphy; the second section deals with trilobite systematics, especially those of agnostid trilobites. Appendix 4 contains publications produced to date in the course of this study.

It is hoped that the biostratigraphic studies carried out in this project will provide the basis for future mapping of Cambrian sediments in Tasmania. This is of particular relevance because most of the major mines on the West Coast of Tasmania are found within or closely associated with Cambrian rocks. Many of the exploration programmes involve the mapping of Cambrian sediments. Western Tasmania is a structurally complex area which has a thick vegetation cover and a deep soil profile. The Cambrian sediments lens rapidly with similar lithologies occurring at stratigraphically widely separated intervals. In such an area the only sure method of determining the relative stratigraphic positions of different units is by palaeontological means.

This thesis is presented in two separate volumes. The first volume contains the text, tables, appendices and references. The second volume contains the text-figures and plates.

PART 1

STRATIGRAPHY

INTRODUCTION

Banks (1956, 1962a, 1965) and Solomon (1965) have reviewed the Tasmanian Cambrian rocks in some detail. The following information which summarizes the relationships between the different groupings of Tasmanian Cambrian rocks is based largely on this work. The writer has also used unpublished work of Dr. K.D. Corbett in the following discussion as well as some of his own observations.

Apart from the often structurally complex areas in which they are found, there are other problems involved in any study of the Tasmanian Cambrian. These include the generally poor outcrop, caused by thick soil and dense vegetation cover, and the fact that the Cambrian rocks are largely confined to the western part of the island where access is often difficult.

Fig. 1 shows the Cambrian palaeogeography of Tasmania. The central feature was a north-south trending Precambrian block termed the Tyennan Geanticline. Across the north-west corner of the island was a northeast-southwest trending high area, or possibly a chain of islands, termed the Rocky Cape Geanticline. In the north of the state was a small high, termed the Forth Nucleus by Corbett (1970). This may have been a separate island or more probably joined to the Rocky Cape Geanticline.

The main body of Tasmanian Cambrian rocks occurs in an arcuate belt around the western and northern margins of the Tyennan Geanticline. Close to the edge of the Tyennan Geanticline in western and northern Tasmania was an arcuate belt of volcanics (the Mt. Read Volcanics) forming the Mt. Read Volcanic Arc. Between the Tyennan and Rocky Cape Geanticlines was the main Cambrian depositional area. This is termed the Dundas Trough, in which sediments were deposited under geosynclinal conditions. In the Dial Range area, in the northern part of the state, there was an offshoot of the main Dundas Trough, termed the Dial Range Trough. Apart from these areas, there were large depositional basins in the Circular Head area to the north-west of the Rocky Cape Geanticline and in south-central Tasmania to the east of the Tyennan Geanticline. Smaller depositional areas near Beaconsfield and Port Sorell, to the north-east of the Forth Nucleus, may have been connected to the main Dundas Trough. Little is known of the palaeogeography to the north-east of the Tyennan Geanticline due to Permian and Mesozoic rocks which cover the older rocks, except for two small areas south-west of Cressy. Further comments on the palaeogeography will be made in the summary of the stratigraphy. Fig. 2 shows the Cambrian rock distribution in Tasmania as well as the localities mentioned in the text.

Rocks of the Cambrian System in Tasmania can be divided into the following categories:

1. Granites
2. Ultrabasic complexes
3. Oonah Formation and Crimson Creek Formation
4. Fossiliferous Middle and Upper Cambrian Sediments
5. The Mt. Read Volcanics

1. Granites

Two small bodies of granite of probable Upper Cambrian age are known from western Tasmania (Fig. 2). They are outside the scope of this thesis and are not discussed further.

2. Ultrabasic Complexes

The Tasmanian ultrabasic complexes of probable Cambrian age have been discussed briefly by Spry (1962, p. 260). They are at present under detailed study by Mr. M. Rubenach (University of Tasmania).

3. Oonah Formation and Crimson Creek Formation

In the area around Zeehan, Renison Bell and Dundas, rocks of the Oonah Formation (Oonah Quartzite and Slate of Spry, 1958) and the Crimson Creek Formation underlie the fossiliferous Middle and Upper Cambrian sediments. The Oonah Formation is at least 2,100 metres thick. The lithology and nomenclature of this unit is discussed by Blissett (1962, p. 22). I prefer the term Oonah Formation to Oonah Quartzite and Slate because it seems to me that this unit will be subdivided upon further work. The Crimson Creek Formation, which overlies the Oonah Formation, consists mainly of siltstones. It is about 3,000 metres thick. Previous workers (e.g., Blissett and Gulline, 1961a; Campana and King, 1963; Solomon, 1965) have considered these groups to be of Lower Cambrian age. However, no fossils have been found in either the Oonah Formation or the Crimson Creek Formation. Until definite Cambrian fossils are found in these sediments, no precise age can be given to them. The writer made an unsuccessful search for fossils in the Crimson Creek Formation in the well exposed sections along road cuttings of the Murchison Highway between Serpentine Hill and Renison Bell. Earlier workers (e.g., Blissett, 1962; Solomon, 1965; Loftus-Hills *et al.*, 1967) have indicated that there is a conformable sequence between the Crimson Creek Formation and the fossiliferous Middle and Upper Cambrian sediments. However, as far as the writer is aware, there is no exposure where such a contact can be inspected. In the writer's opinion, the previously suggested Lower Cambrian age of both the Oonah Formation and Crimson Creek Formation cannot be substantiated at present.

4. Fossiliferous Middle and Upper Cambrian Sediments

Fossiliferous sequences of Middle and Upper Cambrian sediments are found in much of northern and western Tasmania. The detailed biostratigraphy of individual areas is discussed below. Previous workers (e.g., Banks, 1956; Solomon, 1965) have tended to treat all these sediments under the heading "Dundas Group" or under the heading "Dundas

Group and correlates". However, as will be shown below, the term Dundas Group should be restricted to one particular section near Dundas. Furthermore, some fossiliferous Cambrian sediments elsewhere in Tasmania (e.g., near Birch Inlet) have a different age to those found in the type section of the Dundas Group. Thus, neither the terms "Dundas Group" nor "Dundas Group and correlates" should be used in discussing the Tasmanian Cambrian sequences as a whole.

5. Mt. Read Volcanics

The Mt. Read Volcanics consist of acid, intermediate and rare basic lavas, (all of the spilitic suite), ignimbrites and tuffs with a total thickness of about 3,000 metres (Banks, 1965, p. 12). They occur largely along the Mt. Read Volcanic Arc. As noted by Banks, most of the acid volcanics occur close to the Tyennan Geanticline. Basic rocks tend to occur away from the geanticline. Although the fossiliferous Middle and Upper Cambrian sediments have some interbedded lavas and pyroclastics, the age relationship between the Mt. Read Volcanics and the fossiliferous sediments has been a matter of considerable dispute. As noted by Gee *et al*. (1970, see Appendix 4), it has been suggested that the Mt. Read Volcanics may be (1) older than the sediments (Campana *et al*., 1960; Campana and King, 1963), (2) largely contemporaneous with the sediments (Carey, 1953; Banks and Solomon, 1961), (3) essentially younger than, but partly contemporaneous with, the sediments (Campana *et al*., 1958), or (4) partly older and partly contemporaneous with the sediments (Blissett, 1962; Solomon, 1965; Loftus-Hills et al., 1967). This point is discussed again later in this thesis. The distribution of the Mt. Read Volcanics is shown in Fig. 2.

As noted by Banks (1965, p. 13),

> "Towards the end of Cambrian time, during the Jukesian Movement, rejuvenation of the Tyennan Geanticline produced a steeply dipping zone of Cambrian rocks along the western margin of the Geanticline, gently folding elsewhere . . . ."

The fossiliferous Cambrian sediments and the Mt. Read Volcanics are overlain by the Junee Group. As will be shown below, the Junee Group rests unconformably on Cambrian rocks in some localities but with apparent conformity in others.

There is a distinct lithological contrast between the fossiliferous Cambrian sediments and the overlying Junee Group rocks. The Cambrian sediments are predominantly siltstones, greywackes and greywacke conglomerates, whereas quartz-rich conglomerates and sandstones dominate the basal part of the Junee Group.

In the west coast area the basal member of the Junee Group is the Jukes Conglomerate and correlates. The Jukes Conglomerate has a restricted distribution and is found only close to the Tyennan Geanticline. In much of Tasmania the basal member of the Junee Group is a conglomerate (the Owen Conglomerate and correlates) which passes up into a sandstone, termed either the Moina Sandstone (Jennings et al., 1959) or the Caroline Creek Sandstone (Banks, 1962b). In some localities the Owen Conglomerate and Caroline Creek Sandstone appear as a single indistinguishable formation (e.g., near Birch Inlet). Overlying the Owen Conglomerate and Caroline Creek Sandstone throughout Tasmania is the Gordon Limestone. In the Florentine Valley area the Florentine Valley Mudstone is intercalated between the Gordon Limestone (above) and the underlying sandstone unit.

Quilty (1971, p. 183) records an Arenigian fauna from the Florentine Valley Mudstone, 12 km west of Maydena in south-central Tasmania. As noted by Quilty (op. cit. p. 187), this probably indicates that some or most of the underlying sandstones and conglomerates of the basal part of the Junee Group are of Cambrian age. It seems quite probable that the basal Junee Group conglomerates in western Tasmania may also be of late Upper Cambrian age.

1. DUNDAS AREA

Introduction

The Dundas area has been regarded as the type area of the fossiliferous Cambrian sediments of Tasmania since Elliston (1954) first mapped the Cambrian sediments of this area. For this reason it is discussed in more detail than other areas. Elliston (op. cit.) defined the Dundas Group to include 13 formations with a total thickness of 11,575 feet. This succession was amended slightly by Banks (1956, 1962a). Blissett (1962) extensively revised the concept of the Dundas Group, rejected some of Elliston's formations and completely remapped the Dundas area. The Dundas Group, as detailed by Elliston and Blissett, is shown in Table 1. The map produced by Blissett differs considerably from that produced by Elliston. In recent years geologists of Renison Limited have made detailed traverses across much of the Dundas area. Rubenach (1967) mapped an area around Serpentine Hill and has since continued to work in the area. From these sources and the earlier work by Elliston (1954), Blissett and Gulline (1961b) and Blissett (1962), along with the writer's own field work and later palaeontological findings, a map was compiled of the Dundas area (Fig. 3). This map differs considerably from that of Blissett (1962) and bears little resemblance to that of Elliston (1954).

It has been found by the writer and other workers (especially the geologists of Renison Limited) that the lithological units previously included in the Dundas Group show considerable lensing, tonguing

TABLE 1

COMPARISON OF THE DUNDAS GROUP AS DETAILED BY ELLISTON (1954) AND BLISSETT (1962)

a. The Dundas Group as defined by Elliston (1954, p. 163)

Ordovician

JUNEE GROUP

Gordon Limestone

Cambrian

DUNDAS GROUP	Thickness (in feet)
Misery Conglomerate	500
Climie Slate and Tuff	2000
Fernflow Conglomerate and Tuff	470
Comet Slate and Tuff	1050
Fernfields Tuff and Conglomerate	1950
Brewery Junction Slate and Tuff	2450
Curtin Davis Volcanics	1000
Razorback Conglomerate	225
Hodge Slate	530
Red Lead Conglomerate and Tuff	250
Severn Slate	800
South Comet Grit	150
Judith Slate and Tuff	200
Total for Dundas Group	11,575

Precambrian

b. The Dundas Group as detailed by Blissett (1962, p. 32)

Misery Conglomerate (Junee Group)	
Climie Formation	1500
Fernflow Formation	500
Comet Formation	500-1000
Fernfields Formation	?0-1950
Brewery Junction Formation	2000
Razorback Conglomerate	250-750
Hodge Slate	500-600
Red Lead Conglomerate	150-400
Judith Formation	200
Total	5600-8900

and interfingering. At the present state of knowledge, it appears rather doubtful if the formations of the Dundas Group, as seen along the type section between Mt. Razorback and Misery Hill, are in fact formations in the sense of the Australian Code of Stratigraphic Nomenclature (1964). The difficulties in mapping the various lithological units, created by lensing, tonguing and interfingering, are added to by the deep weathering profile and dense vegetation cover. These problems are increased by the great similarity in lithology of stratigraphically widely separated units. The only method of accurately determining the relative stratigraphic position of different lithological units in the area is by palaeontological means.

In the area between Mt. Razorback and Misery Hill the formation names of the Dundas Group have been retained in Fig. 3, and in the following discussion, simply for reference purposes. The Cambrian sediments on the rest of the map are shown by rock type, or, in the less well-known areas, as "Cambrian Undifferentiated". A correlation between the type section and the area north of Mt. Razorback is shown in Fig. 4. This latter section is termed the Black Hill section in the following discussion. The stratigraphy of this area was elucidated mainly by palaeontological means.

Problem of the "Judith Slate" Fauna

Before discussing the Mt. Razorback-Misery Hill and Black Hill sections, the problem of the "Judith Slate" fauna must be discussed.

Elliston (1954), Banks (1956, 1962a) and Blissett (1962) all regard the Judith Slate as the basal formation of the Dundas Group, although Blissett (1962, p. 32) has expressed doubts as to its exact stratigraphic position. The beds of Elliston's type area are probably part of the Crimson Creek Formation (Blissett, op. cit., p. 32).

Elliston (op. cit.) noted the presence of fossils in what he regarded as tuff from the bed of the South Comet Creek at about lat. 41°53.4'S, long. 145°26.0'E (grid 3486E, 8422N). Öpik (1951a) and Banks (1956) recorded Lorenzella, Pachyaspis, Peronopsis, Ptychagnostus, and Pagetia and correlated the fauna with the Ptychagnostus gibbus Zone of Sweden. Banks (pers. comm.) informed me that, in fact, the fossils referred to came from a piece of float embedded in the stream bank. The writer made an unsuccessful attempt to find fossils in this vicinity. The original collection was destroyed by fire at the Bureau of Mineral Resources (Canberra) in the early 1950's. This is unfortunate, for, if these fossils were of P. gibbus Zone, then they were the oldest known from the Dundas area.

The geology of the area in which the fossils were found is confused, and there seems no justification for assuming that the silts and interbedded tuffs of this area are, in fact, part of the Judith Slate as defined by Elliston. Thus, at present the exact stratigraphic position of the so-called Judith Slate in South Comet Creek is unknown.

A. MT. RAZORBACK--MISERY HILL SEQUENCE

There is a conformable sequence of Middle to Upper Cambrian sediments between Mt. Razorback and Misery Hill. This section is part of the original type section of the Dundas Group proposed by Elliston (1954).

1. Greywacke conglomerate

The basal member of the Mt. Razorback-Misery Hill sequence is a deeply weathered unfossiliferous reddish-brown greywacke conglomerate and chert-breccia conglomerate, adequately described by Blissett and Gulline (1961b, p. 140) under "Greywacke Conglomerate". Its contact with the underlying serpentinite mass is nowhere exposed, although it may be a faulted contact. North-west of the present Razorback Mine this conglomerate has a thickness of about 120 metres and is shown by Blissett (1962) on the Zeehan Sheet as Red Lead Conglomerate. However, the type area of the Red Lead Conglomerate is near the Red Lead Mine on South Comet Creek (Fig. 3), and there is no proof that the conglomerate on Mt. Razorback can be correlated with it.

2. Hodge Slate

In the type area near the Razorback Mine, the Hodge Slate is about 190 metres thick and includes hard grey to black laminated micaceous shale, siltstone and mudstone and numerous greywacke partings (Blissett, 1962, p. 33). I consider that the greywacke partings could be interpreted as tuff bands.

The lower parts of the Hodge Slate are well exposed on prospecting tracks about 100 metres north-west of the present Razorback Mine. The writer found poorly preserved, considerably distorted fossils at lat. 41°52.0'S, long. 145°25.4'E (grid 3473E, 8450N). Only Ptychagnostus sp. was recognized. Other trilobite fragments, sponges and cystoids also occur. This fauna is about 30 metres above the base of the Hodge Slate and is thus well above the "dendroid" locality of Thomas and Henderson (1945) as shown by Blissett and Gulline (1961b, Fig. 55). Quilty (1971) has described the dendroids and hydroids from this latter locality (lat. 41°52.2'S, long. 145°25.5'E; grid 3478E, 8446N).

The presence of Ptychagnostus probably indicates a Middle Cambrian age for the Hodge Slate. In the past the Hodge Slate faunas have been correlated with the upper part of the Ptychagnostus atavus Zone or P. punctuosus Zone (Öpik in Banks, 1956, p. 191). However, this age appears to be based on the presence of Solenoparia, and bathyuriscids identified by Öpik and collected by Elliston (1954, p. 168) from what he regarded on lithological grounds as the Hodge Slate in the Bonnie Point area of the North-East Dundas Tram, about 5.5 km to the north-east (Fig. 3). As noted above, such lithological correlations should not be made in the Dundas area, and thus the age of the Hodge Slate cannot be precisely determined at this stage.

3. Razorback Conglomerate

This unfossiliferous unit has been adequately described by Blissett and Gulline (1961b, p. 142). At the summit of Mt. Razorback the Razorback Conglomerate has a thickness of 75 metres (Blissett, 1962, p. 33). It thickens considerably to the north-west and appears to lens out completely 0.5 km. south of Mt. Razorback (Fig. 3).

4. Brewery Junction Formation

The overall lithology of this formation has been described by Blissett (1962, p. 34) and Elliston (1954, p. 170). The formation is mainly a grey, green or purple siltstone interbedded with narrow tuff and/or greywacke horizons. Greywacke-grit and breccia-conglomerate horizons are common and, according to Blissett (1962), increase in thickness and frequency in the upper part of the formation. However, along the Dundas Rivulet the highest conglomerate horizon seen by the writer was about 65 metres below the top of the formation. About 45 metres below the top of the formation the siltstone is decidedly calcareous for a few metres, a feature unusual for Tasmanian Cambrian sequences. A bed, or beds, of keratophyric tuff near the base of the formation has been reported by Banks (1956) and Blissett (1962) from near Dundas.

There are at least four separate fossil horizons in the Brewery Junction Formation, two of which are found in the type section along Dundas Rivulet.

The principal fossil horizon (referred to below as the FE_1 fauna) is found in the bed of the Dundas Rivulet, a few yards downstream from Brewery Junction, at lat. 41°52.8'S, long. 145°25.0'E (grid 3471E, 8434N), and about 50 metres below the top of the formation (Fig. 3). The trilobites found here by the writer include <u>Rhyssometopus</u> (<u>Rhyssometopus</u>) sp. (pl. 33, fig. 10), <u>R</u>. (<u>Rostrifinis</u>) sp., <u>Aulacodigma</u> sp. (pl. 33, fig. 11), <u>Palaeadotes</u> sp. (pl. 33, fig. 7), and a new genus of nepeids (pl. 33, figs. 8, 9), plus the agnostids <u>Idolagnostus</u> sp., <u>Aspidagnostus</u> sp. 1, <u>Ammagnostus</u> (?) sp., <u>Pseudagnostus</u> sp. 2, Agnostid, gen. et sp. indet. no. 10, and Agnostid, gen. et sp. indet. no. 11. A comparison of this faunal list with that given by Öpik (1967, Table 4) shows that the age of the fauna is probably that of the <u>Glyptagnostus stolidotus</u> Zone of the Mindyallan Stage.

The second fossil horizon along Dundas Rivulet is found at lat. 41°52.8'S, long. 145°24.9'E (grid 3469E, 8435N) about 10 metres from the top of the formation. The fossils here are poorly preserved, but appear to be largely similar to those noted above.

The fossil locality noted by Blissett (1962, p. 34), about 400 metres north-west of the Adelaide Mine, is considered by him to be about 245 metres below the top of the formation. However, the exposure in this area is poor, and it is difficult to ascertain with certainty the true stratigraphic position of the fossil horizon except to state that it appears to lie below the Dundas Rivulet fossil localities.

At this locality (BJ_2, lat. 41°53.0'S, long. 145°25.6'E; grid 3480E, 8429N), agnostids are by far the most common type of fossil. They include Clavagnostus sp. 3, Aspidagnostus sp. 2, Oedorhachis (?) distortus sp. nov., Oidalagnostus sp., and Pseudagnostus sp. 5. The polymerids include an undescribed species also found in the Dundas Rivulet localities. The age of this fauna is certainly Mindyallan; the presence of Oidalagnostus (not known above the Mindyallan Cyclagnostus quasivespa Zone in Queensland) and its relative stratigraphic position below the Dundas Rivulet faunas suggest that this fauna is of either the Erediaspis eretes Zone or the Cyclagnostus quasivespa Zone.

In the same vicinity (lat. 41°52.9'S, long. 145°25.6'E; grid 3480E, 8431N) the lowest known fossil horizon (BJ_1) in the Brewery Junction Formation was found by the writer about 60 metres below the BJ_2 fauna. The poorly preserved trilobites include unidentifiable nepeids, plus the two agnostids described in this thesis as Agnostascus (?) sp. 4 and A. (?) sp. 5. The stratigraphic position of this fauna suggests that it is probably of either the Erediaspis eretes Zone or the Cyclagnostus quasivespa Zone.

Banks (1956, p. 173) reported badly deformed fossils from near the top of the Brewery Junction Formation near Dundas, but this locality could not be relocated.

5. Fernfields Formation

As indicated by Elliston (1954, p. 171) the contact between the Brewery Junction and Fernfields Formations is very sharp. It is seen on the north bank of the Dundas Rivulet at 3469E, 8435N. Immediately below the contact the Brewery Junction Formation is a cleaved siltstone while the base of the Fernfields Formation is a coarse conglomerate.

This formation, which is well exposed in the type section, has been described by Blissett (1962, p. 35). Elliston's (1954, p. 170) view of a largely volcanic origin for this formation cannot be substantiated although some of the greywacke beds recorded by later authors could be reworked volcanic material. At the base of the formation there is a profusion of limestone boulders up to 20 cm. across. Only occasional limestone pebbles are seen higher in the formation. As a whole, the formation fines upward although right at the top of the formation is a coarse siliceous conglomerate. The suggested glacial origin of some of the pebbles in this formation (Elliston, 1954) cannot be substantiated (Campana and King, 1963, pp. 22-23).

A poorly preserved trilobite cranidium found by the author along the Dundas Road at lat. $41^{o}52.6$'S, long. $145^{o}24.4$'E (grid 3462E, 8439N) is the only fossil known from the Fernfields Formation. At this locality the formation is much less conglomeratic than along the Dundas Rivulet about 1 km. away.

6. Comet Formation

This formation is well described by Blissett (1962, p. 35) as being composed of "purple, green and grey siltstone, mudstone and shale with scattered bands of greywacke-conglomerate and greywacke-grit". As noted by Blissett, the shales and siltstones are highly cleaved locally. This applies particularly to the type section along Dundas Rivulet.

In the past, numerous fossil localities have been reported in the Comet Slate, e.g., Elliston (1954), Banks (1956, 1962a), Blissett (1962), Gatehouse (1964) and Öpik (1967). However, with one exception these refer to localities in the Black Hill section, which, as shown below, cannot be correlated with the Comet Slate. No fossils are known from the type section. Blissett (1962, p. 36) reported a fossil locality in the Comet Slate from near the junction of the Murchison Highway and the road to Dundas (Fig. 3). However, despite an intensive search by the writer, this locality was not relocated.

7. Fernflow Formation

The Fernflow Formation is about 150 metres thick in the type section along Dundas Rivulet and thickens to the north-west. It is basically a fine reddish siltstone with frequent green or purple sandstone horizons and occasional massive conglomerate beds. Boulders of quartz, quartzite and siltstone are present along with rare basic igneous rocks. A small portion of the lower part of the

Fernflow Formation is well exposed in a small quarry about 100 metres along the Dundas road from the Murchison Highway. Here, the rock is mostly a fine reddish silt with sandier beds, many of which exhibit graded bedding. The coarser beds contain occasional small blebs (1-2 cm. long) of fine silt in random orientation, indicating that the silts have been deposited, solidified, torn up and redeposited as pebbles. Sedimentary structures present include scour surfaces, graded bedding, compactional features and disruptive bedding.

8. Climie Formation

The Climie Formation is about 450 metres thick in the type section along Dundas Rivulet. As noted by Blissett (1962, p. 31), this sequence is "composed mainly of purple and green greywacke, siltstone and highly cleaved slate". Conglomerate beds occur in the lower part of the formation, but become fewer and thinner upwards.

In the vicinity of the Murchison Highway bridge over the Dundas Rivulet, the Climie Formation is overturned and sheared (Blissett, 1962, Fig. 5). Immediately to the south of this bridge the formation is well exposed in the road cuttings. Here fossils were discovered by the writer and Dr. B. Daily. They are generally poorly preserved due to the highly sheared nature of the sediments, and some are seen only as "ghosts" although other fossils are moderately well preserved.

The best fossils are seen about 145 metres from the top of the formation at lat. 41°54.2'S, long. 145°24.2'E (grid 3459E, 8406N). They include *Agnostus* sp. 1, ?*Lotagnostus* sp. and polymerid trilobites including the olenid figured in plate 32, fig. 10. In the same vicinity a second fossil horizon was discovered by the writer about 200 metres below the top of the formation. Here the trilobites include unidentified polymerids and the agnostids, *Agnostus* sp. 1, *Pseudagnostus* sp. 1 and Agnostid, gen. et sp. indet. no. 7.

The age of these two faunas cannot be determined precisely. The single, very poorly preserved internal mould of a cephalon, recorded as ?*Lotagnostus* sp. could also belong in other agnostid genera which have scrobiculate cephala, e.g., *Agnostus* and *Xestagnostus*. If this head is, in fact, *Lotagnostus*, then the age of this fauna is about equivalent to that of the *Ptychaspis-Prosaukia* Zone of the North American time scale. However, the fauna associated with ?*Lotagnostus* is completely different from that associated with *Lotagnostus* sp. aff. *L. trisectus* (Salter) from near Birch Inlet. It thus seems unlikely that the Climie Formation faunas are of *Ptychaspis-Prosaukia* Zone age. Their stratigraphic position indicates that they occur decidedly later than the Mindyallan Brewery Junction Formation faunas. All that can be stated at present is that the Climie Formation faunas probably belong in the later part of the Upper Cambrian.

9. Passage from the Climie Formation to the Misery Conglomerate (= Mt. Zeehan Conglomerate).

Blissett (1962, p. 53) has shown that the Misery Conglomerate of Elliston (1954) may be correlated with the Mt. Zeehan Conglomerate of Waller (1904) and later authors.

The passage from the Climie Formation to the Misery Conglomerate is well exposed in the quarry at the north end of Misery Hill (3451E, 8427N). Blissett (1962, Fig. 5) indicates that the contact between the two formations in the quarry is faulted although a little further south he shows that they are conformable. However, the fault, as mapped by Blissett, appears to be a bedding surface showing well-marked slickensides. The contact between the two formations is about 30 cm. above this bedding plane and is sharp but conformable.

Conformably above the Misery Conglomerate are the other members of the Junee Group, the Moina Sandstone and the Gordon Limestone.

B. BLACK HILL SECTION

In the Black Hill-Grand Prize Mine area, north of Mt. Razorback (Fig. 3), is a poorly exposed, reasonably complete section of fossiliferous Cambrian sediments. In the descriptions which follow, no formal stratigraphic nomenclature has been used.

1. Spilite conglomerate

Along and near a prospecting track, (lat. 41°50.7'S, long. 154°24.6'E), bulldozed southwards from the North-East Dundas Tram up to an adit about one mile south of Serpentine Hill, is a reasonably well-exposed section of the basal member of the Black Hill section. On this track the writer discovered a spilite-rich conglomerate, the pebbles of which are derived from the underlying Melba Spilite. It has a thickness of about 3 metres. Since the Melba Spilite overlies the Serpentine Hill ultrabasic complex, this discovery lends support to a suggestion by Rubenach (1969, pers. comm.) that the ultrabasics are older than the fossiliferous Middle and Upper Cambrian sediments of this area.

2. Siltstone

Overlying the spilite conglomerate is a sequence of siltstone with interbedded sandstone (Fig. 5). Ten metres above the base of the siltstone a thin fossiliferous horizon containing only sponge spicules was found. About 28 metres above the base of the siltstone, Rubenach (1967) discovered about 3 metres of richly fossiliferous siltstone at lat. $41^{o}50.8'$S, long. $145^{o}24.7'$E (grid 3466E, 8474N). This fauna is referred to below as the RB fauna.

The fossils include numerous hydroids and dendroids (Quilty, 1971), gastropods, inarticulate brachiopods, rare hyolithids and both polymerid and agnostid trilobites. The polymerids include *Kootenia* sp. and other species. The agnostids present are *Peronopsis* (?) sp. 1, *Hypagnostus* sp., *Ptychagnostus* (*Ptychagnostus*) *hodgei* sp. nov., *Ptychagnostus* (*Ptychagnostus*) sp., *Ptychagnostus* (*Goniagnostus*) *rubenacha* sp. nov., Ptychagnostus (?) sp. 1, Diplagnostus sp. 1, Agnostid, gen. et sp. indet, no. 5, and Agnostid, gen. et sp. indet. no. 6. The palaeoecology of this fauna is discussed in the palaeoecology section of this thesis.

This fauna is stratigraphically well below the very late Middle Cambrian faunas found at 3472E, 8467N (see p. 28) and is the oldest known trilobite fauna found in the Dundas area with the probable exception of the "Judith Slate" fauna. The combination of Diplagnostus, Ptychagnostus and Hypagnostus is known in Sweden from the P. punctuosus Zone to the top of the Middle Cambrian (Westergård, 1946). Öpik (1961b, p. 67) records Diplagnostus from Queensland in P. gibbus time. However, the presence of Ptychagnostus (Goniagnostus) probably indicates that the fauna listed above is somewhat younger than the P. gibbus Zone. It may be of the P. punctuosus or the P. nathorsti Zone although there are no species in common with the Que River fauna which is of this age (see p. 51). The presence of P. (Goniagnostus) may indicate that this fauna is slightly younger than that from the Que River Beds, and it is thus tentatively placed in the Ptychagnostus nathorsti Zone.

To the east of the fossil locality the siltstone lenses out within 1.5 km, so that the overlying chert-breccia conglomerate merges with the spilite conglomerate (Fig. 3).

3. Chert-breccia conglomerate

The contact between the siltstone discussed above and the overlying unfossiliferous chert-breccia conglomerate is sharp. This conglomerate consists of angular to rounded clasts of chert and quartzite which at the base average 2-3mm. across and become coarser up the unit. The chert predominates. There are also some silt fragments which are similar to the silt found in the underlying siltstone. This seems to indicate that at least part of the underlying siltstone was torn up and redeposited during the deposition of the conglomerate. This conglomerate shows marked lithological similarities with the Razorback Conglomerate in which it was included by Blissett (1962). However, it is stratigraphically well below the Razorback Conglomerate (Fig. 4).

4. Mudstone-greywacke

This unit is that figured by Blissett and Gulline (1961b, Fig. 37) as "Brewery Junction Slate". However, the palaeontological evidence clearly shows that this mudstone-greywacke unit is stratigraphically below the Brewery Junction Formation as known from the type section (Fig. 4).

Poorly preserved fossils (GP_2 fauna) from near the top of this unit are known from lat. $41^{\circ}50.8'$S, long. $145^{\circ}24.7'$E (grid 3472E, 8467N). These include a pagetiid trilobite (probably *Opsidiscus*) and other trilobites which appear to indicate correlation with the very late Middle Cambrian fauna from near St. Valentines Peak, rather than with the Mindyallan faunas of the Brewery Junction Formation.

5. Conglomerate

Overlying the mudstone-greywacke unit is about 150 metres of unfossiliferous conglomerate, described by Blissett and Gulline (1961b, p. 142) as Fernfields Conglomerate, but which is in a similar stratigraphic position to the Razorback Conglomerate (Fig. 4).

6. Siltstone and shale

The overlying unit, consisting of purplish, green and grey siltstones and shales with tuffaceous partings, is described by Blissett and Gulline (1961b, p. 142) and Blissett (1962, p. 36) as Comet Slate. However, a richly fossiliferous horizon, noted by these workers on a creek bank at lat. 41°51.4'S, long. 145°25.1'E (grid 3472E, 8462N), was found by the writer to contain an almost identical fauna (referred to below as the GP_1 fauna) to the FE_1 fauna found in the Brewery Junction Formation along the Dundas Rivulet at 3471E, 8434N. One additional agnostid recognized at 3472E, 8462N was *Agnostardis* sp. 3.

An exact correlation can thus be made between the two localities (Fig. 4), which shows that in this area the so-called Comet Slate of Blissett and Gulline (1961b) largely corresponds to the Brewery Junction Formation.

Two fossil horizons found by the author along Barkers Creek also appear to belong in this siltstone and shale unit. The lower fauna was found at lat. 41°51.3'S, long. 145°26.1'E (grid 3487E, 8463N) and the upper fauna at 3487E, 8462N about 40 metres above the lower one.

Trilobites identified by the author in the lower fauna include *Agnostus* (?) sp., cf. *Cyclagnostus* sp., *Aspidagnostus* sp. 3, and *Oedorhachis* (?) sp., and in the upper fauna include *Aulacodigma* sp., *Agnostus* (?) sp., *Acmarhachis* sp. and *Agnostardis* sp. 1. From what appear to be the same horizons (C. Gatehouse, pers. comm.), Öpik (1967) noted the presence of *Palaeadotes* in the upper fauna and the discovery by Gatehouse (1964) of *Rhyssometopus* (*Rostrifinis*) cf. *rostrifinis* in the lower fauna. The upper fauna along Barkers Creek appears to be from the *Glyptagnostus stolidotus* Zone as suggested by Öpik (1967, p. 32). The agnostids found in the lower fauna seem to have closer affinities to the BJ_2 fauna in the Brewery Junction Formation about 400 metres north-west of the Adelaide Mine. It is possible that the lower fauna along Barkers Creek belongs in the *Cyclagnostus quasivespa* Zone.

Fossils have been recorded from along Barkers Creek by all previous workers in the Dundas area (e.g., Elliston, 1954; Banks, 1956, 1962a; Blissett, 1962; Gatehouse, 1964; and Öpik, 1967). However, these authors have followed Elliston and placed the Barkers Creek faunas in the Comet Slate. It is shown clearly in the above discussion that the fossiliferous siltstones along Barkers Creek are at a similar stratigraphic level to the Brewery Junction Formation (Fig. 4).

7. Conglomerate

The highest unit in the Black Hill area is a conglomerate which is lithologically similar to that underlying the fossiliferous siltstone noted above. It is in a similar stratigraphic position to the Fernfields Conglomerate of the type section. Unidentifiable trilobite fragments were found by the writer in an interbedded pyritic sandstone at lat. 41°51.4'S, long. 145°26.1'E (grid 3486E, 8460N).

C. NORTH-EAST DUNDAS TRAM--RING RIVER AREA

Elliston (1954) and later workers have recorded Cambrian fossils from along the North-East Dundas Tram in the vicinity of Bonnie Pt. and elsewhere (Fig. 3). One such locality has been noted in the above discussion on the Hodge Slate. The only locality in this area which the writer was able to relocate was that noted by Elliston (*op. cit.*) about 300 metres east of Bonnie Point where the late Middle Cambrian or early Upper Cambrian agnostid, *Clavagnostus*, was found in a siltstone. Blissett (1962, p. 35) records the presence of the late Middle Cambrian genus *Nepea* about 400 metres west of Montezuma Bridge.

There is an increase in the volcanic content within the Cambrian sediments from Dundas towards Mt. Read (about 5 km. east of Bonnie Pt.) as the Mt. Read Volcanic Arc is approached. The interbedded volcanics, (including the Curtin Davis Volcanics of Elliston), found around Godkin Ridge, south of the North-East Dundas Tram, are predominantly tuffs and devitrified ignimbrites of rhyolitic to andesitic composition (Forsythe, 1968). Forsythe also records the presence of minor vesicular basic lavas in addition to the finer grained pyroclastics.

2. HUSKISSON RIVER AREA

Blissett (1962, p. 38) states that,

> "About 1 3/4 miles upstream from the mouth of the Huskisson River, a sill-like mass of serpentinite and pyroxenite has intruded dark laminated slaty shale which has been altered at the contact to mottled pale grey and greenish chert".

This shale is the basal unit of a sparsely fossiliferous Cambrian sequence first described by Taylor (1954). Banks (1956, p. 180) summarized Taylor's work in a table which listed 19 formations with a thickness of about 1840 metres conformably overlying about 3050 metres of argillite (equivalent to the Crimson Creek Formation) which unconformably overlies a sequence of jasper, shale, quartzite and tuff. The upper 19 formations have been correlated with the Dundas Group on the basis of the discovery of *Glyptagnostus reticulatus* and dendroids in this section (Blissett, 1962). The dendroids and hydroids in this section have been described by Quilty (1971).

A modified version of the map of the Huskisson River area produced by Blissett (1962, fig. 4) is reproduced here as Fig. 6. Blissett (*op. cit.*, p. 38) has shown that units 1-13 (measuring upstream from the serpentinite contact, i.e., No. 1 is the lowest unit) are in sequence, but the units 14-19 described by Taylor are almost certainly a repetition. Taylor noted the presence of *Glyptagnostus*

Table 2. Huskisson River Section (modified after Taylor, 1954; Banks, 1956; Blissett, 1962).

Formation	Lithology	Thickness (metres)
Gordon Limestone	limestone with minor mudstone	335
Moina Formation (17, top of 19)	sandstone with subsidiary conglomerate	16
Mt. Zeehan Conglomerate equivalent (15 & 16; bottom of 19)	conglomerate (19), coarse conglomerate (16), chert breccia (15)	128-174
14, 18	black pyritic shale with _Glyptagnostus reticulatus_, dendroids and hydroids (18); black slate with inarticulate brachiopods, sponge spicules, dendroids and hydroids (14)	34-92
13	thin bedded shales with tuffaceous bands	272
12	cherty conglomerate	80
11	thin bedded grey shales	186
10	massive feldspathic tuff	28
9	thin bedded shale	49
8	conglomerate with quartz and chert pebbles in coarse sandy matrix	49
7	thin bedded blue-grey shale	92
6	shale formation with 3 bands of fine grey conglomerate with rounded quartz pebbles	107
5	thick-bedded yellow-brown to grey shale	80
4	coarse blue-grey sandstone	52
3	fine grained thin-bedded dark grey shales with dendroids and hydroids	120
2	coarse quartzites, dark shales, fine conglomerates with light quartzites at top	107
1	thin bedded black shale with dendroids and inarticulate brachiopods	116
----- contact with serpentinite -----		
Crimson Creek Formation equivalent		3050

reticulatus in a black shale about 25 metres from the top of unit 18 (Blissett, 1962, fig. 14 and pers. comm.). The overlying unit (19) is a poorly exposed conglomerate, about 122 metres thick, composed of rounded pebbles of sandstone and grey chert, up to about 1 cm. in diameter, set in a sandy matrix. At the top of unit 19 Taylor noted fine conglomerate and sandstone which may be equivalent to the Moina Sandstone (Blissett, 1962, p. 39, and pers. comm.). Formation 19 is overlain with apparent conformity by the Gordon Limestone (Blissett, 1962, p. 58 and pers. comm.). Considering the situation further downstream, Blissett (1962, p. 38) states that, "Mapping indicates that Formation 14 is overlain by a correlate of the Mt. Zeehan Conglomerate, and that it may be equivalent to the *Glyptagnostus reticulatus* shale." Above Formation 14 are 37 metres of chert breccia (Formation 15) which is conformably overlain by 137 metres of coarse conglomerate (Formation 16). This conglomerate is overlain by about 16 metres of sandstone (Formation 17) which Blissett (1962, p. 39) considered may be equivalent to the Moina Sandstone. Formation 17 is overlain by the Gordon Limestone.

From the above remarks it is seen that Blissett's suggestion that units 14 and 18 are equivalent is probably correct. This means that units 15, 16, and 17 (total thickness 190 metres) are equivalent to unit 19 (thickness 122 metres) and in turn to the Mt. Zeehan Conglomerate plus the Moina Sandstone. Such thickness variations are common within the Junee Group conglomerates and sandstones. The stratigraphy of the area, somewhat modified after Taylor (1954, Banks (1956) and Blissett (1962), is given in Table 2. The presence of *Glyptagnostus reticulatus* in unit 18 clearly indicates correlation with one of the two lower Idamean Zones from Queensland, i.e., the *Glyptagnostus reticulatus* - *Olenus ogilviei* Zone or the *G. reticulatus*-*Proceratopyge nectans* Zone.

3. FARRELL RIVULET - HENTY RIVER - GRIEVES TRAM AREAS

Blissett (1962, p. 40) records fossiliferous Cambrian sediments from the south-east part of the Zeehan Quadrangle in the Tom Creek-Farrell Rivulet-Henty River area (Fig. 7). Along Tom Creek is a sequence of green, purple and grey siltstones, greywacke grit and conglomerate. One siltstone bed near lat. 41°55.5'S, long. 145°26.3'E (grid 3491E, 8378N) contains inarticulate brachiopods, polymerid trilobite fragments plus the agnostid trilobite described here as Agnostardis sp. 2. The presence of Agnostardis probably indicates correlation with the Glyptagnostus stolidotus Zone of Queensland and the Brewery Junction Formation from the Dundas area.

Blissett (1962, p. 40) reports that along Farrell Rivulet is a folded sequence of green-grey laminated mudstone and shale, siltstone and fine greywacke with occasional beds of tuff or agglomerate. Poorly preserved brachiopods were found by Blissett at 3532E, 8355N and by the writer at 3513E, 8361N. The succession is similar to that along the Henty River where Blissett found poorly preserved fossils at two localities near 3539E, 8307N. They include pagetiid trilobites and the sponge Chancelloria, thus indicating a Middle Cambrian age for this fauna. Despite a search by the writer in these areas, no fossil localities, other than those mentioned above, were found. In the Farrell Rivulet and Henty River areas the coarse conglomerate bands characteristic of the Dundas area are largely missing.

About 11 km. south of Zeehan along the old Grieves horse tram track on the way to the Queensberry Mine, Forsythe (letters 8/6/71, 23/6/71) found what he regards as a complete sequence of Junee Group sediments (Gordon Limestone, Moina Sandstone, Mt. Zeehan Conglomerate equivalent) conformably overlying shales and tuffs. At about long. $144^{\circ}23.9'E$, lat. $42^{\circ}00.2'S$ (grid 3455E, 8282N) approximately 600 metres below the top of these shales and tuffs, Forsythe discovered what appear to be distorted asaphid trilobite fragments. Unfortunately, the writer was not aware of this locality until well after field work was completed. At present only the thorax and pygidium, originally found by Forsythe, are available. The age of this fauna is unknown, but its stratigraphic position suggests that it is probably of Upper Cambrian age.

4. ZEEHAN AREA

Poorly preserved Cambrian fossils are known from two localities south-west of Zeehan (Fig. 8).

Öpik (1951c) recorded Diplagnostus sp. and cystoids from a black shale which is interbedded with siltstone and greywacke at the eastern end of the Summit Cutting of the Comstock tram (lat. 41°53.8'S, long. 145°18.7'E; grid 3374E, 8412N). Öpik suggested correlation with the Hodge Slate at Dundas.

The writer collected trilobites from this locality which include those described in this thesis as Lejopyge (?) sp., Clavagnostus sp. 4, and Diplagnostus sp. 4. Polymerid fragments were also seen at this locality. This faunal assemblage indicates a late Middle Cambrian age, but no precise date can be given.

From McLeans Creek (lat. 41°55.3'S, long. 145°17.5E; grid 3357E, 8381N) Blissett (1962) reports the possibility of Cambrian greywackes, siltstone and mudstone passing conformably up into the Mt. Zeehan Conglomerate. The mudstone contains rare, poorly preserved fossils. The writer recovered two agnostid fragments (described below as Agnostid, gen. et sp. indet. no. 9) and one polymerid fragment after a search lasting several hours. These fossils do not allow precise dating but have an Upper Cambrian aspect.

An inspection of the supposed passage between the Cambrian sediments and the Mt. Zeehan Conglomerate was inconclusive. At the time of inspection (January, 1969) there was a gap of about 50 metres between the highest Cambrian outcrops (strike 110°, dip 60°S) and the lowest exposure of Mt. Zeehan Conglomerate (strike 90°, dip 45°S). The strike and dip of the Cambrian sediments vary considerably over the small area of exposure.

Campana and King (1963, p. 24) consider that the Cambrian sediments and the Mt. Zeehan Conglomerate in the vicinity of Mt. Zeehan are in faulted contact. However, at the present state of knowledge any one of three interpretations of this contact, i.e., a faulted contact, a conformable contact or an unconformable contact, is equally tenable.

5. SOUTH-CENTRAL TASMANIA

Fossiliferous Cambrian sediments are known from three areas of south-central Tasmania: (a) the Denison Range area, (b) near Adamsfield and (c) along Scotts Peak Road. The locations of these areas are shown in Fig. 2.

(a) Denison Range

In the Denison Range area Dr. K.D. Corbett (1970 and pers. comm.) has mapped about 1220 metres of siltstone, conglomerate, shale and turbidites, some of which contain Upper Cambrian fossils.

The succession proposed by Corbett (1970) for the Denison Range area is as follows:

Top: Gordon Group (Gordon Limestone of earlier workers)

Florentine Group (sandstones and siltstones containing a Lower Ordovician fauna)

Denison Group

Reeds Conglomerate

Great Dome Sandstone (about 460 metres thick)

Base: Singing Creek Siltstone (about 760 metres thick)

Corbett discovered trilobites in the upper part of the Singing Creek Siltstone. In this thesis I have described four agnostid species from this fauna, i.e., Pseudagnostus corbetti sp. nov., P. cf. corbetti, Denagnostus keithi sp. nov., and Agnostid, gen. et sp. indet. no. 8.

Four polymerid species are present including cf. Sigmocheilus and a new species of Proceratopyge. Mr. M.R. Banks (pers. comm.) considers that inarticulate brachiopods associated with these trilobites suggest an age of Elvinia Zone on the North American time-scale. Since most, if not all, of the trilobites noted above are new species, they are of little value with respect to precisely dating the fauna. However, Palmer (1965, p. 73), in discussing the species of Sigmocheilus found in the western U.S.A., has noted that they are common in the Dunderbergia Zone and in the lower part of the Elvinia Zone. Thus at present, although no precise age can be given for the Singing Creek Siltstone, it can be tentatively placed in the middle part of the Upper Cambrian. The Singing Creek Siltstone is conformably overlain by the Great Dome Sandstone which contains rare unidentified gastropods and inarticulate brachiopods. The Great Dome Formation is conformably overlain by the Reeds Conglomerate which is in a similar stratigraphic position to the Owen Conglomerate and other conglomerates of Late Cambrian-Early Ordovician age found elsewhere in Tasmania.

(b) Adamsfield Area

Banks (1962a, p. 137) notes possible Cambrian slate, siltstone, chert and greywacke breccia in the Adams River Valley, west of Adamsfield. Banks (op. cit.) also states:

> "Conglomerates, sands and silts composed of serpentinite detritus overlie serpentinite on the Sawback Range east of Adamsfield. These ancient

> placer deposits contain chromite and osmiridium (Carey and Banks, 1954). The siltstones contain inarticulate and articulate brachiopods, gastropods (Scaevogyra) and trilobites."

Öpik (p. 137 in Banks, 1962a) stated that the fauna was Upper Dresbachian to Lower Franconian in age and that it contains Eoorthis and Billingsella. Jones et al. (1971, Chart 1) consider that this fauna is of Post-Idamean A Stage. The writer has not studied this fauna in any detail due to lack of time.

(c) Scotts Peak Road

Quilty (1971, p. 175) reports the presence of poorly fossiliferous sediments along Scotts Peak Road (Fig. 2). Quilty notes the presence of inarticulate brachiopods, hydroids, dendroids and a possible xiphosuran arthropod. He suggested a Middle Cambrian age for this fauna.

6. SOUTH-WEST TASMANIA

The extent of known and suspected Cambrian rocks in south-west Tasmania is seen in Fig. 2. The presence of Cambrian rocks south of Macquarie Harbour has been postulated on lithological and structural grounds for some years (Banks, 1956, p. 175, 1962a, fig. 8). Scott (p. 138 in Banks 1962a) suggests that the Cambrian rocks of this area can be divided into two assemblages: (i) a sedimentary-volcanic association consisting of chert, shale, calcareous mudstone, greywacke, greywacke conglomerate, quartzite, rare dolomite, basalt, andesite, spilite, shale and tuff and (ii) an acid volcanic association with quartzite and subordinate greywacke and shale.

The area in which these rocks occur is uninhabited, and it is accessible only by sea or by helicopter (on the plains country). The outcrop is poor; there is a considerable depth of weathering, and the country consists of either dense rain forests or open button-grass plains.

In recent years, geologists of the B.H.P. Co. Pty. Ltd. in mapping an area to the west of Birch Inlet, immediately south of Macquarie Harbour, have found extensive occurrences of Cambrian rocks (Fig. 9). These include siltstones, sandstones, greywackes, minor conglomerates, andesites, spilites and serpentinites. The Cambrian rocks are both apparently conformably and unconformably overlain by a fine conglomerate or sandstone which is the basal unit of the Junee Group in this area. The conglomerate is overlain by the Gordon Limestone.

Fossiliferous Cambrian sediments have been found along a prospecting track near lat. $42^{\circ}27.2'$S, long. $145^{\circ}21.1'$E (grid 3417E, 7735N). Beneath the basal sandstones and conglomerates of the Junee Group are about 800 metres of Cambrian sediments. The basal 430 metres of the Cambrian sediments are known only from float material and appear to be mainly siltstone with minor greywacke (? tuff) and conglomerate beds. Regional mapping of the area by geologists of the B.H.P. Co. indicates that the Cambrian sediments are cut off at the base by a fault (Mr. M. Hall, pers. comm.). They abut against Precambrian quartzites and slates.

The well-exposed part of the section commences with a purple and grey-green silt and breccia, passing up into red-green tuffaceous microbreccia, which is overlain by about 30 metres of fine green sandstone. The rest of the section, consisting mainly of siltstone, was measured in detail by the writer (Fig. 10).

The lowest trilobites found to date come from a dark grey siltstone about 247 metres from the top of the siltstone section. Fossils are rare or only moderately abundant in the 46 metres above this bed. Above these fossiliferous beds there are two unfossiliferous parts of the section separated by about 18 metres of fossiliferous siltstone (Fig. 10). The other fossils in this measured section occur between 55 and 107 metres from the top of the siltstone sequence. These beds are by far the most richly fossiliferous. The top 55 metres of siltstone is unfossiliferous. In the uppermost 10 to 12 metres of siltstone sequence, there are occasional thin quartz sandstone and fine quartz conglomerate beds.

A fine quartz conglomerate overlies the siltstone with apparent conformity. It contains some heavy mineral bands and some moderately fine sandstone beds. The clasts are usually no more than a centimetre, and most are less than 0.5 cm. across although there are occasional pebbles up to 3 cm. in diameter. Most of the fragments are quartz and quartzite with some chert and siltstone clasts plus rare metamorphic pebbles. Near 3417E, 7735N this conglomerate is about 120 metres thick and is conformably overlain by Gordon Limestone.

In a syncline to the south-east of the fossiliferous section this conglomerate and sandstone sequence unconformably overlies the Cambrian sediments (Fig. 9). In this syncline the basal Junee Group sandstone has thickened to about 645 metres. It includes a lower and an upper sandstone unit (Oc_1 and Oc_3 respectively in Fig. 9) and a middle micaceous sandstone unit (Oc_2). Each unit is about 215 metres thick. Thus this formation thickens rapidly from west to east in this region. At the base of this sequence in both the synclinal and fossiliferous areas, there is a thin (30 to 60 cm.) band of red and white grit and fine conglomerate (Mr. M. Hall, pers. comm.). This suggests that there is a disconformity in the apparently conformable passage from the Cambrian silts to the basal Junee Group conglomerate at 3417E, 7735N. Nevertheless, there is still a marked difference between the contact of the Cambrian and Junee Group rocks in the two areas (Fig. 9).

There are extensive areas of poorly exposed siltstones and greywackes to the east of the fossil locality and also adjacent to Birch Inlet (Fig. 9). The stratigraphic position of the siltstones to the west of the syncline is probably much the same as that of the fossiliferous sediments. The presence of considerable thicknesses of greywacke interbedded with siltstone adjacent to Birch Inlet suggests that these sediments may be stratigraphically below the fossiliferous sediments near 3417E, 7735N where greywacke is absent. However, as noted previously, there is considerable lensing and tonguing of sediments within the Tasmanian Cambrian.

The fossils from 3417E, 7735N have not been studied in detail. The polymerid trilobites include Proceratopyge. The agnostid trilobites include Agnostus sp. 2, Geragnostus sp. 1, G. sp. 2, G. sp. 3, Lotagnostus sp. aff. L. trisectus (Salter), Birchagnostus inleti sp. nov., Pseudagnostus sp. 3 and P. sp. 4. Rare inarticulate brachiopods are also known from this section. Dictyonema sp. and numerous other dendroid fragments were described by Quilty (1971). The stratigraphic distribution of the agnostids is shown in Fig. 11. There is a marked increase in agnostids towards the top of the fossiliferous section.

The presence of *Lotagnostus* in this fauna is quite significant. This genus is known from Sweden, Scotland, Quebec, Vermont, Alaska, Siberia, Kazazhstan, China and Argentina. The age of *Lotagnostus* from these other localities is equivalent to that of the second highest North American Upper Cambrian Zone, the *Prosaukia-Ptychaspis* Zone. Clarke (1968b, p. 147) suggested a late Middle Cambrian age for this fauna, but the presence of *Lotagnostus* clearly negates this view.

This fauna is now the youngest Cambrian fauna known from Tasmania. Prior to the discovery of *Lotagnostus*, the youngest recorded Cambrian fauna for Tasmania was that from near Adamsfield in south-central Tasmania (Öpik *in* Banks 1962a). Öpik (*op. cit.*, p. 137) dated this Adamsfield fauna as Upper Dresbachian to Lower Franconian (see above, p. 42), i.e., about two zones older (on the North American time scale) than the fauna containing *Lotagnostus* from near Birch Inlet.

Lotagnostus and most other agnostids found in this section are known only from the upper parts of the fossiliferous sequence (Fig. 11). As can be seen from this figure, most of the agnostids found in the upper part of the fauna first appear at much the same level. Only *Geragnostus* sp. 2 and some rare unidentified isolated pygidia and cephala are known from the lower part of the fossiliferous sequence. The polymerids from the lower part of the section also differ from those in the upper part of the section.

It is possible that there was a change in environment at about the time the character of the faunas changed. An alternative explanation is that the faunas, lower in the sequence, could be correlated with the *Conaspis* Zone on the North American time scale, rather than the *Prosaukia-Ptychaspis* Zone to which the *Lotagnostus* fauna is assigned.

7. QUE RIVER AREA

Campana and King (1963) and Barton *et al*. (1966) have mapped extensive areas of probable Cambrian sediments in an area west of the junction of the Que River with Bulgobac Creek. This area was termed the Que Syncline by Campana and King (1963). Fig. 14 shows the distribution of some of these sediments. Although no fossils are known from these sediments, structural and lithological evidence leaves little doubt of their Cambrian age. The sediment types include mudstone, slate, sandstone, greywacke, siliceous conglomerate, greywacke conglomerate, laminated shale and minor amounts of limestone conglomerate. The rocks of this area are generally poorly exposed due to a deep weathering profile and a dense vegetation cover.

Campana and King (1963, p. 23), following Campana *et al*. (1960) and Campana (1961), state that the basal bed of these sediments rests unconformably on the porphyries of the Mt. Read Volcanics, with a period of uplift and erosion prior to the deposition of the sediments. Banks and Solomon (1961) dispute this and claim that at the exposure in question (a railway cutting, 2.4 km. north of Bulgobac), there is a local disconformity but not "angular unconformity". The exposure of the contact between the porphyries and the overlying sediments is not very good. It would appear to me that Banks and Solomon are correct, especially in view of the situation described below with respect to the Que River Beds.

Campana (1961) criticizes the suggestion of Banks and Solomon (1961), "that the only valid basis for stratigraphic correlation is palaeontological" with regard to the Cambrian of Tasmania. Campana (following Banks, 1956) goes on to use Hurdia? davidi as an indication of the Cambrian age of the sediments from the Que Syncline. However, Banks (1962c) has since shown that Hurdia? davidi is probably inorganic.

About 6 km. east of the eastern margin of the Que Syncline, the Que River Beds of Gee et al. (1970) are well exposed along the Murchison Highway in the vicinity of the Murchison Highway bridge over the Que River (Fig. 15). The detailed geology of this area is discussed in Gee et al. (op. cit.), which paper is included in this thesis in Appendix 4.

The Mackintosh map sheet of Barton et al. (1966) shows two fossil localities in what Gee et al. (op. cit.) later called the Que River Beds. The writer was able to locate fossils only at the northern of these two localities at lat. 41°34.7'S, long. 145°41.0'E (grid 3710E, 8803N) on the northern bank of the Que River, where it is bridged by the Murchison Highway. This fauna has been examined briefly by Clarke (1968a) and Gee et al. (1970). It contains agnostid trilobites, hydroids, dendroids, inarticulate brachiopods, sponge spicules and a single xiphosuran. The hydroids and dendroids have been described by Quilty (1971). The following agnostid trilobites from this locality are described below:

Hypagnostus sp. aff. *H. parvifrons* (Linnarsson), *Valenagnostus* (?) sp., *Ptychagnostus* (*Ptychagnostus*) *stenorrhachis* (Grönwall), *Ptychagnostus*? *murchisoni* sp. nov., *Ptychagnostus* sp., *Diplagnostus geei* sp. nov., cf. *Kormagnostus* sp., and Agnostid gen. et sp. indet. no. 1.

In Sweden *Ptychagnostus stenorrhachis* is found in both the *Ptychagnostus punctuosus* Zone and the *Ptychagnostus nathorsti* Zone. In Newfoundland, Hutchinson (1962) described *P. stenorrhachis* from the upper part of the *Paradoxides davidis* Zone, of a similar age to the *P. punctuosus* Zone of Sweden. Thus, the age of the fauna in the Que River Beds is either that of the *P. punctuosus* Zone or the *P. nathorsti* Zone. The palaeoecology of this fauna is discussed in the palaeoecology section of this thesis.

As concluded by Gee *et al.* (*op. cit.*, p. 763):

> "There is little doubt that in this area, the Mt. Read Volcanics and the Que River Beds are interbedded, but locally the Mt. Read Volcanics may be intrusive. This means that the Mt. Read Volcanics are in part at least upper Middle Cambrian and that some of the volcanic rocks are marine."

8. QUEENSTOWN AREA

In the Queenstown area Solomon (1960) has described volcanics and associated sedimentary rocks which he correlated with the Dundas Group. Most of the volcanics were later included in the Mt. Read Volcanics by Solomon (1965, fig. 6). The unfossiliferous sediments noted by Solomon (1960) include conglomerate, sandstone, mudstone and slate.

In September, 1967 the Mt. Lyell Mining and Railway Co. Ltd. completed Diamond Drill Hole C50 in the Comstock area north-east of Queenstown (Fig. 12).

The drill hole (Fig. 13) was collared in Pleistocene glacial moraine deposits and subsequently passed down through the various members of the Junee Group (Gordon Limestone, Owen Conglomerate and Jukes Breccia) and into the Mt. Read Volcanics. The Jukes Breccia rests unconformably on the Mt. Read Volcanics in the Queenstown area. After passing through about 122 metres of unmineralized quartz keratophyre tuffs of the Mt. Read Volcanics, 45 metres of recrystallized limestone were encountered. The limestone, which has no known surface outcrop, is fossiliferous towards the base where it grades into a zone of massive haematite approximately one metre thick. This sequence directly overlies (with possible disconformity) highly sheared and mineralized (pyritic) quartz, sericite and chlorite schists (lithic tuffs) which, where first encountered, contain a massive zone of banded pyritic chert (Mr. K. Reid, pers. comm.). These schists are faulted against the Owen Conglomerate. Thus, the fossiliferous limestone is found interposed between two different sequences of the Mt. Read Volcanics; it separates overlying barren volcanics from underlying mineralized volcanics. The fact that the lower volcanics appear to be more sheared than the upper volcanics may suggest folding of the lower volcanics prior to the deposition of the limestone. Alternatively, the lower volcanic sequence may have been more affected by the late Upper Cambrian Tyennan Movement or the Middle Devonian Tabberabberan Orogeny. Further information will be required before this problem is solved.

The fossils from the limestone have not yet been studied in detail. They include an agnostid trilobite, a polymerid trilobite, (Dorypyge or a closely related genus), small echinoderm plates, hyolithids, small gastropods and inarticulate brachiopods. The four agnostid fragments found to date have been cephala of the same species. They probably belong in Peronopsis, but until pygidia are found, no definite generic determination can be made. The overall aspect of the fauna indicates an Upper Middle Cambrian age.

Campana and King (1963, pp. 48-49) and Markham (1968, p. 217) have proposed that the sulphide mineralization of the Mt. Lyell area is genetically related to the volcanic activity which produced the Mt. Read Volcanics, with subsequent textural modifications taking place during the Middle Devonian Tabberabberan Orogeny. If this is the case, then the presence of the fossils noted above suggests an upper limit of Middle Cambrian to the age of mineralization in the Mt. Lyell area. This is in contrast with the view expressed by Solomon and Elms (1965, p. 481) that the mineralization in the Mt. Lyell area took place towards the end of the Tabberabberan Orogeny. The presence of the fossils also suggests that the Mt. Read Volcanics in the Mt. Lyell area were formed in or close to the sea. The fact that Middle Cambrian limestone overlies the Mt. Read Volcanics with possible disconformity, as well as underlying them, suggests that the Mt. Read Volcanics may extend down into the Lower Cambrian as suggested by Loftus-Hills et al. (1967) and other workers.

A further interesting point is the occurrence of a considerable thickness of limestone, a rock type which is rare in the Tasmanian Cambrian (Banks, 1957). The limestone probably represents a near-shore, shallow bank deposit laid down during a lull in vulcanicity. Its lateral extent is unknown.

9. BATHURST HARBOUR AREA

Jennings (1961) described a sequence of conglomerates, sandstones, siltstones, mudstones and greywackes, with a total thickness of about 1520 metres from near Bathurst Harbour. He regarded these as possibly Cambrian as did Banks (1962a, p. 138, fig. 8). However, Bowen and Maclean (1971), in mapping an area around the Davey River, about 25 km. to the north-west of Bathurst Harbour, considered that correlates of the Bathurst Harbour sequence, found around the Davey River, were probably of Ordovician age. Until fossils are found in these sediments, no firm date can be assigned to them.

10. NEW RIVER LAGOON AREA

Banks (1962a, p. 137) records several thousand feet of conglomerate, siltstone and sandstone from Rocky Boat Harbour just east of New River Lagoon (Fig. 2). The sequence overlies Precambrian dolomite and is overlain with probable unconformity by an equivalent of the Caroline Creek Sandstone. Banks (op. cit.) notes the presence of many sedimentary cycles and also that the coarser rocks contain fragments of dolomite, serpentinite and other ultrabasic rocks and siliceous rocks. Banks states, "By analogy with the rocks at the Sawback Range, these serpentinite-bearing sediments are thought to be Cambrian." The only fossils known from this succession are worm casts and sponge spicules. Its true age cannot, therefore, be determined.

11. ST. VALENTINES PEAK AREA

Pike (1964), in mapping an area around St. Valentines Peak, discovered well-preserved Cambrian fossils in a siltstone near the corner of Hampshire Park Road and Gin Creek Road (lat. 41°21.6'S, long. 145°44.3'E; grid 3758E, 9064N). The rocks in this area are poorly exposed with a thick vegetation cover in many places. Road cuttings and quarries are the principal source of geological information. Since Pike mapped the area, a considerable number of new roads have been made. These have exposed good sections of Cambrian rocks and have been used by the writer in remapping the St. Valentines Peak area (Fig. 16).

The Cambrian rocks to the north and west of St. Valentines Peak are exposed in a regional anticline which appears to plunge north in the southern part of the area and south in the central part of the area. They are overlain with apparent conformity by a chert conglomerate which is the basal member of the Junee Group in this area. These sediments were later intruded by the Devonian Hampshire Hills Granite and finally partly covered by Tertiary basalt.

The best exposed sections are along the PMG Road, Black Pit Road and adjacent roads, and along Hampshire Park Road between PMG Road and Black Pit Road. North of this area, the Cambrian rocks tend to be covered by basalt or intruded by granite; south of this area, there is considerably less outcrop, even in the road cuttings. The stratigraphic column for the western limb of the anticline in the PMG Road-Black Pit Road area is described below and summarized in Fig. 17.

The lowest unit exposed in the PMG Road-Black Pit Road area is a cherty, pyritic sandstone and siltstone which is well exposed in a quarry at the end of Black Pit Road. The overlying unit is a devitrified incipiently to moderately welded tuff of rhyolitic to rhyodacite composition. Devitrified cuspate shards are common in the ground mass; there are some small recrystallized spherulites; the quartz phenocrysts are angular to rounded. The whole assemblage is typical of an ash flow (Dr. C.D. Branch, pers. comm.). This unit is about 100 metres thick.

The welded tuff is overlain by about 75 to 100 metres of poorly exposed sandstone and siltstone. The overlying unit is about 100 metres thick. In outcrop it has a green and white striped appearance with the white stripes being more resistant to weathering. This unit is concordant with the surrounding units. In thin section the green parts of the rock are distinctly nodular and consist of epidote group minerals, diopside (?), minor amounts of scapolite, tremolite (reasonably common) and isolated nodules of vesuvianite. The white parts of the rock are much finer grained and consist largely of a mineral, with low birefringence, which cannot be identified with certainty. Traces of carbonate and some clay are also present in the finer grained parts of the rock. The composition of the rock varies considerably over a short distance, but its overall appearance remains the same. This rock is possibly of contact metasomatic origin (Dr. A.S. Joyce, pers. comm.) and may have been an impure limestone or dolomite which was affected by the intrusion of the Hampshire Hills Granite.

The overlying unit is a hard laminated and non-laminated, slightly pyritic, pale grey chert, which is about 375 metres thick on the western limb of the anticline and about 230 metres thick on the eastern limb of the anticline. The chert weathers to a buff coloured siltstone. It is overlain by 1.5 metres of deeply weathered brown siltstone and 11 metres of grey siltstone. Overlying the grey siltstone is a 50 cm. lens of microbreccia which is separated by about one metre of grey siltstone from a lens of breccia which varies from 15 to 45 cm. in thickness over the two metres in which it is exposed. This upper breccia lens consists of angular pebbles of chert and quartzite up to 2 cm. across, but which average 0.5 to 1 cm. across. It tends to be disconformable on the underlying siltstone.

The upper breccia lens is overlain by 3.5 metres of poorly fossiliferous, micaceous grey-green siltstone and interbedded grit beds. The fossils are unidentifiable brachiopod and trilobite fragments discovered by the writer and Dr. B. Daily at lat. $41^{o}20.0'S$, long. 145^{o} $44.0'E$. Despite intensive collecting, no recognizable trilobites have been found. The fossiliferous siltstone is separated from the basal Junee Group conglomerate by a 5 to 10 cm. band of very fine grey siltstone.

The section near the contact between the Junee Group conglomerate and the underlying, apparently conformable, siltstone is shown in Fig. 18.

The main fossil locality in the St. Valentines Peak area at 3758E, 9064N is about 3 km. south of the section discussed above. The fossils at this locality include the trilobites Nepea sp., a zacanthoid (pl. 32, fig. 6), Schmalenseeia gostinensis sp. nov., Opsidiscus argusi sp. nov., Peronopsis ekip sp. nov. Valenagnostus banksi sp. nov., Clavagnostus rawlingi sp. nov., Pseudoclavagnostus sisponorep sp. nov., Aspidagnostus cf. riani, Buckagnostus compani sp. nov., Agnostascus (?) sp. 2, Agnostid, gen. et sp. indet. no. 2, and Agnostid, gen. et sp. indet. no. 3.

This faunal list indicates that the age of this fauna is close to the Middle Cambrian/Upper Cambrian boundary. Nepea is not recorded above the Lejopyge laevigata Zone in Northern Australia (Öpik, 1970). The highest recorded species of Opsidiscus is O. depolitus Romanenko from "layers transitional between the Middle and Upper Cambrian" (Poletaeva and Romanenko, 1970, p. 75). Clavagnostus is known from both Middle and Upper Cambrian sequences. However, as far as I am aware, Aspidagnostus and Agnostascus are known only from the early Upper Cambrian. At both Christmas Hills and in the Sugarloaf Gorge (see below) Buckagnostus is known only from late Middle Cambrian faunas. Although the question cannot be decided with certainty, it appears that the main St. Valentines Peak fauna is either of the

Lejopyge laevigata III Zone of Öpik (1961b) or the Middle Cambrian/ Upper Cambrian Passage Zone of Öpik (1967).

In the area where this fauna is found, the outcrop is very poor. In fact, the best fossils are found in sediment trapped in the roots of fallen trees. There are two other fossil localities in the immediate vicinity. Both are found in road cuttings of the Hampshire Park Road (Fig. 16). The more southerly of these localities appears to have a similar fauna to that noted above. The northern locality at lat. 41°21.4'S, long. 145°44.6'E (grid 3764E, 9066N) has only very poorly preserved fossils which include unidentified polymerid trilobites and Agnostascus (?) sp. 2. Its stratigraphic position indicates that it is slightly younger than the main fauna.

The outcrop in the area, where the main late Middle Cambrian fauna is located, is not good enough to determine its exact stratigraphic position with respect to the units of the PMG Road-Black Pit Road section. However, if the proposed structure is correct, and the regional anticline plunges northwards in the southern part of the area as shown in Fig. 16, then this fauna occurs stratigraphically below the lowest unit of the PMG Road-Black Pit Road section (Fig. 17).

12. NORTH-WEST COAST

Burns (1964) mapped the Cambrian rocks of the Dial Range Trough which extends from near Gunns Plains north to Bass Strait. The Dial Range Trough is flanked on either side by Precambrian rocks; it widens rapidly near Gunns Plains and joins the Dundas Trough just south of this area. The Cambrian and Ordovician successions in the Dial Range area are summarized in Table 3. A map of the Dial Range Trough is given in Fig. 19. A columnar section of the Cambrian rocks of the Dial Range area is given in Fig. 20.

The Lobster Creek Volcanics are massive, intermediate to acid, volcanics and outcrop along the axis of the Trough. Burns (1964, p. 33) suggests that they may have been a submarine volcanic pile.

The Cateena Group, as proposed by Burns (op. cit., p. 33), "is defined as that group of rocks, predominantly mudstone, which overlies the Precambrian unconformably and the Lobster Creek Volcanics with an inferred disconformity and is overlain by the Barrington Chert in the Dial Range Area". The succession within the Cateena Group is given in Table 3.

The Isandula Conglomerate outcrops in the bed of the Gawler River near 4132E, 9215N, where it is at least 180 metres thick. It consists of angular pebbles of purple mudstone averaging 1 cm. in diameter set in a feldspathic sandstone matrix. It appears to be a basal

TABLE 3

THE CAMBRIAN AND ORDOVICIAN SUCCESSIONS IN THE DIAL RANGE AREA

(modified after Burns, 1964)

		Thickness (metres)
JUNEE GROUP		
Gordon Limestone		610
DIAL SUBGROUP		
Moina Sandstone	} indistinguishable in places	5-245
Duncan Conglomerate	} indistinguishable in places	0-550
? Unconformity (not always present)		
Gnomon Mudstone (not always present)		0-10
Jukesian Unconformity		
Beecraft Megabreccia and correlates (Teatree Point Megabreccia, Westbank Beds) equivalent to, or unconformably overlying, the Radfords Creek Group		<150
RADFORDS CREEK GROUP		
Mudstone, sandstone and conglomerate		300++?
Applebee Volcanics (keratophyric)		60
Mudstone, tuffs, sandstone and conglomerate, (including Sprent Formation)		450+?
Disconformity		
Motton Spilite		0?-600
Barrington Chert		75-850+
Hardstaff Unconformity		
CATEENA GROUP		
Mudstone, sandstone and conglomerate		c. 320
Wilsonia Volcanics		0-105
Mudstone and sandstone		c. 170
Kerrison Volcanics		35-120
Mudstone, sandstone, claystone and conglomerate		300
Isandula Conglomerate		180
Disconformity ?		
Lobster Creek Volcanics		300

wedge of restricted distribution on the eastern margin of the Dial Range Trough and may interfinger with the overlying mudstone (Burns, 1964). The overlying formation is at least 300 metres thick and consists of interbedded sandstone, mudstone and subordinate conglomerate. Fossils are known from this formation along the Isandula Road (Fig. 19).

The best preserved fossils found in this formation come from a quarry at lat. 41°13.8'S, long. 146°08.3'E (grid 4129E, 9231N). The fossils found by the writer include inarticulate brachiopods, Penarosa sp. and other polymerid trilobites, a pagetiid and the agnostid described in this thesis as Peronopsis sp. 1. The age of this fauna, (termed here the I_3 fauna), cannot be determined precisely although in Northern Australia Penarosa is known in the Ptychagnostus atavus, Euagnostus opimus and Ptychagnostus punctuosus Zones. It seems likely that this fauna is of a similar age. At three other localities in the Isandula Road area (Fig. 19), at much the same stratigraphic level, poorly preserved, unidentifiable trilobites are known.

Burns (1964, p. 34) described in detail a section from Cateena Point (lat. 41°09.9'S, long. 146°08.6'E; grid 4131E, 9304N) about 2.5 km. south-west of Ulverstone. Burns listed 22 lithological units immediately below the Kerrison Volcanics. There is a succession of laminated siltstone, tuff, feldspathic sandstone, claystone, black siliceous mudstone and greywacke conglomerate. Some of the claystone horizons exhibit intrastratal folding, mud pellets, sedimentary dykes, cross-bedding and "flow marks" on the upper surface (Burns, 1964, p. 35). Pull-apart structures are present in the greywacke conglomerate unit. Gravitational slumps and sedimentary slides are also in evidence.

At Cateena Point in the siltstone immediately below the Kerrison Volcanics are poorly preserved dendroids and hydroids (described by Quilty, 1971), inarticulate brachiopods and trilobites. The trilobites include the agnostid Peronopsis sp. 2, Dorypyge sp. and other polymerids including a member of the Corynexochidae (figured here as pl. 31, fig. 3). The exact age of this fauna is unknown. It is stratigraphically higher than the Isandula Road faunas and may be of Ptychagnostus punctuosus or P. nathorsti age as suggested by Burns in Banks (1962a, p. 134). Sponge spicules are found at two other localities in this formation.

The Kerrison Volcanics are composed of bedded tuff with mudstone interbeds at the north end of the Dial Range Trough, porhyritic lava with flow texture further south, and includes sodic-potassic trachyte with agglomerate and mudstone along the northern edge of the Dial Range Trough (Burns, 1964). Burns considers that the Kerrison Volcanics were deposited as one continuous layer.

Overlying the Kerrison Volcanics are up to 490 metres of mudstone, sandstone and conglomerate which are described by Burns (1964, pp. 39-40). Some of the sandstone beds exposed along Hardstaff Creek between 4025E, 9230N and 4034E and 9233N contain unidentifiable trilobites and dendroid fragments. In the south-east part of the Dial Range Trough, the tuffs and lavas of the Wilsonia Volcanics separate these sediments into two formations which are indistinguishable on lithological grounds (Burns, 1964, p. 41).

After the deposition of the Cateena Group there was a period of faulting and erosion represented at present by the Hardstaff Unconformity. The Barrington Chert, which is found immediately above this unconformity, has a maximum thickness of at least 850 metres but is generally about 75 metres thick (Burns, 1964, p. 41 and fig. 6). Barrington Chert also occurs outside the Dial Range Trough extending up to 22 km. south-east of Gunns Plains. Burns (1964, p. 41) in describing the chert states:

> "The chert is thinly-laminated, black and white. The laminae show pull-apart structures of several kinds (usually tiny faults, the faulted zones passing into transformational breccia) and soft sediment slump structure including isoclinal recumbent folds."

As noted above, the base of the Barrington Chert is identified as the Hardstaff Unconformity. When Burns did his field work, there was no outcrop in which the unconformity was definitely exposed. However, from considerations of the general geology in the Hardstaff Creek area, where the Barrington Chert directly overlies both the Lobster Creek Volcanics and the Cateena Group, it is seen that there is an unconformity present. Since Burns did his field work, the Bass Highway has been rerouted between Penguin and Ulverstone and at 4102E, 9332N the contact between the Barrington Chert and the Cateena Group can be seen. It is difficult to determine the nature of contact, but if an unconformity is present, it is not marked by angular relationships.

The Motton Spilite conformably overlies the Barrington Chert in the northern and eastern parts of the Dial Range Trouch. The present distribution of the Motton Spilite is shown in Fig. 19. Rock types within the formation include pyroxene basalt and spilite. Scott (1952) records pillow lava from this formation east of Penguin. As shown by Burns, the Motton Spilite is not found west of a line drawn approximately south from a point about a mile east of Penguin. Burns (op. cit., p. 158) states:

> "Only remnants of the Motton Spilite are preserved so the original form of this formation cannot be reconstructed. There is an abrupt cut-off on the western edge . . . for example, the Radfords Creek Group directly overlies Barrington Chert in Walloa Creek but at least 2000 feet of Motton Spilite overlies Barrington Chert at North Motton. The Radfords Creek Group is transgressive across the Motton Spilite and the data suggest that this transgression is due to considerable erosion."

As shown by Fig. 19, the Motton Spilite outcrops in an elongated north-south zone about 20 km. long and 1.5-4 km. wide along the eastern margin of the Dial Range Trough. The Motton Spilite is confined almost entirely to the Dial Range Trough, and it is possibly related to a line of fractures on either side of the trough (or possibly solely related to fractures along the eastern edge).

The Sprent Formation (Jennings et al., 1959) overlies the Motton Spilite in the area between Gunns Plains and Sprent. In the Sugarloaf Gorge it is about 150 metres thick, whereas near Preston it is about 300 metres thick. On the Gunns Plains road at the bottom of the descent into the gorge (4069E, 9190N), the Sprent Formation outcrops as a hard, dark grey, greenish conglomerate. Burns (1964, p. 48) states that

> "The conglomerate of the Sprent Formation has not been recognized away from the outcrops recorded by Jennings et al. (1959) and appears to be lenticular."

In the Gunns Plains-Sprent area this certainly appears to be the case. However, Jennings et al. (1959) also record the Sprent Formation from outcrops near Claude Road and Gowrie Park, about 20 km. southeast of Preston. In view of the lenticular nature of the Sprent Formation in the Sugarloaf Gorge Area, it would seem that the rocks noted from Claude Road and Gowrie Park belong to some other formation. In the Sugarloaf Gorge area the Sprent Formation is the basal unit of the Radfords Creek Group.

Burns (1964, p. 46) defines the Radfords Creek Group as

> ". . . that group of rocks, predominantly mudstone, overlying the Barrington Chert and unconformably overlain by the Dial Group in the Dial Range area. The Group consists of tuff and lava, greywacke and quartzose conglomerate."

In Walloa Creek the Radfords Creek Group is apparently conformable on the Barrington Chert, but in the Leven River east of Mt. Lorymer it abuts against Motton Spilite and contains boulders and lithic fragments derived from the spilite (Burns, op. cit. p. 158).

The distribution of the Radfords Creek Group, as known at present, is shown in Fig. 19. The Radfords Creek Group, as such, is missing on the foreshore near Penguin where the Teatree Point Megabreccia disconformably overlies the Motton Spilite (Burns, 1964, p. 51). As noted above, Burns considers that the Radfords Creek Group was transgressive on to the Motton Spilite, and it seems possible that the depositional area of the Radfords Creek Group did not extend greatly beyond its present outcrops. This is substantiated by the fact that the clasts of the Radfords Creek Group Sediments are almost entirely derived from the older Cambrian units.

The writer considers that it is possible that the Hardstaff Movement uplifted much of the eastern and possibly some of the northern areas of the Dial Range Trough so that these areas became source areas for the Radfords Creek Group sediments. The Sprent Formation indicates further localized movement in the south-east of the Dial Range Trough subsequent to the volcanic activity which produced the Motton Spilite.

The Radfords Creek consists essentially of an upper and a lower sedimentary sequence separated by the keratophyric Applebee Volcanics (Table 3). The lower sedimentary succession is best exposed in the Sugarloaf Gorge area, particularly along road cuttings of the main road to Gunns Plains and along an older timber track along the western side of Sugarloaf Gorge.

In the Sugarloaf Gorge area near Gunns Plains, Banks (1956) and Burns (1964) have measured part of the lower sedimentary sequence of the Radfords Creek Group. Table 4 summarizes this work which has since been slightly modified by the writer. The total thickness of the Radfords Creek Group exposed in this sequence (units 2 to 15) is about 765 metres. Burns (1964, p. 48) noted a thickness of about 380 metres for the same sequence. He considered that even this thickness was excessive and that it was due largely to tectonic repetition. This is quite possibly the case, but not to the extent suggested by Burns. An inspection of the outcrops along the Gunns Plains Road in Sugarloaf Gorge indicates that units 10, 11, 12, 13, 14 and the upper part of unit 15 (a total thickness of at least 200 metres) are in continuous sequence with only minor faulting. Unit 15 appears to have a stratigraphic thickness of 460 metres along the road, although the outcrop is not continuous and there is the possibility of repetition by faulting. It would appear to the writer that the sedimentary sequence below the Applebee Volcanics is thicker in the Sugarloaf Gorge area (near the centre of the Dial Range Trough) than further west near the junction of Applebee and Walloa Creeks where it is about 120 metres thick and closer to the western margin of the Dial Range Trough.

Fossils have been found in three of the units noted in Table 4. Banks (1956) reported Clavagnostus from unit 15. The writer

TABLE 4

SECTION THROUGH RADFORDS CREEK GROUP IN THE SUGARLOAF GORGE
(near 4056E, 9175N)

(Modified after Banks 1956, Burns 1964)

UNIT		Metres
Top		
Gordon Limestone (Junee Group)		
Fault		
1.	"West conglomerate" (Junee Group)	37
Inferred unconformity		
2.	Brecciated greywacke	26
Major Fault		
3.	"Middle conglomerate"	13
4.	Mudstone with _Ptychagnostus_ near top	22
5.	Tuff	5.5
6.	Mudstone	18
7.	Greywacke	4
8.	Mudstone	33
9.	Greywacke sandstone, conglomerate and tuff	14
Major Fault		
10.	"East conglomerate"	23
11.	Mudstone	19
12.	Tuff, lava	19
13.	Argillite with _Lejopyge_, _Ptychagnostus_, _Pianaspis_?, etc.	90
14.	Tuff and lava	19
15.	Argillite with _Buckagnostus_ (near top)	460
Break ??		802.5
Sprent Formation		
Base		

N.B. The unit numbers are the same as given by Burns (1964, p. 47). They are retained for the sake of uniformity.

was unable to relocate Clavagnostus, but found a single, poorly preserved, almost complete specimen of Buckagnostus sp. about 10 metres from the top of unit 15. Unit 13 is moderately fossiliferous, with only trilobites being found to date. These include Hypagnostus cf. brevifrons (Angelin), Pseudophalacroma ? sp., Ptychagnostus (Goniagnostus) sp., ?Lejopyge laevigata (Dalman), L. l. armata (Linnarsson). Pseudoclavagnostus (?) nevel sp. nov., Diplagnostus sp. 2 and Pianaspis (?) leveni sp. nov. This fauna is discussed further in the section on palaeoecology. The presence of ?Lejopyge laevigata, L. l. armata, Hypagnostus cf. brevifrons and Ptychagnostus (Goniagnostus) sp. indicates an age for this fauna of either the Lejopyge laevigata II Zone or the L. laevigata III Zone of Öpik (1961b). The discovery by the writer of one very poorly preserved specimen of Ptychagnostus near the top of unit 4 lends some support for Burns' suggestion of tectonic repetition in this sequence.

Stratigraphically above the fauna with Lejopyge, Banks (1956, p. 185) found trilobites in a greywacke exposed along an old timber track on the west side of the Sugarloaf Gorge. Fig. 21 is a geological sketch map of the fossiliferous sediments along this track. As can be seen from Fig. 21, the fossiliferous sediments have undergone considerable folding. The writer found four poorly fossiliferous horizons near lat. $41^{\circ}15.4'S$, long. $146^{\circ}04.2'E$ (grid 4065E, 9192N). The lowest exposed bed of this sequence, a siltstone, contains inarticulate brachiopods plus the trilobites Nepea sp., Clavagnostus sp. 2, Aspidagnostus sp. 4, Valenagnostus sp. 1, and possibly Peronopsis. Agnostascus (?) sp. 1, Nepea and other trilobites occur slightly higher in the section (Fig. 21). This fauna is very similar to the main fauna at St. Valentines Peak and is probably either of the Lejopyge laevigata III Zone or the Middle Cambrian/Upper Cambrian Passage Zone. The structure of the Sugarloaf Gorge area is complex and not fully understood. This fact, plus the steep topography, accounts for the apparent stratigraphically close proximity of the sediments containing the fauna discussed above and the Sprent Formation (Fig. 19).

The thickness of the upper sedimentary sequence of the Radfords Creek Group is not known with certainty. The writer measured a section near Riana which has a thickness of about 300 metres, and the total thickness of the upper sedimentary sequence may be considerably greater than this figure.

Near Riana fossils have been found in the upper sedimentary sequence at several localities (Fig. 19). The most important of these localities is in a quarry at lat. 41°13.0'S, long. 146°00.2'E (grid 4004E, 9240N). Here inarticulate brachiopods and trilobites are found in a laminated siltstone. The trilobites include Ferenepea (pl. 32, figs. 11, 12) and other polymerids, and the agnostids Clavagnostus burnsi sp. nov., Pseudoclavagnostus (?) inara sp. nov., Aspidagnostus riani sp. nov., Agnostascus (?) sp. 3 and Pseudagnostus sp. aff. P. ampullatus Öpik.

Most of the fossils at this locality occur in a 5 mm. band of slightly coarser siltstone. However, most of the fauna is also known from the surrounding siltstone. The trilobite assemblage indicates a Mindyallan age for this fauna although the precise age within the Mindyallan Stage cannot be determined.

The stratigraphically youngest trilobites known from the Riana area are found at lat. 41°12.7'S, long. 146°00.0'E (grid 4000E, 9250N). Here Clavagnostus burnsi and Pseudagnostus sp. aff. P. ampullatus Öpik are known from a siltstone. This is within 120 metres of the chert and quartzite conglomerate which is the basal member of the Junee Group in this area. The nature of the contact between the Cambrian siltstones and the Junee Group cannot be seen near Riana although it is an unconformable contact elsewhere in the Dial Range area. The other fossil localities from near Riana contain only unidentifiable brachiopod and trilobite fragments.

The Beecraft Megabreccia and its correlates, the Teatree Point Megabreccia and the rocks of the Westbank Chaos, (purely a structural term), outcrop along the coast between Penguin and Ulverstone at the northern end of the Dial Range Trough. On the west side of the Trough they abut against the Precambrian basement; in the centre they overlie the Motton Spilite and on the eastern side of the Trough overlie Precambrian basement. Banks (1962a, p. 139, fig. 11) considered that this situation indicated an unconformity between the Radfords Creek Group and the megabreccias. Burns (p. 135 in Banks 1962a) considers that the large boulders of the Teatree Point Megabreccia "slid from the west into normal greywacke sediments of the Radfords Creek Formation". However, as noted by Burns (1964, p. 158), either his or Banks' view leads to the same conclusion, i.e., "the flanks of the trough were uplifted and the cover removed in part by gravitational down-sliding of marginal deposits towards the axis of the trough". Burns suggests that the allochthonous lithologies may belong to an unstable shelf association and also that during the formation of the megabreccias the Dial Range Trough was tilted to the south and was asymmetrical with a narrow, deep western margin.

The Beecraft Megabreccia consists of large boulders, blocks and large slabs of siltstone, tuff, chert and chert breccia (the allochthonous succession of Burns) set in a matrix (autochthonous material) of greywacke conglomerate and sandstone which exhibits graded bedding. Parts of the greywacke contain large numbers of rock fragments, particularly lava. Burns (1964, p. 53) states that "The autochthonous beds may interfinger laterally with the Motton Spilite or may overlie that formation unconformably, but in either case are generally younger than the Motton Spilite." Some of the larger slabs of the allochthonous succession are up to 120 metres long. The Teatree Point Megabreccia contains autochthonous greywacke mudstone, conglomerate and sandstone, and allochthonous slabs up to 10 metres long of chert, bedded, internally brecciated, limestone, and massive calcareous dolomite. The Westbank Beds of the Westbank Chaos outcrop on the western margin of the Dial Range Trough unconformably over the Precambrian rocks. They are correlated with the Teatree Point Megabreccia on lithological grounds. Greywacke sandstone, mudstone and some conglomerate make up the autochthonous succession whilst the allochthonous lithologies occur in slabs up to 60 metres long. Burns has determined a succession of units for the lithologies of the autochthonous beds as follows:

(Top) Conglomerate

Interbedded sandstone and mudstone

Interbedded mudstone and calcareous mudstone

Bedded limestone

Massive calcareous dolomite

Greywacke conglomerate with boulders of dolomite.

Burns (1964, p. 58) points out that the lithologies of the large slabs, i.e., the spilitic tuff, dolomite, cross-bedded calcarenite, chert granule conglomerate and continuous framework conglomerate are rare or unknown in the Cambrian. He goes on to suggest that the megabreccias were formed by "gravity downsliding of large masses of semi-indurated material from the flanks of the trough", which at this time was very shallow and very narrow. Burns (p. 58, 158) regards the megabreccias as the first products of the Jukesian Movement.

There is a pronounced structural hiatus between the Gnomon Mudstone and the underlying Cambrian rocks (Burns, p. 67). In other parts of Tasmania (e.g., Misery Hill and Birch Inlet) the equivalents of the Duncan Conglomerate, which overlies the Gnomon Mudstone, probably extend down into the Cambrian, so it seems likely that both the Gnomon Mudstone and part of the Duncan Conglomerate also belong to the Cambrian.

South and south-east of the Dial Range Trough are extensive occurrences of poorly exposed Cambrian rocks (Fig. 2). A considerable part of this area has been mapped by geologists of the Tasmanian Geological Survey in the course of mapping the Sheffield and Middlesex 1 inch to 1 mile map sheets (Jennings _et al_., 1959; Jennings, 1963, respectively). Lack of time prevented the writer from making any more than a brief reconnaissance of this area. However, it seems clear that the Cambrian rocks of this area are in need of remapping. This is particularly so in the case of the Gog Range Greywacke which is shown as covering large areas of the Sheffield sheet. In the north-west part of the Sheffield sheet, the Gog Range Greywacke includes sediments which were later shown by Burns (1964, fig. 4) to belong in both the Cateena Group and the Radfords Creek Group. This view is supported by field work done by the writer in both the Sugarloaf Gorge and Isandula Road areas and is incorporated within Fig. 19.

There has been only one report of Cambrian fossils from within this large area. Jennings (p. 136 _in_ Banks 1962a) noted the presence of "_Pseudagnostus_, other agnostids and trilobites which suggest an Upper Cambrian age (Öpik, pers. comm., 1960)", in a piece of slate float presumed to have come from the Gog Range Greywacke.

13. CIRCULAR HEAD

In the far north-west part of Tasmania there are considerable areas of known and suspected Cambrian rocks (Fig. 22). None of this large area has been mapped in detail, and the overall stratigraphic sequence is unknown. The outcrop is generally poor with the soil cover and weathered rock reaching a depth of up to 20 metres.

Gulline (1959, p. 23), in discussing the Cambrian rocks of the northern part of Circular Head, states:

> "The sedimentary assemblage consists of tuffs, siltstones, greywackes, breccias and conglomerates, the igneous rocks being basic lava, volcanic breccia and agglomerate. Siltstones, tuffs, greywackes and lavas are the most common rocks. The volcanic breccia was seen only at the mouth of the Montagu River and the agglomerate at West Montagu."

Gulline (op. cit., p. 24) discovered fossils in a siltstone near Christmas Hills (Fig. 24). He considered this to be within 100 metres of the base of the Cambrian sediments in this area. However, field work by the writer indicates that there is probably a considerably greater thickness of Cambrian sediments beneath the fossiliferous horizons than suggested by Gulline.

The principal fossil locality at Christmas Hills is at lat. $40^{\circ}54.1'$S, long. $144^{\circ}29.8'$E (grid 3075E, 9610N). The writer has made extensive collections from this locality. As noted in Jago and Buckley (1971; see Appendix 4), there are two almost entirely different Upper Middle Cambrian faunas in direct contact at this locality. The lower fauna contains great numbers of the agnostid trilobite Buckagnostus debori sp. nov., plus three other agnostid species, viz. Peronopsis gullini sp. nov., Valenagnostus brittoni sp. nov., and Clavagnostus milli sp. nov. Polymerid trilobites of the lower fauna include Nepea sp. (pl. 31, fig. 8), Proampyx sp. (pl. 31, fig. 7), an asaphid, very rare examples of Dorypyge sp., plus at least two other species as figured in pl. 31, figs. 9-12. Inarticulate brachiopods, hyolithids and rare hydroids are also known from this fauna.

The upper fauna includes Centropleura sp. (pl. 32, figs. 1, 2). Amphoton sp. (pl. 32, fig. 3), Pianaspis sp. (pl. 32, figs. 4, 5) and other polymerids. The agnostid trilobites found in the upper fauna are Peronopsis gullini sp. nov., Hypagnostus cf. brevifrons (Angelin), Grand-agnostus sp., Ptychagnostus (Ptychagnostus) cf. aculeatus (Angelin), Ptychagnostus (Goniagnostus) buckleyi sp. nov., Clavagnostus sp. 1, Diplagnostus sp. 3, Buckagnostus debori sp. nov., Agnostid, gen. et sp. indet. no. 3 and Agnostid, gen. et sp. indet. no. 4. Inarticulate brachiopods, dendroids, hydroids, hyolithids and sponge spicules are also found in this fauna. The dendroids and hydroids have been described by Quilty (1971).

The lower fauna is contained within about 20 metres of well sorted, buff coloured, slightly micaceous siltstone, with the frequency of most fossil species increasing up the section. Nepea is not known from near the base of the section. The basal part of the overlying fauna is found in a pale buff-coloured laminated siltstone which generally becomes harder and greyer up the section and was probably quite dark at the time of deposition. Further aspects of both the upper fauna and the lower fauna are discussed in the palaeoecological section of this thesis.

The two faunas are almost entirely different with only Clavagnostus, Peronopsis and Buckagnostus being common genera. Only part of a single pygidium of Clavagnostus sp. 1 is known from the upper fauna. Buckagnostus debori and Peronopsis gullini are the only two species common to both faunas, and they are both much less common in the upper fauna than in the lower fauna.

The presence of Centropleura, Pianaspis, Ptychagnostus cf. aculeatus and Hypagnostus cf. brevifrons in the upper fauna indicates that the age of this fauna is either that of the Lejopyge laevigata II Zone or the L. laevigata I Zone of Öpik (1961b). The age of the lower fauna cannot be determined precisely. However, the fact that Buckagnostus debori and Peronopsis gullini occur in both faunas, plus the presence of Clavagnostus, Proampyx and Nepea in the lower fauna, suggests that the lower fauna is only slightly older than the upper fauna. It is probably not older than the L. laevigata I Zone.

The boundary between the sediments containing the two faunas was dug out in December, 1967 by the writer and Mr. J. Buckley. The results are described below and summarized in Fig. 23.

The faunal change is abrupt with distinctly different siltstones on either side of the boundary. The uppermost 60 cm. of the lower fauna is contained within sediment that is much more weathered than the sediments above and below. The boundary between the sediments containing the two faunas occurs at the top of a 2.5 cm. band of ferruginous purple siltstone. The highest known example of the lower fauna occurs within 2 cm. of the purple siltstone. Nepea and Valenagnostus brittoni are known from this level. The lowest known example of the upper fauna comes from about 9 cm. above the boundary. At this level Amphoton, Hypagnostus cf. brevifrons and Buckagnostus debori are known. The lowest Centropleura found to date is about 43 cm. above the boundary. Thus at the present there is a maximum of about 13 cm. of sediment between the lowest known member of the upper fauna and the highest known member of the lower fauna.

The marked change in faunas across this boundary, the different sediment types containing the faunas, and the highly weathered nature of these sediments may indicate a disconformity at this level. A second explanation for the abrupt faunal change is that there is no disconformity, but rather the upper fauna represents an incoming fauna which displaced the original fauna due to a change in environment. Whether or not there is a disconformity at this level, there is certainly a change in environmental conditions (see palaeoecology section).

The lower fauna is seen at two other localities in the vicinity of Christmas Hills, and the upper fauna is seen at one other place (Fig. 24). However, the outcrop at these localities is too poor to allow the stratigraphic relationships between the sediments containing the two faunas to be determined. Poorly preserved trilobite fragments were found by the writer in a tuffaceous sandstone just south of the area shown in Fig. 24. The stratigraphic position of this sandstone in relation to the siltstone containing the better known faunas is not known.

Well-exposed sections of what are probably Cambrian rocks are found along the eastern shores of the Duck River estuary north of Smithton. Rock types include shales, volcanic breccia (including volcanic bombs) and tuff (Carey and Scott, 1952). Siltstone and sandstone are also found in this section. Gulline (1959) suggested a total thickness of about 1525 metres near Smithton. On the foreshore at Stony Point, Montagu, a series of siltstones, sandstones, graded sandstones, and black shales is found with a total thickness of around 600 metres. There appears to be some carbonaceous material present in the black shales.

Longman and Matthews (1962) report a probable Cambrian sequence from south and southwest of Trowutta about 21 km. south of Smithton. They agree with Gulline (1959) in that the Cambrian sediments in the Trowutta-Nabageena area disconformably overlie the Precambrian Smithton

Dolomite. The basal unit in the Trowutta area is a dolomitic breccia (6-30 metres thick), grading up into about 150 metres of greywacke, shale and intraformational breccia. These rocks are overlain by flows of tholeitic basalt varying in thickness from 60 to 150 metres. These are overlain by fine tuff and greywacke up to 60 metres thick, which is, in turn, overlain by coarse tuff and volcanic breccia of unknown thickness. The writer made unsuccessful searches for fossils in the Montagu, Smithton, and Trowutta areas.

14. DELORAINE-GOLDEN VALLEY

Wells (1957) described a sequence of about 2130 metres of greywacke conglomerate, greywacke, subgreywacke, siltstone, slate, volcanic breccia, spilite and keratophyre from the south-west of Deloraine which he regarded as Cambrian on lithological and structural grounds. The sequence rests unconformably on Precambrian quartzites and schists and is overlain unconformably by Junee Group sediments. The writer was unable to find fossils in these sediments and had difficulty in tracing the various formations as proposed by Wells. I feel that this area needs remapping.

15. CRESSY

Banks (1962a, p. 137), in noting some work of Voisey (1949), states, "Slates, phyllites and sheared tuffs near O'Connor's Peak, south-west of Cressy, are lithologically like Cambrian rocks elsewhere . . .."

16. BEACONSFIELD AREA

Green (1959) mapped an area around Beaconsfield. He reported the presence of Cambrian fossils in a siltstone about 5 km. south-east of Beaconsfield. Dr. R.D. Gee (pers. comm.) has since remapped this area in the course of mapping the Beaconsfield Map Sheet for the Tasmanian Geological Survey. A modified version of the bedrock geology of the Beaconsfield area, as mapped by Gee, is shown in Fig. 25. In this area the Cambrian rocks consist of mafic and ultramafic igneous rocks, overlain by siltstone and slate, which to the south of Beaconsfield are interbedded with a quartz keratophyre unit.

The fossils found by Green came from about 140 metres below the top of the siltstone and shale sequence at lat. 41°14.4'S, long. 146°51.0'E (grid 4779E, 9217N). Here poorly preserved brachiopods and trilobites are found in a somewhat phyllitic micaceous siltstone. Öpik (1967, p. 32) has recorded *Erediaspis* from this locality and considered this fauna to be of Mindyallan age. The writer and Dr. B. Daily collected trilobites from this locality, the best preserved of which is figured here as plate 32, figs. 7-9. I consider that a definite generic assignment cannot be made on the basis of the specimens known to me. Thus, the cranidium figured in plate 32, figs. 7-9 is termed cf. *Erediaspis* sp.

The Cambrian siltstone is overlain with apparent conformity by the basal sandstone and conglomerate member of the Junee Group in this area. This is overlain by the Gordon Limestone.

17. PORT SORELL

In the Port Sorell area Banks (1962a, p. 136) and Dr. R.D. Gee (pers. comm.) have noted the presence of siltstones, carbonaceous pyritic shale, sandstone, greywacke, chert and dolerite which they consider to be of Cambrian age on lithological and structural grounds. The writer made an unsuccessful search for fossils in this area.

18. WARATAH AREA

Banks (1956, p. 182; 1962a, p. 133) has noted the presence of probable Cambrian sediments and volcanics near Waratah (Fig. 2). The writer has made only a brief inspection of these rocks and did not find any Cambrian fossils. The arthropod trail, *Tasmanadia twelvetreesi* (Glaessner, 1957, p. 103) from north-west of Waratah has been shown by Gulline (1967) to be of Upper Palaeozoic age rather than Cambrian as previously suggested.

Queensland stages	Queensland zones (after Öpik 1961b, 1963, 1967, 1970)	North American zones	North American stages
	No Zone names		
		Saukia	TREMP.
		Ptychaspis–Prosaukia	FRANCONIAN
		Conaspis	FRANCONIAN
		Elvinia	FRANCONIAN
IDAMEAN	Irvingella tropica – Agnostotes inconstans	Dunderbergia	DRESBACHIAN
IDAMEAN	Erixanium sentum	Dunderbergia	DRESBACHIAN
IDAMEAN	Corynexochus plumula	Aphelaspis	DRESBACHIAN
IDAMEAN	Glyptagnostus reticulatus – Proceratopyge nectans	Aphelaspis	DRESBACHIAN
IDAMEAN	Glyptagnostus reticulatus – Olenus ogilviei	Aphelaspis	DRESBACHIAN
MINDYALLAN	Glyptagnostus stolidotus	Crepicephalus	DRESBACHIAN
MINDYALLAN	Cyclagnostus quasivespa	Cedaria	DRESBACHIAN
MINDYALLAN	Erediaspis eretes	Cedaria	DRESBACHIAN
	Passage Zone	Bolaspidella	
	Lejopyge laevigata III / II / I	Bolaspidella	
	Ptychagnostus nathorsti	Bolaspidella	
	Ptychagnostus punctuosus	Bolaspidella	
	Euagnostus opimus [=Hypagnostus parvifrons]	Bolaspidella	
	Ptychagnostus atavus	Bolaspidella	
	Ptychagnostus gibbus		

HUSKISSON RIVER AREA	JUNEE GROUP; UNITS 14, 18; UNITS 1–13
MT RAZORBACK – MISERY HILL SECTION DUNDAS	JUNEE GROUP; CLIMIE FORMATION; FERNFLOW FORMATION; COMET FORMATION; FERNFIELDS FORMATION; BREWERY JUNCTION FORMATION; RAZORBACK C.; HODGE SLATE; GREYWACKE CONG.
BLACK HILL SECTION DUNDAS	CONGLOMERATE; SILTSTONE AND SHALE; CONG.; MUDSTONE-GREYWACKE; CHERT BRECCIA CONG.; SILTSTONE; SPILITE CONG.
NORTH-EAST DUNDAS TRAM, FARRELL RIVULET, HENTY RIVER, AND GRIEVES TRAM LOCALITIES	GRIEVES TRAM LOCALITY; TOM CREEK LOCALITY; BONNIE PT. AREA; HENTY RIVER LOCALITIES
ZEEHAN AREA	McLEANS CREEK LOCALITY; SUMMIT CUTTING LOCALITY
BIRCH INLET AREA	JUNEE GROUP; FOSSILIFEROUS SILTSTONE; UNFOSSILIFEROUS SILTSTONE AND SANDSTONE
SOUTH-CENTRAL TASMANIA	REEDS CONG.; GREAT DOME SANDSTONE; SINGING CREEK SILTSTONE; ADAMSFIELD LOCALITY; SCOTTS PEAK ROAD LOCALITY
QUEENSTOWN AND QUE RIVER AREAS	QUEENSTOWN LOCALITY; QUE RIVER BRIDGE LOCALITY
ST. VALENTINES PEAK AREA	JUNEE GROUP; SILTSTONE; CHERT; METASOMATIC ROCK; SANDSTONE AND SILTSTONE; WELDED TUFF; SANDSTONE AND SILTSTONE; SILTSTONE AT GIN CK. RD.
DIAL RANGE TROUGH	JUNEE GROUP; UPPER SEDIMENTARY SEQUENCE OF RADFORDS CREEK GROUP; APPLEBEE VO.; LOWER SEDIM. SEQUENCE OF RADFORDS CG.; MOTTON SPIL.; BARRINGTON CHERT; CATEENA GROUP
BEACONSFIELD AREA	JUNEE GROUP; SILTSTONE AND SLATE
CHRISTMAS HILLS	UPPER FAUNA; LOWER FAUNA

Table 5. Correlation chart of fossiliferous Cambrian rocks of Tasmania.

STRATIGRAPHICAL AND PALAEOGEOGRAPHICAL CONCLUSIONS

Table 5 is a correlation chart of all fossiliferous Cambrian sections and localities in Tasmania which are discussed in this thesis. It summarizes the age relationships between these sections and localities as determined by the writer in the course of this study. Stratigraphic findings of local significance are dealt with in the discussion of the appropriate area, section or locality.

The Middle Cambrian zones of the correlation table are based on the work of Öpik (1961b, 1967, 1970). The early Upper Cambrian faunas of Tasmania are correlated with the zones of the Idamean and Mindyallan stages from Queensland as set out in Öpik (1963, 1967). The rest of the Tasmanian Upper Cambrian faunas are correlated with the standard North American zones. The correlation between the Idamean and Mindyallan stages and the North American zones is after Öpik (1963, p. 13; 1967, p. 13). The Payntonian Stage of Jones *et al*. (1971) is not referred to in the correlation chart because (a) there are no known faunas of this age in Tasmania and (b) the writer would prefer to see zones set up prior to the naming of stages. It should also be noted that Chart 1 of Jones *et al*. (*op*. *cit*.) is, in my opinion, completely incorrect with respect to Tasmania. They show the Comet Slate as being equivalent to the Mindyallan; as is shown above, the Brewery Junction Formation was deposited during the Mindyallan. The exact age of the Comet Slate is unknown at present. Further, Jones *et al*. ignore the presence of the Fernflow Formation between the Comet Slate and the Climie Formation. They also differentiate between the Misery Conglomerate and the Mt. Zeehan Conglomerate despite the fact that Blissett (1962) showed that these two formations are correlates.

As was stated in the Introduction to the Stratigraphy, one of the most controversial points in the study of Tasmanian Cambrian rocks has been the age relationships between the Mt. Read Volcanics and the fossiliferous Middle and Upper Cambrian sediments. Solomon (1965, p. 468) stated, "the age of the volcanics is an intractable problem". However, it has been shown above in at least two localities (Que River, Queenstown) that there are fossiliferous late Middle Cambrian sediments associated with the Mt. Read Volcanics. This indicates that the Mt. Read Volcanics are at least partly contemporaneous with the fossiliferous Cambrian sediments. The fact that volcanic activity continued into the early Upper Cambrian in the Dial Range Trough (Applebee Volcanics) and in the St. Valentines Peak area (welded tuff) suggests that the Mt. Read Volcanics may have still been forming in lower Upper Cambrian times. The lower limit of the age of the Mt. Read Volcanics is still unknown although it may extend down into the Lower Cambrian (see p. 54).

The exact nature of the relationship between the fossiliferous Cambrian sediments and the overlying Junee Group rocks has also been a problem. As was stated in the Introduction to the Stratigraphy, the

Jukesian Movement affected the rocks close to the Tyennan Geanticline more than it did those towards the centre of the Dundas Trough. The Junee Group rocks unconformably overlie the Cambrian rocks (both Mt. Read Volcanics and fossiliferous sediments) close to the Tyennan Geanticline, but with apparent conformity away from the Tyennan Geanticline (Fig. 26). The close proximity of a definitely unconformable relationship and an apparently conformable relationship in the Birch Inlet area (Fig. 9) underlines the extent of the rapid decrease in intensity of the Jukesian Movement away from the Tyennan Geanticline.

It was noted in the discussion of the separate areas that there are apparently conformable relationships between the Junee Group and the underlying Cambrian sediments near Birch Inlet (3417E, 7735N), Misery Hill, Huskisson River, along the Grieves tram track, near St. Valentines Peak and near Beaconsfield.

In western Tasmania, in the Huskisson River section, near Misery Hill and near Birch Inlet, there are fossiliferous Cambrian sediments immediately below the supposedly conformable passage. In the Huskisson River section, Glyptagnostus reticulatus is found about 25 metres below the base of the Junee Group. The presence of Glyptagnostus reticulatus indicates an age of one of the two lower Idamean Zones from Queensland (see Stratigraphy) and correlation with the Aphelaspis Zone on the North American time-scale.

In the section near 3417E, 7735N, west of Birch Inlet, Lotagnostus and other trilobites are found about 55 metres below the base of the Junee Group. The presence of Lotagnostus indicates an age of Prosaukia-Ptychaspis Zone on the North American time-scale. Thus, the fauna containing Lotagnostus is about four zones younger (on the North American time-scale) than that of the Glyptagnostus-fauna along the Huskisson River.

In the Mt. Razorback-Misery Hill section near Dundas, the Climie Formation is overlain with apparent conformity by the basal member of the Junee Group there referred to as the Misery Conglomerate. Fossils are found about 145 metres below the contact. These include an olenid, Agnostus and a cephalon of what could be Lotagnostus. If Lotagnostus is present, then this fauna belongs in the Prosaukia-Ptychaspis Zone. However, the rest of the fauna in the Climie Formation is completely different from that associated with Lotagnostus near Birch Inlet. It thus seems probable that the two faunas are of different age. Thus, in western Tasmania there are apparently conformable sequences from fossiliferous Upper Cambrian sediments through to the Junee Group in at least three localities. However, the fossils immediately below the contact are of two and probably three different ages, despite their similar stratigraphic position. This conclusion indicates that the apparently conformable contacts between the Cambrian sediments and the Junee Group in the central parts of the Dundas Trough are in reality disconformable ones.

The fossils in the siltstone immediately below the apparently conformable contact with the Junee Group on PMG Road near St. Valentines Peak are, unfortunately, unidentifiable. In the Dial Range Trough near Riana fossils of Mindyallan age occur within 120 metres of the overlying Junee Group although the nature of the contact cannot be determined. Near Beaconsfield there is a poor fauna of probable Mindyallan age occurring in a siltstone about 140 metres below the base of the apparently conformably overlying Junee Group.

It is possible that the fauna on the PMG Road, or the fauna from float material near Sheffield (see p. 77) or some as yet undiscovered fauna may be of an Upper Cambrian age younger than Mindyallan age. However, at present no Upper Cambrian fossils younger than the Mindyallan Stage are known to occur in northern Tasmania. This fact, taken in conjunction with the markedly different ages of the sediments found immediately beneath the basal Junee Group rocks in western Tasmania, suggests that the fossiliferous Cambrian sediments of western and northern Tasmania are everywhere disconformable beneath the Junee Group.

The progressive decrease in age of the sediments beneath the Junee Group from Mindyallan in northern Tasmania, Idamean in the Huskisson River area to Ptychaspis-Prosaukia Zone near Birch Inlet in the south-west suggests that Tasmania was tilting to the south throughout much of the Upper Cambrian with the sea retreating progressively southwards (Fig. 27). This is in accord with a suggestion by Burns (1964, p. 159) who proposed a southward tilt of the Dial Range Trough during the deposition of the Radfords Creek Group in Mindyallan times. Alternatively, it is possible that post-Mindyallan Cambrian sediments were deposited in northern Tasmania and eroded away before being covered by the initial Junee Group sediments in latest Upper Cambrian times. However, if there was any great extent and thickness of post-Mindyallan Cambrian sediments in northern Tasmania, it seems unlikely that they all should be eroded away prior to the latest Upper Cambrian. Fig. 27 summarizes the writer's present views on the changing palaeogeography of Tasmania during Middle and Upper Cambrian times. Further discoveries of fossils may cause these views to be modified.

The suggested gradual southwards tilt of Tasmania was interrupted in the latest Upper Cambrian by the Jukesian Movement, which, as noted above, had its greatest effect close to the Tyennan Geanticline with the older rocks being considerably folded. It seems likely that little or no folding of the Cambrian sediments took place toward the centre of the Dundas Trough.

When considered on a continental scale, Tasmania was part of the Tasman Orthogeosyncline during Middle and Upper Cambrian times. When fitted into the overall Gondwanaland situation, it seems likely that the Tasmanian area consisted of a group of small volcanic islands situated off the coast of the Australia-Antarctica part of Gondwanaland

(Fig. 28). This island chain may have extended at least as far north as Victoria where basic lavas and pyroclastics are overlain by fossiliferous Middle and Upper Cambrian black shales and tuffs (Thomas and Singleton, 1956).

PART II

PALAEONTOLOGY

INTRODUCTION

With the exception of three species, the taxonomic part of this thesis deals with agnostid trilobites. Almost all specimens dealt with here are housed in the collection of the Geology Department, University of Tasmania. The number after the prefix UT refers to a specimen number in that collection. A few agnostids from the Birch Inlet area have a number prefixed by TMD which refers to the palaeontological collections of the Tasmanian Mines Department.

METHODS

All Tasmanian Cambrian trilobites are preserved as internal and external moulds; there is rarely any trace of the original skeletal material.

A Burgess Vibro-tool, set up as shown in Robison (1965, fig. 1), was used to clean out the matrix from around the internal and external moulds. This method was found to be very efficient, because most of the sediments enclosing the fossils were weathered silts and could be dug out very quickly. Where the enclosing sediment was sufficiently cohesive, latex rubber casts of the external moulds were prepared, whitened and then photographed. However, in most cases the sediment tended to disintegrate as the latex cast was taken off the specimen. In these cases the rock was first impregnated with a very dilute acetone solution of "Glyptol" which after drying served to bind the sediment together. A silicone rubber cast could then be prepared, whitened and photographed. Red coloured Dow Corning "Silastic 589 RTV" Silicone Rubber was used in conjunction with a catalyst. It was found that the catalysts, which allowed the rubber to set over a period of 24 hours, were more satisfactory than those which allowed a shorter curing period. A disadvantage is that silicone rubber tends to wear away on rubbing. Even when stored in an envelope and not handled, the pressure of the envelope can flatten out nodes and other high features. Some protective medium (e.g., cotton wool, or a latex cover) should be used to protect the specimen after preparation. It is best to photograph the cast as soon as possible after preparation. Magnesium oxide was used to whiten the casts prior to photography. Internal moulds were used only where the external mould could not be located or where the internal mould showed some feature that could not be seen clearly on the external mould.

The whitened specimens were photographed with a Leica 35 mm. camera set up on a Leitz Reprovit II. Even illumination with a spot in the top left corner was used where possible. However, because of the shape and position of some specimens, this was not always possible. In the initial stages of this study Adox KB-17 film was used. In the later stages of this study, after the manufacture of KB-17 had ceased, Ilford Pan F film was used. When developed in Ilford Hyfin developer, Pan F gives negatives of good resolution. No photographs in this thesis have been retouched.

DISTORTION OF FOSSILS

All Tasmanian Cambrian fossils have undergone tectonic distortion to some extent. As noted by Henningsmoen (1960, p. 207), there are three main types of symmetrical distortion with respect to the orientation of bilaterally symmetrical fossils such as trilobites: (a) a dorso-ventral compression (flattening), (b) where the length is enlarged with respect to the width and (c) where the width is enlarged with respect to the length. In this thesis trilobites which have undergone distortion type (b) are stated to have undergone E-W distortion (e.g., pl. 6, fig. 5), and those that have undergone distortion type (c) are stated to have undergone N-S distortion (e.g., pl. 6, fig. 6). Those fossils in which the distortion has been asymmetrical are stated here to have undergone intermediate distortion (i.e., the compression took place at an oblique angle to the length of the trilobite, e.g., pl. 1, fig. 4). In cases where no comment is made about the type of distortion, it is because the distortion is so slight as to make it difficult to determine what type of distortion has taken place.

All statements made in the descriptions, such as, "the cephalon is about as wide as is long", are made after taking the effect of distortion into account. Admittedly, this is a subjective assessment, but I feel that, after inspecting and studying several thousand distorted agnostid specimens, such a judgment seems reasonable. I had hoped to follow up some statistical work I did in an honours project (Jago, 1965) and to make a detailed statistical analysis of the effects of distortion on the Tasmanian Cambrian trilobites. However, I did not have time to do more than some preliminary work, which is not included in this thesis. Unless otherwise stated, all length measurements noted in this thesis were taken along the axis of the trilobite; all width measurements were taken parallel to the anterior end of the pygidium, or parallel to the posterior end of the cephalon.

PALAEOECOLOGY

The world-wide distribution of many agnostid trilobite species has led several workers to the conclusion that they led a pelagic existence (Öpik, 1961b, p. 130; Lochman-Balk and Wilson, 1958, p. 325; Lochman, 1971, p. 92). The author agrees with this view. In their study of North American and European Lower and Middle Cambrian faunas, Lochman-Balk and Wilson (op. cit.) noted the tendency for agnostids to occur in faunas which they interpreted as having lived away from the craton with an "increasing abundance of the Agnostidae towards and into the extracratonic euxinic realm." Whether or not one agrees with the biofacies concept of Lochman-Balk and Wilson, it seems quite clear from text-figures 1 to 5 of these authors that the agnostids showed a marked preference for the open-sea environment. Robison (1964b, p. 991) observed a different geographic distribution pattern of agnostid and non-agnostid trilobites. He suggested that whereas some non-agnostid trilobites are distributed throughout a single faunal province, many agnostid trilobites occur in more than one province but are restricted to certain biofacies.

In the author's studies on Tasmanian Cambrian trilobites only the agnostid trilobites have been studied in any detail. However, the author considers that two and possibly three distinctly different trilobite assemblages can be distinguished within the Cambrian System in Tasmania. This study is based mainly on a study of the Tasmanian

Upper Middle Cambrian and Lower Upper Cambrian agnostids, particularly the former.

The three assemblages recognized are as follows:

(1) Agnostid assemblage,

(2) Ptychagnostid--non-nepeid assemblage,

(3) Nepeid-clavagnostid-peronopsid assemblage.

Apart from these faunal assemblages, there are some examples of thanacoenotic fossils (see below), thus confirming the suggestion of Banks (1962a, p. 145) that shallow and deep water faunas may be intercalated in the Tasmanian Cambrian.

Assemblage (1) Agnostid assemblage

The trilobite element of this assemblage is characterized by a complete, or almost complete, absence of polymerid trilobites. Common associates of the agnostids are dendroids, hydroids, sponge spicules and inarticulate brachiopods.

Assemblage (1) is known from three locations:

(1) Que River Beds,

(2) RB locality, Black Hill section, Dundas area,

(3) Sugarloaf Gorge road section, unit 13.

(1) Que River Beds

At the Que River locality (lat. 41°34.7'S, long. 145°41.0'E) the trilobite fauna is limited entirely to agnostids. Other faunal elements include hydroids and dendroids (described by Quilty, 1971), inarticulate brachiopods and sponge spicules (Gee *et al.*, 1970, Appendix 4). As noted in Gee *et al.* (1970), one unusual feature of this fauna is the large proportion of complete agnostid specimens. Table 6 (p. 101) shows a count of every available agnostid cephalon and pygidium. In this table each individual cephalon or pygidium is counted as one unit; thus, a complete agnostid has two units. From the table it can be seen that 60.5% of the known cephala and pygidia are found in complete specimens.

This high proportion of complete specimens, together with the presence of carbonaceous material and pyrite nodules (see Gee *et al.*, *op. cit.*), probably implies quiet, strongly reducing conditions and the consequent absence of benthonic scavengers and a low proportion of moulted individuals. However, the breaking up of the pygidium of *Ptychagnostus stenorrhachis* (Grönwall), as seen in pl. 5, fig. 3, probably indicates the presence of at least some scavengers.

The hydroids, dendroids and agnostids led a planktonic existence (see below, p. 119). It is possible that the inarticulate brachiopods were attached to floating seaweed in a manner similar to that suggested by Ruedemann (1934). The sea bottom must have been unsuitable for polymerid trilobites to have lived there, although apparently suitable for the existence of sponges and possibly inarticulate brachiopods. The lack of any sign of polymerid fragments also indicates that they were rare or absent in the seas above the depositional area of the Que River Beds.

TABLE 6

Analysis of agnostid trilobites from Que River Beds at Que River Bridge (lat. 41°34.7'S, long. 145°41.0'E)

	Complete Specimens	Separate Cephala	Separate Pygidia	Total No. Specimens	Total Cephala & Pygidia
Ptychagnostus (?) murchisoni sp. nov.	10	5	10	25	35
Ptychagnostus stenorrhachis (Grönwall)	3	3	4	10	13
Ptychagnostus sp.*	2	1	--	3	5
Diplagnostus geei sp. nov.	3	--	3	6	9
cf. Kormagnostus sp.	2	1	--	3	5
Hypagnostus sp. aff. H. parvifrons (Linnarsson)	1	--	--	1	2
Valenagnostus (?) sp. 2	1	--	--	1	2
Agnostid gen. et sp. indet. no. 1	2	--	--	2	4
Very poorly preserved unidentifiable specimens, 2 complete specimens, 7 individual cephala or pygidia				9	11
					86

*includes Ptychagnostus spp. (see p. 211)

Total no. of cephala and pygidia = 86

No. of cephala and pygidia in complete specimens = 52

Percentage of cephala and pygidia in complete specimens = 60.5%

The age of this fauna is either of the Ptychagnostus punctuosus Zone or the P. nathorsti Zone (Gee et al., 1970).

(2) RB locality, Black Hill section, Dundas area

At the RB locality (grid 3466E, 8474N; lat. 41°50.8'S, long. 145°24.7'E) in the Black Hill section about a mile south of Serpentine Hill in the Dundas area there are two fossiliferous horizons in the siltstone overlying the basal conglomerate (see Stratigraphy section). The lower one contains only sponge spicules whereas the upper one contains both agnostid and polymerid trilobites, inarticulate brachiopods, rare hyolithids, gastropods, rare sponge spicules, and dendroids and hydroids in great profusion.

The agnostids which are present include Hypagnostus sp., Ptychagnostus (Ptychagnostus) hodgei sp. nov., Ptychagnostus (Ptychagnostus) sp., Ptychagnostus (Goniagnostus) rubenacha sp. nov., Diplagnostus sp. 1, and Peronopsis (?) sp. 1. The various species of Ptychagnostus are by far the most common of the agnostid species. The agnostids are found associated with the hydroids, dendroids, inarticulate brachiopods and gastropods. There are several complete agnostids available although nowhere near the proportion found in the Que River Beds.

Within the siltstone at this locality there are rare, quite thin (5-6mm.) slightly coarser layers of fine sandstone. It is from these layers that almost all the polymerid trilobites at the RB locality have been found. The polymerids, which include Kootenia sp., are all preserved as individual skeletal fragments. These fossils in this layer clearly represent death assemblages washed in from neighbouring, somewhat more elevated, areas of the sea floor.

Thus, at the RB locality there are two distinct faunas:

(a) the agnostid assemblage which represents the fauna actually living on the sea floor and in the waters above during the time of deposition of the silts, and

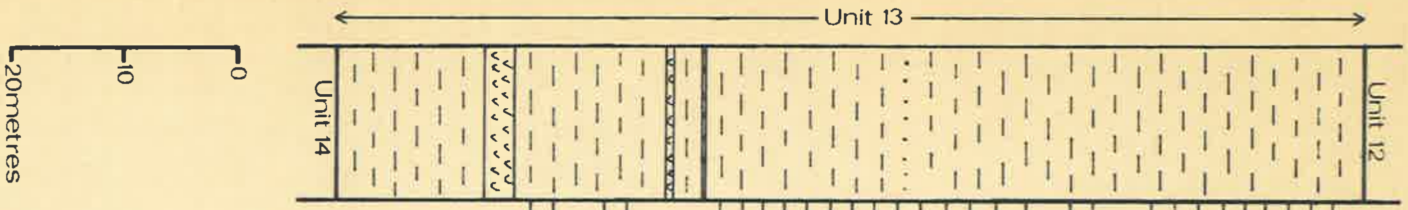
(b) the thanatocoenotic fauna, mainly of polymerid trilobites, which represents the skeletons and moults of a near-shore, shallow water fauna which was later swept by currents into deeper waters.

(3) Sugarloaf Gorge Road Section, Unit 13 of Burns (1964), (lower sedimentary sequence, Radfords Creek Group)

Unit 13 of the Sugarloaf Gorge Road Section (see Stratigraphy) was sampled very fully and all trilobites collected from it are indicated in Table 7 (p. 104) along with their position within the unit.

As can be seen from this table, only one polymerid species is present, and the fauna is otherwise composed entirely of agnostids. No hydroids, dendroids or inarticulate brachiopods are known.

Of the effaced agnostids in Unit 13, *Lejopyge laevigata armata* (Linnarsson) is easiest to recognize because of its spinose nature. ?*Lejopyge laevigata* (Dalman) and *Pseudophalacroma* (?) are difficult to



Unit 13 consists of thinly bedded argillite with some interbedded tuff horizons(⋯) and rare sandstone beds

?*Lejopyge laevigata* (Dalman)					?								?									7	1	1			
Lejopyge laevigata armata (Linnarsson)			1		3	1	1		1	1	1			5			1				3							
Pseudophalacroma (?) sp.	1																					2		2		1		
*unidentified effaced agnostids					5	1	1			1	2			5			2		1				5	2	3	1	1	1
Pseudoclavagnostus (?) *nevel* sp. nov.					8						1			?														
Ptychagnostus (*Goniagnostus*) sp.												8			1													
Hypagnostus cf. *brevifrons* (Angelin)											5																	
Diplagnostus sp. 2					1										?													
Pianaspis (?) *leveni* sp. nov.											13																	

*The unidentified effaced agnostids probably belong in *Lejopyge laevigata*, *L. laevigata armata* and *Pseudophalacroma* (?) sp.

Table 7. Stratigraphic distribution of trilobite species in Unit 13 of the lower sedimentary sequence of the Radfords Creek Group as exposed in Sugarloaf Gorge along the road to Gunns Plains near lat. 41°16.1′S, long. 146°03.7′E. All specimens collected by the writer from this unit are tabulated here.

differentiate, especially with respect to the cephalon (see p. 219). It is probable that most of the unidentified effaced agnostids listed in Table 7 belong in one of these two species, with the possibility of some belonging in L. l. armata. It thus appears that ?Lejopyge laevigata, L. l armata and Pseudophalacroma (?) extend over much of Unit 13.

Quite a number of agnostid specimens in Unit 13 are complete, but, nevertheless, there is some evidence of the presence of scavengers. Plate 8, fig. 10 shows a more or less complete specimen of Ptychagnostus (Goniagnostus) sp. which has the right side of the pygidium broken away and lying a short distance away from the rest of the skeleton. Perhaps the presence of scavengers is the reason for the absence of dendroids and hydroids.

As seen in Table 7, the only polymerid known to be present in Unit 13 is Pianaspis (?) leveni sp. nov. which occurs only at one level. A further interesting point is that Pseudoclavagnostus (?) nevel sp. nov., Ptychagnostus (Goniagnostus) sp., and Hypagnostus cf. brevifrons (Angelin) are each largely confined to a single horizon. In the case of H. cf. brevifrons, it is confined to the same horizon as Pianaspis (?) leveni.

The implication is that the specimens of Pseudoclavagnostus (?) nevel, Ptychagnostus (Goniagnostus) sp., Hypagnostus cf. brevifrons and Pianaspis (?) leveni, found in Unit 13, represent the remains of occasional vagrant trilobite swarms which invaded the seas of the Dial Range

Trough from the main Dundas Trough in late Middle Cambrian times. It is probably relevant to this point that the site of Unit 13 was approximately in the central part of the southern end of the Dial Range Trough and would thus have been easily accessible to vagrant trilobites from the main Dundas Trough. The effaced agnostids represent the indigenous fauna.

The almost total lack of anything but agnostids indicates to the author that the bottom conditions were inimical to life, except perhaps for the occasional scavenger. Although the present colour of the sediments is buff to brownish grey due to weathering, it seems likely that the original sediment was a laminated black shale.

Thus, in summary, the writer sees the agnostid assemblage as essentially a planktonic open sea type fauna living over a stagnant bottom, which was largely unsuitable for the existence of polymerid trilobites, although suitable for sponges and possibly inarticulate brachiopods.

Assemblage (2) Ptychagnostid--non-nepeid assemblage

This assemblage is closely related to assemblage (1) in that the agnostids found in both assemblages are characterized by the presence of *Ptychagnostus* or its derivative *Lejopyge*. Nepeids are so far unknown in assemblage (2). Assemblage (2) is known definitely only in the upper fauna at Christmas Hills. Assemblage (2) can be either separated as a distinct assemblage because it appears to be in some respects intermediate between assemblages (1) and (3), or it can be considered as a variation of assemblage (1).

The upper fauna at Christmas Hills contains dendroids, hydroids, inarticulate brachiopods, hyolithids and sponge spicules as well as a rich assemblage of both agnostid and polymerid trilobites. The polymerid trilobites include Centropleura, Amphoton, Pianaspis and others; the agnostids include Grandagnostus sp., Hypagnostus cf. brevifrons (Angelin), Ptychagnostus (Ptychagnostus) cf. aculeatus (Angelin), Ptychagnostus (Goniagnostus) buckleyi sp. nov., Diplagnostus sp. 3, Buckagnostus debori sp. nov., Peronopsis gullini sp. nov. and Clavagnostus sp. 1. Clavagnostus sp. 1 is known from only one partial pygidium; Buckagnostus debori and Peronopsis gullini are much less common in the upper than in the lower fauna at Christmas Hills and, in fact, are quite rare in the upper fauna. The most common agnostid in the upper fauna is that described as Agnostid, gen. et sp. indet. no. 4. Of the recognizable forms Ptychagnostus buckleyi is common and Grandagnostus sp. and Diplagnostus sp. 3 are reasonably abundant.

As noted in the stratigraphic section of this thesis, the upper fauna is found in a laminated dark grey siltstone which was probably quite dark at the time of deposition. It appears that the depositional conditions were quiet as is substantiated by the laminations, the preservation of the hydroids and dendroids and the presence of a considerable number of complete trilobite specimens (both agnostids and polymerids). Scavengers were probably largely absent.

It should be noted that there is a marked similarity between the agnostid fauna of the upper fauna at Christmas Hills with the agnostids found in assemblage (1). Similar elements are Ptychagnostus and Diplagnostus. Another similarity is the reasonable abundance of hydroids, dendroids and inarticulate brachiopods in both the Christmas Hills upper fauna and those of assemblage (1) (with the exception of the Sugarloaf Gorge fauna).

The major difference between the upper fauna at Christmas Hills and the faunas of assemblage (1) is the presence of abundant polymerids in the former. As noted previously, the agnostids probably led a pelagic existence. Öpik (1961b, p. 130) concluded that Centropleura was a pelagic hunter. The only other common polymerid in the upper fauna is Amphoton, but its mode of life is unknown.

The fact that there are several species of polymerid trilobites coexisting with the agnostids implies that the conditions for life in the seas around Christmas Hills during the time of the existence of the upper fauna were different from those suggested for assemblage (1).

The author interprets assemblage (2) as existing somewhat closer to the shoreline and probably in shallower water than did assemblage (1). This view is supported by the manner in which Kootenia and other polymerids, interpreted as a thanatocoenosis, are found at the RB locality (see above, p.102).

Assemblage (3) Nepeid-clavagnostid-peronopsid assemblage

This assemblage is characterized by the presence of the Nepeidae, Clavagnostus (rare), Peronopsis (in the Middle Cambrian) and the absence of Ptychagnostus.

Assemblage (3) is known from the lower fauna at Christmas Hills, the main fauna near St. Valentines Peak, Riana, the lowest fauna on the track up the west side of the Sugarloaf Gorge and the main fossil locality (I_3) on Isandula Road.

(i) Lower fauna at Christmas Hills

Jago and Buckley (1971) reported the abrupt faunal change between the older and younger faunas at Christmas Hills despite the very similar ages of the faunas.

The lower fauna is very well known with approximately 5,000 individual trilobites collected by the author. It is a much richer fauna in terms of density of trilobite specimens than is the upper fauna. On the other hand, the upper fauna shows greater diversity in numbers of trilobite species and also a greater density of such groups as the hydroids, dendroids and inarticulate brachiopods. In fact, despite the intensive collecting, less than ten hydroid and dendroid specimens are known from the lower fauna. These facts, plus the lower proportion of complete trilobites (about 2% as against about 8%), indicate the sediments containing the lower fauna were deposited in slightly more turbulent, probably shallower, water, or that there were more scavengers present in the lower fauna as compared with the upper fauna.

Among the polymerids of the lower fauna, Proampyx and Nepea are reasonably common. The agnostids known from the lower fauna are Buckagnostus debori sp. nov. in great abundance, Peronopsis gullini sp. nov., Clavagnostus milli sp. nov. and Valenagnostus brittoni sp. nov. As noted above, rare examples of Buckagnostus debori and Peronopsis gullini also occur in the upper fauna.

The fact that this fauna is probably of Lejopyge laevigata I age and does not contain either Ptychagnostus or its derivative Lejopyge must be regarded as significant because Ptychagnostus and Lejopyge are prominent at this time in Queensland (Öpik, 1961b) and Sweden (Westergård, 1946).

At Christmas Hills the fact that there was an interpreted shallower water fauna (see below) overlain by a deeper water fauna indicates a transgressing sea in the Christmas Hills area about L. laevigata I or II time.

(ii) St. Valentines Peak

The age of the main St. Valentines Peak fauna is probably either Lejopyge laevigata III Zone or the Middle-Upper Cambrian passage

Zone (see Stratigraphy section). The agnostids from this fauna include Aspidagnostus cf. riani, Clavagnostus rawlingi sp. nov., Valenagnostus banksi sp. nov., Buckagnostus compani sp. nov., Peronopsis ekip sp. nov., Pseudoclavagnostus sisponorep sp. nov. and others. Other trilobites include Opsidiscus argusi sp. nov., Schmalenseeia gostinensis sp. nov., Nepea and a zacanthoid.

This fauna shows pronounced affinities with the lower fauna at Christmas Hills despite the difference in age of about two Zones. Common genera are Clavagnostus, Valenagnostus, Buckagnostus, Peronopsis and Nepea. It seems clear that the two faunas lived in similar environments.

(iii) Lowest fauna - west side of Sugarloaf Gorge

This fauna is known from only a few specimens. It includes Nepea sp., Clavagnostus sp. 2, Aspidagnostus sp. 4 and possibly Peronopsis sp. It is a fauna similar to that noted above from St. Valentines Peak and may be of the same age (see Stratigraphy).

(iv) Isandula Road

The Cateena Group at the main fossil locality on Isandula Road, I_3, (lat. 41°13.8'S, long. 146°08.3'E) contains a scattered fauna which includes Penarosa sp., Peronopsis sp. 1 and a pagetiid. This fauna is probably about Ptychagnostus atavus Zone to P. punctuosus Zone in age (see Stratigraphy). Despite intensive collecting, Ptychagnostus is unknown from this locality. The combination of a nepeid, a pagetiid and Peronopsis is reminiscent of the situation at St. Valentines Peak.

As seen on Figure 19, the I_3 locality is very close to the eastern margin of the Dial Range Trough. This supports the hypothesis that this faunal assemblage is basically a shallow water assemblage.

(v) Riana

The main fossil locality in the Radfords Creek Group near Riana is in a quarry at (4004E, 9240N). Most of the fossils are found in a narrow (5 mm.) band of slightly coarser siltstone within the surrounding siltstone. The fossils include the nepeid Ferenepea and the agnostids Clavagnostus burnsi sp. nov., Aspidagnostus riani sp. nov., Pseudoclavagnostus (?) inara sp. nov. and Pseudagnostus sp. aff. P. ampullatus. The age of this fauna is Mindyallan, but the precise zone of the Mindyallan in which it falls is unknown (see Stratigraphy).

Although only rare species of Ptychagnostus, Lejopyge, Hypagnostus or Diplagnostus extend into the Upper Cambrian, the marked similarity of the Riana fauna (e.g., the presence of a nepeid along with Clavagnostus and Aspidagnostus) with the St. Valentines Peak fauna suggests to the author that the Riana fossil assemblage belongs in assemblage (3).

A further point of interest of the fauna in the Riana quarry is its occurrence in a narrow band. From this occurrence it appears that this narrow band represents material worked in by currents from a topographically higher area of the sea floor. However, in this case (as opposed to that at the RB locality) there are scattered representatives of much of the same fauna in the surrounding siltstone. The principal exception to this is Ferenepea, which is known to date only from the narrow band, possibly suggesting that Ferenepea shows a preference for shallower water while the other members of the fauna have a wider environmental tolerance. However, Ferenepea is not common in the narrow band, and fossils are scarce in the surrounding siltstone so that no definite statements should be made at this stage.

The author interprets assemblage (3) as being a reasonably near shore, essentially shallow water fauna. The Tasmanian situation supports Öpik's (1970, p. 8) contention that nepeids probably lived either on shallow sea floors or near the surface of the sea.

The author considers it significant that although Diplagnostus and Hypagnostus are usually rare where they are found, these genera are unknown from any of the known examples of assemblage (3). This is despite the fact that one or both genera are found at similar stratigraphic levels in Tasmania and in other parts of the world, e.g., Sweden (Westergård, 1946), Utah (Robison, 1964a), Queensland (Öpik, 1961b) and Newfoundland (Hutchinson, 1962). Diplagnostus and Hypagnostus seem to be typical of assemblages (1) and (2).

Other Tasmanian Middle Cambrian and Early Upper Cambrian faunas

The GP_1/FE_1 faunas near Dundas include both a nepeid and Aspidagnostus and may belong in assemblage (3). The BJ_2 fauna near the Adelaide Mine, Dundas contains *Clavagnostus* and may also belong in assemblage (3).

The fauna found in the Hodge Slate about 100 metres north of the present Razorback Mine is badly preserved, and the only trilobite recognized is *Ptychagnostus*. The presence of *Ptychagnostus* and that of hydroids and dendroids somewhat lower in the Hodge Slate in this vicinity (see Stratigraphy) indicates that this fauna belongs in assemblage (1).

The Summit Cutting fauna near Zeehan is very poorly preserved, the agnostid identifications are tentative, and no inferences can be made about it. The fauna at Cateena Point, near Ulverstone, of *Ptychagnostus punctuosus* Zone or *P. nathorsti* Zone (see Stratigraphy) contains *Peronopsis*, polymerid trilobites as well as dendroids and hydroids. This association probably indicates affiliation with assemblage (2).

Unit 18 of the Huskisson River sequence is a black pyritic shale which contains *Glyptagnostus reticulatus* as the only trilobite associated with hydroids, dendroids and sponge spicules. This situation is rather similar to that at Que River. It seems likely that in the early Upper Cambrian, *Glyptagnostus* occupied a similar ecological niche to that of *Ptychagnostus* in the Middle Cambrian and was basically an open sea dweller. The fauna of unit 18 is tentatively placed in assemblage (1).

Summary

The conclusion drawn from the above discussion is summarized in Fig. 29. Despite the fact that agnostids led a pelagic existence, it can be seen from the above discussion that in the late Middle and early Upper Cambrian within the Tasmanian region there are at least two different agnostid assemblages, (a) an off shore assemblage, discussed above as assemblage (1), with assemblage (2) as a variation of assemblage (1), and (b) a near shore assemblage, discussed above as assemblage (3).

It is interesting to compare the situation as shown above (Fig. 29) for the trilobites, dendroids and hydroids with that deduced by Elles (1939) for Ordovician and Silurian assemblages of England. Fig. 30 is taken out of Elles (op. cit.).

In general terms Elles' "Plankton Region" would correspond to assemblage (1), assemblage (2) would correspond to the outer and middle parts of Elles' "Off Shore Region" and assemblage (3) would correspond to the inner part of Elles' "Off Shore Region".

As far as the author is aware, no similar association based largely on agnostid assemblages has been proposed. However, other pelagic groups such as ammonites (Scott, 1940) and graptolites (Skevington, 1969) show distinct different contemporaneous assemblages in reasonably close proximity.

Comparisons with other Cambrian faunas

The overall setting of the Victorian Cambrian is similar to that in Tasmania with a combination of thick volcanics and sediments being present. Unfortunately, little has been published on the Victorian Cambrian except for a short summary by Thomas and Singleton (1956).

Black shales near Monegetta contain a rich dendroid fauna of Middle Cambrian age. In life these would have been floating organisms, and although no agnostids are reported from this fauna, they can be provisionally placed in assemblage (1).

Similar dendroids are also known from shales of the Knowsley East Formation. However, these beds also contain two trilobite horizons, the "*Dinesus* Band" and the "*Amphoton* Band". The latter contains both *Nepea* and *Peronopsis* and thus belongs in assemblage (3). Although the writer has not visited the Victorian localities, it seems possible that the trilobites of both the "*Dinesus* Band" and the "*Amphoton* Band" represent shallow water faunas washed into deeper water after death.

Öpik (1961a, 1961b, 1963, 1967, 1970) has described all the Middle Cambrian and early Upper Cambrian nepeids from northern Australia and also a great number of agnostids.

Unfortunately, Öpik (1970) does not give full details of the agnostids associated with the Middle Cambrian nepeids. Thus, no check can be made to determine whether or not a similar clavagnostid-nepeid assemblage exists in Queensland.

However, Öpik (1967, vol. 2, pp. 5-16) gives quite detailed lists of the late Middle and early Upper Cambrian faunas in the north-western Queensland. Unfortunately, most of these lists deal with early Upper Cambrian faunas, whereas most of the deductions on the Tasmanian work were done on Middle Cambrian faunas. It may be significant that these faunal lists reveal that at every locality where Clavagnostus bisectus Öpik is recorded so is at least one species of nepeid, thus lending support to the reality of the proposed clavagnostid-nepeid assemblage. On the other hand, Ptychagnostus nodibundus Öpik and Lejopyge laevigata armata (=L. cos Öpik) occur together with nepeids and Clavagnostus bisectus at locality G 417 (Öpik, 1967).

With regard to the Queensland faunas one point that does seem to have significance is the situation at locality G 103 of Öpik (1967). At this locality there are chert biscuits weathered out of shale overlying a red sandstone. The chert contains polymerid genera including Ascionepea janitrix Öpik but no agnostids whereas in the sandstone, only agnostids are present. These include Lejopyge laevigata (Dalman), L. l armata (Linnarsson) and Ptychagnostus fumicola Öpik. The clavagnostid Triadaspis bigeneris Öpik is also present in the sandstone, but since the evidence in Tasmania is based on the presence of Clavagnostus, the presence of Triadaspis with Lejopyge and Ptychagnostus may not be significant from the environmental angle.

However, since most of the Tasmanian occurrences used in deducing the presence of the three faunal assemblages are of Middle Cambrian rather than Upper Cambrian age, it is difficult to assess the relevance of the above discussion to the situation in Tasmania.

In the Queensland Middle Cambrian there is certainly some coexistence of nepeids and ptychagnostids as is evidenced by the association of *Penarosa meniscops* Öpik and a cephalon of *Ptychagnostus* (Öpik, 1970, pl. 14, fig. 2) in the Inca Formation.

Öpik (1961b, pp. 179-185) gives some faunal lists for various localities in the Burke River area. At the localities where long faunal lists are given, the most common association is the *Centropleura*-agnostid association noted by Öpik (1961b, p. 130). The agnostids associated with *Centropleura* are usually different species of *Ptychagnostus*, *Lejopyge* and *Hypagnostus*, a situation rather analogous to that in the Christmas Hills upper fauna (assemblage (2)) from Tasmania. It seems significant to the writer that there is no mention of *Clavagnostus* or *Nepea* and only one mention of *Peronopsis* in the faunal lists given by Öpik (1961b).

This seems to lend some support to the above-mentioned proposed separation of the agnostids into different environmental groups.

Gatehouse (1969), in dealing with a shallow water, late Middle Cambrian fauna from the Neptune Range in Antartica, notes the presence of a nepeid and a species of *Peronopsis*. There is no mention of *Ptychagnostus*, and thus this fauna probably fits into assemblage (3).

The work of Robison (1964a) shows that Ptychagnostus and Peronopsis coexisted in Utah in late Middle Cambrian times. Hutchinson (1962) gives localities indicating a similar coexistence in south-east Newfoundland of Peronopsis, Hypagnostus and Ptychagnostus. Westergård (1946, Table, pp. 12, 13) shows that Ptychagnostus and Peronopsis occur together in the Middle Cambrian of Sweden. An inspection of rubber casts of Clavagnostus repandus (Riks specimens 33 and 34) from Sweden also revealed the presence of Lejopyge laevigata. Thus, the situation in the Middle Cambrian of Sweden, south-east Newfoundland and Utah appears different to that in Tasmania.

The writer can offer no firm explanation for this fact. However, it is probably relevant that the Middle Cambrian of Sweden has a maximum thickness of about 70 metres (deduced from Westergård, 1946) and is a condensed sequence. The Middle Cambrian of Newfoundland is also a condensed sequence (North, 1971, p. 232). This is in marked contrast to the great thickness of sediment preserved in the Middle Cambrian of Tasmania where upwards of 1500 metres of sediment, representing only part of the Middle Cambrian, is preserved in the Dial Range Trough.

It will be noted also that the writer considers that both the hydroids and dendroids found in the Tasmanian Cambrian probably led a planktonic existence. Bulman (1957) and Berry (1962) along with earlier authors consider that the dendroids or at least the majority of dendroids were part of the sessile benthos. Bouček (1957) disputed this view and considered the dendroids to be epiplanktonic. Bulman (1970) allows the possibility of both a benthonic and planktonic existence for dendroids. The writer considers that the association of the dendroids and hydroids with assemblages (1) and (2) suggests that the representatives of these groups found in the Tasmanian Cambrian probably led a planktonic existence.

Agnostid trilobites are widely used for dating Middle and Upper Cambrian rocks. The above proposal that different agnostid groups existed in different environments simply means that extra care should be taken in making correlations based on agnostid trilobites.

CLASSIFICATION AND MORPHOLOGY OF AGNOSTID TRILOBITES

Öpik (1961b, 1963, 1967) has discussed the classification of agnostid trilobites, culminating in his detailed classification of 1967. This classification differs considerably from those of Kobayashi (1939, 1962), Hupé (1953), Howell (1959) and Pokrovskaya (1960a). Öpik (1967) discussed his "Tabular Classification of Agnostids" in some detail. This classification is accepted here as it seems to me to be much more objective and consistent than previous classifications. The only reservations I have about Öpik's classification is with respect to Criterion IV, the shape of the glabellar rear. As noted below in the discussion on Diplagnostus, this criterion is difficult to use, and I consider that it should be eliminated in favour of some other feature.

The morphology and terminology of agnostids has been discussed by Palmer (1955), Öpik (1961a, 1963, 1967) and Robison (1964a). The suggestions put forward by these workers are similar. However, the terminology of Öpik is the most complete and is usually followed in the descriptions given below.

Robison (1964a, p. 515) has suggested that an enrolled condition may have been the normal mode of life of agnostid trilobites for the following reasons:

(1) the pleural furrows of the thoracic segments of agnostid trilobites are reflexed forward rather than backwards as in non-agnostid trilobites;

(2) there are no posteriorly reflexed pleural tips on the thoracic segments of agnostid trilobites;

(3) points (1) and (2) suggested to Robison (op. cit.) that "the lack of streamlining indicates that the animal was not adapted for locomotion in an unrolled position";

(4) ventral doublures are absent on the pleurae of the thoracic segments;

(5) the segments are modified to form a tight seal between the posterior end of the cephalon and the anterior end of the pygidium during enrollment.

Points (4) and (5) seem to me to be simply adaptations for enrollment. Many other trilobites are known to enroll, and it is not suggested that this is their normal mode of existence. In a non-enrolled position the thorax of an agnostid would be set well below the level of both the cephalon and the pygidium. The lateral margins of the thoracic segments are placed adaxially as compared with the lateral margins of the cephalon and pygidium. Thus it seems to me that the lack of streamlining would have little effect on the animal and that points (1) to (3) of Robison are unimportant. I see no reason why the enrolled position should be considered to be the normal mode of life of the agnostid trilobites.

In considering the enrolled position of agnostids, it is possible that the cephalo-thoracic aperture of (Robison, 1964a, p. 515) could be related to maintaining hydrostatic equilibrium when the agnostid went into the enrolled position.

SYSTEMATIC DESCRIPTIONS

Phylum ARTHROPODA Siebold and Stannius, 1845

Class TRILOBITA Walch, 1771

Order MIOMERA Jaekel, 1909

Suborder AGNOSTINA Salter, 1864

Superfamily AGNOSTACEA M'Coy, 1849

Family AGNOSTIDAE M'Coy, 1849

Subfamily QUADRAGNOSTINAE Howell, 1935

Genus PERONOPSIS Hawle and Corda, 1847

Synonymy: See Palmer, 1968, p. 31.

Type species: *Battus integer* Beyrich, 1845, p. 44, pl. 1, fig. 19.

Diagnosis: See Robison, 1964a, p. 530 and discussion on *Peronopsis ekip* sp. nov. (below, p. 130).

Peronopsis gullini sp. nov.

pl. 1, figs. 1-10

Material: One large almost complete specimen, UT 86599, the holotype, and two smaller complete specimens are known. Numerous individual pygidia are available. Individual cephala of *Peronopsis gullini* sp. nov. are impossible to differentiate from those of *Buckagnostus debori* sp. nov. with certainty. However, the latter is a larger agnostid than *Peronopsis gullini*, and thus all the large cephala of this type in the lower fauna at Christmas Hills are confidently included in *Buckagnostus debori*.

Selection of Holotype: The specimen, UT 86599, (pl. 1, fig. 1) is selected as holotype because it is the largest, best preserved complete specimen.

Measurements: UT 86599, the holotype, an almost complete specimen, E-W distortion, total length, 9.3mm.; cephalon, length, 3.7mm., width, 2.8mm.; pygidium, length (without articulating half-ring), 3.7mm., width, 3.2mm. UT 92468, pygidium, N-S distortion, length, 2.5mm., width, 3.3mm.

Diagnosis: *Peronopsis gullini* sp. nov. has an angular glabellar rear, moderately large, simple basal lobes and a transverse glabellar furrow which is arched to the posterior. The cephalic margins converge forward to a well-rounded cephalic front; the pygidial margins diverge slightly to the short border spines. The posterior pygidial rim is wide, slightly elevated and flatly convex; the posterior marginal furrow is wide and deep; both the rim and the marginal furrow narrow considerably to the anterior. The pygidial axis extends the full length of the acrolobe and in large specimens slightly on to the posterior marginal furrow. The pleural fields are narrow and smooth. The transverse pygidial axial furrows are effaced; there is a prominent node on the second axial segment.

Description: The moderately convex cephalon is about as wide as it is long. The cephalic margins converge gradually from the posterior to the broadly rounded cephalic front. There is a wide, shallow marginal furrow and a narrow, flatly convex, slightly elevated rim. Both rim and furrow narrow to the posterior. The short, blunt posterolateral spines have a wide base. There is no preglabellar median furrow; the cheeks are smooth, the basal lobes are moderately large and simple.

The glabella is outlined by deep, moderately wide furrows; it has a length about 0.7 that of the cephalon and a width about one-third that of the cephalon. The shallow transverse glabellar furrow is arched to the posterior. The posterior glabellar segment has a length of 0.7-0.75 that of the glabella. On the holotype the glabellar rear is angular, although the angularity is probably exaggerated by the E-W distortion (the glabellar rear is not properly visible on other cephala). There is a small centrally placed node on the posterior glabellar segment.

The moderately convex pygidium is about as wide as it is long. From the anterior, the margins diverge slightly to short border spines, which are placed about opposite the axial posterior. Between the spines the posterior margin is evenly curved. There is a wide, flatly convex, slightly elevated posterior rim, a wide convex elevated lateral rim, and a wide deep marginal furrow. Both the rim and the furrow narrow considerably to the anterior. The shoulder furrows are narrow and shallow. The elevated shoulders are strongly geniculate, with the fulcra close to the axis. The large facets are smooth and flat. The wide articulating furrow has a deep pit on either side of the shallow central region. The articulating half-ring is narrow and convex.

The axial furrows are wide and deep; the axis stands out well above the smooth pleural fields. The axis extends the full length of the acrolobe in mature specimens. In the smallest available pygidium the axial posterior is separated from the posterior marginal furrow by a very short, shallow post-axial furrow. In the larger specimens the axis extends slightly on to the marginal furrow.

The axis is slightly constricted in the region of the second axial segment; the transverse axial furrows are almost obsolete; there is a well-developed node on the second axial segment. The posterior of the node is blunt; to the anterior of the node there is a low ridge extending to the anterior margin of the acrolobe. The axial posterior is sharply rounded.

Discussion: *Peronopsis gullini* sp. nov. is quite close to *P. fallax minor* (Brögger). It differs from the latter in that it has a greater pygidial axial constriction, and the pygidial posterior is slightly more pointed. The pygidial axial rear reaches the posterior marginal furrow in all the larger specimens of *P. gullini* which is not the case with *P. fallax minor*. The basal lobes of *P. gullini* are larger than those of *P. fallax minor*. As noted in the description, the pygidial axis of *P. gullini* extends further to the posterior in larger specimens than in smaller specimens.

Occurrence and Age: *Peronopsis gullini* sp. nov. comes from both the lower and upper faunas at Christmas Hills (lat. 40°54.1'S, long. 144°29.8'E; grid 3075E, 9610N); its age is late Middle Cambrian and probably of the *Lejopyge laevigata* I Zone, or of the *L. laevigata* II Zone.

<u>Peronopsis</u> <u>ekip</u> sp. nov.

pl. 1, figs. 11-17

<u>Material</u>: Three partial cephala and four partial pygidia are available for descriptive purposes. All are well preserved.

<u>Measurements</u>: Cephala: UT 92692, length, 1.9mm.; UT 92710, length of glabella, 1.2mm. Pygidia: UT 92687, the holotype, the length, (including axial half-ring), 1.3mm., width, 1.4mm.; UT 92689, length, (without articulating half-ring), 1.8mm.

<u>Selection of Holotype</u>: The pygidium, UT 92689, (pl. 1, fig. 11) is chosen as the holotype as it is the most complete pygidium available.

<u>Diagnosis</u>: The cephalon has a glabella with a sharply rounded glabellar front and a rounded glabellar rear. The transverse glabellar furrow is arched strongly to the posterior. A small elongated glabellar node is placed towards the glabellar posterior. The posterior glabellar segment has a low anterior portion and a relatively high posterior portion. There is a vestigial preglabellar median furrow.

The subquadrate pygidium has a wide border, with short border spines. The almost parallel-sided, wide axis reaches the posterior marginal furrow. The pygidial rear is broadly rounded. The transverse axial furrows are almost entirely effaced; the axis is slightly constricted at the second segment. There is a prominent node on the second segment; there is a small node towards the axial posterior.

<u>Description</u>: The moderately convex cephalon is about as long as it is wide. There is a moderately wide marginal furrow and a moderately wide,

slightly elevated, convex rim. The cheeks are smooth. The glabella is outlined by deep, wide axial furrows and has a length about 0.7 that of the cephalon. Immediately to the anterior of the sharply rounded glabellar front is a vestigial preglabellar median furrow which extends only a short distance towards the marginal furrow. The glabella rear is rounded. The basal lobes are small, simple and separated. The glabella expands slightly to the anterior and is widest just behind the transverse glabellar furrow. The shallow transverse glabellar furrow is arched to the posterior. The anterior third of the posterior glabellar segment is composed of two lobes which are outlined by faint furrows which run inwards and forwards from points on the axial furrows just to the anterior of the midpoint of the posterior segment. The posterior glabellar segment, particularly its posterior region, stands out strongly above the rest of the cephalon. The highest part of the glabella is just in front of the posterior margin. There is a small postero-centrally placed elongated node on the posterior glabellar segment.

The subquadrate pygidium is about as wide as it is long. There is a wide, shallow marginal furrow. The gently convex rim is wide; the border spines are short. The shoulders are gently geniculate, with the fulcra being close to the axis. The articulating furrow is wide with a shallow central region and deep extremities. The convex articulating half-ring has a lenticular outline.

The pygidial axis is distinctly convex and markedly elevated above the less convex, smooth pleural fields. It is outlined by wide, moderately deep axial furrows which are sub-parallel for most of their length. The furrows become shallow towards the bluntly rounded axial posterior which just reaches the marginal furrow. The axis is about 0.4 the width of the pygidium. The almost effaced axis has three annulations which are indicated by faint lateral indentations. It is very slightly constricted at the second annulation. The anterior and second annulations each have a length about 0.2 that of the axis. There is a very prominent central node, with a steep posterior margin on the second annulation. A small node occurs towards the posterior of the posterior axial segment.

Discussion: The presence of a vestigial preglabellar median furrow may cast some doubt in the placing of this species in *Peronopsis*. However, the species described by Robison (1964a, p. 531) as *Homagnostus incertus* has such a furrow, and as noted by Öpik (1967, p. 139), this species should be referred to *Peronopsis incertus* (Robison). *P. quadrata* (Tullberg), as illustrated by Westergård (1946, pl. 3, fig. 28), also shows a short preglabellar median furrow. Thus, the diagnosis of *Peronopsis* given by Robison (1964a, p. 529) should be amended to include forms with an incomplete preglabellar median furrow.

Peronopsis ekip sp. nov. has a small node placed towards the posterior of the pygidial axis; this feature is unique in *Peronopsis* as far as the author is aware.

Occurrence and Age: Peronopsis ekip sp. nov. comes from the main fauna in the St. Valentines Peak area near lat. 41°21.6'S, long. 145°44.3'E (grid 3758E, 9064N); its age is of either the late Middle Cambrian Lejopyge laevigata III Zone, or the Middle Cambrian/Upper Cambrian Passage Zone.

Peronopsis sp. 1

pl. 2, figs. 1-4

Material: The specimens available are an internal mould of a cephalon and thorax, UT 92485, part of the corresponding external mould, UT 92486, the internal mould of a pygidium, UT 92487, and a partial external mould of a pygidium, UT 92488. All specimens are figured.

Measurements: Cephalon and two thoracic segments, UT 92485, intermediate distortion, total length, 2.4mm.; length of cephalon, 1.7mm, width of cephalon, 2.1mm. Pygidium, UT 92487, (intermediate distortion), length, 1.3mm., width, 1.3mm.

Description: The cephalon is about as wide as it is long. There is a moderately deep, wide marginal furrow and a wide convex rim. The border narrows markedly to the posterior. The cheeks are smooth. There is no preglabellar median furrow. The glabella has a length about 0.7 that of the cephalon. The glabellar rear is broadly rounded; the glabellar front is evenly rounded; the glabella tapers evenly forward. The glabella is outlined by deep, wide axial furrows which shallow to the anterior; the deep, wide transverse glabellar furrow is almost straight. The posterior glabellar segment has a length about 0.7 that of the glabella. There is a small circular node placed just to the posterior of the centre of the posterior glabellar segment. There are faint lateral indentations in the margins of the glabella just forward of the centre of the posterior glabellar segment. These suggest the presence of a pair of lobules at the anterior of the posterior glabellar segment. The basal lobes are small, simple, and unconnected.

The pygidium is about as wide as is long. There is a moderately wide, deep marginal furrow and a wide convex rim. The border spines are of moderate length but do not show up well on the photographs. The shoulder furrows are wide and moderately deep. The shoulders are elevated. The shallow articulating furrow is arched to the posterior at its centre. The articulating half-ring is narrow (sag.) and slightly convex. The pleural areas are smooth. The almost effaced axis does not reach the marginal furrow. The wide axial furrows shallow to the posterior. The axial posterior is pointed. The axis has a length about 0.7 that of the pygidium; it tapers to the posterior with a slight constriction at the second axial segment. There is a large node on the second axial segment. There is a very short post-axial median furrow.

Discussion: The genus Peronopsis contains about 75 described species and subspecies, many of which show considerable intraspecific variation.

The value of the material described above is decreased by the fact that the pygidium is known mostly from an internal mould and that there are so few specimens. It is thus referred to as Peronopsis sp. 1 until further specimens are obtained. It is related to Peronopsis fallax (Linnarsson), but differs in having longer pygidial border spines and a more effaced pygidial axis.

Occurrence and Age: Peronopsis sp. 1 is found in a mudstone of the Cateena Group exposed in a quarry on Isandula Road at lat. 41°13.8'S, long. 146°08.3'E (grid 4129E, 9231N) (I_3 fauna); its age is Middle Cambrian, probably between the zones of Ptychagnostus atavus and P. punctuosus.

Peronopsis sp. 2

pl. 2, figs. 5-8

Material: Five cephala and three pygidia are available for inspection. All are poorly preserved.

Measurements: Cephalon: UT 53451, (E-W distortion), length, 3.2mm. Pygidia: UT 53446, (N-S distortion), length (including axial half-ring), 2.1mm., width, 2.3mm.; UT 53440b, (E-W distortion), length (including axial half-ring), 1.9mm., width, 1.7mm.

Description: The cephalon is about as wide as it is long. There is a deep, wide marginal furrow and a moderately wide somewhat flattened rim. The simple basal lobes are probably connected behind the broadly rounded glabellar rear. There is no preglabellar median furrow. The axial furrows are wide and moderately deep. The glabella has a length about two-thirds that of the cephalon. The transverse glabellar furrow is shallow and probably straight. The posterior glabellar segment has a length about 0.7 that of the glabella. No distinct glabellar node is preserved.

The pygidium is about as wide as it is long. There is a wide, moderately deep marginal furrow and a wide posterior rim. The lateral rims narrow markedly to the anterior. The presence or absence of border spines cannot be determined from the available specimens. The shoulder furrows are deep and wide; the shoulders are narrow and convex; the fulcra are close to the axis. The shallow articulating furrow is arched distinctly to the posterior at its centre; it is deeper at either extremity. There is a convex articulating half-ring. The strongly convex wide axis extends to the posterior marginal furrow. The axial furrows are wide and deep. The pygidial rear is broadly rounded. The smooth pleural areas are small. The axis is largely effaced with a slight constriction in the region of the second axial segment and a slight expansion towards the anterior of the posterior axial segment. There is probably a node on the second axial segment.

Discussion: The specimens described above are too poorly preserved to refer to a known species or to be the basis of a new species. They are referred to Peronopsis sp. 2. This species has a wider pygidial axis than most species of Peronopsis; the axis is of a comparable width to that of P. incertus (Robison). Peronopsis sp. 2 differs from P. incertus in having no sign of a preglabellar median furrow.

Occurrence and Age: Peronopsis sp. 2 is found in a siltstone of the Cateena Group exposed at Cateena Point (lat. 41°09.9'S, long. 146° 08.6'E; grid 4131E, 9304N); its age is Middle Cambrian, probably either Ptychagnostus punctuosus Zone or P. nathorsti Zone.

Peronopsis ? sp. 1

pl. 2, fig. 9

Material: One poorly preserved incomplete cephalon (UT 88126), which has undergone intermediate distortion, is available for description.

Description: The complete cephalon would probably be about 1.4mm. long and 1.6mm. wide. There is a wide, shallow marginal furrow and a wide, slightly convex rim. The margins of the acrolobe are very steep. At the anterior the border is about .15 the length of the cephalon. The markedly tapered glabella is outlined by deep, moderately wide axial furrows; it stands out markedly above the cheeks. The transverse glabellar furrow is deep and wide. The anterior glabellar segment has a sub-traphezohedral outline. The posterior glabellar segment is distinctly elevated above both the cheeks and the anterior glabellar segment. It has a high area (rather than a distinct node) placed just to the anterior of the centre of the lobe. The posterior part of the cephalon is poorly preserved, but the glabellar rear is probably well rounded.

Discussion: This cephalon is very poorly preserved. It probably belongs in the subfamily Quadragnostinae. It is questionably referred to *Peronopsis* although the border is wider than is usual in *Peronopsis*. A definite assignation cannot be made until more and far better preserved examples of this type of cephalon are known.

Occurrence and Age: *Peronopsis* ? sp. 1 comes from about 28 metres above the base of the lowest siltstone unit of the Black Hill Section, Dundas at lat. 41°50.8'S, long. 145°24.7'E (grid 3466E, 8474N) (RB fauna); its age is Middle Cambrian and possibly that of the *Ptychagnostus nathorsti* Zone.

Genus HYPAGNOSTUS Jaekel, 1909

Hypagnostus Jaekel, 1909, p. 399; Kobayashi, 1939, p. 122; Lermontova, 1940, p. 129; Westergård, 1946, p. 43; Ivshin, 1953, p. 17; Howell, 1959, p. 184; Öpik, 1961b, p. 57; Robison, 1964a, p. 529; Öpik, 1967, p. 82; Palmer, 1968, p. 31.

Cyclopagnostus Howell, 1937, p. 1166; Howell, 1959, p. 175.

Tomagnostella Kobayashi, 1939, p. 150; Howell, 1959, p. 128.

Type Species: *Agnostus parvifrons* Linnarsson, 1869, p. 82, pl. 2, figs. 56, 57.

Diagnosis: See Robison, 1964a, p. 529.

Discussion: Westergård (1946, p. 44) and later authors have included *Spinagnostus* Howell 1935 in *Hypagnostus*. However, Shaw (1966, p. 848) has redescribed the type species of *Spinagnostus*, *S. franklinensis* Howell, and concluded that *Spinagnostus* should be excluded from *Hypagnostus*. Shaw's interpretation will be followed here until better preserved examples of *Spinagnostus franklinensis* clarify the situation.

Hypagnostus cf. *brevifrons* (Angelin)

pl. 2, figs. 10-15

Synonymy: Westergård, 1946, p. 48, pl. 5, figs. 24-29 (this reference gives the pre-1946 synonymy); Chu, 1959, p. 213, pl. 1, figs. 6-9; Öpik, 1961b, p. 58, pl. 18, figs. 6-10.

Material: Two poorly preserved specimens are known from the upper fauna at Christmas Hills: one is an almost complete specimen; the other consists of a cephalon and thorax. From Unit 13 of the Sugarloaf Gorge section two small, very poorly preserved complete specimens are known as well as two moderately well-preserved cephala and two pygidia of similar preservation.

Measurements: Christmas Hills, upper fauna, UT 92473, complete specimen, (N-S distortion), total length, 7.3mm.; cephalon, length, 3.2mm.; width, 3.7mm.; pygidium, length, about 3.1mm. (without articulating half-ring), width, 3.9mm. Sugarloaf Gorge fauna, UT 92492, cephalon, (N-S distortion), length, about 2.0mm., width, 2.5mm. UT 92493, pygidium, (E-W distortion), length (including axial half-ring), 1.9mm.

Description: The moderately convex cephalon is probably a little wider than it is long. The border consists of a moderately wide, flatly convex rim, and a narrow, shallow marginal furrow. The single lobed glabella stands out slightly above the smooth cheeks. It has a length about half that of the cephalon, and at its widest (at the anterior of the small, simple basal lobes) it has a width about 0.4 that of the cephalon. The glabella tapers forward to the well-rounded glabellar front. The cephalon is widest in its central regions. The basal lobes are joined by a narrow connecting band.

The moderately convex pygidium is probably slightly wider than it is long. It is widest at the anterior and has a broadly rounded posterior margin. The border consists of a wide, flatly convex rim and a narrow, moderately deep marginal furrow. There are no border spines. The shoulder furrows are shallow and moderately wide; they meet the marginal furrows at an angle somewhat in excess of 90° and well to the posterior of the articulating furrow. The moderately convex shoulders are of moderate width; the width increases slightly adaxially. The fulcra are placed close to the axis. The articulating furrow is narrow, shallow and arched to the posterior. The articulating half-ring is narrow and convex. There is no post-axial median furrow. The pleural fields are smooth. The pygidial axis is outlined by moderately deep and wide furrows. It has a fairly sharply rounded posterior and has a length about 0.7 that of the pygidium. The transverse axial furrows are obsolete; the axis is contracted in the region of the second axial segment on which there is an elongated node.

Discussion: The overall appearance of the form described above is very similar to that of *Hypagnostus brevifrons* (Angelin) as described and illustrated by Westergård (1946, p. 48, pl. 5, figs. 24-29). The glabella is tapered forward; the largely effaced pygidial axis stops well short of the posterior margin of the acrolobe, and there is no post-axial median furrow which are features which correspond to those of *Hypagnostus brevifrons*. However, the largest known specimens of the form described above are about half the size of the largest Swedish and Queensland specimens of *H. brevifrons* as described and illustrated by Westergård (*op. cit.*) and Öpik (1961b, p. 58) respectively. A further point is that the border of the pygidium of the Tasmanian specimens appears to be slightly wider than *H. brevifrons* as illustrated by both Westergård (1946) and Öpik (1961b). The preservation of the Tasmanian specimens is such that it cannot be seen if a glabellar node is present in the same position as those on the Swedish specimens illustrated by Westergård (*op. cit.*, pl. 5, figs. 24, 25, 28). A feature noted on rubber casts (Riks 105, 106) of Westergård's specimens, figured by him, pl. 5, figs. 27 and 26 respectively, is the presence of a small node close to the posterior of the pygidial axis. This feature was not reported by Westergård (op. cit.). It is in a similar position to the posterior axial node of Hypagnostus correctus Öpik (1967, text fig. 16). Such a feature is too small to be preserved on the poorly preserved pygidia described above. It cannot be stated with certainty that these Tasmanian specimens belong to Hypagnostus brevifrons, and thus they are referred to H. cf. brevifrons.

Occurrence and Age: Hypagnostus cf. brevifrons (Angelin) comes from (a) Unit 13 of the lower sedimentary sequence of the Radfords Creek Group as exposed along Gunns Plains Road, and (b) the upper fauna at Christmas Hills (lat. 40°54.1'S, long. 144°29.8'E; grid 3075E, 9610N); its age is late Middle Cambrian, from about the Lejopyge laevigata I Zone, the L. laevigata II Zone and the L. laevigata III Zone.

Hypagnostus sp. aff. H. parvifrons (Linnarsson)

pl. 2, fig. 16; pl. 3, fig. 1

The synonymy of Hypagnostus parvifrons is given by Westergård (1946, p. 45) and Robison (1964a, p. 529).

Material: One small almost complete specimen, UT 92496, is available for descriptive purposes.

Measurements: UT 92496, N-S distortion, total length, 3.0mm.; cephalon, length, 1.4mm., width, 1.9mm.; pygidium, length (without articulating half-ring), 1.3mm., width, 1.9mm.

Description: The cephalon is probably about as wide as it is long. The moderately wide rim is elevated only slightly above the narrow, shallow marginal furrow. The border is widest at the anterior. The single lobed glabella has an almost trapezohedral shape with a very gently arched almost truncated front. The glabella is outlined by shallow, wide furrows; it has a length just over 0.4 that of the cephalon and is widest at the anterior end of the basal lobes. The cheek surface is probably smooth and fairly flat; the acrolobe margins are steep. The small basal lobes are poorly preserved. The glabella is markedly more convex than the rest of the acrolobe. There is no distinct node on the glabella, but there is a prominent high area in the posterior and central parts of the glabella. The broadly rounded glabellar rear is steep.

The pygidium is about as wide as it is long. The border is wide with a wide rim and a narrow, shallow marginal furrow. The pygidial axis is trisegmented and extends just over 0.7 of the length of the pygidium. The axis stands out markedly above the smooth pleural fields, which are separated behind the posterior end of the axis by a depressed area which is formed partly by a depressed anterior extension of the rim and partly by the junction of the axial furrows and the marginal furrow. The width of the axis at its anterior is just under half that of the pygidium. The axis is slightly constricted at the join of the first and second segments; it is widest at about its midpoint. There is a sharply rounded, almost pointed, axial posterior. The anterior transverse axial furrow is best developed laterally and can be traced faintly across the axis. The second transverse furrow is seen only at its lateral extremities. The two anterior axial segments are of approximately equal length (sag); the anterior one is slightly wider. The length of the posterior axial segment is about two-thirds that of the axis. The pygidial axis shows no distinct node (probably due to distortion); the apex of the axis is very close to the anterior end of the posterior axial segment and may represent a posteriorly directed node of the second segment. The axis slopes smoothly and steeply away on all sides from the apex.

Discussion: This one rather small, possibly immature, specimen is referred to *Hypagnostus* sp. aff. *H. parvifrons* (Linnarsson). It is similar to *H. parvifrons* in that it has a short, somewhat truncated cephalon, and a strongly convex largely effaced pygidial axis which does not extend as far to the posterior as do the pleural fields. The profile of the pygidial axis is not unlike that of *Hypagnostus parvifrons mammillatus* (Brögger) illustrated by Westergård (1946, pl. 5, figs. 3b, 4b). There is no distinct node on either the glabella or pygidial axis; these features are probably obliterated by distortion. The rear part of the glabella of *Hypagnostus* sp. aff. *H. parvifrons* is steeper than that of _H_. _parvifrons_. The basal lobes of _H_. sp. aff. _H_. _parvifrons_ appear to be even smaller than the small basal lobes of _H_. _parvifrons_ from Sweden and Utah as illustrated by Westergård (1946) and Robison (1964a). The cephala of _H_. _parvifrons_ from both Sweden and Utah have a distinct connecting band between the basal lobes. The presence or absence of this feature cannot be determined in the specimen from Que River. Until more specimens of the species become available to resolve whether or not nodes are present on the cephalon and pygidium, the assignment to _parvifrons_ cannot be decided upon.

Occurrence and Age: _Hypagnostus_ sp. aff. _H_. _parvifrons_ (Linnarsson) comes from the Que River Beds at lat. 41°34.7'S, long. 145°41.0'E (grid 3710E, 8803N); its age is Middle Cambrian, of either the _Ptychagnostus punctuosus_ Zone or the _P_. _nathorsti_ Zone.

Hypagnostus sp.

pl. 3, fig. 2

Two very poorly preserved cephala of _Hypagnostus_ are known from the RB locality of the Black Hill section in the Dundas area. Their preservation is such that they are not worth describing.

The fauna at locality RB also contains a cephalon which may belong to _Peronopsis_ (described in this thesis as _Peronopsis_ ? sp. 1) and five pygidia which could belong to either _Hypagnostus_ or _Peronopsis_. Of these pygidia, two lack border spines, have a short axis and have a post-axial median furrow; the others are spinose with an axis which extends to the posterior marginal furrow.

Since pygidial spines are known in very few species of Hypagnostus (Öpik, 1967, p. 84), but are reasonably common in Peronopsis, the non-spinose pygidia probably belong with Hypagnostus. The spinose pygidia are referred to as Agnostid, gen. et sp. indet. no. 6, (pl. 27, fig. 11), and the non-spinose pygidium as Agnostid gen. et sp. indet. no. 5, (pl. 27, figs. 9 and 10).

Occurrence and Age: Hypagnostus sp. comes from about 28 metres above the base of the lowest siltstone unit of the Black Hill section, Dundas at lat. 41°50.8'S, long. 145°24.7'E (grid 3466E, 8474N), (RB fauna); its age is Middle Cambrian, possibly the Ptychagnostus nathorsti Zone.

Genus GRANDAGNOSTUS Howell, 1935

Grandagnostus Howell, 1935a, p. 221; 1959, p. 181; Öpik, 1961b, p. 65 (part); Rasetti, 1967, p. 37; Poulsen, 1969, p. 7.

Phalacroma Kobayashi, 1939, p. 136 (part); Westergård, 1946, p. 92, (part).

Type Species: Grandagnostus vermontensis Howell, 1935a, p. 221, pl. 22, figs. 8-11.

Diagnosis: A very large agnostid in which the cephalon and pygidium are almost completely effaced. The cephalic border, if present, is extremely narrow. There is a small subcentral circular node on the cephalon. The subquadrate pygidium has a wide border, which narrows only slightly to the anterior. There is a small circular node towards the pygidial anterior. The articulating half-ring is wide (tr.) and very narrow (sag.).

Discussion: Grandagnostus is discussed below in the discussion on the genus Valenagnostus nov.

Grandagnostus sp.

pl. 3, figs. 4-9

Material: About twelve somewhat crushed specimens, all of which have undergone tectonic distortion, are available. Five of the specimens are more or less complete.

Measurements: UT 86627 (internal mould of largest complete specimen, E-W distortion), total length, 20.0mm.; cephalon, length, 10.0mm., width, 10.3mm.; pygidium, length (without articulating half-ring) 8.6mm, width, 9.0mm. UT 92475, almost complete specimen, (N-S distortion), length, about 8.0mm.; cephalon about 3.9mm., width, 5.1mm.; pygidium, length (without articulating half-ring), 3.5mm., width, 4.6mm. UT 86879g, (enrolled specimen, E-W distortion), total length, 8.8mm.; pygidium, length, 7.2mm. (including articulating half-ring), width, 6.5mm.

Description: The very large, almost entirely effaced, cephalon is slightly wider than it is long. The lateral margins of the cephalon are quite steep, but the rest of the cephalon is only gently convex. The cephalon has a circular outline with a straight posterior margin. The border is not visible on most specimens, but on some cephala traces of a very narrow border are present. On some specimens (e.g., UT 92475) a narrow slightly upraised posterior rim and a narrow, shallow border are present on either side of a faintly outlined, rounded glabellar rear. Apart from this the cephalon is entirely effaced. The apparent centrally placed node on UT 92478 (pl. 3, fig. 4) is due to distortion.

Even the thoracic segments are quite simple and have few furrows on them. The anterior thoracic segment is decidedly longer (sag.) than the posterior one.

The sub-square pygidium has an evenly rounded posterior margin. The margins diverge slightly away from the anterior end of the pygidium until the pygidium is widest about two-thirds of the distance towards the posterior. The pygidium is slightly wider than it is long. It is distinctly smaller than the cephalon. This is shown well in all complete specimens and also in UT 86879g (pl. 3, fig. 6), an enrolled specimen where the anterior end of the cephalon considerably overlaps the pygidial posterior. The pygidium is almost flat with a wide border consisting of a wide, gently convex rim, which narrows to the anterior, and a wide, moderately deep marginal furrow. The shoulder furrows and marginal furrow are continuous. The shoulder furrows narrow considerably adaxially; the facets are large and flat. The shoulders are narrow and upraised. The articulating device is not well preserved in any specimen. However, in UT 86632 (pl. 3, fig. 9) the articulating half-ring, although poorly preserved, is clearly wide (tr.) and narrow (sag.). The articulating furrow is narrow (sag.) and shallow. There are faint traces of a moderately wide axis, of unknown length, at the anterior end of most pygidia. These axial traces are accentuated by the crushing of the pygidium.

Discussion: The species described above is not well enough preserved to be the basis for a new species. It is smaller than *Grandagnostus glandiformis* (Angelin) and does not possess well-defined nodes as do *G. glandiformis* and *G. vermontensis*. However, such nodes would be difficult to see due to distortion. This species is referred to as *Grandagnostus* sp.

Occurrence and Age: *Grandagnostus* sp. comes from the upper fauna at Christmas Hills (lat. 40°54.1'S, long. 144°29.8'E; grid 3075E, 9610N); its age is late Middle Cambrian, either of the *Lejopyge laevigata* I Zone or the *L. laevigata* II Zone.

Genus VALENAGNOSTUS nov.

Diagnosis: The almost entirely effaced cephalon has a narrow rim and a narrow marginal furrow. There is a small node on the posterior part of the cephalon. At the posterior of the pygidium the rim is wide and convex, and the marginal furrow is wide. The border narrows greatly to the anterior. A narrow, tapered vestigial axis extends to the marginal furrow; it is tapered most close to its anterior and again at about two-thirds of the distance of the posterior. There is a terminal axial node.

Type species: Agnostus nudus Beyrich var. marginata Brögger, 1878, p. 73, pl. 6, fig. 3.

Discussion: The effaced agnostid species usually described under the generic names, Phalacroma, Grandagnostus and Phalagnostus are difficult to assign to any particular genus. As noted by Öpik (1961b, p. 91), Phalacroma refers to agnostids with a wide, non-effaced pygidial axis like that of P. bibullatum (Barrande). Thus all species, which have both the cephalon and pygidium effaced and have been described as Phalacroma, must be reassigned to other genera.

Howell (1935a, p. 221) erected the genus Grandagnostus for a very large agnostid which has both the cephalic and pygidial acrolobes almost completely effaced, a wide pygidial border and a very narrow or absent cephalic border. In this genus, Howell (op. cit), included the type species, Grandagnostus vermontensis Howell from Vermont and Agnostus glandiformis Angelin from Sweden. Unfortunately, G. vermontensis is poorly preserved. Westergård (1946, p. 96) refers to cephala of glandiformis up to 16mm. long and 15mm. wide.

There appear to me to be at least two and probably three distinct genera represented by the species included by Westergård (1946) in _Phalacroma_. Two of these genera are represented by the forms described by Westergård as _P. glandiforme_ (Angelin) and _P. marginatum_ (Brögger).

These two genera are best compared by a comparison of _glandiforme_ and _marginatum_. The writer has had at his disposal rubber casts of many of the specimens of both species that are illustrated by Westergård _op. cit._, pls. 15, 16). Rubber casts of some of the specimens described by Westergård as _Phoidagnostus bituberculatus_ (Angelin), _Phalacroma scanicum_ (Tullberg) and _P. resectum_ (Grönwall) were also available.

The most obvious difference between _glandiforme_ and _marginatum_ is that the former is much larger. The narrow cephalic border of _marginatum_ is much better developed than that of _glandiforme_. Westergård (1946, p. 95) notes that no cephalon of _glandiforme_ which has retained the test shows a border, but in some of the exfoliated specimens, including the lectotype, a narrow rim is visible.

The most marked differences of form are in the pygidia. The pygidial border of _glandiforme_ consists of a very wide, shallow furrow and a gently convex rim. The rim is moderately wide at the posterior and quite narrow at the anterior. The border narrows slightly to the anterior. This is in marked contrast with the border of marginatum. At the posterior the pygidial border of marginatum is very wide (in some specimens it has a length (sag.) over a quarter that of the complete pygidium). It consists of a narrow, shallow marginal furrow and a very wide, gently convex rim. The rim narrows greatly to the anterior where it is quite narrow; overall, the border narrows markedly to the anterior.

There is a faint but well-developed axis on marginatum which extends the full length of the acrolobe and has a terminal node. The axis of marginatum is very similar to that figured by Öpik (1961b, text fig. 20) for his species Grandagnostus imitans. The axis of glandiforme is poorly outlined, and there is no terminal node. The articulating half-ring of glandiforme is long (tr.) and narrow (sag), that of marginatum is shorter (tr.) and longer (sag.).

Howell (1955, p. 925) erected a new genus, Phalagnostus, with type species Battus nudus Beyrich in an attempt to solve the complex nomenclatural problem of the effaced agnostids (see Howell, op. cit., for details). Howell (op. cit., p. 926) states:

> "Phalagnostus differs from Grandagnostus in being smaller, in having a less quadrate pygidium, in having the node on the axial positions of the pygidium elongate, instead of circular and in having a more circular cranidium."

Snajdr (1958, p. 76) has restudied the Czechoslovakian forms of Battus nudus Beyrich and also revised the genus Phalagnostus. Snajdr (op. cit., p. 78) includes the following species in Phalagnostus, viz. Phalagnostus nudus (Beyrich), P. prantli Snajdr, P. eskiriggei (Hicks), P. scanicus (Tullberg), P. resectus (Grönwall), P. marginatus (Brögger), and P. glandiformis (Angelin). The last four species are described by Westergård (1946) as Phalacroma. However, marginatus and glandiformis are shown above to belong to separate genera. The species marginatus and nudus are also considerably different, especially in the nature of the pygidial border, pygidial axis, terminal axial node and cephalic border. They are regarded by the present writer as belonging to different genera. Species of the marginata-type are included below in the new genus Valenagnostus.

Grandagnostus vermontensis Howell is poorly preserved and difficult to compare with other species. However, it would seem from a comparison of the photographs of vermontensis with rubber casts of the specimens described by Westergård (1946) as Phalacroma glandiforme (Angelin) that vermontensis and glandiforme do belong in the same genus Grandagnostus Howell, as originally suggested by Howell (1935a). In fact, Poulsen (1969, p. 9) regards Grandagnostus vermontensis as a junior synonym of G. glandiformis, thus making the latter the type species. Shaw (1966, p. 848) described an incomplete cephalon as Grandagnostus vermontensis Howell(?), the query being due to the lack of the cephalic node on Shaw's specimen. A well-preserved example of *vermontensis* is required before it can be decided whether or not it is conspecific with *glandiforme*.

Because Snajdr (*op. cit.*) included both species *nudus* and *glandiformis* in *Phalagnostus*, a comparison of the two species seems warranted. Apart from the rubber casts of *glandiformis* noted above, the author has at his disposal rubber casts of one pygidium of *nudus* (figured in Snajdr, 1958, pl. 5, fig. 9) and the holotype of *Phalagnostus prantli* Snajdr (1958, pl. 6, fig. 1).

The species *glandiformis* is bigger than *nudus*; the cephalic posterior of *nudus* shows more traces of the glabellar rear and basal lobes than does that of *glandiformis*. The pygidial borders of *glandiformis* and *nudus* are similar in that they do not narrow much to the anterior. The pygidial rim of *nudus* is wider than that of *glandiformis* especially in the anterior region. The articulating half-ring of *glandiformis* is very narrow (sag.) and comparatively wide (tr.) compared to the narrow (sag.) half-ring of *nudus*. The pygidia of *glandiformis* generally have a more quadrate outline than those of *nudus*. Another difference between the two species is in the arrangement of the pygidial muscle scars; those of *nudus* as illustrated by Snajdr (1958, text-fig. 11) are smaller and more numerous than those of *glandiforme* illustrated by Westergård (1946, pl. 16, fig. 2).

On each shoulder region of *nudus* there is a transverse furrow which extends across the antero-lateral corner of the pygidium, across the anterior of the rim and almost to the pygidial margin. This furrow is distinct from the marginal furrow. No such furrow is seen in glandiformis. A similar furrow is also seen in Phalagnostus prantli Snajdr, Phalacroma scanicum (Westergård, 1946, pl. 14, figs. 16, 17, 18) and in the species described by Hutchinson (1962, p. 90) as Phalacroma nudum (Beyrich).

Rasetti (1967, p. 38) considers that it is possible that this anterolateral transverse furrow is, in fact, the shoulder furrow and that the wide rim around the pygidium is part of the acrolobe. Poulsen (1969, p. 9) supports Rasetti's suggestion that the pygidium of Phalagnostus may not have a true border. Both Rasetti and Poulsen consider that the antero-lateral transverse furrow described above is of generic significance. The writer agrees with this conclusion but feels that the question of the presence or absence of a border cannot be determined on the available material.

Öpik (1961b) referred two new species, imitans and velaevis, to Grandagnostus, and in 1967 (p. 86) he described G. evexus. Öpik (1961b, p. 54) states that there are two groups within Grandagnostus, (i) species without a cephalic marginal border, e.g., G. velaevis, and (ii) species with a border, e.g., G. imitans. Öpik (op. cit., p. 67) differentiates between Grandagnostus and Phalagnostus on the grounds that the latter has no basal lobes. This appears to the writer to be an error. Basal lobes or traces of them are seen on all but the most effaced agnostid cephala and appear to be a fundamental part of the agnostid anatomy. Furthermore, species such as Grandagnostus glandiformis (Angelin) and Phalagnostus prantli Snajdr do possess vestigial basal lobes. This is shown by an inspection of a rubber cast, Riks 88, the cephalon of glandiforme figured by Westergård (1946, pl. 15, fig. 4) and a rubber cast (No. "Prague" 11), the complete holotype of Phalagnostus prantli (figured by Snajdr, 1958, pl. 6, fig. 1; figured here as pl. 9, fig. 2). The basal lobes of these species are difficult to see in the photographs noted above but are certainly present.

No comment can be made by the author on the species described by Pokrovskaya (1958) in Phalacroma, because the author has not seen that paper. The pygidium figured and described by Hajrullina (1962, p. 30, pl. 4, fig. 3) as Phalacroma rabutensis cannot be compared in detail with other species because of the poorly reproduced photo of rabutensis. Phalacroma thorali Howell (1935b, p. 227, pl. 22, figs. 19, 20) is poorly preserved and cannot be placed with certainty into any genus, although its narrow pygidial border excludes it from Grandagnostus.

Öpik (1961b, p. 86) suggests, and Palmer (1968, p. 32) agrees that Agnostus bituberculatus Angelin, 1851, belongs in Phalagnostus. However, Agnostus bituberculatus has no transverse furrow near the anterolateral corners of the pygidium as has Phalagnostus, and should not be included in that genus.

The following conclusions are drawn from the above discussion:

(i) a new genus, _Valenagnostus_ must be erected to include the following species, _Valenagnostus marginata_ (Brögger), _V. imitans_ (Öpik), _V. evexus_ (Öpik); _V. banksi_ sp. nov., and _V. brittoni_ sp. nov., with _V. marginata_ as the type species.

(ii) the other effaced agnostids usually described under _Grandagnostus_, _Phalacroma_ or _Phalagnostus_ should be split into at least two genera, i.e., _Grandagnostus_ Howell, with _G. glandiformis_ (Angelin) as the best known species, and _Phalagnostus_ Howell, with _P. nudus_ (Beyrich) as type species. Other species which should be included in _Phalagnostus_ are _P. prantli_ Snajdr and _P. scanicus_ (Tullberg).

(iii) the generic position of _Agnostus bituberculatus_ Angelin 1851 is not yet known.

(iv) the position of the species described by Öpik (1961b, p. 67) as _Grandagnostus velaevis_ and that described by Westergård (1946) _Phalacroma resecta_ (Grönwall) is not known.

(The specific names of the Swedish species are sometimes spelt differently in the conclusions to the names in the discussion. The names in the conclusions are those used by the original authors; the names in the discussion are those used by later authors whose material is under discussion.)

It would seem that the best way of solving the rather unsatisfactory situation regarding the effaced agnostids discussed above is for a single worker to study the types, or casts of types, of each described species and revise each species carefully.

Valenagnostus banksi sp. nov.

pl. 4, figs. 1-7

Material: Many well-preserved, almost complete pygidia are available. Unfortunately, only a few external moulds of reasonably complete cephala are known.

Measurements: Cephalon, UT 92707, E-W distortion, length, 2.3mm., width, 1.8mm. Pygidia: UT 92713, E-W distortion, length (including articulating half-ring), 2.6mm., width, 2.4mm.; UT 92693, N-S distortion, length (without articulating half-ring), 1.4mm., width, 1.8mm.

Selection of Holotype: The pygidium, UT 92713 (pl. 4, fig. 3), is chosen as the holotype.

Diagnosis: The strongly convex, almost entirely effaced cephalon is about as wide as it is long. There is a narrow cephalic border with short cephalic spines. The strongly convex pygidium is about as wide as is long. The border is wide with a wide elevated rim and a moderately wide, shallow marginal furrow, both of which narrow greatly to the anterior. The faintly outlined axis has a very prominent terminal node.

Description: The strongly convex cephalon is about as wide as it is long. The narrow rim has a similar slope to the acrolobe margin and is separated from the acrolobe by a very narrow, shallow marginal furrow. Short cephalic spines are known only from internal moulds. The cephalon is almost entirely effaced. The glabella is only very faintly outlined at the posterior, and it fades completely to the anterior. The glabellar rear is rounded. A small centrally located node is found at the posterior end of the cephalon about one-third of the distance from the posterior to the anterior margin. The posterior ends of basal lobes may be faintly outlined in UT 92707 (pl. 4, fig. 1).

The strongly convex pygidium is about as wide as it is long. The posterior border is wide with a wide elevated rim and a moderately wide, shallow marginal furrow. Both the rim and the marginal furrow narrow greatly to the anterior; near the anterolateral corners the border is quite narrow. The narrow shoulders are gently convex; the shoulder furrows are narrow and shallow. The basic articulating device has a moderately deep articulating furrow which is arched slightly forward. The narrow (sag.), convex, articulating half-ring is arched slightly forward.

At the centre of the posterior margin the border is about 0.2 the length of the pygidium. The pygidium has an evenly rounded outline. The margins diverge slightly from the anterolateral corners to a point just over half-way along the pygidium; from this point the posterior margin is broadly and evenly rounded. There are no border spines. The almost effaced narrow axis stands out very slightly above the smooth pleural regions. It extends the full length of the acrolobe and has a prominent terminal node. In the region of the axial rear the acrolobe is arched slightly forward. The axis is moderately wide at the anterior and tapers more or less evenly to the posterior. There is a small centrally placed anterior axial node about 0.25 of the distance from the anterior to the posterior end of the axis. The axis shows no trace of segmentation.

Discussion: The terminal pygidial axial node of *Valenagnostus banksi* is much more prominent than that of other species of *Valenagnostus*. The pygidial marginal furrow of *V. banksi* is wider than that of either *V. imitans* or *V. marginata*. The pygidia of *V. evexus* and *V. brittoni* are much more effaced than that of *V. banksi*.

Occurrence and Age: *Valenagnostus banksi* sp. nov. comes from the main fauna in the St. Valentines Peak area near lat. 41°21.6'S, long. 145°44.3'E (grid 3758E, 9064N); its age is of either the late Middle Cambrian *Lejopyge laevigata* III Zone, or the Middle Cambrian/Upper Cambrian Passage Zone.

Valenagnostus brittoni sp. nov.

pl. 4, figs. 8-14

Material: About fifty pygidia and cephala in varying stages of preservation are available for descriptive purposes. Unfortunately, some of the best preserved specimens are available only as internal moulds. It is on these specimens that the small cephalic spines can be seen. All the figured specimens are external moulds.

Measurements: UT 86877, cephalon, (E-W distortion), length, 3.2mm., width, 2.4mm.; UT 86850c, holotype pygidium, (N-S distortion), length, 2.5mm., width, 3.1mm.; UT 92474, pygidium, (E-W distortion), length, 2.8mm., width, 2.3mm.

Selection of Holotype: The pygidium, UT 86850c (pl. 4, fig. 13), is selected as holotype.

Diagnosis: *Valenagnostus brittoni* sp. nov. has an almost effaced cephalon, a narrow cephalic border and a small cephalic node. The pygidium has an extremely wide pygidial border which narrows greatly to the anterior. There is a faintly outlined axis with a small terminal node.

Description: The strongly convex cephalon is about as wide as it is long. The border is narrow with a narrow, shallow marginal furrow and a narrow, convex rim. The shape of the rim is continuous with that of the very steep acrolobe margin. There are very small postero-lateral spines present. The straight posterior margin is steep with the top slightly overhanging the base.

The margins of the cephalon diverge slightly away from the posterior margin; the cephalon is widest at its midpoint; it has an evenly curved anterior margin. The cephalon is almost entirely effaced with just faint traces of the posteriors of the basal lobes and in some specimens vestiges of a moderately long and wide glabella (brought out by the distortion and crushing of the specimens). A small cephalic node is present.

The pygidium is about as wide as it is long with an acrolobe of slightly less convexity than that of the cephalon. At the posterior, the border is very wide (about 0.3 the length (sag.) of the pygidium); it is composed of a deep, wide marginal furrow and a wide, elevated convex rim; the border decreases in width considerably to the anterior where it is quite narrow. The shoulder area is not visible in many specimens; however, on an unfigured internal mould one shoulder is well exposed. The shoulder furrows are narrow and shallow; the facets are large and concave; the fulcra are large and blunt and are placed about mid-way between the anterolateral corners and the centre of the articulating device. The articulating furrow is shallow and moderately wide with a slight depression at either end near the fulcra. The articulating half-ring is long (tr.), narrow (sag.) and gently convex. On many specimens there is a faintly outlined pygidial axis which extends the entire length of the acrolobe. There is a small axial terminal node. There is a small axial node at the anterior end of the axis about 0.25 of the distance from the anterior to the posterior of the axis. The axis is wide at the anterior (about 0.45 of the pygidium width); immediately behind the anterior margin the axis narrows considerably from whence it tapers evenly (except for a slight central widening) to the terminal node.

Discussion: The pygidial border of Valenagnostus brittoni is wider than those of V. evexus, V. imitans and V. banksi. Some of the pygidia of V. marginata figured by Westergård (1946, pl. 14) have a pygidial border of similar width to that of V. brittoni. However, these specimens are smaller pygidia, and the larger pygidia of marginata have a narrower border than does V. brittoni. The pygidial axis of V. brittoni is less obvious than those of V. banksi or V. marginata. V. brittoni does not have the elongate anterior axial node of V. imitans.

Occurrence and Age: Valenagnostus brittoni sp. nov. comes from the lower fauna at Christmas Hills (lat. 40°54.1'S, long. 144°29.8'E; grid 3075E, 9610N); its age is late Middle Cambrian, probably of the Lejopyge laevigata I Zone.

Valenagnostus sp. 1

pl. 8, fig. 12

One poorly preserved internal mould of a pygidium (UT 92498) of Valenagnostus is known from the lowest fauna on the timber track on the west side of the Sugarloaf Gorge. It has a very prominent terminal axial node, and it may belong to Valenagnostus banksi. However, no firm determination can be made. The age of Valenagnostus sp. 1 is probably of the late Middle Cambrian Lejopyge laevigata III Zone or of the Middle Cambrian/Upper Cambrian Passage Zone.

Valenagnostus(?) sp.

pl. 9, figs. 1, 4

Material: One specimen, UT 92499, is available. It is an external mould in which the cephalon and pygidium are clearly preserved but with no sign of the thorax. The specimen has undergone N-S distortion, and the thorax was probably pushed under the cephalon. The cephalon is 2.0mm. long, 2.2mm. wide and its maximum height is 0.6mm. The pygidium is 2.0mm. long, 2.2mm. wide and has a maximum height of 0.3mm.

Description: The moderately convex cephalon has a subcircular outline with a straight posterior margin. There is no evidence of a border, except possibly in the left posterolateral corner. This feature could be due to the effects of distortion; a narrow border may have been present but if so is not preserved. The surface of the cephalon is almost entirely effaced. There is a trace of the posterior end of a narrow glabella with a rounded rear which is outlined by faint axial furrows. There are faint traces of small, separate basal lobes. In longitudinal cross-section the outline of the cephalon is a smooth curve with the maximum height at a point a little to the posterior of the centre.

The pygidium has a "subtriangular" outline. The posterior border is wide with a wide, shallow marginal furrow and a wide partly convex rim; the border narrows markedly to the anterior. The shoulder furrows are narrow and shallow; the shoulders are narrow and convex. The articulating device cannot be seen. The length of the unconstricted acrolobe is about five-sixths that of the pygidium. In profile the pygidium has a steeply inclined anterior end with the apex of the pygidium occurring very close to the anterior margin. From the apex the acrolobe slopes gently back to the posterior margin. The pygidium is much less convex than the cephalon (pl. 9, fig. 4). The acrolobe may be entirely effaced although there is a suggestion of a wide pygidial axis at the extreme anterior end of the pygidium.

Discussion: This specimen is questionably described as Valenagnostus and is referred to Valenagnostus(?) sp. It is similar to Valenagnostus in that both the cephalon and pygidium are almost entirely effaced, and there is a wide pygidial border which narrows considerably to the anterior. No cephalic border is visible, but this may be a factor of preservation. If a cephalic border exists on Valenagnostus(?) sp., then it must be very narrow. The anterior axial trace on the pygidium of Valenagnostus(?) sp. is wider than the anterior part of the axis on any known species of Valenagnostus; there is no sign of a terminal axial node on Valenagnostus(?) sp. The difference in convexity of the aerolobes of the cephalon and the pygidium of Valenagnostus(?) sp. is markedly greater than in any described species of *Valenagnostus*.

Until more specimens of *Valenagnostus*(?) sp. are known, its generic position must remain open.

Occurrence and Age: *Valenagnostus*(?) sp. comes from the Que River Beds at lat. 41°34.7'S, long. 145°41.0'E (grid 3710E, 8803N); its age is Middle Cambrian, either of the *Ptychagnostus punctuosus* Zone or the *P. nathorsti* Zone.

Genus PSEUDOPHALACROMA Pokrovskaya, 1958

Pseudophalacroma Pokrovskaya, 1958, p. 79, Öpik, 1961b, p. 90; Chu, 1965, p. 139.

Type Species: *Pseudophalacroma crebra* Pokrovskaya, 1958, p. 79, pl. 3, figs. 4-6.

Diagnosis: See Öpik 1961b, p. 90.

Pseudophalacroma ? sp.

pl. 8, figs. 11, 13, 14

Material: Several complete specimens in a poorly to moderately preserved condition are available. Several individual cephala and pygidia in a similar state of preservation are known. The following description is based mainly on specimens UT 92500 (the best preserved external mould) and UT 92501 (the best preserved internal mould).

Measurements: UT 92500, E-W distortion, total length, 5.3mm.; cephalon, length, 2.7mm., width, 2.2mm.; pygidium, length, 2.4mm. (without articulating half-ring), width, 2.0mm. UT 92501, internal mould, E-W distortion, total length, 6.3mm.; cephalon, length, 2.7mm., width, 2.3mm.; pygidium, length (without articulating half-ring), 2.5mm., width, 2.4mm.

Description: The strongly convex cephalon is probably about as wide as it is long. The border is narrow. The narrow rim is difficult to see due to the very steep sides of the acrolobe; the rim appears to be a continuation of the acrolobe with the outline of the cephalon being interrupted by the narrow, shallow marginal furrow. There are short posterolateral spines. The cephalon is almost entirely effaced with only the posterior end of the glabella being outlined. The cephalon has a steep posterior end. The basal lobes are small and simple with a very narrow connecting band between them which passes under the broadly rounded glabellar rear. The basal lobes are outlined by shallow furrows; the axial furrows do not extend past the anterior ends of the basal lobes. The rest of the cephalon appears to be smooth. The pygidium is probably about as long as is wide. It is considerably less convex than the cephalon and has a truncated anterior end. The wide border is composed of a wide, elevated strongly convex rim which narrows considerably to the anterior and a wide deep marginal furrow. At the posterior the border has a length (sag.) about 0.15 that of the pygidium. The shoulder furrows are moderately wide and deep; the convex shoulders are of moderate width; the fulcra occur just over half way from the anterolateral corners to the axial furrows. The axis is outlined only in its anterior region. It consists of at least two segments, the more posterior of which is narrower (tr.) than the other. A small node is present on the second axial segment; it is also the highest point on the axis but is not visible on the photographs of these specimens. At the anterior the axis has a width about 0.45 that of the pygidium. The axial furrows are shallow but distinct along the first axial segment. They can be barely made out along most of the second axial segment, to the posterior of which they vanish. The pleural fields appear to be smooth.

Discussion: This species is tentatively referred to Pseudophalacroma Pokrovskaya rather than Valenagnostus nov. because (1) the glabellar rear and posterior portions of the basal lobes are better outlined than in Valenagnostus, (2) the pygidial border is somewhat narrower than that of Valenagnostus, (3) there is no terminal pygidial axial node (the apparent node on specimen UT 92501 (pl. 8, fig. 14) is not centrally placed and is due to the preservation). Pseudophalacroma ? sp. described above may be related to Pseudophalacroma sp. K of Öpik (1961b, p. 94, pl. 22, fig. 12).

Occurrence and Age: Pseudophalacroma ? sp. comes from Unit 13 of the lower sedimentary sequence of the Radfords Creek Group as exposed along the Gunns Plains Road; its age is late Middle Cambrian, either of the Lejopyge laevigata II Zone or the L. laevigata III Zone.

Genus BIRCHAGNOSTUS nov.

Birchagnostus is monotypical with *B. inleti* sp. nov. as type species.

Diagnosis: Both the cephalon and pygidium of *Birchagnostus* are largely effaced. The cephalic border is narrow; there is a narrow, shallow marginal furrow, a narrow rim, and short posterolateral spines. On most specimens the glabella is outlined faintly, especially at the posterior; the glabellar rear is rounded.

The pygidial border is considerably wider than the cephalic border; there is a moderately wide and deep marginal furrow and a moderately wide, convex rim. Border spines are absent. The *Agnostus*-like axis is outlined faintly but distinctly by depressions and swellings, rather than by distinct furrows. There is a small node on the second axial segment. There is no post-axial median furrow.

Discussion: The pygidial axis, although largely effaced, has a similar outline to that of *Agnostus pisiformis* as illustrated by Henningsmoen (1958, pl. 5). The axis of *Birchagnostus inleti*, apart from being considerably more effaced than that of *A. pisiformis*, also differs in that the anterior pair of axial segments are smaller than those of *pisiformis*.

The similarity of the pygidial axis of *Birchagnostus*, as compared with *Agnostus*, suggests that *Birchagnostus* belongs in the Agnostinae. However, the articulating device of *Birchagnostus* is of the basic type as opposed to the agnostoid type found in the Agnostinae

(Öpik, 1967). This, plus the fact that the pygidial border of *Birchagnostus* is moderately wide, suggests that *Birchagnostus* belongs in the Quadragnostinae. It is possible that *Birchagnostus* may be descended from *Peronopsis* in a similar way to the manner in which Öpik (1967, p. 87) proposed that *Peratagnostus* descended from *Hypagnostus*. However, in the case of *Birchagnostus* the time break between the last known examples of *Peronopsis* (latest Middle Cambrian) and *Birchagnostus* (*Prosaukia*-*Ptychaspis* Zone in the late Upper Cambrian) is considerably greater than between *Hypagnostus* and *Peratagnostus*.

The combination of a narrow cephlic border, a moderately wide pygidial border and a basic articulating device, taken in conjunction with the largely effaced cephalon and *Agnostus*-like largely effaced pygidial axis, distinguishes *Birchagnostus* from all other agnostid genera.

If, as proposed above, *Birchagnostus* does belong in the Quadragnostinae, then it is the youngest known member of this subfamily (cf. Öpik, 1967, Table 6).

Birchagnostus inleti sp. nov.

pl. 14, figs. 2-13

Material: Many individual cephala and pygidia and a few complete or ~~partially~~ almost complete specimens are available for description.

Selection of holotype: UT 92572 (pl. 14, fig. 2) is selected as the holotype because it is the best preserved of the complete or ~~partially~~ almost complete specimens. All the essential features of the species can be seen on this specimen except the articulating device.

Diagnosis: See generic diagnosis.

Measurements: UT 92572, exposed length, 10.5mm. (length of complete specimen would be about 10.9mm.); length of cephalon, 5.1mm. Cephala: UT 92573, length 5.0mm., width 4.5mm.; UT 92580 (internal mould), length, 3.3mm., width 3.3mm. UT 92574 (not figured), length, 2.6mm., width 2.5mm. Pygidia: UT 92575 (not figured), length (including axial half-ring), 3.3mm., width, 3.1mm.; TMD 5118, length (including axial half-ring), 4.7mm.; UT 92576, length (including axial half-ring), 4.7mm., UT 92577 (not figured), length (without axial half-ring), 5.9mm., width (estimated), 5.4mm.

Description: The almost effaced moderately convex cephalon is about as long as it is wide; in some specimens the length is probably greater than the width even allowing for the slight distortion that these specimens have undergone. The border is narrow with a narrow, shallow marginal furrow which interrupts the slope of the cephalon rather than occurring as a depression. Below the marginal furrow is the narrow rim which sometimes disappears towards the anterior. There are very short posterolateral spines.

The glabella is faintly outlined, with small, simple basal lobes and a well-rounded glabellar rear. As with the pygidial axis, the glabella is much more distinct in the internal mould than in the external mould; this indicates that the test was thick. The glabella has a length about 0.7 that of the cephalon. The transverse glabellar furrow is faintly preserved on some specimens; the anterior glabellar segment has a length about 0.25 that of the glabella. The glabella is slightly more convex than the rest of the cephalon; this convexity is exaggerated by distortion. In some specimens the cephalon shows a crack near the expected position of a preglabellar median furrow. However, the position of the crack is not consistent; in other specimens there is no sign of a furrow, and thus there is probably no preglabellar median furrow.

The pygidium has a similar convexity to the cephalon; it is a little longer than it is wide. The border has a slightly variable width. It is moderately wide with a moderately wide and deep marginal furrow and a moderately wide, convex rim. The shoulder furrows are narrow and shallow; the shoulders are narrow and slightly elevated; the facets are nowhere visible; the fulcra are close to the axis. There is a basic articulating device with a narrow, shallow articulating furrow, and a low, convex, narrow (sag.) articulating half-ring; there is no axial recess. There are no border spines.

The axial region is seen better in some specimens than in others. Except at the very anterior the axis is never outlined by distinct furrows. It is present as a raised area and is delineated by depressions and swellings on the acrolobe. The axis is trilobate and has a length about 0.7 that of the pygidium. The axis is wide; the first two segments are short (sag.) with each being about the same length and having a combined length between one-third and 0.4 of the axial length (a precise determination cannot be made because of the vagueness of the axial posterior). There is a small postero-centrally placed node on the second axial segment. There is a broadly rounded pygidial rear; there is no post-axial median furrow; the pleural areas are smooth.

Occurrence and Age: *Birchagnostus inleti* sp. nov. comes from west of Birch Inlet from near lat. 42°27.2'S, long. 145°21.1'E (grid 3417E, 7735N); its age is that of the *Prosaukia*-*Ptychaspis* Zone within the Upper Cambrian.

Subfamily PTYCHAGNOSTINAE Kobayashi, 1939

Genus PTYCHAGNOSTUS Jaekel, 1909

Synonymy: Robison, 1964a, p. 522, gives the most detailed recent synonymy. The following synonymy should be added.

Ptychagnostus: Snajdr, 1958, p. 70; Pokrovskaya, 1960a, p. 58; Rushton, 1966, p. 35; Palmer, 1968, p. 28.

Goniagnostus: Pokrovskaya, 1960a, p. 58.

Doryagnostus: Pokrovskaya, 1960a, p. 58.

Triplagnostus: Pokrovskaya, 1960a, p. 58.

Diagnosis: See Robison, 1964a, p. 522.

Discussion: The Tasmanian forms add nothing to the concept of the genus Ptychagnostus as formulated by Öpik, 1961b (p. 77). Any necessary discussion is given after the relevant species.

Ptychagnostus (Ptychagnostus) stenorrhachis (Grönwall)

pl. 5, figs. 1-4

Synonymy: Agnostus stenorrhachis Grönwall, 1902, p. 76, pl. 1, fig. 16; Triplagnostus stenorrhachis (Grönwall) Kobayashi, 1939, p. 146; Ptychagnostus (Triplagnostus) stenorrhachis (Grönwall), Westergård, 1946, p. 72, pl. 10, figs. 3, 4; Ptychagnostus (Triplagnostus) stenorrhachis (Grönwall), Hutchinson, 1962, p. 80, pl. 8, figs. 1-5.

Type species: Agnostus stenorrhachis Grönwall, 1902, p. 76, pl. 1, fig. 16.

Material: Three complete specimens and several individual pygidia and cephala are present, usually as both internal and external moulds.

Measurements: UT 89197 (not figured), complete internal mould, (N-S distortion), total length, 11.3mm.; cephalon, length, 5.0mm., width, 5.2mm.; pygidium, length, 5.4mm., width, 4.6mm. UT 92503, cephalon, (E-W distortion), internal mould, length, 5.1mm., width, 4.5mm.
UT 92504, cephalon, (N-S distortion), length, 5.1mm., width, 6.3mm.
UT 92505, pygidium, (E-W distortion), length 6.1mm., width, 5.5mm.

Description: The moderately convex cephalon is about as wide as it is long. The marginal furrow is narrow and shallow; the convex rim is of moderate width, with a slight anterior widening, where the preglabellar median furrow meets the marginal furrow. Small posterolateral spines are present. The cheeks are mildly scrobiculate. The preglabellar median furrow is shallow, being deepest and widest at either end. The glabella is about three-quarters the length of the cephalon. The axial furrows are deep at the posterior becoming shallower anteriorly. The anterior glabellar lobe is subpentagonal. A pair of faint furrows emerge from the anterior glabellar lobe just forward of the "pentagonal corners" and curve outwards and then obliquely forwards to join the preglabellar median furrow at approximately right angles at a point about one quarter of the distance to the marginal furrow.

The transverse glabellar furrow is of moderate width and not as deep as the axial furrows. It is arched to the anterior. The anterior glabellar lobe is just over a third the length of the glabella. The basal lobes are small, simple and appear to be unconnected. There is a well-developed circular node in the centre of the posterior glabellar lobe. The glabella is just under a quarter of the width of the cephalon at the transverse glabellar furrow. There are faintly developed posterior glabellar furrows directed inwards and forward on the anterior part of the glabella.

The moderately convex pygidium is about as wide as it is long. The marginal furrow is narrow and moderately deep; the convex rim is moderately wide. There are no border spines. The convex shoulders widen adaxially; the fulcra are close to the axis. The narrow shoulder furrows are moderately deep. Neither the facets nor the articulating device are known in the Tasmanian material.

The pleural areas are smooth. A post-axial median furrow appears to be clearly present in the more distorted specimens, but in the best preserved specimen, UT 92505 (pl. 5, fig. 2), it is faint, being best developed at the anterior. The axial furrows are deep and moderately wide. The length of the axis is just over three-quarters that of the pygidium. The trisegmented axis is widest at the anterior where it has a width just over half that of the pygidium. The axis is constricted at the second axial segment. The transverse axial furrows are well developed with the anterior one being arched markedly forward and the posterior one being arched sharply to the posterior at its mid-point. It is arched around the posterior of a long, low node or spine which extends almost the entire length of the second segment. This node is exaggerated by distortion in UT 92505 (pl. 5, fig. 2) and almost eliminated by distortion in other specimens. The first segment is about half the width (sag.) of the second, and the posterior segment is just over twice the length of the other two segments combined.

Discussion: In discussing P. stenorrhachis from Newfoundland, Hutchinson (1962, p. 81) notes, "a pair of short, indistinct furrows opposite the front of the anterior glabellar lobe, which curve obliquely forward parallel to the dorsal furrow, and join the preglabellar furrow." He also notes that they are faintly outlined in Westergård's specimen (1946, pl. 10, fig. 3). These furrows are present in the Que River material. Hutchinson suggests that these furrows could be a specific character. An inspection of photographs and rubber casts of many other species of Ptychagnostus failed to produce similar furrows, thus lending support to Hutchinson's view.

Ptychagnostus stenorrhachis is shown in Westergård (1946, pl. 10, figs. 3, 4) where the post-axial median furrow in the pygidium is only faintly outlined. However, in rubber casts of the type material (e.g., Riks 372, figured by Westergård, 1946, pl. 10, fig. 4) this furrow is faint but distinct and is strongest anteriorly. This agrees with the situation shown in UT 92505 (pl. 5, fig. 2), the least distorted of the Que River specimens. The pygidial axis, as shown in Westergård, is wider than that of the Que River specimens, but Westergård states that the figured specimen has a wider axis than the holotype. The post-axial median furrow is clearly outlined in specimens of stenorrhachis figured by Hutchinson (1962, pl. 8, figs. 3, 4a). Some specimens, e.g., UT 92504 (pl. 5, fig. 1) and UT 92506 (pl. 5, fig. 3), from Que River show a little more scrobiculation on the cephalon than that figured by Westergård. The fulcra of stenorrhachis in both the Swedish and Newfoundland forms are in a similar position to those in the Que River specimens. Probably the most striking feature of stenorrhachis is the marked backward arching of the central part of the second axial segment. This feature is present in the Que River form. The elongated node on the second axial segment is very prominent in UT 92505 (pl. 5, fig. 2), but its height is greatly exaggerated due to distortion, and in other specimens it is quite low. A further feature indicating that the Que River form belongs to stenorrhachis is the long, thin nature of the pygidial axis. A similar feature is seen in *P. hybridus* (Brögger), but the cephalon of this species is not scrobiculate.

Cobbold and Pocock (1934, p. 342, pl. 44, fig. 22) figure a pygidium from Rushton, England as *Agnostus stenorrhachis* Grönwall. However, their figure is inadequate for comparative purposes, and the specific designation of the English forms must remain open until further work is done on the Rushton material.

Occurrence and Age: *Ptychagnostus* (*Ptychagnostus*) *stenorrhachis* (Grönwall) comes from the Que River Beds at lat. 41°34.7'S, long. 145° 41.0'E (grid 3710E, 8803N); its age is Middle Cambrian, either of the *Ptychagnostus punctuosus* Zone or the *P. nathorsti* Zone.

Ptychagnostus (Ptychagnostus) hodgei sp. nov.

pl. 5, figs. 5-12

Material: Abundant separated pygidia and cephala and rare complete specimens in varying states of preservation are known. All specimens have been considerably distorted.

Measurements: UT 88159, cephalon (E-W distortion), length of acrolobe, 4.8mm., width of acrolobe, 4.0mm. UT 92511, length of glabella, 3.5mm. UT 92618, cephalon, (intermediate distortion), length, 3.8mm., width, 3.6mm. UT 92512, cephalon, (intermediate distortion), length, 2.8mm., width, 2.8mm. UT 92513, pygidium (N-S distortion), length of axis, 2.1mm., width of pygidium, 4.0mm. UT 88136, pygidium, (E-W distortion), length 2.3mm. (including articulating device), width, 2.1mm. UT 88127 (not figured), pygidium, (N-S distortion), length (without articulating device), 2.7mm., width, about 3.7mm.

Selection of Holotype: The cephalon, UT 88159 (pl. 5, fig. 5), is selected as holotype as it best shows the features of the cephalon on which the species is based.

Diagnosis: Ptychagnostus (Ptychagnostus) hodgei sp. nov. is a species with a highly scrobiculate cephalon, which has a narrow border and short posterolateral spines. There is a well-marked longitudinal scrobicule in the posterior part of the cheeks and a well-marked, small quadrangular "box"-like arrangement of scrobiculae on either side of the axis next to the transverse glabellar furrow. The anterior ends of the basal lobes tend to be confluent with the rest of the glabella.

The trisegmented pygidium has a post-axial median furrow, but no border spines. The pygidial border is wider than the cephalic border. The moderately wide rim is almost flat. The central part of the anterior transverse axial furrow is arched well forward; the central part of the posterior transverse axial furrow is arched strongly backward. The central axial segment possesses a prominent node towards the posterior. The axis is constricted at the second axial segment. The pleural areas are smooth.

Description: The moderately convex cephalon is about as wide as it is long. It has a very narrow border with a narrow marginal furrow and a narrow rim. The posterolateral spines are short. The cheeks are highly scrobiculate. The length (sag.) of the glabella is about 0.8 to 0.85 that of the cephalon. The axial furrows and the preglabellar median furrow are both narrow and of moderate depth. The transverse glabellar furrow is straight, narrow and moderately deep. The anterior glabellar segment is subtriangular with a subangular anterior end. At the transverse glabellar furrow the glabella has a width about 0.3 that of the cephalon. The length of the anterior glabellar segment is about 0.4 that of the glabella.

The shape of the basal lobes is not fully determined due to distortion. They are large and appear to extend about one third of the length of the posterior glabellar segment. They have wide bases and show a weak bilobation in most specimens. As is shown very clearly in UT 92514 (pl. 5, fig. 9), the basal lobes are confluent with the rest of the glabella. The adaxial basal lobe furrows extend about one-third of the distance along the posterior glabellar segment. The narrow connective band beneath the broadly rounded glabellar rear is separated from the glabella by a narrow, shallow furrow.

There is a pair of lateral glabellar furrows on the anterior part of the posterior glabellar segment. These furrows are moderately deep near the axial furrows and fade adaxially; each extends across about one-third of the glabella. There is no pronounced node on the glabella. Between the basal lobes is a high area which extends forward about half-way to the transverse axial furrow.

Despite the distortion of all specimens, the caecal pattern can be determined. On each cheek there appear to be three first order rugae to the anterior of the transverse glabellar furrow although variation between different specimens leads to the possibility of there being four anterior primary rugae. In all specimens there is a strong scrobicule directly opposite the transverse glabellar furrow. To the anterior of this scrobicule is a primary ruga which is outlined at the anterior by a strong primary scrobicule which is directed toward the end of the transverse glabellar furrow at an angle of about 45° to the axial furrows. This ruga is divided into two or three secondary rugae. Anterior to this primary ruga are either two or three primary rugae; the exact number cannot be determined due to variation between specimens. In primary and secondary scrobiculae alike the adaxial end of each scrobicule is usually a small pit. The primary scrobiculae in the anterior part of the cephalon have their adaxial pits about one-quarter of the distance from the axial furrow to the acrolobe margin.

On each cheek near the transverse axial furrow are two small scrobiculae which join the axial furrow. The more anterior of the two meets the axial furrow just to the anterior of the transverse axial furrow. It extends at right angles to the glabella for a short distance before turning to the posterior where it runs into the second furrow. This second furrow meets the axial furrow a short distance to the posterior of the transverse glabellar furrow. These two furrows form a small quadrangular "box" immediately adjacent to the axis.

In the posterior part of each cheek is a longitudinal scrobicule which extends from near the posterior of the cephalon forward to a point on the cheek about midway between the axial furrow and the acrolobe margin, opposite the centre of the anterior lobe of the posterior glabellar segment. The course of this scrobicule is varied although in many specimens its anterior end is connected by a short scrobicule to the posterolateral corner of the "box".

Between the longitudinal scrobicule and the axis the scrobiculation is confined to small pits or short scrobiculae. Between the longitudinal scrobicule and the acrolobe margin the scrobiculae and rugae are not as well defined as those in the anterior part of the cephalon. There are about five small rugae in the posterolateral part of the cephalon. They get smaller to the posterior.

Thus, there are two distinct scrobicule patterns on the cephalic cheeks--a radial pattern on the anterior part of the cheek and a more complex pattern on the posterior part of the cheek.

The pygidium is about as wide as it is long. The border is moderately wide with a narrow, shallow marginal furrow and a moderately wide, almost flat rim. The smooth pleural regions are separated behind the axis by a moderately deep post-axial median furrow. There are no border spines. The shoulder furrows are narrow and shallow. The elevated convex shoulders are somewhat geniculate on most specimens, but in some of the more distorted specimens the geniculation appears much stronger. The fulcra are placed adaxially about one-third of the distance along the shoulders.

The narrow articulating furrow is arched slightly to the posterior. It is moderately deep at either end with the central third being more shallow and slightly wider. The articulating half-ring is simple; it is longest (sag.) at the centre. The length of the axis is 0.80 to 0.85 that of the pygidium. The axis is widest very close to the anterior margin of the first axial segment. The axial furrows converge slightly inward to form a constriction at the second axial segment. From the constriction the axis widens slightly to a point a little to the posterior of the second transverse axial furrow before converging to the bluntly rounded axial posterior. The axis has a width about 0.4 to 0.45 that of the pygidium. The first transverse axial furrow is arched to the anterior. From both ends it runs forwards and inwards with a slight exaggeration of the forward convexity at the centre. This gives a waist and an overall dumb-bell shape to the anterior axial lobe. The ends of the posterior transverse axial furrow are directed inwards and backwards with the central third of the furrow being more sharply directed to the posterior, giving an anvil-like outline to the second axial segment. There is a prominent node toward the posterior of the second axial segment. The posterior axial segment has an arrowhead outline. The posterior axial segment is a little longer (sag.) than the other two segments combined.

Discussion: *P. hodgei* has many similarities with the species *P. atavus* (Tullberg), *P. punctuosus affinis* (Brögger) and *P. punctuosus* (Angelin). Westergård (1946, p. 79) regarded these species as forming a continuous evolutionary series with intermediate stages. Hutchinson (1962, p. 84) in discussing *P. punctuosus* from Newfoundland includes forms that could be included in *P. punctuosus affinis* and notes the presence of transitional forms. However, he does not discuss *P. atavus* in this respect. The writer has had at his disposal rubber casts of many of the specimens of *atavus*, *punctuosus affinis* and *punctuosus* figured by Westergård (1946, pls. 11, 12) and agrees with Westergård's conclusion.

These specimens also show that the basal lobes of *atavus* and *punctuosus affinis* are more distinctly bilobed than those of *hodgei*, with the basal lobes of *punctuosus* being bilobed to a similar extent to those of *hodgei*. *P. hodgei* is closest to *P. atavus* with the pygidia being indistinguishable. However, there are differences between the cephala of the two species. Some specimens of *P. atavus* show a structure similar to the quadrangular "box" of *hodgei* and also longitudinal furrows in the posterior part of the cephalic cheeks. However, neither feature is as well defined in *atavus* as in *hodgei*. The cephala of *atavus* are generally less scrobiculate than those of *hodgei*. The anterior part of the basal lobes of some specimens of *atavus* are confluent with the glabella as is the case in *hodgei*.

The cephala of *P. punctuosus affinis* have a similar degree of scrobiculation to those of *P. hodgei*, but neither the quadrangular "box" nor the longitudinal posterior scrobicule is as well developed. The pygidium of punctuosus affinis has low granules over the pleural areas, and the axis has pairs of lateral impressions. Neither feature is seen in P. hodgei. P. punctuosus is readily distinguished from P. hodgei by the granules which cover the cephalic cheeks and the pygidial pleural areas. The quadrangular box and longitudinal scrobicule are poorly developed in P. punctuosus.

Both P. akanthodes Robison and P. richmondensis (Walcott), as illustrated by Robison (1964a, pl. 79), exhibit a posterior longitudinal scrobicule and a quadrangular "box". However, in neither case are they as well developed as in hodgei. Further, both richmondensis and akanthodes have very large cephalic spines, and akanthodes has small pygidial spines.

The series atavus, punctuosus affinis and punctuosus extends through the top three Zones of the Paradoxides paradoxissimus Stage in Sweden. The species richmondensis and akanthodes occur in rocks of similar or possibly slightly younger age in Utah; P. hodgei is possibly of the P. nathorsti Zone. This suggests that the cephalic caecal pattern seen in these species arose sometime in the early part of the paradoxissimus Stage (and equivalents) and disappeared in the early part of the Paradoxides forchhammeri Stage (on the Swedish timescale).

Occurrence and Age: Ptychagnostus (Ptychagnostus) hodgei sp. nov. comes from about 28 metres above the base of lowest siltstone unit of the Black

Hill section, Dundas at lat. 41°50.8'S, long. 145°24.7'E (grid 3466E, 8474N) (RB locality); its age is Middle Cambrian, possibly that of the Ptychagnostus nathorsti Zone.

Ptychagnostus (Ptychagnostus) cf. aculeatus (Angelin)

pl. 6, fig. 1

Synonymy: See Palmer, 1968, p. 28.

Material: One poorly preserved partial pygidium, which has undergone N-S distortion, is available for description.

Measurements: UT 86877a, exposed length, 1.9mm. Length and width of complete specimen would have been about 2.1mm. and 2.7mm., respectively.

Description: The moderately convex pygidium is probably about as wide as it is long. The border is almost entirely missing. The shoulder furrows are of moderate width and depth. The shoulders are narrow near the lateral margins of the pygidium and widen adaxially. The fulcra appear to be close to the axis. The articulating device is not visible. The axis is outlined by moderately wide and deep axial furrows. There appears to be a narrow, shallow post-axial median furrow. The pleural fields are covered with large granules which are aligned in rows parallel to the axial furrows. There also appear to be large tubercles on the first axial segment, but they are much fainter than those on the pleural areas. The axial details are largely obscured. The axis, which stands out distinctly above the pleural regions, is of the Ptychagnostus (Ptychagnostus) type. At the anterior the axis is about 0.4 of the width of the acrolobe. From the anterior the axis narrows along the first axial segment which is tripartite, with the lateral lobules larger than the central lobule. The first transverse axial furrow is arched strongly forward. From the posterior of the anterior axial segment the axis tapers to the sharply rounded axial rear, with a slight expansion at the anterior of the posterior axial segment. The second axial segment is also tripartite with the central lobe standing out above the lateral lobules; there is a spine at the posterior end of the central lobule. The poor preservation does not allow the posterior extent of the spine to be determined although there is a strong suggestion of quite a long spine. The posterior axial segment is slightly longer than the two anterior axial segments combined.

Discussion: The Christmas Hills specimen has the following features in common with *Ptychagnostus aculeatus* (Angelin): (a) large granules over the pleural areas and on at least part of the axis, (b) a faint post-axial median furrow and (c) a trisegmented axis which may have quite a long spine.

P. aculeatus also exhibits closely spaced, small granules over its surface. The Christmas Hills form does not show this feature clearly although there is a suggestion of it. The poor preservation makes retention of such minor features difficult. *P. aculeatus* has no border spines, but the border of the Christmas Hills specimen is not preserved and so this feature cannot be compared.

The contraction of the axis at the second axial segment is not as marked as in the pygidia of _P. aculeatus_ from Sweden, as illustrated by Westergård (1946, pl. 12, figs. 9 and 10), and from Queensland, as illustrated by Öpik (1961b, pl. 21, figs. 4a, b), but is similar to that figured from Alaska by Palmer (1968, pl. 6, fig. 20). The Tasmanian form is also smaller than those noted above. This fact may not be significant, but the faintness of the post-axial median furrow of the Tasmanian form may indicate that it is a quite mature specimen (see comment by Westergård, 1946, p. 80). Thus, the pygidium discussed from Christmas Hills is closely related to _aculeatus_ if, in fact, it is not _aculeatus_. However, without better preservation and also the presence of a cephalon a definite specific assignation cannot be made. The Christmas Hills specimen is here referred to _Ptychagnostus_ (_Ptychagnostus_) cf. _aculeatus_ (Angelin).

If the Christmas Hills form is _P. aculeatus_, then the already widespread geographic distribution of this species is extended. It is already known from Sweden, Norway, Alaska and Queensland. Nowhere is it common, thus, limiting its use for correlation purposes. In Sweden it is "everywhere infrequent" (Westergård, 1946, p. 80); in Alaska Palmer (1968, p. 28) records a single pygidium, and in Queensland most of the specimens came from a single bedding plane (Öpik, 1961b, p. 80).

In Sweden _P. aculeatus_ is reported only from the _Solenopleura brachymetopa_ Zone. In Queensland Öpik reports it from both the _Ptychagnostus cassis_ Zone and the _Proampyx agra_ Zone which extends its range up to about the middle of the Swedish Lejopyge laevigata Zone (Öpik, 1961b, fig. 15). The exact age of the Alaskan fauna in which aculeatus was found was not determined by Palmer (op. cit.), but it is of a similar age to both the Swedish and Queensland occurrences.

Occurrence and Age: Ptychagnostus (Ptychagnostus) cf. aculeatus (Angelin) comes from the upper fauna at Christmas Hills (lat. 40°54.1'S, long. 144°29.8'E; grid 3075E, 9610N); its age is late Middle Cambrian, either of the Lejopyge laevigata I Zone or the L. laevigata II Zone.

Ptychagnostus (Ptychagnostus) sp.

pl. 6, figs. 2-4

Material: Two almost complete specimens, UT 92515 and UT 92516, and three partially preserved cephala, UT 92516, UT 88125, UT 88133a, are available. All specimens are poorly preserved.

Measurements: UT 92515, complete specimen, (intermediate distortion), total length, (excluding cephalic border), 4.4mm.; cephalon, length of acrolobe, 2.1mm., width of acrolobe, 1.9mm.; pygidium, length, 2.1mm., width, about 2.0mm. UT 92516, complete specimen, (E-W distortion), total length, 6.1mm., pygidium, length, 2.4mm. UT 88125, cephalon, (N-S distortion), length, 2.2mm., width, about 2.6mm. UT 88133a, cephalon, (E-W distortion), length, 2.5mm., width, 1.8mm.

Description: The cephalon is strongly convex and about as wide as it is long. The narrow border is composed of a narrow, shallow marginal furrow and a narrow, convex, elevated rim. The posterolateral regions are not well preserved in any specimen. The cheeks appear to be faintly scrobiculate although this is difficult to determine due to the distortion of the specimens. There is a narrow, deep preglabellar median furrow. The glabella is outlined by deep, moderately wide axial furrows. The length of the glabella is about 0.8 that of the acrolobe. The transverse axial furrow is of moderate depth and is arched slightly to the posterior. At the transverse axial furrow the glabella has a width about 0.3 that of the acrolobe. The anterior glabellar segment has a length about 0.4 that of the glabella. The axial furrows converge markedly along the glabella from the broadly rounded glabellar rear to the glabellar front to give a triangular outline to the glabella (including the small basal lobes). The anterior ends of the basal lobes seem to be confluent with the rest of glabella. The details of the glabella surface are obscured by distortion effects.

The pygidium is strongly convex with a narrow border consisting of a narrow, moderately deep, marginal furrow and a narrow, elevated rim. The shoulder furrows are wide and moderately deep; the shoulders are narrow and elevated; the fulcra are close to the axis. Border spines appear to be absent. The smooth pleural fields are separated to the posterior of the axis by a post-axial furrow which is deep and wide near the axis, but narrow and shallow where it descends into the marginal furrow. The axis has a length about 0.7 that of the pygidium and is outlined by wide and deep axial furrows. It is constricted at the second axial segment. The axis has a bluntly rounded posterior, is decidedly convex and stands out well above the pleural fields.

The axis has only the anterior transverse furrow, which is moderately deep laterally, but quite shallow in the central region where it is arched forward. The anterior axial segment shows faint signs of trilobation. On the second axial segment is a well-developed node. The posterior transverse axial furrow is effaced.

Discussion: None of the specimens are well enough preserved to assign them to any described species or to be the basis of a new species. The trisegmented nature of the pygidial axis places this form in *Ptychagnostus* (*Ptychagnostus*), and it is referred to *Ptychagnostus* (*Ptychagnostus*) sp.

Occurrence and Age: *Ptychagnostus* (*Ptychagnostus*) sp. comes from about 28 metres above the base of the lowest siltstone unit of the Black Hill section, Dundas at lat. 41°50.8'S, long. 145°24.7'E (grid 3466E, 8474N) (RB locality); its age is Middle Cambrian, possibly of the *Ptychagnostus nathorsti* Zone.

Ptychagnostus ? *murchisoni* sp. nov.

pl. 6, figs. 5-10

Material: Ten complete or partially complete specimens, five separate cephala and ten separate pygidia are available for descriptive purposes. All have been considerably distorted.

Diagnosis: A large agnostid in which both the cephalon and the pygidium are moderately convex and slightly wider than long. The cephalon is almost entirely effaced with a faint node a little to the posterior of its midpoint. The narrow cephalic border is a little narrower than the pygidial border. The articulating device is basic; the fulcral points are close to the axis. The trisegmented pygidial axis is outlined by shallow axial furrows which fade to the posterior. The axis is constricted at the second segment which bears a low node. There are no border spines or post-axial median furrow.

Measurements: UT 92507, complete specimen, (E-W distortion), total length, 12.6mm.; cephalon, length, 5.4mm.; pygidium (without articulating half-ring), length, 5.7mm. UT 92508, the holotype complete, (E-W distortion), total length, 13.2mm.; cephalon, length, 6.0mm., width, 6.0mm.; pygidium (without articulating half-ring), length, 5.9mm., width, about 5.6mm. UT 92509, complete specimen, (N-S distortion), total length, 8.6mm.; cephalon, length, 4.0mm., width, 5.7mm.; pygidium (without articulating half-ring), length, 4.0mm., width, 5.5mm. UT 92510, cephalon, (E-W distortion), internal mould, length, 3.1mm., width about 2.7mm. UT 89211, pygidium, (N-S distortion), internal mould, length (without articulating half-ring), 4.0mm., width, 5.0mm. UT 89206, pygidium, (N-S distortion), length (without articulating half-ring), 1.9mm., width, 2.7mm.

Selection of Holotype: UT 92508 (pl. 6, fig. 5) is selected as the holotype because it is the best preserved complete specimen.

Description: The moderately convex, almost entirely effaced cephalon is slightly wider than it is long. A low, small node is present a little to the posterior of the midpoint of the cephalon. The narrow, moderately deep marginal furrow is widest at the anterior. The rim is narrow, convex and widest at the anterior. Short posterolateral spines are present. There are vestigial traces of the basal lobes present in some specimens (e.g., UT 92508, pl. 6, fig. 5). There appear to be traces of axial furrows in UT 92510 (pl. 6, fig. 8) although these could be due to distortion.

The moderately convex pygidium is slightly wider than it is long. The pygidial border is slightly wider than the cephalic border. The narrow rim is weakly convex; the narrow marginal furrow is of moderate width. The shoulder furrows are narrow and moderately shallow; the shoulders are narrow; the fulcral points are close to the axis. The basic articulating device has a narrow, moderately deep articulating furrow. The articulating half-ring is low, short (sag.) and convex. The axial furrows are faintly, but distinctly, developed and are accentuated by distortion in all specimens; they fade to the posterior. The trisegmented axis extends about three-quarters the length of the pygidium. The posterior segment is larger than the two anterior segments combined. The axis is constricted at the second segment. At its widest the axis is just under half the width of the pygidium. The middle segment contains a well-marked median node.

Discussion: *Ptychagnostus* ? *murchisoni* sp. nov. is of a similar type to both *P. ciceroides* (Matthew) and *P. convexus* Westergård. In both these large species, the cephalon and pygidium are highly convex; the cephalon is partly effaced; the transverse pygidial axial furrows are somewhat effaced, and there are no border spines or post-axial median furrow on the pygidium.

Some cephala of *P. convexus* show faint scrobiculation (Westergård, 1946, p. 73). It is difficult to determine from the photographs of *P. ciceroides*, given by Hutchinson (1962, pl. 10, figs. 1, 2, 8), whether this species has a faintly scrobiculate cephalon. However, *P. ciceroides* from Greenland, as figured by Poulsen (1969, p. 5, fig. 5), shows no sign of scrobiculation. The cephalon of *P.*? *murchisoni* is not scrobiculate. *P. convexus* and *P. ciceroides* are probably more convex that *P.*? *murchisoni* even allowing for the distortion of the latter. *P.*? *murchisoni* is much more effaced than *P. convexus*. *P.*? *murchisoni* is closer to *P. ciceroides* than to *P. convexus*. It is a little more effaced than *ciceroides*, and the posterior end of the pygidial axis in *murchisoni* is usually almost obliterated whereas in *ciceroides* it is distinctly visible except in the specimen figured by Hutchinson (*op. cit.*) as pl. 10, fig. 7.

The species from Que River is referred to Ptychagnostus with a query due to the effaced nature of the cephalon. The pygidium is similar to those of Ptychagnostus (Ptychagnostus). If murchisoni (and ciceroides) are to be included in Ptychagnostus, then the diagnosis of the genus given by Robison (1964a, p. 522) and Palmer (1968, p. 28) will have to be revised and the generic character based solely on the pygidium. The writer agrees with Hutchinson (1962, p. 85) and regards such species as ciceroides and murchisoni as being in an evolutionary line in the process of effacement. The writer also agrees with both Hutchinson (op. cit., p. 88) and Poulsen (1969, p. 6) that the erection of a new genus is unnecessary at this stage.

Occurrence and Age: Ptychagnostus? murchisoni sp. nov. comes from the Que River Beds at lat. 41°34.7'S, long. 145°41.0'E (grid 3710E, 8803N); its age is Middle Cambrian and either of the Ptychagnostus punctuosus Zone or the P. nathorsti Zone.

Ptychagnostus (Goniagnostus) rubenacha sp. nov.

pl. 7, figs. 1-6

Material: Five cephala and five pygidia are available for description; internal and external moulds of all specimens are available.

Selection of Holotype: The pygidium, UT 92517 (pl. 7, fig. 4), is selected as holotype.

Measurements: Cephala: UT 88133, internal mould, (N-S distortion), length, 2.3mm., width, 3.3mm.; UT 92518, (N-S distortion), length, 1.9mm., width, about 2.6mm. Pygidia: UT 88133c, (intermediate distortion), length, about 2.3mm., width, about 2.3mm.; UT 92517, holotype, (N-S distortion), length, about 2.3mm., width, about 2.8mm.

Diagnosis: Ptychagnostus (Goniagnostus) rubenacha sp. nov. has short posterolateral cephalic spines and long pygidial border spines. The cephalic axial furrows are deep; the cheeks are highly scrobiculate. The scrobiculae are deep. The transverse glabellar furrow is slightly arched forward at its centre. The pygidium has a well-defined post-axial median furrow. The pleural areas are smooth.

Description: The cephalon is perhaps slightly wider than it is long. It has a narrow border with a narrow, shallow marginal furrow and a narrow, convex, elevated rim. There are small elevated posterolateral spines. The cheeks are highly scrobiculate and are divided in front of the glabella by a narrow, moderately deep preglabellar median furrow. The glabella, which is outlined by narrow, deep axial furrows, has a length about 0.75 that of the cephalon. The transverse glabellar furrow is slightly arched forward at its centre and is deepest at either end. At the transverse axial furrow the width of the glabella is just under 0.3 that of the cephalon.

The anterior glabellar segment, which is slightly elevated above the cheeks, is subtriangular and is about 0.4 as long as the entire glabella. The basal lobes are broad of moderate length and subsquare.

From the posterior margin they extend about one-third of the distance towards the transverse glabellar furrow. There is a rectangular, convex, longitudinal median area on the posterior glabellar segment. This area extends the entire length of the segment and is almost half the width of the glabella. It increases in height to the posterior, reaching a high blunt peak towards the wide, broadly rounded glabellar rear. The glabellar posterior overhangs the connective band. The posterior glabellar segment has two pairs of deep lateral furrows directed inwards and slightly backwards which mark off three pairs of lobes within the segment. The most posterior of these lobe pairs is the pair of basal lobes. The glabella is slightly expanded immediately behind the transverse glabellar furrow.

On each cheek there is a primary scrobicule which runs outward and slightly forward from a point near the end of the transverse glabellar furrow. Anterior to this scrobicule are three primary rugae, with the scrobiculae showing a radial distribution away from the glabella. In the posterior portion of each cheek there appear to be three primary rugae, the anterior two of which are outlined by radiating scrobiculae which end in the lateral margins of the cephalon. The most posterior ruga is partly outlined by the axial furrows. There are also small scrobiculae on the adaxial regions of the cheeks.

The moderately convex pygidium is possibly slightly wider than it is long. The border is moderately wide, with a narrow marginal furrow of intermediate depth and a wide convex rim. Border spines are present, which vary from minute (more of a swelling on the rim than a distinct spine) to quite pronounced and long (e.g., UT 92517, pl. 7, fig. 4). The shoulders are almost straight, but slope posteriorly away from the axis. The shoulder furrows are shallow. The fulcra are placed about half-way between the axial furrows and the anterolateral corners.

The pleural fields are smooth and separated behind the axis by a post-axial furrow of moderate width and depth. The axial furrows are narrow and deep. The length of the axis is about 0.75 that of the pygidium. The axis is quadrilobate, constricted in the region of the second segment, and has a bluntly pointed rear. The anterior segment is tripartite with the lateral lobules extending slightly more to the posterior than the central lobule. The anterior axial furrow is arched slightly forward at its centre. The second segment is also tripartite with the central lobule possessing a strong node. This node rises from the anterior to the posterior and culminates close to the posterior of the central lobule which extends strongly to the posterior. The middle transverse axial furrow is thus strongly arched to the posterior around the central lobule of the second axial segment. Both the anterior and middle axial furrows are moderately deep laterally but are quite shallow across the central region of the axis.

The second axial segment is slightly longer than the first axial segment, and together they are about 0.35 - 0.40 as long as the axis. The third and fourth segments are broadly convex and are divided by a wide, deep furrow which is narrowest at the centre. The axis is slightly constricted at this furrow. The furrow has a small elevation at its centre. The third segment has a broadly rounded, convex central region. The posterior segment is much less elevated above the pleural regions than the anterior three segments which are strongly elevated above the pleural fields.

Differences from other species: See discussion after *Ptychagnostus (Goniagnostus) buckleyi* (see p. 203).

Occurrence and Age: *Ptychagnostus (Goniagnostus) rubenacha* sp. nov. comes from about 28 metres above the base of the lowest siltstone unit of the Black Hill section, Dundas at lat. 41°50.8'S, long. 145°24.7'E (grid 3466E, 8474N) (RB locality); its age is Middle Cambrian, possibly that of the *Ptychagnostus nathorsti* Zone.

Ptychagnostus (Goniagnostus) buckleyi sp. nov.

pl. 7, figs. 7-9; pl. 8, figs. 1-3

Material: One very well preserved external mould of an almost complete specimen (UT 92472), plus about twenty separate pygidia and cephala preserved as external moulds are available. Counterparts of most of these specimens are available.

Selection of Holotype: The almost complete specimen, UT 92472 (pl. 7, fig. 7), is selected as holotype because of its completeness and good preservation.

Measurements: UT 92472, complete specimen, (N-S distortion); total length, 8.7mm.; cephalon, length, 4.0mm., width, 5.3mm.; pygidium, length, 3.9mm., width, 5.3mm. UT 86880i, cephalon, (E-W distortion), length, 2.8mm., width, 2.4mm. UT 86872m, cephalon, (N-S distortion), length, 2.0mm., width, 2.7mm. UT 86873a, pygidium, (N-S distortion), length, 2.9mm., width, 4.3mm.

Diagnosis: Ptychagnostus buckleyi sp. nov. has moderately long, slightly divergent posterolateral spines on both cephalon and pygidium. The cephalic axial furrows and scrobiculae are moderately deep. The cephalic border is narrow; the pygidial border is somewhat wider. The pygidium has large shoulders and a shallow post-axial median furrow. The pleural areas of the pygidium are covered with closely spaced, small nodes. Some of these features are found in other species of Ptychagnostus (Goniagnostus), but the combination of the above characteristics is unique.

Description: The gently convex cephalon is probably a little wider than it is long. There is a narrow border with a narrow, shallow marginal furrow and a narrow, convex, elevated rim. There are posteriorly directed, slightly divergent posterolateral spines with thick bases, which extend posteriorly to points opposite the junction of the thoracic segments.

The glabella has a length about 0.75-0.80 that of the cephalon. It is outlined by narrow, moderately deep furrows. There is a narrow, shallow preglabellar median furrow. The transverse glabellar furrow is almost straight with a slight forward deflection in the central region and at either extremity. The anterior glabellar segment is subtriangular and has a length about 0.4 that of the glabella.

The posterior glabellar segment is trilobate (including basal lobes). The basal lobes are subtrapezohedral and have a length about one-third that of the posterior glabellar segment. The wide glabellar rear is broadly rounded; a very narrow rim beneath the glabellar rear connects the posterior marginal rims and is separated from the basal lobes by narrow, shallow furrows.

Extending the length of the posterior glabellar segment is a raised area which has a width about half that of the glabella. This area increases in height to the posterior, being barely perceptible at the anterior lobe, and reaches a peak in the form of an elongated keel at the centre of the posterior lobe, opposite the centre of the basal lobes.

The posterior glabellar segment has two pairs of deep lateral furrows, which are directed inwards and slightly backwards from the axial furrows. Each furrow extends about one-quarter of the distance across the glabella. The anterior pair is deeper than the posterior pair, which at their adaxial extremities have a deep pit.

The axial furrows converge along the basal lobes, diverge and then converge around the middle posterior glabellar lobe, and diverge markedly along the posterior two-thirds of the anterior lobe before converging to the transverse glabellar furrow. There is a marked decrease in width of the glabella at the transverse glabellar furrow.

The cheeks are highly scrobiculate. On each cheek there is a primary scrobicule which runs outwards and slightly forwards from a point near the end of the transverse glabellar furrow. (On UT 92472, pl. 7, fig. 7, this scrobicule appears to meet the transverse glabellar furrow, but this appearance is due to the effect of the N-S distortion which this specimen has undergone.) To the anterior of this scrobicule there are three primary rugae on each cheek. The scrobiculae show a radial distribution, with secondary scrobiculae of various lengths between the main scrobiculae. In the posterior portion of the cheeks where there are three or four primary rugae, the rugae are not as well defined as in the anterior part of the cheeks. All these scrobiculae tend to be deepest adaxially and shallow outwards. There is a pair of short scrobiculae in the adaxial region of the cheeks, with each member of the pair arising from the axial furrow near the anterior end of the middle glabellar lobe. There is a small pit at the abaxial end of each of these scrobiculae.

The gently convex pygidium is probably slightly wider than it is long. The pygidial border is wider than that of the cephalon; there is a narrow, shallow marginal furrow and a moderately wide, gently convex rim. Moderately long, slightly divergent border spines are present; the border width increases near the spine bases which are about opposite the end of the pygidial axis. The shoulder furrows are narrow and shallow. The shoulders are large; the facets are not clearly preserved but appear to be quite big; the fulcra occur just abaxial of the midpoints between the anterolateral corners and the axial furrows. The articulating furrow is shallow at the centre with the lateral parts being deeper; it is arched to the posterior. The articulating half-ring is small, low and convex and has a lenticular outline.

The pleural areas are separated behind the axis by a narrow, shallow post-axial median furrow. The pleural areas apparently have a closely spaced reticulate veination. However, this feature is probably caused by the distortion of closely spaced, small nodes. The axial furrows are moderately wide and deep; the axis stands out well above the pleural areas. The length of the axis is about 0.75 that of the pygidium.

The axis is quadrilobate, constricted at the anterior axial furrow, with a bluntly pointed rear. The anterior segment is tripartite with the lateral lobules extending slightly more to both the posterior and the anterior than the central lobule. The narrow, moderately deep, anterior axial furrow is arched slightly forward at its centre. The lateral lobules are slightly wider (tr.) than the centre lobule. The second segment is tripartite with a central lobule possessing a strong node. The central lobule extends markedly to the posterior so that the middle transverse axial furrow is arched strongly to the posterior at the centre.

The second axial segment is slightly larger than the anterior axial segment. The third and fourth axial segments are somewhat more convex than the anterior segments; they are divided by a wide, deep furrow which is narrowest at the centre. The axis is slightly constricted at this furrow.

Discussion and Comparison with other species: Both *buckleyi* and *rubenacha* belong to the subgenus *Goniagnostus* as defined by Öpik (1961b, p. 77). In both *buckleyi* and *rubenacha* the cephalic scrobiculae are deeper than those of *Ptychagnostus* (*Goniagnostus*) *nathorsti* (Brögger), the type species of the subgenus. This is confirmed by inspection of rubber casts of specimens of *nathorsti* discussed and figured by Westergård (1946). The pygidial border spines of the Tasmanian forms are much larger than those of *nathorsti*. The large cephalic posterolateral spines in *buckleyi* are similar to those figured for *Ptychagnostus* (*Goniagnostus*) *fumicola* Öpik (1961b, text fig. 28). In contrast *P. rubenacha* has small cephalic posterolateral spines. Both *buckleyi* and rubenacha have a distinct post-axial median furrow whereas the pygidium of fumicola has no such furrow. The post-axial median furrow of rubenacha is deeper than that of buckleyi.

The pygidial pleural areas of rubenacha are smooth; those of buckleyi are covered by closely spaced, small nodules, and those of fumicola are covered by coarse granules. The pygidial pleural areas of the early Upper Cambrian P. (G.) nodibundus are also covered with coarse granules (Öpik, 1967). The pygidial border spines of P. (Goniagnostus) sp. aff. nathorsti, illustrated by Öpik (1961b, text fig. 30), and of P. (G.) cf. nathorsti, Whitehouse (1939, p. 259, pl. 25, fig. 20), are much smaller than those of either buckleyi and rubenacha, as are those of Goniagnostus aff. nathorsti of Chu (1965, p. 13, pl. 1, figs. 4-7). The pygidial pleural areas of this Chinese form appear to be smooth in contrast to those of buckleyi. The pygidium illustrated by Chu (op. cit., pl. 1, fig. 8) as Goniagnostus sp. is similar to that of buckleyi in that they both appear to have closely spaced, small nodes which are partly confluent. However, buckleyi has larger shoulders and bigger border spines.

The species described by Whitehouse (1939, p. 258, pl. 25, figs. 21-23) as Goniagnostus purus belongs to Ptychagnostus (Ptychagnostus) rather than to P. (Goniagnostus). The fact that the pygidial axis is trisegmented can be seen in pl. 25, fig. 23. However, Whitehouse

(p. 259) clearly recognized that purus is close to P. (Ptychagnostus) gibbus and questioned the differentiation of Goniagnostus and Ptychagnostus on the basis of the former having pygidial spines. Westergård (1946, p. 80) raised the same query. Westergård (op. cit., p. 81) included scanensis in Goniagnostus presumably on the basis of the small pygidial spines on this species. Only two pygidia of this species were known to Westergård, and he states (p. 82), "the transverse depression across the end-lobe is very weak." A close inspection of rubber cast Riks 445 (figured by Westergård, 1946, pl. 12, fig. 17) reveals no such depression, and thus scanensis belongs to P. (Ptychagnostus) rather than P. (Goniagnostus).

The species described by Whitehouse (1939, p. 260, pl. 25, fig. 19) as Goniagnostus scarabaeus is difficult to compare with either buckleyi or rubenacha due to the poor photographic reproduction of scarabaeus. The description by Whitehouse (op. cit., p. 260) notes, "there are three or four pits on either side of the posterior glabellar lobe and one on each side of the anterior lobe." These features are not seen in either buckleyi or rubenacha. Whitehouse (op. cit., p. 260) gives a small line diagram of scarabaeus in which there is no sign of a fourth axial segment. On the other hand, he states that scarabaeus is perhaps closer to nathorsti than it is to other members of Goniagnostus. This may indicate that the pygidial axis is quadrisegmented and that *scarabaeus* belongs to the subgenus *Goniagnostus*. The photograph reproduced in Whitehouse (1939, pl. 25, fig. 19) is not clear on this point.

Ptychagnostus (*Goniagnostus*) *spiniger* (Westergård) has large diverging posterolateral spines which appear slightly more divergent than those of *buckleyi* although this may be due to different preservation. However, the main difference between *spiniger* and the Tasmanian forms is that the pygidial axis of *spiniger* narrows all the way to its posterior. In both *rubenacha* and *buckleyi* the third axial segment is distinctly wider than the second axial segment.

The specimen figured by Howell (1935c, figs. 3, 4) as *Goniagnostus confluens* (Matthew) appears to belong to *P.* (*Ptychagnostus*) rather than *P.* (*Goniagnostus*). *P. confluens* is trisegmented, and the apparent quadrisegmentation in Howell's photo appears to be due to distortion.

Occurrence and Age: *Ptychagnostus* (*Goniagnostus*) *buckleyi* sp. nov. comes from the upper fauna at Christmas Hills (lat. 40°54.1'S, long. 144°29.8'E; grid 3075E, 9610N); its age is late Middle Cambrian, ~~probably~~ either of the *Lejopyge laevigata* I Zone, or the *L. laevigata* II Zone.

Ptychagnostus (*Goniagnostus*) sp.

pl. 8, figs. 4-10

Material: Several poorly to moderately well-preserved cephala and one poorly preserved complete specimen, UT 92519, are available. No well-preserved, complete pygidium is available. However, specimen UT 92520 has a fairly well-preserved, incomplete pygidium. The description of the pygidium is based mainly on this specimen. All specimens except one cephalon (UT 92521) and one poorly preserved pygidium (UT 92522, not figured) are internal moulds.

Measurements: UT 92520, length of glabella, 3.0mm. UT 92523, cephalon, length of acrolobe, 2.3mm., width of acrolobe, 2.3mm. UT 92524, cephalon, length, 4.0mm. UT 92525, small complete specimen: cephalon, length, 1.9mm., width, 2.0mm.; pygidium, length, 1.7mm., width, 1.7mm. UT 92526, cephalon, length, 3.1mm., width, 3.3mm. UT 92521, cephalon, length of acrolobe, 2.5mm., width of acrolobe, 2.3mm. UT 92519, pygidium, length, 2.0mm., width, 2.1mm.

Description: The cephalon is about as wide as it is long. The border is composed of a narrow, shallow marginal furrow and a narrow, upraised rim. The cheeks are highly scrobiculate. There is a wide, moderately deep preglabellar median furrow. The glabella is outlined by deep, moderately wide axial furrows; it has a length approximately 0.7-0.8 that of the cephalon (the nature of the specimens does not allow a more accurate determination). The wide, moderately deep transverse glabellar furrow is arched to the posterior (except in UT 92523, where it is arched to the anterior). The anterior glabellar segment is subtriangular with a broadly rounded anterior end; it has a length approximately 0.4 that of the glabella. At the transverse glabellar furrow the glabella has a width approximately 0.3 that of the acrolobe. The posterior glabellar segment is trilobed (including the basal lobes) with two evenly spaced pairs of lateral glabellar furrows. The glabella expands slightly at each of the two anterior lobes. Each of the anterior pair of lateral furrows extends across about one-third of the glabella from the axial furrows. The anterior lateral furrows are wide and deep. The posterior pair of lateral furrows are more a pair of moderately deep pits rather than furrows. To the posterior of these pits are the small, subquadrate basal lobes which are outlined on the adaxial margins by moderately deep and wide furrows which extend parallel to the axis of the glabella. The central one-third of the posterior glabellar segment consists of a rounded ridge which extends all the way along the segment increasing in height to the posterior.

As indicated above, the only good pygidial detail is seen in UT 92520, pl. 8, fig. 10, which is an incomplete, fairly well-preserved specimen. It occurs as two closely associated fragments which were probably originally separated by a scavenger.

The border is composed of a narrow, shallow marginal furrow and a narrow, flat, elevated rim. The rim widens appreciably to two flat, short border spines. Anterior to the spines the pygidial margin is almost straight; the posterior margin of the pygidium between the spines is probably evenly curved. The shoulder furrows are narrow and shallow. The shoulders are not preserved well but appear to be reasonably wide. The articulating device is not visible. The pleural regions are smooth. There is a well-developed post-axial median furrow. The pygidial axis is outlined by narrow, moderately deep furrows. Although the axis is never clearly preserved as a single unit, it appears to be quadrisegmented and the species thus belongs in Ptychagnostus (Goniagnostus). The length of the axis appears to be about 0.75 that of the pygidium. The two anterior segments are short (sag.) and are outlined by distinct, narrow, shallow lateral furrows, the anterior pair of which run inwards and forwards from the axial furrows; the posterior pair of lateral furrows run inwards and backwards and meet around the posterior end of the prominent rounded ridge; this ridge extends along the centre of the two anterior axial segments and may extend just over on to the third segment. The ridge is just under one-third of the width of the axis.

Discussion: The Sugarloaf Gorge specimens of Ptychagnostus (Goniagnostus) are not well enough preserved to place in any particular species although they clearly belong to a single species of Ptychagnostus (Goniagnostus). Thus, they are placed in Ptychagnostus (Goniagnostus) sp. The Sugarloaf Gorge form appears to be less scrobiculate than nathorsti. It has short border spines on the pygidium in contrast to the long spines of both buckleyi and rubenacha and does not possess the coarse granules on the pleural areas as does fumicola.

Occurrence and Age: Ptychagnostus (Goniagnostus) sp. comes from unit 13 of the lower sedimentary sequence of the Radfords Creek Group as exposed along the Gunns Plains Road; its age is late Middle Cambrian, either of the Lejopyge laevigata II Zone or the L. laevigata III Zone.

Ptychagnostus ? sp. 1

pl. 3, fig. 3

Material: One well-preserved cephalon, UT 92489, (length, 4.5mm., width, 5.4mm.), which has undergone some distortion, is available.

Description: The cephalon is probably about as wide as it is long. The border is of moderate width with a narrow, moderately deep marginal furrow. The rim is of moderate width at the anterior, widening slightly immediately in front of the preglabellar median furrow, and narrowing towards the posterior. The smooth cheeks are divided by a shallow preglabellar median furrow. The glabella is outlined by moderately deep dorsal furrows which shallow to the anterior. The shallow transverse glabellar furrow is distinctly reflexed forward at its centre. The glabellar front is broadly rounded. The anterior glabellar segment is gently domed and stands out slightly above the cheeks. The anterior half of the posterior glabellar segment is slightly flattened, possibly due to the effects of distortion. The posterior half of the posterior glabellar segment is a broad, high dome which falls away sharply at the posterior. This dome stands out markedly above the rest of the cephalon. The posterior glabellar segment is widest just to the anterior of its midpoint where the dorsal furrows diverge slightly, but distinctly, possibly indicating the presence of two lobes within the posterior glabellar segment. The glabellar rear is broadly rounded; the basal lobes are short, convex and triangular. There is a narrow connecting band.

Discussion: This single cephalon has no pygidium with which it can be associated. It is tentatively placed in *Ptychagnostus* and is referred to as *Ptychagnostus* ? sp. 1.

Occurrence and Age: *Ptychagnostus* ? sp. 1 comes from about 28 metres above the base of lowest siltstone unit of the Black Hill section, Dundas at lat. 41°50.8'S, long. 145°24.7'E (grid 3466E, 8474N); its age is possibly Middle Cambrian, that of the *Ptychagnostus nathorsti* Zone.

Ptychagnostus spp.

Some extremely distorted specimens of *Ptychagnostus* are found in a siltstone about 100 metres north of the present Razorback open cut (see p. 17). They can be safely assigned to *Ptychagnostus* but are too badly distorted to be worth figuring. There are three unfigured, very poorly preserved specimens of *Ptychagnostus* from the Que

River Bridge locality (see p. 51), which do not appear to belong to P. stenorrachis (Grönwall). In the Stratigraphic section of this thesis these specimens are referred to as Ptychagnostus sp. from their respective localities.

Genus LEJOPYGE Hawle and Corda, 1847

Synonymy: Lejopyge Hawle and Corda, 1847, p. 51; Kobayashi, 1937, pp. 437-447; 1939, p. 131; Lermontova, 1940, p. 130; Westergård, 1946, p. 87; Hupé, 1953, p. 61; Pokrovskaya, 1958, p. 72; 1960a, p. 60; Howell, 1959, p. 178; Öpik, 1961b, p. 85; 1967, p. 93; Robison, 1964a, p. 521; Palmer, 1968, p. 27.

Miagnostus Jaekel, 1909, p. 401.

Type Species: Battus laevigatus Dalman, 1828, p. 136.

Discussion: Before discussing Lejopyge it should be noted that rubber casts of many of the Swedish examples of Lejopyge laevigata Dalman and its subspecies, as illustrated by Westergård (1946), were available to the author. Many of these casts are figured in this thesis in plates 10 and 11 (see Appendix 2 for details).

Westergård (1946, p. 87) and Öpik (1961b, p. 76, 85) have discussed Lejopyge, its species and subspecies, and its relationship with other genera in some detail. Both writers, along with other recent authors, have noted the close relationship of Lejopyge and

Ptychagnostus. However, Pokrovskaya (1960a, p. 60) includes Lejopyge and Ciceragnostus in a separate subfamily Lejopyginae, while Ptychagnostus is included in another subfamily, the Ptychagnostinae. The work of Öpik and Westergård shows that such a separation is unjustified. Moreover, Öpik (1967, p. 76) indicates that the two species of Ciceragnostus, cicer and barlowi, are "neither congeneric nor cofamilial". Also, on his Tabular Classification of Agnostids Öpik (1967, Table 5) shows that neither of these species is in the same subfamily as Lejopyge.

Since 1961 two new species of Lejopyge have been described: (i) L. calva Robison (1964a, p. 521), which is the nominate species of the youngest of the three subzones of the late Middle Cambrian Bolaspidella Assemblage Zone of Utah and Nevada; and (ii) L. cos Öpik (1967, p. 93) from the two lower zones (Erediaspis eretes Zone and Cyclagnostus quasivespa Zone) of the Mindyallan Stage of northwest Queensland.

Öpik's diagnosis of L. cos is as follows:

> "Leiopyge cos sp. nov. is distinguished by well developed posterior section of the cephalic axial furrows and rather distinct but relatively small basal lobes, short pygidial marginal spines, and two median nodes on the pygidial axial lobe; the additional node is placed on the anterior axial annulation."

Part of Öpik's differential diagnosis of L. cos is,

> "The marginal pygidial spines of L. cos are shared by Leiopyge laevigata armata (Linnarsson), but armata has only one node, on the

> second axial annulation; furthermore, the cephalic spines of armata are long (short in cos, as observed on specimens not illustrated)."

However, the specimens figured by Westergård (1946, pl. 13, figs. 28, 29, 30, 31) as L. laevigata armata (Linnarsson) fit this description perfectly. (It should be mentioned that the anterior of the two nodes cannot be seen in Westergård's figures.) As seen in the photographs of the two specimens labelled Riks 455 (pl. 11, figs. 4, 5, 7, 8 herein), there are, in fact, two nodes on each of the pygidia figured by Westergård as pl. 13, figs. 30 and 31. Also, the spines on both these specimens are quite small and similar to those illustrated by Öpik (1967, pl. 5, fig. 5, text fig. 20) for L. cos.

Öpik maintains (1961b, p. 87 and 1967, p. 93) that L. laevigata armata has long cephalic and pygidial posterolateral spines. On the other hand, Westergård (1946, pl. 13, figs. 28-36) in his illustrations of armata allows great variation in the length of these spines--they vary from quite small to very long. Westergård (p. 89) also notes, when discussing armata, that,

> "Forms with shorter spines and more or less distinctly furrowed cheeks connect this long-spined smooth form on the one hand with the typical laevigata and on the other hand with the subspecies perrugata."

This is borne out by a cephalon with short spines on Riks 455 (pl. 10, fig. 5, herein). It would thus appear that L. cos is conspecific with at least some of the specimens illustrated by Westergård as *L. l. armata*.

A further complication is added in that the pygidium (Riks 457) figured by Westergård (*op. cit.*, pl. 13, fig. 25) as *L. laevigata* has small posterolateral spines and also appears to have an anterior axial node (pl. 10, figs. 9, 10, herein); it is thus conspecific to the specimen illustrated as *armata* in Westergård (*op. cit.*, pl. 13, figs. 30, 31). Westergård (pp. 87-90) has noted the great variation within *Lejopyge laevigata* and also the fact that there are intermediate forms between *Lejopyge laevigata* and the subspecies *armata*, *perrugata* and *rugifera* and even between the subspecies. A diagram summarizing Westergård's statements is given below, with the arrows indicating gradation between the species and subspecies of *Lejopyge*.

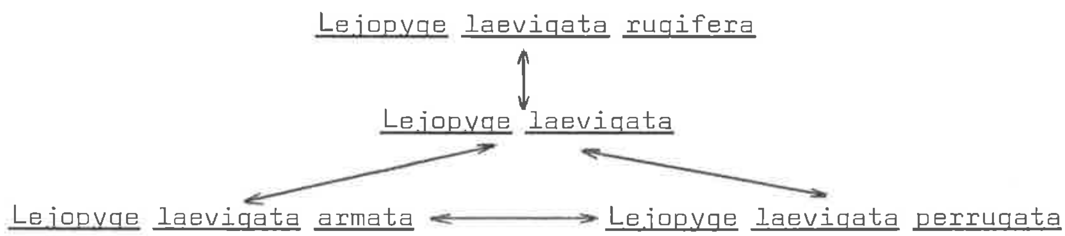


Table 8 sets out the presence or absence of pygidial nodes and spines for certain specimens of *Lejopyge*, many of which are illustrated by Westergård (1946).

In most pygidia where there is not a definite anterior axial node there appears to be a slight general swelling in the position where

Specimen No.	Designated name or association and figuring herein	figuring in Westergård (1946)	Spine Characteristics	Axial node 1	Axial node 2	Other Remarks
Riks 37	*L. laevigata* (not figured)	pl. 13, fig. 23	?change in marginal slope	?	p	
Riks 460	*L. laevigata* (pl. 10, fig. 11)	pl. 13, fig. 26	absent	a	p	
Riks 457	*L. laevigata* (pl. 10, figs. 9, 10)	pl. 13, fig. 25	very small	?	p	
Riks 458	*L. laevigata* (pl. 10, fig. 13)	pl. 13, fig. 24	absent	p	p	trace of post-axial median furrow
Riks 458	Additional small specimen on same cast (pl. 10, fig. 12)	not figured	minute	?	p	
Riks 456	*L. laevigata* (pl. 11, figs. 1, 2)	pl. 13, fig. 20	absent	a	p	
Riks 456	Additional small specimen on same cast (pl. 10, fig. 14)	not figured	slight change in marginal slope	?	p	seems to be a very small node to the posterior of axial node 2; trace of post-axial median furrow present
Riks 418	*L. laevigata* (pl. 10, fig. 2)	pl. 16, fig. 9	absent	a	p	complete specimen
Riks 455	*L. l. armata* (pl. 11, figs. 7, 8)	pl. 13, fig. 30	very small	p	p	
Riks 455	*L. l. armata* (pl. 11, figs. 4, 5)	pl. 13, fig. 31	very small	p	p	
Riks 402	pygidium associated with cephalon of *L.l.p.* (pl. 11, fig. 9)	not figured	present	a	p	spines broken--length indeterminate
Riks 402	largest incomplete pygidium associated with cephala of *L.l.p.* (pl. 11, fig. 10)	not figured	present	?	p	on other pygidia on Riks 402 the first node may be present
Riks 399	pygidium associated with *L.l.r.* (pl. 11, figs. 11, 12)	not figured	absent	?	p	
Robison (1964a)	*L. calva*		absent	a	p	
Öpik (1967)	*L. cos*		small	p	p	

L.l.p. = *L.l. perrugata*
L.l.r. = *L.l. rugifera*

p = present
a = absent
? = uncertain

axial node 1 = node on first axial segment
axial node 2 = node on second axial segment

TABLE 8. Characteristics of the pygidia of different species of *Lejopyge*

the node would be expected. This could indicate that the node is the external expression of part of the underlying agnostid anatomy which is better expressed in some specimens of laevigata than others.

The characteristics listed in Table 8 (p. 216) confirm Westergård's observations regarding the great variation among members of L. laevigata and also the gradation from one subspecies to another.

Lejopyge cos, as described by Öpik (1967), would fit on the diagram on page 215 (the "triangular" diagram) somewhere on the line between Lejopyge laevigata and L. l. armata. If Westergård's work is valid, then the existence of L. cos as a separate species must be very doubtful. Another point is that the pygidia of L. l. armata, as illustrated by Öpik, 1961b (pl. 22, figs. 2, 3, 4), presumably have no node on the anterior axial annulation. Whether this is so or not cannot be clearly determined from the illustrations given by Öpik. If, in fact, there is no anterior node on the Queensland Middle Cambrian and Passage Zone forms, then this may indicate a difference due to geographical dispersion. There may also be an evolutionary trend between the forms described by Öpik (1961b) as L. l. armata and those described by him in 1967 as L. cos. Such an evolutionary trend regarding the length of the spines is suggested by a footnote of Westergård (1946, p. 89). In this he noted one Swedish location in which the spines of armata, especially the pygidial spines, are usually much shorter in the higher part of the L. laevigata Zone than they are in the lower parts of this zone.

The fact that Lejopyge cos, as described by Öpik, is identical to at least some specimens of Lejopyge laevigata armata, as described and illustrated by Westergård leads to some interesting possibilities. First, it should be noted that L. cos is the youngest reported form of Lejopyge and that the youngest members are apparently at least two zones younger than the Swedish forms of L. laevigata armata to which it appears to be identical.

One possibility is that the form described as L. cos existed in Australia later than it did in Sweden. If this is the case, then the usefulness of Lejopyge laevigata armata for correlation purposes is greatly diminished. A second possibility is that the Middle Cambrian/Upper Cambrian boundary as recognized in Sweden and Queensland may, in fact, be of slightly different ages. Öpik (1967, p. 8) notes that throughout the world the exact change from a Middle to an Upper Cambrian fauna in a continuous sequence cannot be pinpointed. Thus, it is quite possible that there could be some slight variation in the positioning of the Middle Cambrian/Upper Cambrian boundary as seen by various authors. In view of the presence of both L. laevigata and L. l. armata in the Queensland Zone of Passage between definite Middle Cambrian and Upper Cambrian faunas, and the fact that in Sweden these species both occur in the uppermost Middle Cambrian *Lejopyge laevigata* Zone (C_3), it is possible that the upper part of the C_3 zone is equivalent to the Queensland Zone of Passage of Öpik (1967).

It should also be noted in this discussion that neither the pygidia nor the cephala of *Lejopyge laevigata armata* from Queensland (see Öpik, 1961b, pl. 21, fig. 10; pl. 22, figs. 1-4) seem to have particularly big spines. With respect to spine length they are intermediate between the extremes illustrated by Westergård (1946, pl. 13).

The complete gradation between *L. laevigata* and its subspecies raises the question of the validity of these subspecies. In this respect a detailed restudy of the Swedish *Lejopyge laevigata* and its subspecies as recognized by Westergård would probably be rewarding.

Öpik (1961b, p. 94) differentiates between the cephala of *Pseudophalacroma dubium* and *Lejopyge* as follows:

(a) *dubium* has a more salient front than *Lejopyge*,

(b) *dubium* has considerably shorter residual dorsal furrows,

(c) the furrows around the basal lobes are much more effaced in *dubium* than in *Lejopyge*.

However, although (a) is valid, points (b) and (c) seem to be no longer valid with respect to the later published species *Lejopyge calva* Robison (1964a, p. 521, pl. 83, figs. 1-4). In distorted specimens such as those from Tasmania, it is difficult to differentiate between Pseudophalacroma and Lejopyge on the basis of cephalic differences. However, the pygidia are distinct; the pygidial border of Pseudophalacroma is decidedly wider than that of Lejopyge; the marginal furrow of Pseudophalacroma is also deeper and more distinctly outlined; marginal spines are never present on Pseudophalacroma.

Lejopyge calva has been described from the western U.S.A. by Robison (1964a) and from Alaska by Palmer (1968). It is of a similar age as Lejopyge laevigata from Sweden; it is different from the latter in that it is much more effaced. In view of the variation in L. laevigata and its subspecies in Sweden, it is possible that calva could merely be a more effaced form of laevigata and be conspecific with it, (possibly as a subspecies), and that geographic dispersion is the main factor in causing a slightly different evolution to take place. However, the large number of specimens showing consistent characters probably indicates a distinct species.

?Lejopyge laevigata (Dalman)

pl. 9, figs. 5, 6

Synonymy: See Palmer, 1968, p. 28.

Material: About twelve specimens from the Sugarloaf Gorge section are provisionally assigned to Lejopyge laevigata (Dalman).

Measurements: UT 92527, complete internal mould, (E-W distortion), total length, 6.8mm.; cephalon, length, 3.5mm., width, 2.7mm.; pygidium, length, 3.1mm., width, 2.8mm.; UT 92528, pygidium, (E-W distortion), length, 4.0mm., width, about 3.6mm.

Discussion: The usually poor preservation of fossils in the Sugarloaf Gorge section makes the differentiation of effaced agnostids difficult. *Lejopyge laevigata armata* (Linnarsson) is easily differentiated by means of its long spines. However, there appear to be two other groups of effaced agnostids present in the Sugarloaf Gorge section--one of which is possibly *Lejopyge laevigata* (Dalman) and the other may be a species of *Pseudophalacroma* Pokrovskaya. As observed by Öpik (1961b, p. 94) when discussing *Pseudophalacroma dubium* from Queensland, the cephala of *P. dubium* and *Lejopyge* are similar. The same would apply to other species of *Pseudophalacroma*. As noted in the discussion on *Lejopyge* (see p. 219), two of Öpik's criteria for differentiating between the cephala of *dubium* and *Lejopyge* are invalid, and the third one (i.e., that *dubium* has a more salient front than *Lejopyge*) cannot be used in the Sugarloaf Gorge material.

The pygidia of ?*Lejopyge laevigata* and the *Pseudophalacroma* ? sp. from the Sugarloaf Gorge show about equal effacement. The differences are (a) the rim of *Pseudophalacroma* ? sp. is wider than that of ?*Lejopyge laevigata*, (b) the posterior of the acrolobe of *Pseudophalacroma* ? sp. is sharper than that in ?*Lejopyge laevigata*, and (c) the acrolobe in *Pseudophalacroma* ? sp. has a "subtriangular" appearance.

It should be noted that ?Lejopyge laevigata from the Sugarloaf Gorge appears to be more effaced than the Swedish or Queensland examples of L. laevigata; it may be that the Sugarloaf Gorge form does not belong with laevigata.

Banks (1956, p. 185) refers to a record of Öpik (1951c) in which Öpik records the occurrence of Lejopyge laevigata and L. laevigata armata from the same Sugarloaf Gorge location as the forms noted here as ?Lejopyge laevigata, Pseudophalacroma ? sp. and L. laevigata armata. The forms reported by Öpik as L. laevigata are probably recorded here as ?Lejopyge laevigata and Pseudophalacroma ? sp.

Occurrence and Age: ?Lejopyge laevigata (Dalman) comes from Unit 13 of the lower sedimentary sequence of the Radfords Creek Group as exposed along the Gunns Plains Road; its age is late Middle Cambrian, either of the Lejopyge laevigata II Zone or the L. laevigata III Zone.

Lejopyge laevigata armata (Linnarsson)

pl. 9, figs. 7-12

Agnostus laevigatus var. armata Linnarsson, 1869, p. 82, pl. 2, figs. 58, 59.

Lejopyge laevigata armata (Linnarsson) Westergård, 1946, p. 89, pl. 13, figs. 28-36; Öpik, 1961b, p. 87, pl. 21, figs. 10a, b; pl. 22, figs. 1-4.

Lejopyge cos Öpik, 1967, p. 93, pl. 57, figs. 5, 6; text fig. 20.

Material: A total of about twenty specimens identifiable as Lejopyge laevigata armata were collected by the author from the Sugarloaf Gorge section along Gunns Plains Road.

Measurements: UT 92529, cephalon, length, 4.5mm. UT 92530, cephalon, length, 4.7mm. UT 92531, pygidium, length (including axial half-ring), 2.8mm.; width, 2.7mm. UT 92532, pygidium, length (including axial half-ring), 4.3mm., width, 3.8mm.

Discussion: There appears to be no essential difference between the Sugarloaf Gorge forms and the Swedish forms of *L. laevigata armata* figured by Westergård (1946, pl. 13, figs. 28-36). *L. laevigata armata* has been previously recorded from the Sugarloaf Gorge by Öpik (1951c), Banks (1956, 1962a) and Burns (1964).

Occurrence and Age: *Lejopyge laevigata armata* (Linnarsson) comes from Unit 13 of the lower sedimentary sequence of the Radfords Creek Group as exposed along the Gunns Plains Road; its age is late Middle Cambrian, either of the *Lejopyge laevigata* II Zone or the *L. laevigata* III Zone.

Lejopyge (?) sp.

pl. 10, fig. 1

Material and Comments: One incomplete, poorly preserved pygidium is available for comment. The anterior part of this pygidium is all that can be seen. There is a basic articulating device present. The pygidial axis is almost effaced and is seen clearly only near its very anterior. The combination of a basic articulating device with an almost effaced axis indicates that this specimen may belong in *Lejopyge*.

Occurrence and Age: *Lejopyge* (?) sp. comes from a black shale at the eastern end of the Summit Cutting of the Comstock tram (lat. 41°53.8'S long. 145°18.7'E; grid 3374E, 8412N); its age is late Middle Cambrian.

Subfamily AGNOSTINAE M'Coy

Genus AGNOSTUS Brongniart, 1822

Synonymy: See Palmer, 1962, p. 12

Type Species: *Entomolithus paradoxus* X *pisiformis* Linneaus, 1757, p. 122.

Diagnosis: See Palmer, 1962, p. 12

Discussion: Palmer (1960, p. 62; 1962, p. 12) differentiates *Agnostus* and *Homagnostus* on the basis of the latter having an incomplete preglabellar median furrow and a broader, more bluntly rounded pygidial axis. Henningsmoen (1958) and Öpik (1963) consider *Homagnostus* to be a subgenus of *Agnostus*. The view of Palmer is followed here.

Agnostus sp. 1

pl. 11, figs. 13-16; pl. 12, figs. 1-6

Material: There are two reasonably complete specimens, plus several individual cephala and pygidia available for description. All specimens are distorted, some a little, others considerably.

Measurements: UT 92535, partially complete specimen, (N-S distortion), cephalon, length, about 2.7mm., width, about 3.5mm.; pygidium, length of axis, 2.0mm. UT 92536, internal mould of complete specimen, (E-W distortion), total length, about 8.6mm.; cephalon, length, about 3.9mm., width, 3.1mm.; pygidium, length, 3.8mm., width, 3.2mm.

Description: The moderately convex cephalon is about as wide as it is long. The border is narrow, with a shallow, narrow marginal furrow and a narrow, convex rim. The posterolateral corners are nowhere well preserved. The smooth cheeks are separated at the front by a shallow, preglabellar median furrow which extends to the marginal furrow.

The glabella is outlined by narrow, moderately deep axial furrows which shallow slightly to the anterior. The glabella is slightly more convex than the cheeks; it has a length about 0.7 that of the cephalon; the glabellar rear is very broadly rounded; the basal lobes are small and simple.

There is a well-defined, narrow, shallow transverse glabellar furrow which is arched to the posterior. The anterior glabellar segment has a subpentagonal outline; it has a length about 0.35-0.4 that of the glabella. Immediately to the posterior of the transverse glabellar furrow, the glabella widens slightly, and immediately behind this slight expansion, there is a slight constriction of the glabella. The posterior glabellar segment has a faint node at its centre.

The moderately convex pygidium is about as wide as it is long. The border is slightly wider than that of the cephalon with a shallow marginal furrow and a narrow, slightly elevated, almost flat rim at the posterior which becomes more convex to the anterior. There are short border spines; the shoulder furrows are narrow and shallow; the shoulders are narrow, convex and elevated. The fulcra appear to be close to the axis. Neither the facets nor the articulating device are preserved. The pleural areas are smooth; there is no post-axial median furrow.

The moderately wide trilobate axis is outlined by moderately deep, narrow furrows. The axis has a length about 0.7-0.75 that of the pygidium. The first two axial lobes have a combined length (sag.) about 0.4-0.45 that of the axis; they are separated by narrow, shallow lateral furrows which are directed quite strongly inwards and forwards. The second axial lobe is separated from the posterior lobe by an almost straight transverse furrow which is bent back at its centre around the posterior of an elongated, convex ridge which extends the length of the anterior pair of axial segments. This ridge separates the anterior lateral furrows. The posterior axial lobe is slightly expanded; the axial rear is evenly rounded; the axis is constricted at the second axial lobe. The expansion of the posterior lobe is more pronounced in specimens which have undergone N-S distortion than those which have undergone E-W distortion.

Discussion: This species belongs in *Agnostus* Brongniart, 1822. However, it is not well enough preserved to be referred to either an existing species or be the basis of a new species. Hence it is referred to *Agnostus* sp. 1.

Occurrence and Age: *Agnostus* sp. 1 comes from (a) about 145 metres below the top of the Climie Formation at lat. 41°54.2'S, long. 145°24.2'E (grid 3459E, 8406N); and (b) about 200 metres below the top of the Climie Formation at lat. 41°54.2'S, long. 145°24.2'E (grid 3460E, 8405N); its age is late Upper Cambrian (zone indeterminate).

Agnostus sp. 2

pl. 12, figs. 7, 8

Rare, poorly preserved specimens of Agnostus are known from the measured section near Birch Inlet. Two pygidia are illustrated here as pl. 12, figs. 7, 8. Although the pygidial axis of specimen UT 92545 (pl. 12, fig. 7) is clearly longer than that of UT 92546 (pl. 12, fig. 8), these two specimens are tentatively placed in the same species, Agnostus sp. 2, until further specimens of Agnostus are known from this section.

Occurrence and Age: Agnostus sp. 2 comes from west of Birch Inlet from near lat. 42°27.2'S, long. 145°21.1'E (grid 3417E, 7735N); its age is late Upper Cambrian, Prosaukia-Ptychaspis Zone.

Agnostus (?) sp.

pl. 12, figs. 9-14

Material: Several individual cephala and pygidia are available for descriptive purposes. All specimens are poorly preserved and have undergone considerable tectonic distortion.

Measurements: Cephalon, UT 92547, intermediate distortion, length, 3.3mm., width, about 2.7mm. Pygidium, UT 92548, N-S distortion, width across border spines, 2.3mm.

Description: The cephalon has a narrow, shallow marginal furrow and a narrow, convex rim. There is a well-developed preglabellar median furrow. The glabellar front is slightly angular. The axial furrows are narrow. The shallow, transverse glabellar furrow is arched very gently to the posterior. Other details of the glabella are obscured. The small basal lobes are connected behind the well-rounded glabellar rear.

The pygidium has a narrow border with wide posterolateral corners which bear short border spines. The marginal furrow is shallow and narrow; the rim is narrow and convex. The shoulder regions and articulating device are nowhere distinctly preserved. The trisegmented, reasonably narrow axis is outlined by narrow, moderately deep furrows. It extends almost the full length of the acrolobe. On some specimens there are two poorly defined transverse axial furrows towards the axial anterior. There is a well-developed node on the second axial segment. The posterior axial segment is very slightly expanded. Across the posterolateral corners the axis has a width about one-third that of the pygidium.

Discussion: These specimens are too poorly preserved to be placed with certainty in any genus or species. They are placed questionably in *Agnostus*. The glabellar front of *Agnostus* (?) sp. is slightly angular. The diagnosis of *Agnostus* given by Palmer (1962, p. 12) indicates that the glabellar front should be well rounded. A further point is that in the pygidium of *Agnostus* (?) sp. the axis seems to reach the posterior border in some specimens but not in others. However, a close study of the specimens concerned indicates that the apparent continuation of the axis to the border is due to distortion effects, with the axis stopping just short of the border. In at least one specimen, UT 92552, (pl. 12, fig. 12), the pleural lobes are confluent behind the axis as required by the diagnosis of Agnostus given by Palmer (1962, p. 12).

Occurrence and Age: Agnostus (?) sp. comes from (a) the lower fauna of the siltstone and shale unit exposed in Barkers Creek (Black Hill section, Dundas) at lat. 41°51.3'S, long. 145°26.1'E (grid 3487E, 8463N); and (b) from the upper fauna of the siltstone and shale unit exposed in Barkers Creek (Black Hill section, Dundas) at lat. 41°51.4'S, long. 145°26.1'E (grid 3487E, 8462N); its age is early Upper Cambrian that of the Glyptagnostus solidotus Zone and possibly that of the Cyclagnostus quasivespa Zone.

Genus IDOLAGNOSTUS Öpik, 1967

Idolagnostus Öpik, 1967, p. 104

Diagnosis: See Öpik, 1967, p. 104

Type Species: Idolagnostus agrestis Öpik, 1967, p. 104, pl. 59, figs. 9, 10; pl. 60, figs. 1, 2; pl. 63, fig. 10; text figs. 25, 26.

Idolagnostus sp.

pl. 12, figs. 15-17

Material: Two cephala and four pygidia are known from the FE_1 locality near Dundas. They are all poorly preserved.

Measurements: Cephalon, UT 92553, (E-W distortion), length, about 1.1mm. Pygidium, UT 92555, (N-S distortion), length (including axial half-ring), 1.5mm., width, 1.7mm.

Description: The cephalon and the pygidium are both small. All known specimens have a length of less than 2.0mm.

The cephalon has a moderately wide border with a convex rim and a reasonably deep marginal furrow; the cephalic spines are not clearly visible; the cheeks appear to be smooth; the axial furrows are deep; the deep preglabellar median furrow shallows forward. The trilobate glabella has a very small anterior glabellar segment. The anterior transverse glabellar furrow is of moderate depth and arched strongly to the posterior. The posterior two glabellar segments are elevated well above the anterior segment and the rest of the cephalon. The posterior transcurrent glabellar furrow is placed just to the posterior of the centre of the glabella; it is arched very slightly to the anterior. The preservation is too poor to determine the presence or absence of a glabellar node. The basal lobes are short and wide; they appear to meet behind the glabellar rear. There is no occipital collar as far as can be determined.

The pygidium is not as convex as the cephalon; it is about as wide as it is long. There is a moderately wide border with short border spines placed well forward of the axial rear. The rim is convex and elevated; the marginal furrow is moderately deep. The shoulder furrows are narrow. The articulating half-ring is short (sag.) and elevated; the articulating furrow is narrow and shallow, being deepest at either end.

The axial furrows are wide and deep at the anterior; they shallow to the posterior. The trisegmented axis has no distinct transverse axial furrows. The anterior pair of axial segments are poorly preserved in all cases, but there appears to be a well-developed node on the second axial segment. The axis is slightly constricted at the second axial segment. The posterior axial lobe is slightly expanded; it narrows markedly to a well-rounded posterior and just reaches the marginal furrow. There is a distinct terminal node. At least four pairs of notulae are seen in specimen UT 92555 (pl. 12, fig. 17).

Discussion: Although the preservation of *Idolagnostus* sp. is not suitable for the erection of a new species, it is sufficient to allow a worth-while comparison with the two species described by Öpik (1967).

The available specimens of *Idolagnostus* sp. are about the same size as both *Idolagnostus agrestis* Öpik and *I. dryas* Öpik. *Idolagnostus* sp. has pygidial border spines, a feature not seen in *I. agrestis*. The pygidium of *I. dryas* is not described by Öpik (1967). *Idolagnostus* sp. further differs from *I. agrestis* in that it does not appear to have an occipital collar on the cephalon and the preglabellar median furrow is not as deep as that of *I. agrestis*. There is a distinct terminal pygidial axial node in *Idolagnostus* sp. as well as well-developed notulae. Both features are also present in *I. agrestis*. *Idolagnostus* sp. has a well-rounded glabellar front, in marked contrast to the distinctly angular glabellar front of *I. dryas*. The posterior transverse glabellar furrow of *Idolagnostus* sp. is placed further to the posterior than that of *I. dryas*.

Idolagnostus sp. is thus clearly distinguished from both of the described species. Better material is required before a new species can be erected.

Occurrence and Age: *Idolagnostus* sp. is found in the Brewery Junction Formation at lat. 41°52.8'S, long. 145°25.0'E (grid 3471E, 8434N) (FE_1 fauna); its age is early Upper Cambrian, probably that of the *Glyptagnostus stolidotus* Zone.

Genus GERAGNOSTUS Howell, 1935

Synonymy: See Palmer, 1968, p. 23.

Type Species: *Agnostus sidenbladhi* Linnarsson, 1869, p. 82, pl. 2, figs. 60, 61.

Discussion: Time did not allow a detailed study to be made of the three species illustrated as *Geragnostus* sp. 1 (pl. 13, figs. 1-6), *Geragnostus* sp. 2 (pl. 13, figs. 7, 8) and *Geragnostus* sp. 3 (pl. 13, fig. 9). In these circumstances no generic discussion is given herein.

Geragnostus sp. 1 differs from *G.* sp. 2 and *G.* sp. 3 in that the margins of the pygidium of *G.* sp. 1 diverge to the posterior, whereas those of *G.* sp. 2 and *G.* sp. 3 converge to the posterior. *Geragnostus* sp. 1 is by far the most common of these three species from the Birch Inlet fauna. The cephala included in *G.* sp. 1 are those in which the margins diverge to the anterior. No cephala can be definitely included in either *G.* sp. 2 or *G.* sp. 3. *Geragnostus* sp. 3 differs from *G.* sp. 2 in that there is a single node on the second axial segment of the former and a distinct ridge along both the first and second axial segments of the latter.

Occurrence and Age: These species come from west of Birch Inlet from near lat. 42°27.2'S, long. 145°21.1'E (grid 3417E, 7735N); their age is late Upper Cambrian with *Geragnostus* sp. 1 and *G.* sp. 3 being of *Prosaukia-Ptychaspis* Zone and *G.* sp. 2 probably of the *Conaspis* Zone.

Genus ACMARHACHIS Resser, 1938

Acmarhachis Resser, 1938, p. 47; Howell, 1959, p. 173; Palmer, 1962, p. 19; 1968, p. 28.

Type Species: *Acmarchachis typicalis* Resser, 1938, p. 47, pl. 10, figs. 4, 5.

Diagnosis: The cephalon has a well-defined bilobed glabella. There may be a shallow preglabellar median furrow present. The glabellar rear is well rounded; the basal lobes are small, and the cephalic border is narrow. The transverse glabellar furrow is arched gently to the posterior.

The pygidium has a trisegmented well-defined axis, which is constricted at the second segment. Both the longitudinal axial furrows and the transverse axial furrows are well developed. There is a well-developed node on the second axial segment. The large posterior axial segment is somewhat expanded. The axis either reaches or almost reaches the posterior border. The narrow, well-defined border bears a pair of short border spines.

Discussion: Palmer (1962, p. 19 and 1968, p. 28) has maintained that *Acmarhachis* Resser, *Oedorhachis* Resser and *Cyclagnostus* Lermontova are synonyms and furthermore belong in the Pseudagnostidae. However, in a lengthy discussion Öpik (1967, p. 108) has noted that *Oedorhachis* belongs in the Diplagnostidae, while *Acmarhachis* and *Cyclagnostus* belong in the Agnostidae. He concluded that due to insufficient descriptions of the type material, the question of the synonymy of *Acmarhachis* and *Cyclagnostus* could not be resolved, and he continued to treat them as separate genera until further information on the type material becomes available. The writer agrees with Öpik's conclusions.

If *Acmarhachis* and *Cyclagnostus* are to remain separate genera, then the writer considers that *Acmarhachis* sp. of Shaw (1952, p. 481) should be retained in *Acmarhachis* rather than placed in *Cyclagnostus* as suggested by Öpik (1967, p. 108). The sharply rounded pygidial axis of *Acmarhachis* sp. of Shaw seems much closer to that of *A. typicalis* as illustrated by Resser (1938, pl. 10, fig. 5) than to the much more broadly rounded axis of *Cyclagnostus elegans* as illustrated by Lermontova (1940, pl. 49, fig. 10a).

Because the writer disagrees with the concept of *Acmarhachis* of Palmer (1962), a new generic diagnosis is given above. Resser's original diagnosis is entirely inadequate.

Acmarhachis sp.

pl. 13, fig. 10

Material and Measurements: One poorly preserved pygidium, UT 92564, (N-S distortion), length (without axial half-ring), 0.8mm., width, 1.5mm.

Description: The moderately convex pygidium is probably about as wide as it is long. There is a narrow, moderately deep marginal furrow and a narrow, convex rim. The presence or absence of border spines cannot be determined. The shoulder regions and the articulating device are poorly preserved. The trisegmented axis extends the full length of the acrolobe. It is outlined by narrow, moderately deep furrows. Each of the anterior pair of axial segments has about the same length (sag.). They are outlined by distinct transverse axial furrows. There is probably a small node at the centre of the second axial segment. The combined length (sag.) of the two anterior segments is about 0.3 that of the axis. The posterior axial lobe is slightly expanded, being widest just to the anterior of its centre. The sharply pointed axial rear just reaches the marginal furrow and separates the pleural areas. The presence or absence of a terminal axial node, or of pleural caecae, cannot be determined due to the deformation of the pygidium.

Discussion: This pygidium is tentatively referred to as *Acmarhachis* sp. This is because it has a sharp pygidial posterior, rather similar to that of *A. typicalis* Resser, and quite dissimilar to the well-rounded pygidial posterior of *Cyclagnostus elegans* Lermontova. The pygidial axis of *Acmarhachis* sp. is much narrower than that of any described species of either *Acmarhachis* or *Cyclagnostus*. *Acmarhachis* sp. may or may not have border spines. Until better material is available no more comment can be made.

Occurrence and Age: *Acmarhachis* sp. comes from the upper fauna of the siltstone and shale unit exposed in Barkers Creek (Black Hill section, Dundas) at lat. 41°51.4'S, long. 145°26.1'E (grid 3487E, 8462N); its age is early Upper Cambrian, that of the *Glyptagnostus stolidotus* Zone.

Genus CYCLAGNOSTUS Lermontova, 1940

Cyclagnostus Lermontova, 1940, p. 126; Howell, 1959, p. 182; Pokrovskaya, 1960a, p. 58; Öpik, 1967, p. 107. (non Hupé 1953, p. 65.)

Type Species: Cyclagnostus elegans Lermontova, 1940, p. 127, pl. 49, figs. 10, 10a.

Diagnosis: See Öpik, 1967, p. 109.

cf. Cyclagnostus sp.

pl. 13, figs. 11, 12

The only available specimen, UT 92565, is a considerably distorted pygidium known from both the internal and the external mould. It is best compared with Cyclagnostus. The broadly rounded pygidial axis reaches the border. The border spines appear to be quite long in the photograph (pl. 13, fig. 12), but it is difficult to be sure of what is spine and what is rock in the specimen. The pygidium seems to differ from Cyclagnostus in that the anterior transverse axial furrow is only weakly outlined. Until much better material is available, no definite generic or specific assignation can be made.

Occurrence and Age: cf. Cyclagnostus sp. comes from the lower fauna of the siltstone and shale unit exposed in Barkers Creek (Black Hill section, Dundas) at lat. 41°51.3'S, long. 145°26.1'E (grid 3487E, 8463N); its age is early Upper Cambrian, possibly that of the Cyclagnostus quasivespa Zone.

Genus LOTAGNOSTUS Whitehouse, 1936

Synonymy: See Palmer, 1968, p. 25.

Type Species: Agnostus trisectus Salter, 1864, p. 10, pl. 1, fig. 11.

Diagnosis: Palmer (1955, p. 91) and Öpik (1963, p. 54) have both satisfactorily diagnosed *Lotagnostus*.

Discussion: Palmer (1955) and Öpik (1963) have discussed the generic concept of *Lotagnostus* in some detail. Also Öpik (1967, p. 67) has commented on the three annulations in the anterior part of the pygidial axis.

Öpik (1966, p. 12) has noted the importance of *Lotagnostus* in inter-regional correlation. The genus is known from Sweden, Scotland, Siberia, Kazakhstan, Quebec, Vermont, Alaska, China, and Argentina. It is recorded now from Tasmania and Australia for the first time. The age of *Lotagnostus* throughout the world appears to be that of the *Prosaukia-Ptychaspis* Zone, i.e., the uppermost zone of the Franconian on the North American time-scale.

It should be noted that *Goniagnostus atenuatus* Rusconi, 1955 belongs in *Lotagnostus*. This was found by inspection of rubber casts of this species obtained from Dr. B. Daily. These casts (Nos. Rusconi 18208, 18209) included the holotype (specimen 18208) and are figured here as pl. 19, figs. 1 and 2 respectively.

Lotagnostus sp. aff. *L. trisectus* (Salter)

pl. 13, figs. 13-19

Synonymy: See Rasetti, 1959, p. 381.

Material: All the material is poorly to moderately well preserved. One almost complete and several individual cephala and pygidia are available for description.

Measurements: Complete specimen, UT 92566, internal mould, total length, 7.9mm.; cephalon, length, 3.4mm., width, 3.6mm.; pygidium, length (without articulating half-ring), 3.2mm., width, 3.8mm. Cephalon, UT 92567, internal mould, length, 5.5mm., width, 6.1mm. Pygidium, UT 92568, length (including axial half-ring), 4.3mm.

Description: The moderately convex cephalon is slightly wider than it is long. There is a narrow, shallow marginal furrow and a narrow, convex border. There is a well-developed preglabellar median furrow. The posterolateral corners are nowhere visible. There are closely spaced, shallow scrobiculae covering the cheeks. The glabella is outlined by narrow, moderately deep furrows. It has a length between 0.7 and 0.75 that of the cephalon. The glabellar front is slightly angular. The basal lobes are large, simple and extend about half the distance to the transverse glabellar furrow. The shallow, narrow, transverse glabellar furrow is broadly arched to the posterior. The large anterior glabellar segment has a length about one-third that of the glabella. Toward the anterior of the posterior glabellar segment, there is a pair of lateral furrows which are directed inwards and forwards and delineate a pair of lateral glabellar lobes. These lobes bulge slightly into the cheeks. Extending from between these lobes towards the glabellar posterior is a wide keel which stops well short of the broadly rounded glabellar rear.

The pygidium is slightly wider than it is long. There is a narrow, shallow marginal furrow and a narrow, convex rim. Short border spines are placed opposite, or just to the anterior of, the axial rear. There are narrow, shallow shoulder furrows and narrow, convex shoulders. The fulcra are close to the axis; the facets are not visible. The large, convex articulating half-ring extends across the wide axial anterior.

The pleural fields are covered with closely spaced, apparently irregular scrobiculae. The longitudinally trifid pygidial axis does not reach the marginal furrow. It has a length about 0.75 that of the pygidium. The anterior part of the axis consists of three segments; the posterior lobe has a length about 0.6 that of the axis. Two of the three transverse axial furrows are well developed, but the furrow between the second and third segments is very shallow.

The anterior axial segment consists of a prominent central region, and two larger lateral lobules with distinct longitudinal furrows separating the central from the lateral regions. The axis narrows along the first axial segment. The anterior transverse axial furrow extends faintly across the central ridge. The second and third segments, taken together, are a little longer (sag.) than the first segment. In both these segments there is a distinct central ridge which rises to a distinct node on the third segment. The very shallow second transverse furrow does not extend across this ridge; the third transverse furrow does extend across the central ridge.

Immediately to the posterior of the third posterior axial furrow, the posterior axial lobe expands slightly before contracting to the axial rear. There is no post-axial median furrow. The intranotular axis is very well defined by narrow, moderately deep, notular furrows. It is widest a little distance from the anterior of the lobe, tapers slightly to the axial rear, and extends very slightly to the posterior of the extranotular axis to give a slightly pointed appearance to the axial rear.

Discussion: This species appears to be closely related to *Lotagnostus trisectus* (Salter) and is referred to as *Lotagnostus* sp. aff. *L. trisectus* (Salter). It differs from *L. trisectus* in that the glabellar front of the latter is more angular and the pygidial node of *trisectus* is narrower and more prominent than the Tasmanian form. The third pygidial axial segment of *L. trisectus* is more prominent than that of *L.* sp. aff. *L. trisectus*.

Occurrence and Age: *Lotagnostus* sp. aff. *L. trisectus* (Salter) comes from west of Birch Inlet from near lat. 42°27.2'S, long. 145°21.1'E (grid 3417E, 7735N); its age is Upper Cambrian, *Prosaukia*-*Ptychaspis* Zone.

?Lotagnostus sp.

pl. 14, fig. 1

Only one large cephalon, UT 92571, is known. It is a poorly preserved internal mould, (length, 4.7mm., width, 7.3mm.), which has undergone N-S distortion. There is a narrow, shallow marginal furrow and a flat, moderately wide rim. The little of the acrolobe that is preserved shows strong scrobiculation.

This cephalon could possibly belong in Lotagnostus Whitehouse, Xestagnostus Öpik, or Agnostus Brongniart. It is placed questionably in Lotagnostus until more specimens are known.

Occurrence and Age: ?Lotagnostus sp. comes from about 145 metres below the top of the Climie Formation at lat. 41°54.2'S, long. 145° 24.2'E (grid 3459E, 8406N); its age is late Upper Cambrian (zone indeterminate).

Family CLAVAGNOSTIDAE Howell, 1937

Subfamily CLAVAGNOSTINAE Howell, 1937

Genus CLAVAGNOSTUS Howell, 1937

Clavagnostus Howell, 1937, p. 1164; 1959, p. 174; Kobayashi, 1939, p. 120; 1943, p. 307; Lermontova, 1940, p. 129; Westergård, 1946, p. 55; Hupé, 1953, p. 64; Pokrovskaya, 1960a, p. 59; 1960b, p. 161; Öpik, 1967, p. 114.

Tomorhachis Resser, 1938, p. 51.

Culipagnostus Rusconi, 1952, p. 11.

Type Species: _Agnostus_ _repandus_ Westergård _in_ Holm and Westergård, 1930, p. 13, pl. 1, figs. 35-39, (40-43?); pl. 4, figs. 11, 12.

Diagnosis: The cephalon has a glabella with no transverse glabellar furrow. The cephalic cheeks are smooth. Long or short cephalic spines are present. There is usually an anterocentrally placed, small glabellar node. The simplimarginate pygidium has a long lanceolate axis. To the posterior of the axial centre is a pair of low pits (the "clavagnostid pits"). On the anterior part of the axis the transverse axial furrows are effaced. A low rounded longitudinal ridge extends along most of the anterior part of the axis. The posterior part of the axis is more depressed than the elevated anterior part. The border spines are short to long.

Discussion: Öpik (1967, p. 113) recognizes two separate genera in the different species described as _Clavagnostus_, with _C_. _repandus_ (Westergård, 1930) and _C_. _sulcatus_ Westergård, 1946 representing the different genera. The writer agrees with Öpik in differentiating these species into separate groups. However, there seems to be a third group of species which could be placed in _Clavagnostus_ and which is intermediate between the forms represented by _C_. _sulcatus_ and _C_. _repandus_. This third group is represented by _C_. _burnsi_ sp. nov. from Riana. It is characterized by a pygidium similar to that of C. repandus and a cephalon similar to that of the C. sulcatus group.

The described species of Clavagnostus can be placed in three groups.

I. The C. repandus group which is characterized by a rounded glabellar front, no preglabellar median furrow, and a blunt pygidial axis which reaches the posterior border (see pl. 14, figs. 16, 17). The known members of this group are C. repandus and C. milli sp. nov.

II. The C. burnsi group which is characterized by an angular glabellar front, a preglabellar median furrow and a blunt pygidial axis which reaches the posterior border. C. burnsi sp. nov. and possibly C. rawlingi sp. nov. and C. chipiquensis (Rusconi) are members of this group. C. rawlingi is included with hesitation because of the lack of certainty as to whether or not the cephalon and pygidium described in this species are, in fact, conspecific (see description of C. rawlingi). The pygidium of C. chipiquensis (Rusconi) illustrated by Poulsen, 1960 (p. 1, fig. 14), is similar to that of C. repandus and C. burnsi (see pl. 14, fig. 19). The cephalon of chipiquensis is not described by Poulsen. However, the pygidium figured by Poulsen (op. cit., pl. 1, fig. 13) as Peronopsis ultima appears to be a Clavagnostus cephalon. An inspection of a rubber cast (U.S. 595) of the specimen figured by Poulsen reveals the presence of a basal lobe (the other one is not preserved) and traces of long cephalic spines (see pl. 14, fig. 18, herein). The glabellar front is pointed, and there is a preglabellar median furrow. This cephalon (U.S. 595) is similar to that of _C. burnsi_ sp. nov. and may be the cephalon of _C. chipiquensis_.

III. The _C. sulcatus_ group of species is characterized by a preglabellar median furrow and a pointed pygidial axis. The group includes _C. sulcatus_ Westergård, 1946, _C. bisectus_ Öpik, 1967, _C. repandiformis_ Kobayashi, 1943, _C. ovalis_ Pokrovskaya, 1960b, _C. aequalis_ Howell, 1937 and probably _Tomorhachis spinosa_ Resser, 1938. The last two species are known only from their pygidia. The species with known cephala have angular glabellar fronts with the exception of _ovalis_ which has a rounded or subangular glabellar front. _C. sulcatus_ differs from other members of the group by having a pointed cephalic front (see pl. 14, figs. 14, 15). _C. repandiformis_ has very long cephalic and pygidial spines. No photograph of _C. ovalis_ is available, but the diagram given by Pokrovskaya (1960b, p. 161, ill. 44) shows that the pygidial axis extends to the border. In other species in the _C. sulcatus_ group the pygidial axis stops short of the border.

The different combination of characters noted above in groups I, II, and III and the variation within the groups emphasizes the close and gradational relationship of all the species discussed above. The discovery of _C. burnsi_, intermediate between the _C. repandus_ and _C._

sulcatus groups raises the question of whether or not these groups belong in separate genera as suggested by Öpik (1967, p. 113). As noted by Öpik (1967, p. 114), if the as yet unknown cephalon of *Tomorhachis spinosa* is found to be similar to those of the *C. sulcatus* group, then the species of this group could be placed in the genus *Tomorhachis*. It would also be possible to erect a new genus to accommodate members of the *C. burnsi* group and have a total of three genera for the species discussed above. However, in view of the close and gradational relationship between the three groups, additional generic names seem unwarranted. The author considers that all the species noted above should be included in the single genus *Clavagnostus*.

Clavagnostus milli sp. nov.

pl. 15, figs. 1-6

Material: Four cephala and four pygidia are used for descriptive purposes. A few other specimens of this rare species are known.

Measurements: UT 86860b, the holotype cephalon, (N-S distortion), length, 1.7mm., width, about 2.1mm. UT 86607, pygidium (N-S distortion), length (including axial half-ring), 2.3mm., width, 2.9mm.

Selection of Holotype: The best preserved cephalon, UT 86860b (pl. 15, fig. 1), is selected as the holotype.

Diagnosis: *C. milli* is a species with very long, markedly divergent cephalic spines. The cephalon has an angular glabellar rear, a well-rounded glabellar front and an anteriorly placed glabellar node but no preglabellar median furrow. The pygidial border spines are long; the pygidial axis is wide and extends onto the pygidial border. The pygidium is simplimarginate.

Description: The markedly convex cephalon is about as wide as it is long. There is a moderately wide, convex, elevated rim and a narrow, shallow marginal furrow. There is no preglabellar median furrow. The spines are very long, diverge markedly and arise from broad tumid bases. The glabella has a length between 0.65 and 0.7 that of the cephalon, and at its widest has a width between 0.25 and 0.3 that of the cephalon. The glabella has an elliptical outline and is bounded by narrow, moderately deep glabellar furrows which shallow to the anterior. The glabella is strongly convex and stands out well above the smooth cheeks. The basal lobes are large; there is a narrow connecting band behind the angular glabellar rear. There is a small circular node on the anterior part of the glabella. In front of this node the glabella is somewhat depressed; this depressed area probably represents an anterior glabellar segment. The glabella is widest in the region of the node.

The moderately convex pygidium is probably about as wide as it is long. The lateral borders are of moderate width with a moderately wide, convex, elevated rim and a shallow, marginal furrow. There are long divergent border spines. The posterior border is wide with a narrow posterior marginal furrow and a wide, flatly convex, elevated rim. The shoulder furrows are narrow and shallow; the shoulders are narrow with the fulcra about half-way between the acrolobe margins and the axial furrows. There is a narrow (sag.) convex articulating half-ring. The narrow articulating furrow is shallow at the centre and deepens abaxially. The smooth pleural fields sit well above the border.

The axis, which extends the full length of the acrolobe and protrudes slightly into the border, is outlined by moderately wide and deep axial furrows. The large clavagnostid pits are found about two-thirds of the distance from the anterior to the posterior of the axis. The anterior part of the axis is strongly convex and distinctly elevated above the pleural fields. The posterior part of the axis is very slightly depressed beneath the level of the surrounding pleural regions.

The axis is wide at the anterior (about 0.4 the width of the pygidium); it is very slightly constricted in the region of the second axial segment. From a little distance anterior of the pits, the axial furrows are straight and converge evenly to the posterior marginal furrow. The posterior of the axis has a width about 0.2 to 0.25 that of the distance between the border spines. On the anterior part of the axis there is a prominent, centrally placed, elongated node or keel. There is no sign of transverse axial furrows on the anterior part of the axis.

Discussion: Clavagnostus milli is closest to C. repandus of the described species of Clavagnostus. The long cephalic and pygidial spines distinguish milli from repandus. The pygidium of C. chipiquensis (Rusconi), illustrated by Poulsen, 1960 (pl. 1, fig. 14), is similar to that of milli. The axis of milli seems to be wider in relation to the width of the acrolobe than that of chipiquensis. As noted above (p. 244), the cephalon of C. chipiquensis may be the specimen described by Poulsen as Peronopsis ultima. If this is so, then C. chipiquensis is in the C. burnsi group of species whereas C. milli is in the C. repandus group of species.

Occurrence and Age: Clavagnostus milli sp. nov. comes from the lower fauna at Christmas Hills (lat. 40°54.1'S, long. 144°29.8'E; grid 3075E, 9610N); its age is late Middle Cambrian, probably of the Lejopyge laevigata I Zone.

Clavagnostus burnsi sp. nov.

pl. 15, figs. 7-16

Material: Most of the Riana material comes from an approximately 5mm. thickness of sediment (see p. 74). In this 5mm. layer of sediment, nine pygidia assignable to Clavagnostus and ten pygidia assignable to Aspidagnostus were collected by the author. At the same level a total of fifteen cephala of either Clavagnostus or Aspidagnostus were collected. None of the cephala found at Riana have a pointed cephalic front as in previously described species of Aspidagnostus. However, it seems reasonable to assume that in those fifteen cephala there should be representatives of both Aspidagnostus and Clavagnostus. One basis of separation that is used by the author is the fact that in all published species of Aspidagnostus the glabella widens slightly to the anterior and is widest toward the anterior although the glabella of Aspidagnostus sp. 2, noted below, narrows forward. On the other hand, the widest part of a Clavagnostus glabella is toward the glabellar posterior. Another factor taken into account is that the pygidia of Clavagnostus at Riana have long, thin spines, whereas the pygidia of Aspidagnostus at Riana have short spines. Some of the cephala at Riana exhibit long, thin spines and these seem to belong to Clavagnostus.

Measurements: Cephala: UT 92584, (holotype, intermediate distortion), length, 1.1mm., width, about 1.0mm.; UT 92600, (E-W distortion), length, 2.2mm., width, about 1.6mm. Pygidia: UT 92584, (N-S distortion), length (without axial half-ring), 1.2mm.; UT 92585, (intermediate distortion), length (including axial half-ring), 1.3mm.

Selection of Holotype: The cephalon, UT 92584, figured as pl. 15, fig. 9, is selected as the holotype.

Diagnosis: The strongly convex cephalon has a pointed glabellar front and an angular glabellar rear. There is a narrow, shallow marginal furrow and a moderately wide, elevated rim. The preglabellar median furrow shallows toward the anterior and does not always reach the marginal furrow. The cephalic spines are long and thin.

The moderately convex pygidium has a narrow, shallow marginal furrow and a moderately wide, convex, elevated rim. The posterior rim is wider than the lateral rims. The border spines are long and thin. The lanceolate axis extends to the posterior border; the narrow axial rear is bluntly rounded. There is a shallow pair of clavagnostid pits in the posterior part of the axis, which is depressed below the level of the smooth pleural areas. There is an elongated ridge extending along the centre of the elevated anterior part of the axis.

Description: The small, strongly convex cephalon has steep acrolobe margins. The border is composed of a narrow, shallow marginal furrow and a moderately wide, elevated rim. The border narrows slightly to the posterior. A pair of long, thin spines emerge from low on the posterolateral corners.

The glabella is outlined by narrow, moderately deep furrows. The cheeks are smooth; they are divided in front by a preglabellar median furrow which is moderately deep at the posterior but shallows to the anterior and does not always meet the marginal furrow. In some of the figured specimens the convexity of the cephalic acrolobe obscures the fading of the preglabellar median furrow. In some specimens it tends to widen slightly at the anterior. The glabella has a length about 0.65

that of the cephalon. The glabellar rear is angular. The basal lobes are small, simple and unconnected. The narrow glabella is widest just in front of the basal lobes where it is about 0.4 to 0.45 the width of the cephalon. From its widest point the glabella narrows gradually to a sharply pointed front; the glabella has an overall elongated tear-drop outline. There is an anterocentrally placed, low, elongated node on the glabella, apart from which the glabella is smooth.

The moderately convex pygidium is about as wide as it is long. The moderately wide border is composed of a narrow, shallow marginal furrow and a moderately wide, convex, elevated rim. The posterior rim is a little wider than the lateral rims which narrow to the anterior. The border spines are long and thin. The shoulder furrows are continuous with the marginal furrows; the shoulders are convex and elevated; the fulcra occur just abaxial to the midpoint between the axial furrows and the anterolateral corners. The articulating device is nowhere well preserved. The pleural areas are probably smooth. (They look pitted in some specimens, but this is due to distortion, and the apparent pits are not consistent.) The axis extends the entire length of the acrolobe; it is outlined by narrow, moderately deep axial furrows. There is no sign of transverse axial furrows. The clavagnostid pits occur at the posterior of the axis about 0.65 to 0.70 the distance from the anterior to the posterior of the axis. The posterior part of the axis is depressed below the level of the pleural areas; the anterior part of the axis stands out somewhat above the pleural areas. There is an elongated ridge extending along the centre of the anterior part of the axis.

Discussion: The position of Clavagnostus burnsi in relation to other species of Clavagnostus is discussed above (p. 243). If, in fact, as suggested above, the specimen figured by Poulsen (1960, pl. 1, fig. 13) as the pygidium of Peronopsis ultima is the cephalon of C. chipiquensis, (Rusconi), then this is the nearest species to C. burnsi. The cephala are very similar. However, the pygidial spines of C. burnsi are larger than those of chipiquensis. The bluntly rounded pygidial axial rear of chipiquensis is wider than the rather narrow axial rear of burnsi. The clavagnostid pits of C. burnsi are placed slightly more to the posterior than those of C. chipiquensis. The differences between C. burnsi and C. rawlingi sp. nov. are noted in the discussion of rawlingi.

Occurrence and Age: Clavagnostus burnsi sp. nov. comes from the upper sedimentary sequence of the Radfords Creek Group as exposed near Riana in a quarry at lat. 41°13.0'S, long. 146°00.2'E (grid 4004E, 9240N) and also within 120 metres of the base of the Junee Group at lat. 41°12.7'S, long. 146°00.0'E (grid 4000E, 9250N); its age is early Upper Cambrian, Mindyallan Stage.

Clavagnostus rawlingi sp. nov.

pl. 15, figs. 17, 18

Material: One cephalon, UT 92719, and one pygidium, UT 92727, from the same locality near St. Valentines Peak are provisionally placed in the same species. The pygidium has slightly pitted pleural areas, a feature not seen in other species of Clavagnostus; however, the other characters of the pygidium indicate that it belongs to Clavagnostus. The single-lobed glabella of specimen UT 92719 narrows towards the anterior in contrast to the normal forward expansion of the glabella of Aspidagnostus, which is the other possible generic designation of this cephalon. It is thus placed in Clavagnostus. Since these two specimens are the only known representatives of Clavagnostus from this locality, they are referred to the same species.

Measurements: Cephalon, UT 92719, (N-S distortion), length, 1.5mm., width, 1.9mm. Pygidium, UT 92727, (E-W distortion), length (including axial half-ring), 1.8mm., width, 1.6mm.

Selection of Holotype: The pygidium, UT 92727 (pl. 15, fig. 18), is selected as holotype because of the pitted pleural areas, a feature unique in Clavagnostus.

Diagnosis: The cephalon has a long, narrow glabella with a rounded or subrounded rear and a pointed front. There is a well-developed preglabellar median furrow. The pygidium has a wide, posterior margin; the axis is slightly shorter than the pleural areas. The clavagnostid pits consist of a pair of elongated furrows, the posterior ends of which connect with the axial furrows. There is a wide, elongated ridge on the anterior part of the axis. The pleural areas are gently pitted near the marginal furrow in the posterior part of the pygidium.

Description: The cephalon is about as wide as it is long. There is a narrow, moderately deep, marginal furrow and a convex, elevated, moderately wide rim. The posterior furrows are wide and deep at the margins becoming shallower adaxially and if they reach the glabellar furrows, they do so faintly. The posterior rims are wide, elevated and convex; they narrow adaxially. The posterolateral spines are not visible; the one spine base present is large. The basal lobes, which are connected behind the rounded (or subrounded) glabellar rear, are not clearly outlined and appear to merge with the cheeks. There are pits and depressions on the cheeks of the single available cephalon, but it cannot be determined whether or not these are natural or due to distortion. The glabella is long (about 0.7 the length of the cephalon) and narrow (about 0.2 the width of the cephalon at the widest part of the glabella). The glabella is outlined by narrow, moderately deep, glabellar furrows. The preglabellar median furrow is moderately wide and deep; it extends to the marginal furrow. The glabella has an elongated spear head outline with a pointed front. There is a large, centrally placed, elongated node which reaches its maximum elevation at its anterior.

The pygidium has a wide posterior border between short, thick, elevated border spines. The marginal furrow is narrow and shallow. The rim is wide and gently convex between the spines, with a short median region which extends forward to meet the axis. The lateral rims narrow to the anterior. The shoulder and marginal furrows are continuous. The shoulders are narrow and convex; neither the facets nor the fulcra are clearly visible. The articulating furrow is narrow and shallow and is gently concave to the anterior. The articulating half-ring is narrow (sag.) and has an elongated lens-shaped outline. The pleural areas are gently pitted close to the marginal furrow in the central and posterior parts of the pygidium. The axis does not extend as far to the posterior as do the pleural areas; it has a wide, straight posterior margin. No transverse furrows are visible on the anterior part of the axis. The axial furrows are narrow and deep; from the anterior they converge gradually to the position (0.25 of the length along the axis) where the axis is about 0.25 the width of the pygidium. From this constriction the furrows diverge until the axis is widest at about its midpoint, where it is about 0.3 the width of the pygidium. To the posterior of the widest point the axial furrows are straight and converge to the axial posterior where the axis has a width about 0.1 that of the pygidium. There is a strongly elevated median ridge (about one-third the width of the axis) which is most prominent between the anterior waist and the widest part of the axis but which also extends forward less conspicuously to the articulating furrow. The ridge is widest at the constriction of the axis. Two deep longitudinally elongated clavagnostid pits occur in the posterior part of the axis. From their anteriors the pits are curved abaxially (arched adaxially) to join the axial furrows about 0.8 of the distance from the anterior to the posterior of the axis. There is a moderately deep, transverse furrow across the anterior end of the pits.

Discussion: As noted in the generic discussion, Clavagnostus rawlingi may belong in the C. burnsi group of species. C. rawlingi differs from all known species of Clavagnostus in that the pygidial pleural areas are slightly pitted. The elongated nature of the clavagnostid pits also distinguishes C. rawlingi from other species of Clavagnostus. The width of the glabella in relation to that of the cephalon is less in rawlingi than in other species of Clavagnostus. The pygidial spines and pygidial axis of rawlingi are shorter than those of either C. chipiquensis (Rusconi) or C. burnsi sp. nov.

Occurrence and Age: Clavagnostus rawlingi sp. nov. comes from the main fauna in the St. Valentines Peak area near lat. 41°21.6'S, long. 145° 44.3'E (grid 3758E, 9064N); its age is either late Middle Cambrian Lejopyge laevigata III Zone or the Middle Cambrian/Upper Cambrian Passage Zone.

Clavagnostus sp. 1

pl. 15, fig. 19

Material: One reasonably well-preserved, partial pygidium (UT 86872i) is available.

Description: This specimen is moderately convex and has undergone N-S distortion. It has an exposed length of 1.0mm.; this would be close to the complete length. There is a moderately wide, gently convex rim and a narrow, shallow marginal furrow. There are long, well-developed border spines. The shoulder areas are not visible. The articulating device consists of a narrow (sag.), convex articulating half-ring which extends almost the full width of the axis. The articulating furrow is narrow and shallow.

The anterior part of the pygidial axis (in front of the clavagnostid pits) stands out well above the smooth pleural areas. At the pygidial anterior the axis has a width about 0.3 that of the pygidium. The axis is outlined by narrow, shallow furrows; it does not extend as far to the posterior as do the pleural fields. The clavagnostid pits are poorly outlined; they appear toward the posterior of the axis about 0.75 of the distance along the axis. On the anterior part of the axis is a long, centrally placed ridge.

Discussion: As only one specimen is known, this pygidium is referred to *Clavagnostus* sp. 1. It differs from *C. milli* in that (a) the axis of *Clavagnostus* sp. 1 does not extend to the posterior border, whereas that of *C. milli* extends slightly onto the border and (b) the pits of *Clavagnostus* sp. 1 are placed more to the posterior than those of *C. milli*.

Occurrence and Age: *Clavagnostus* sp. 1 comes from the upper fauna at Christmas Hills (lat. 40°54.1'S, long. 144°29.8'E; grid 3075E, 9610N); its age is late Middle Cambrian, either of the *Lejopyge laevigata* I Zone or the *L. laevigata* II Zone.

Clavagnostus sp. 2

pl. 15, fig. 20

Material and measurements: One poorly preserved pygidium, UT 92601 of length, (including articulating half-ring), 1.4mm. is available.

Description: The moderately convex pygidium is about as wide as it is long. The border is composed of a narrow, shallow marginal furrow and a wide flatly convex rim. The posterior margin extends slightly forward at its centre to meet the axis. Border spines are present, but the preservation does not allow their size to be determined. The pleural areas are probably smooth. The axis is outlined by wide and deep furrows. The clavagnostid pits are found about 0.65 of the distance from the anterior to the posterior end of the axis. The anterior part of the axis stands out well above the pleural areas, which in turn sit well above the level of the posterior part of the axis. The articulating furrow seems narrow and shallow, with a shallow pit at either end. The articulating half-ring appears narrow (sag.) and gently convex.

Discussion: This specimen is too poorly preserved to assign it to any particular species, and it is referred to *Clavagnostus* sp. 2.

Occurrence and Age: Clavagnostus sp. 2 comes from the lowest fauna exposed along the old timber track on the west side of Sugarloaf Gorge, lat. 41°15.4'S, long. 146°04.2'E. It comes from within the lower sedimentary sequence of the Radfords Creek Group; its age is probably of the late Middle Cambrian, Lejopyge laevigata III Zone or of the Middle Cambrian/Upper Cambrian Passage Zone.

Clavagnostus sp. 3

pl. 16, figs. 1, 2

About six poorly preserved pygidia definitely assignable to Clavagnostus are known from the BJ_2 locality near Dundas. At this locality Aspidagnostus is also known, and it was found difficult to differentiate the cephala of Aspidagnostus and Clavagnostus. One cephalon (on specimen UT 54958) has a pointed cephalic front and is among those assigned to Aspidagnostus sp. 2.

The Clavagnostus from this locality is too poorly preserved to warrant detailed description. It has a pointed pygidial axis which does not extend to the marginal furrow, and the clavagnostid pits are placed close to the posterior of the axis. This Clavagnostus belongs to the C. sulcatus group of species and is referred to as Clavagnostus sp. 3.

Occurrence and Age: Clavagnostus sp. 3 comes from the Brewery Junction Formation at lat. 41°53.0'S, long. 145°25.6'E (grid 3480E, 8429N) (BJ_2

locality); its age is early Upper Cambrian, either of the *Erediaspis eretes* Zone or the *Cyclagnostus quasivespa* Zone.

Clavagnostus sp. 4

pl. 16, fig. 3

Material and Comments: Only one poorly preserved, incomplete cephalon (UT 92604) is available for comment. This specimen, if complete, would have a length of about 3.2mm. It is referred to *Clavagnostus* because of its single lobed glabella which has a well-rounded front.

Occurrence and Age: *Clavagnostus* sp. 4 comes from a black shale at the eastern end of the Summit Cutting of the Comstock tram (lat. 41°53.8'S, long. 145°18.7'E; grid 3374E, 8412N); its age is late Middle Cambrian.

Genus PSEUDOCLAVAGNOSTUS nov.

Type Species: *Pseudoclavagnostus sisponorep* sp. nov.

Diagnosis: The cephalon has a narrow marginal furrow and a narrow rim. The long cephalic spines arise from wide bases. The glabella is single lobed with vestiges of a transverse glabellar furrow. There is no pre-glabellar median furrow. The cheeks are smooth. The pygidium has narrow lateral borders but a moderately wide posterior border between the two long border spines. The pleural areas are smooth. The long, pointed, effaced pygidial axis does not extend to the marginal furrow. There is a short post-axial median furrow. Both the cephalon and the pygidium are strongly convex.

Discussion: The cephalon, with the single lobed, or vestigially bilobed glabella and strong cephalic spines indicates affiliation with the Clavagnostidae. However, Pseudoclavagnostus is placed only tentatively in this family because the pygidial axis shows no sign of the pits so characteristic of all described members of the Clavagnostidae.

The non-zonate pygidium and almost effaced pygidial axis indicate that Pseudoclavagnostus may belong in the Subfamily Clavagnostinae. The pygidium of Pseudoclavagnostus, if considered by itself, could be placed in Peronopsis, i.e., Pseudoclavagnostus could be considered as intermediate between Clavagnostus and Peronopsis.

Pseudoclavagnostus sisponorep sp. nov.

pl. 16, figs. 4-6, 11

Material: Two partially complete agnostids, one individual cephalon and one individual pygidium are available for description. All are reasonably preserved.

Selection of Holotype: The most complete specimen, UT 92698 (pl. 16, fig. 5), is selected as holotype.

Diagnosis: See generic diagnosis.

Measurements: UT 92698, the holotype, (intermediate distortion), total length, about 2.3mm.; cephalon, length, about 0.9mm., width, about 0.8mm.; pygidium, length (without articulating half-ring), 1.1mm., width, 1.3mm.

UT 92699, cephalon, (N-S distortion), length, 1.2mm.; width, 1.2mm.
UT 92686, pygidium, (N-S distortion), length (without articulating half-ring), 1.1mm., width, 1.3mm.

Description: The strongly convex cephalon is about as wide as it is long. There is a narrow, shallow, marginal furrow, and a slightly elevated, narrow convex rim. There are long cephalic spines which arise from wide bases. They extend along the lateral thoracic margins almost to the anterior margin of the pygidium. There is no preglabellar median furrow. (The apparent furrow in both UT 92698 (pl. 16, fig. 5) and UT 92699 (pl. 16, fig. 4) is a distortion feature.) The cheeks are smooth. The glabella is outlined by wide, deep subparallel axial furrows; it has a bluntly rounded front. The glabella has a length about two-thirds that of the cephalon. The basal lobes are small, simple and connected behind the glabellar rear. The posterior portion of the glabella is very high and is greatly elevated above the cheeks and also above the flat anterior third of the glabella, which is below the level of the surrounding cheeks in the three available specimens. The marked change in elevation from the low anterior third of the glabella to the high posterior portion may represent the vestige of a bisegmented glabella. The glabellar rear is not seen clearly in any available specimen. It is either rounded or subangular. The glabellar rear is very steep.

The pygidium is not as strongly convex as the cephalon. It is about as wide as it is long. The marginal furrow is narrow and shallow; the slightly elevated, gently convex rim is moderately wide between the long border spines but narrows to the anterior. There is a small median salient in the pygidial border. The shoulder furrows are narrow and shallow; the shoulders are narrow and convex; the fulcra are not visible. The articulating device is not visible.

The strongly convex pygidial axis stands out strongly above the smooth pleural fields which are separated behind the axis by a short, narrow, shallow post-axial furrow. The axis has no transverse furrows; it is somewhat constricted at the position of a second axial segment. The axial rear is bluntly pointed. The axis has a length about 0.7 that of the pygidium. There is a low, elongated node on the anterior half of the axis.

Occurrence and Age: *Pseudoclavagnostus sisponorep* sp. nov. comes from the main fauna in the St. Valentines Peak area near lat. 41°21.6'S, long. 145°44.3'E (grid 3758E, 9064N); its age is either late Middle Cambrian, *Lejopyge laevigata* III Zone or the Middle Cambrian/Upper Cambrian Passage Zone.

Pseudoclavagnostus (?) *nevel* sp. nov.

pl. 16, figs. 7-10

Material: Two moderately well-preserved cephala (UT 92605, UT 92606), one poorly preserved specimen (UT 92607) which has an associated cephalon and pygidium from the one animal, two poorly preserved cephala (UT 92608, UT 92609) and a poorly preserved pygidium (UT 92610) are available for description.

Selection of Holotype: The best preserved cephalon, UT 92605 (pl. 16, fig. 7) is selected as the holotype.

Diagnosis: The cephalon of this small agnostid has a narrow border with a moderately wide, flat rim and long posterolateral spines. There is no preglabellar median furrow. The basal lobes are small and simple. A vestigial bilobation of the apparently monolobed glabella is outlined by a distinct narrowing of the glabella towards the anterior. The pygidium has a narrow border with two short border spines. The posterior border extends slightly forward at its centre to meet the narrow pointed axis.

Measurements: UT 92605, cephalon, (N-S distortion), length, 1.2mm., width, 1.3mm. UT 92607, cephalon (intermediate distortion), length, 1.1mm., width, about 1.1mm.; pygidium, length, 1.1mm., width, 1.0mm.

Description: The small, moderately convex cephalon is about as wide as it is long. There is a narrow, shallow, marginal furrow and a moderately wide, flat rim. A pair of thick, moderately long posterolateral spines arise from wide bases. The cheeks appear to be smooth. There is no preglabellar furrow. The glabella is outlined by moderately wide and deep furrows; it has a length about two-thirds that of the cephalon.

Between the tips of the short, small, simple basal lobes and about the midpoint of the glabella, the glabella has parallel sides. A vestigial bilobation of the apparently monolobed glabella is outlined by a sharp narrowing of the glabella towards the anterior. At the same point the glabella on some specimens appears to have a faint transverse glabellar furrow, but this is probably due to the effects of distortion. No other glabellar details can be seen except that the glabellar rear is angular.

No pygidium is very well or completely preserved. The markedly convex pygidium is about as wide as it is long. The marginal furrow is narrow and shallow. There are two short border spines between which the posterior rim is wider than the narrow lateral rims. The posterior border extends slightly forward at its centre to meet the narrow pointed axis, which is outlined by moderately wide and deep furrows. The axis has a length about 0.8 that of the pygidium. The pleural fields are smooth. No axial details can be clearly seen. The articulating device is never well preserved, but the articulating furrow has a deep pit at either end.

Discussion: This species is questionably included in *Pseudoclavagnostus*. It is similar to *Pseudoclavagnostus sisponorep* in that it has a "clavagnostid" type cephalon with an apparently monolobed glabella and large cephalic spines associated with a pygidium which has an axis without clavagnostid pits.

Pseudoclavagnostus (?) nevel differs from P. sisponorep in that it has a narrowed glabellar anterior, an angular glabellar rear, shorter pygidial spines and a pygidial axis which reaches the posterior border. The pygidial axis of P. (?) nevel is narrower and is more pointed than that of P. sisponorep.

The cephalon of P. (?) nevel is similar to that of Utagnostus trispinulus Robison (1964a, pl. 82, figs. 21-24) except that the glabella of U. trispinulus has a distinct transverse glabellar furrow. However, the pygidium of Utagnostus has a wide, somewhat expanded, axis and a trispinose margin.

Occurrence and Age: Pseudoclavagnostus (?) nevel sp. nov. comes from Unit 13 of the lower sedimentary sequence of the Radfords Creek Group as exposed along the Gunns Plains Road; its age is late Middle Cambrian, either of the Lejopyge laevigata II Zone or the L. laevigata III Zone.

Pseudoclavagnostus (?) inara sp. nov.

pl. 16, figs. 12-15

Material: Two cephala and two pygidia are available for descriptive purposes.

Measurements: Cephalon, UT 92594, (N-S distortion), length, 0.7mm., width, 0.9mm. Pygidium, UT 92596, holotype (E-W distortion), length (including articulating half-ring), 0.9mm., width, 0.7mm.

Diagnosis: Pseudoclavagnostus (?) inara sp. nov. is a small agnostid with a cephalon which has a narrow monolobed glabella and no preglabellar median furrow. The cheeks are smooth, posterolateral spines are present and the basal lobes are small. There is no distinct glabellar node. The borders of both the cephalon and the pygidium are narrow except for the moderately wide posterior pygidial border. The pygidium has a narrow, tapered axis which extends almost the full length of the acrolobe. Border spines are present. The posterior border has a median salient which extends toward the rounded axial posterior. The axis has no transverse furrows. The articulating half-ring is long (sag.); the articulating furrow is shallow.

Selection of Holotype: The pygidium, UT 92596 (pl. 16, fig. 12), is selected as the holotype.

Description: The cephalon has a narrow, shallow marginal furrow and a narrow, convex rim. Cephalic spines of indeterminate length arise from the posterior border. There is no preglabellar median furrow; the cheeks are smooth. The narrow single-lobed glabella is outlined by narrow, deep axial furrows. The glabella tapers markedly forward to the narrow sharply rounded glabellar front; it has a length about two-thirds that of the cephalon. The glabellar rear is not visible, but it may be broadly rounded. The basal lobes are small. There is no distinct glabellar node.

The pygidium has an overall rectangular shape with outwardly curved margins. It is about as wide as it is long. There is a narrow, shallow marginal furrow and short border spines. Between the spines the convex rim is of moderate width; the lateral rims narrow to the anterior. The posterior border has a small median salient which extends forward toward the axial rear. The shoulder furrows are narrow and shallow; the shoulders are wide and convex; the fulcra are not clearly preserved. The articulating half-ring is slightly wider (tr.) than the axis; it is long (sag.) and narrows only slightly at either end. It is arched forward as is the narrow, shallow articulating furrow.

The pleural fields are smooth and have quite steep lateral margins. The axial furrows are narrow and deep. The narrow axis extends most of the length of the acrolobe. There is a small depression immediately behind the axis formed by the junction of the axial and marginal furrows. The median salient of the rim is much more marked in UT 92595 (pl. 16, fig. 13) than in UT 92596 (pl. 16, fig. 12). The smooth, strongly convex axis has a width about 0.3 that of the pygidium at its anterior and narrows to the posterior. There are no transverse axial furrows. There is a slight expansion of the axis at a point about three-quarters of the distance from the anterior to the posterior of the axis. The posterior 0.2 of the axis is distinctly contracted giving a nipple-like effect to the sharply rounded axial rear. There are no axial nodes.

Discussion: This species is included only questionably in Pseudoclavagnostus, mainly because the pygidial axis is much more tapered than either that of P. sisponorep or P. (?) nevel. However, in common with both these species, P. (?) inara has the combination of a spinose cephalon with a monolobed, or apparently monolobed, glabella associated with a spinose pygidium which has a tapered, long, effaced, non-pitted axis. Pseudoclavagnostus (?) inara differs from both P. sisponorep and P. (?) nevel in that the pygidial axis has a sharp contraction towards its posterior, as well as having a rounded posterior. The cephalic spines of inara, although not fully visible, seem smaller than those of either nevel or sisponorep. The glabella of inara does not show the distinct vestigial bilobation as do those of sisponorep and nevel.

Occurrence and Age: Pseudoclavagnostus (?) inara sp. nov. comes from the upper sedimentary sequence of the Radfords Creek Group as exposed near the quarry at Riana at lat. 41°13.0'S, long. 146°00.2'E (grid 4004E, 9240N); its age is early Upper Cambrian, Mindyallan Stage.

Subfamily ASPIDAGNOSTINAE Pokrovskaya, 1960

Genus ASPIDAGNOSTUS Whitehouse, 1936

Aspidagnostus Whitehouse, 1936, p. 104, (cephalon only); Kobayashi, 1939, p. 164, (cephalon only); Howell, 1959, p. 173, (cephalon only);

Pokrovskaya, 1960a, p. 61, (cephalon only); Palmer, 1962, p. 14; Öpik, 1967, p. 115.

Type Species: Aspidagnostus parmatus Whitehouse, 1936, p. 105, pl. 9, fig. 5 only.

Diagnosis: See Öpik, 1967, p. 116 [except for character (5)].

Aspidagnostus riani sp. nov.

pl. 16, figs. 16-22

Material: Five individual cephala and about ten individual pygidia are available for descriptive purposes.

Measurement: Cephala: UT 92598, (holotype), (N-S distortion), length, 1.0mm.; UT 92598, (intermediate distortion), length, 1.0mm., width, 1.3mm.; UT 92589, length, including axial half-ring, 1.5mm., width, 1.6mm.

Selection of Holotype: The cephalon, UT 92598, figured as pl. 16, fig. 16, is chosen as holotype.

Diagnosis: Aspidagnostus riani sp. nov. has smooth cheeks, an elongated glabellar ridge, simple basal lobes and apparently no median ogive on the anterior cephalic rim. The pygidial pleural areas are smooth; there is no distinct segmentation in the anterior part of the pygidial axis, and there is a strong central keel extending the length of the anterior part of the pygidial axis.

Differential Diagnosis: The lack of a distinct median ogive distinguishes riani from other species of Aspidagnostus. A. riani has smooth cephalic cheeks in contrast to the pitted cheeks of A. stictus Öpik and A. lunulosus (Kryskov) and the shallow, radial furrows of A. rugosus Palmer. A. riani does not have a distinct segmentation in the anterior part of the pygidial axis as do A. inquilinus Öpik and A. stictus Öpik. The glabella of rugosus is shorter than that of riani. The glabellar rear of A. laevis Palmer is much narrower and more extended between the basal lobes than is A. riani.

Description: The small, moderately convex cephalon is about as wide as it is long. The narrow border has a narrow, shallow marginal furrow and a narrow, convex, elevated rim. There may be a median ogive on both cephala in UT 92598, the specimens figured as pl. 16, figs. 16, 17. However, this feature is not seen on other cephala. The moderately long posterolateral spines are wide at the base and arise from the wide, smooth posterior cephalic rim. The spines are directed at an angle of just over 90° to the posterior margin. The single basal lobes are moderately large. The glabella is outlined by wide, deep furrows; the preglabellar median furrow is somewhat variable; it is wide and deep at the posterior but does not always reach the marginal furrow. The glabella is well elevated above the smooth cheeks; it has a length about 0.75 that of the cephalon and has an angular rear. The glabella expands slightly forward for about 0.75 to 0.8 of its length; from the widest point of the glabella the axial furrows converge to the bluntly pointed glabellar front. At its widest the glabella has a width about one-third that of the cephalon. The glabella is smooth with a centrally placed, low ridge extending about half its length. There are no other glabellar details visible. The occipital collar is visible on one internal mould, UT 92594 (pl. 16, fig. 18), where the collar appears as a short extension of the glabella but set well below the level of the glabella. There appears to be an elongated ridge extending from the glabellar rear onto the occipital collar, although this could be due to the effects of distortion. The occipital collar extends slightly to the rear of the posterior of the basal lobes.

The zonate pygidium may be slightly wider than it is long. It has narrow, shallow marginal furrows. The lateral rims are narrow, convex and elevated. There are median-length border spines. The gap in the pygidial collar is deep and narrow. On either side of the gap is a strong knob. Immediately behind the gap is a depressed flange bearing the median spine. At the anterior of this flange between the posterior ends of the collar knobs there is a small but moderately deep pit.

The articulating device consists of a moderately wide, shallow articulating furrow which is arched to the posterior and a short (sag.), elevated articulating half-ring which does not extend the full width of the axis. The shoulder furrows are narrow and shallow; the shoulders are nowhere well preserved. The pleural fields are smooth.

The clavagnostid pits are very deep and occur at the posterior of the axis about two-thirds of the distance from the anterior to the posterior of the axis. The pits are contained in a deep depression which extends right across the axis with only a slight central ridge between the pits. The posterior one-third of the axis is depressed slightly below the pleural fields. The anterior two-thirds of the axis stands well above the pleural fields. There is no distinct differentiation into segments on the anterior part of the axis. A strong, central keel extends the entire length of the axis in front of the pits. The posterior one-third of the anterior part of the axis is depressed slightly, and in this area the keel stands out more clearly than it does further to the anterior.

At the anterior end of the pygidium the axis has a width about 0.45 that of the pygidium. Immediately behind the anterior end of the axis it narrows sharply to give a slight axial constriction; from this constriction the axis widens slightly to about its midpoint from where the axis narrows sharply to the clavagnostid pits. At these pits the axis has a width between 0.25 and 0.3 that of the pygidium. From the clavagnostid pits the axial furrows are straight and converge evenly to the pointed axial posterior. The axis extends the entire length of the acrolobe but does not quite extend as far to the posterior as do the pleural fields.

Discussion: Aspidagnostus riani sp. nov. is placed tentatively in Aspidagnostus. It conforms with Aspidagnostus, as defined by Öpik (1967, p. 116), except that it has no median ogive on the anterior cephalic border, and the basal lobes are simple; on the basis of these differences, it seems unnecessary to the writer to erect a new genus in which to place riani. A further factor is that both A. laevis and and A. rugosus (Palmer, 1962, p. 15) appear to have simple basal lobes. This fact is recognized by Öpik (1967, p. 120, fig. 30) for laevis. This is in contrast to Öpik's statement (op. cit., p. 116) that one of the diagnostic characters of Aspidagnostus is the presence of composite basal lobes. There is a suggestion of a median ogive in both cephala (including the holotype) on specimen UT 92598 (pl. 16, figs. 16, 17), but if present, it is not as well defined as on other species of Aspidagnostus.

Occurrence and Age: Aspidagnostus riani sp. nov. comes from the upper sedimentary sequence of the Radfords Creek Group as exposed in a quarry near Riana at lat. 41°13.0'S, long. 146°00.2'E (grid 4004E, 9240N); its age is early Upper Cambrian, Mindyallan Stage.

Aspidagnostus cf. riani

pl. 17, figs. 1-6

Material: Three cephala and four pygidia are available for description.

Measurements: Cephalon, UT 92731, E-W distortion, length, 1.4mm., width, 1.2mm. Pygidium, UT 92729, N-S distortion, length (including axial half-ring), 1.0mm., width, 1.3mm.

Description: The moderately convex cephalon is about as wide as it is long. There is a narrow, shallow marginal furrow and a narrow, convex rim. The posterolateral corners are not seen properly in any specimen. (The apparent spine in UT 92731 (pl. 17, fig. 2) is an artifact of preservation.) The simple basal lobes are moderately large. The glabella is outlined by wide, deep furrows. The preglabellar median furrow is exceedingly variable in the three available specimens. In specimens UT 92701 (pl. 17, fig. 3) and UT 92731 (pl. 17, fig. 2) there is a well-developed preglabellar median furrow; in specimen UT 92732 (pl. 17, fig. 1) there is hardly any sign of a preglabellar median furrow.

The single lobed glabella is well elevated above the smooth cheeks. The glabellar rear is angular and somewhat drawn out perhaps with an occipital collar, but this feature cannot be seen clearly. The glabella expands slightly forwards for most of its length; the glabellar front is bluntly pointed. There is a centrally placed, low ridge which extends about half the length of the glabella.

The pygidium of A. cf. riani cannot be distinguished from that of A. riani and is not described separately.

Discussion: It is quite possible that the species described above from St. Valentines Peak as Aspidagnostus cf. riani is conspecific with A. riani from Riana. The pygidia of the two forms are indistinguishable.

The cephalon of A. cf. riani from St. Valentines Peak is not as well known as that of A. riani.

The two best preserved cephala of A. cf. riani, UT 92731 (pl. 17, fig. 2) and UT 92732 (pl. 17, fig. 1), have undergone E-W and N-S distortion respectively. It is possible that the apparently well-developed preglabellar median furrow in UT 92731 (pl. 17, fig. 2) is partly due to E-W distortion, but the feature seems to be genuine. On the other hand, UT 92732 (pl. 17, fig. 1), which has undergone N-S distortion, would be expected to show some trace of a preglabellar median furrow, if such a furrow is present in A. cf. riani. This problem will be solved only when more specimens become available. Until the cephalon of A. cf. riani is known better, no specific assignation can be made with surety.

A. cf. riani occurs in a fauna of Lejopyge laevigata III Zone or Middle Cambrian/Upper Cambrian Passage Zone age. It is thus the oldest known species of Aspidagnostus. It is possible that A. cf. riani and A. riani represent ancestral forms of the species of Aspidagnostus, described by Öpik (1967) and Palmer (1962), with the later forms developing a median cephalic ogive.

Occurrence and Age: Aspidagnostus cf. riani comes from the main fauna in the St. Valentines Peak area near lat. 41°21.6'S, long. 145°44.3'E (grid 3758E, 9064N); its age is late Middle Cambrian, the Lejopyge laevigata III Zone, or the Middle Cambrian/Upper Cambrian Passage Zone.

<u>Aspidagnostus</u> sp. 1

pl. 17, figs. 7-10

<u>Material</u>: Two cephala and four pygidia of <u>Aspidagnostus</u> are available for inspection. The best preserved pygidium, UT 92613, has a length of 1.6mm. (including axial half-ring). The material is too poorly preserved to assign it to any known species or to be the basis of a new species. It is referred to as <u>Aspidagnostus</u> sp. 1.

<u>Occurrence and Age</u>: <u>Aspidagnostus</u> sp. 1 is found in (a) the siltstone and shale unit of the Black Hill section Dundas exposed at lat. $41^{o}51.4'$S, long. $145^{o}25.1'$E (grid 3472E, 8462N) (GP_1 locality), and (b) Brewery Junction Formation at lat. $41^{o}52.8'$S, long. $145^{o}25.0'$E (grid 3471E, 8434N)(FE_1 locality); its age is probably early Upper Cambrian, that of the <u>Glyptagnostus</u> <u>stolidotus</u> Zone.

<u>Aspidagnostus</u> sp. 2

pl. 17, figs. 11, 12

Two pygidia and several cephala of <u>Aspidagnostus</u> are known from the BJ_2 locality of the Brewery Junction Formation near Dundas. The specimens are poorly preserved, and a description is not warranted. However, in these specimens, in contrast to those of <u>Aspidagnostus</u> <u>riani</u> sp. nov., the median ogive on the cephalon is clearly visible (e.g., in specimen UT 54958, pl. 17, fig. 12). There appears to be only one species of <u>Aspidagnostus</u> present, and it is referred to <u>Aspidagnostus</u> sp. 2.

Occurrence and Age: Aspidagnostus sp. 2 comes from the Brewery Junction Formation at lat. 41°53.0'S, long. 145°25.6'E (grid 3480E, 3429N); its age is early Upper Cambrian, either of the Erediaspis eretes Zone or the Cyclagnostus quasivespa Zone.

Aspidagnostus sp. 3

pl. 17, fig. 13

Material: One poorly preserved, considerably distorted cephalon (UT 92615) is available. It has a length of 4.0mm.

Description: The border is moderately wide at the anterior but narrows to the posterior. There is a well-defined median ogive at the anterior of the cephalon. The wide posterior border bears a pair of very long spines. The glabellar rear is angular; the glabellar front is angular; the glabella has a length about two-thirds that of the cephalon. The axial furrows are narrow and moderately deep. The preglabellar median furrow is narrow and shallow. There is a narrow, long keel near the anterior end of the glabella. The cheeks appear to be smooth.

Discussion: The very long spines differentiate this specimen from described species of Aspidagnostus. However, the poor preservation of the only known specimen does not allow the erection of a new species. Thus, it is referred to Aspidagnostus sp. 3.

Occurrence and Age: Aspidagnostus sp. 3 comes from the lower fauna of the siltstone and shale unit exposed in Barkers Creek (Black Hill section, Dundas) at lat. 41°51.3'S, long. 145°26.1'E (grid 3487E, 8463N); its age is early Upper Cambrian, possibly that of the Cyclagnostus quasivespa Zone.

Aspidagnostus sp. 4

pl. 17, fig. 14

One poorly preserved partial cephalon, UT 92498, is known. It has a similar appearance to the cephalon of A. riani, but without better preservation no firm assignation can be made. It is referred to Aspidagnostus sp. 4.

Occurrence and Age: Aspidagnostus sp. 4 comes from the lowest fauna exposed along the old timber track on the west side of Sugarloaf Gorge, lat. 41°15.4'S, long. 146°04.2'E. It comes from within the lower sedimentary sequence of the Radfords Creek Group; its age is probably of the late Middle Cambrian, Lejopyge laevigata III Zone or the Middle Cambrian/Upper Cambrian Passage Zone.

Family DIPLAGNOSTIDAE Whitehouse, 1936

Subfamily DIPLAGNOSTINAE

Genus DIPLAGNOSTUS Jaekel, 1909

Diplagnostus Jaekel, 1909, p. 396; Kobayashi, 1939, p. 140; Westergård, 1946, p. 61; Rusconi, 1952, p. 10; Hupé, 1953, p. 63; Howell, 1959, p. 175; Pokrovskaya, 1960a, p. 57; Poulsen, 1960, p. 10; Öpik, 1961a,

p. 413 ff; 1961b, p. 69; 1967, p. 126; Hutchinson, 1962, p. 78; Chu, 1965, p. 135; Poulsen, 1969, p. 4.

Enetagnostus Whitehouse, 1936, p. 91; (non Lermontova, 1940, p. 128)

Type Species: Agnostus planicauda Tullberg, 1880 (non Angelin, 1851).

Diagnosis: See Öpik, 1961b, p. 69.

Discussion: Kobayashi (1939, p. 140) included the following species in Diplagnostus:

Diplagnostus planicauda (Angelin, 1851)

Diplagnostus planicauda vestgothicus (Wallerius, 1895)

Diplagnostus planicauda bilobatus Kobayashi, 1939 (= Agnostus planicauda Tullberg, 1880, figs. 24a, b, non Angelin)

Diplagnostus humilis (Whitehouse, 1936).

Westergård (1946, p. 61) and Öpik (1961b, p. 69) discussed the genus in some detail. Rusconi (1952, p. 10) described a pygidium from Argentina as D. jarillensis. However, the diagram given by Rusconi allows no comparison to be made between jarillensis and other species of Diplagnostus. Poulsen (1960, p. 10) described a single small cephalon from the same locality, but possibly not the same horizon, which he tentatively assigned to D. jarillensis. A rubber cast (Cop. 8) of this specimen (pl. 18, fig. 4) reveals a faint median sulcus on the frontal glabellar segment and a rounded glabellar rear without lateral angular indentations to receive the basal lobes. D. crassus

Öpik (1967, p. 126) also has no such lateral indentations as well as having a rounded glabellar rear. The specimen, Cop. 8, is very convex and quite small (1.6mm. long, 1.7mm. wide) and may be an immature form and thus not truly representative of the species. Rusconi (1955) described _D. indianus_, but Poulsen (1960, p. 11) notes that it is doubtful if this species belongs in _Diplagnostus_.

Öpik (1961b, p. 71) described _Diplagnostus_ cf. _planicauda vestgothicus_ from three cephala which he considered provisionally as conspecific. The features of this species which differentiate it from _D. planicauda vestgothicus_ are as follows:

(a) a stronger convexity of each lobe in the Queensland form,

(b) a pair of additional glabellar furrows which give a "croix de Lorraine" shape to the glabellar posterior, and

(c) the greater scrobiculation of _D. planicauda vestgothicus_.

Öpik (1967, p. 126) described _Diplagnostus crassus_ from a single cephalon found in the _Lejopyge laevigata_ II Zone of Queensland. Öpik (_op. cit._) gave the following diagnosis,

> "a species with a very convex cephalon, scrobiculate cheeks, an incomplete preglabellar median furrow, and a wavey transverse glabellar furrow; distinguished by its broadly rounded glabellar rear without lateral angular indentations to receive the basal lobes."

As noted above, _D. jarillensis_ has these last two features, although its cheeks are smooth and the preglabellar furrow is complete, thus distinguishing it from *D. crassus*. It should be noted here that *D. planicauda* (rubber cast, U.S. 289, figured in Westergård, 1946, pl. 8, fig. 22; figured herein as pl. 17, fig. 21) on close inspection reveals a rounded glabellar rear, although it does have lateral angular glabellar indentations.

The fact that at least three species of *Diplagnostus* (i.e., *crassus*, *jarillensis* and *planicauda*) have a rounded glabellar rear, whereas in other species of *Diplagnostus* the glabellar rear is angular, casts some doubt on the usefulness of criterion IV in Öpik's Tabular Classification of Agnostids (Öpik, 1967, Table 5). The author has sometimes found this criterion (shape of glabellar rear) difficult to use, and it is not always clear whether a particular species has a rounded, an angular, or a subangular glabellar rear. In passing it may be noted that the two species of *Eoagnostus* described by Rasetti and Theokritoff (1967) differ in this respect; *E. acrorhachis* (Rasetti and Theokritoff, *op. cit.*, pl. 20, figs. 1-3, 6-12) has a rounded or at most a subangular glabellar rear, whilst E. *roddyi* Resser and Howell, 1938 (Rasetti and Theokritoff, *op. cit.*, pl. 20, figs. 16, 18) has an angular glabellar rear. In the author's opinion the shape of the glabellar rear is not of first order value for classificatory purposes.

Hutchinson (1962, p. 78) described *Diplagnostus nordengi* from the Middle Cambrian of Newfoundland and included it in *Diplagnostus* "with some hesitation". The simplimarginate pygidial posterior excludes _nordengi_ from _Diplagnostus_, and it probably belongs in _Peronopsis_.

Westergård (1946, p. 61), like Kobayashi (1939, p. 141), suggested that _Diplagnostus planicauda bilobatus_, _D. planicauda_ and _D. planicauda vestgothicus_ form a continuous evolutionary series. Both Westergård and Kobayashi appear to base their opinions on the study of the cephala of the above species. The stratigraphic position in Sweden is in agreement with Westergård's and Kobayashi's hypothesis (Table 9, p. 285).

The following comments are based on a study of rubber casts of _Diplagnostus planicauda_, _D. planicauda bilobatus_ and _D. planicauda vestgothicus_ (see Appendix 2 for details). All the specimens of _D. planicauda bilobatus_, figured in Westergård (1946), are available as well as other specimens of this species on the same rubber casts but not figured by Westergård. Some of these specimens are refigured here in pl. 17, figs. 15-18. It may be noted in passing that the cephalon figured by Westergård (pl. 8, fig. 15) as _bilobatus_ has no median sulcus (see pl. 17, fig. 19 herein) and should be excluded from _Diplagnostus_. The only figured specimens of _vestgothicus_ available are those illustrated by Westergård (1946, pl. 8, figs. 26, 27). These specimens are figured here as pl. 17, figs. 22, 23, respectively. However, several other specimens, both pygidia and cephala, are available on Riks 353 and

TABLE 9

POSITION AND FREQUENCY OF THE SPECIES OF *DIPLAGNOSTUS* FROM SWEDEN
(based on Westergård, 1946)

	Zones			
	B_4	C_1	C_2	C_3
D. planicauda bilobatus Kobayashi	f.c.	f.c.	r.*	
D. planicauda (Angelin)			i.	
D. planicauda vestgothicus (Wallerius)			v.r.	f.c.

f.c. = fairly common
i. = infrequent
r. = rare
v.r. = very rare

The Swedish zones noted above are as follows (after Westergård, 1946):

top C_3 - Zone of *Lejopyge laevigata*

C_2 - Zone of *Solenopleura brachymetopa*

C_1 - Zone of *Ptychagnostus lundgreni* and *Goniagnostus nathorsti*

B_4 - Zone of *Ptychagnostus punctuosus*

**Diplagnostus planicauda bilobatus* Kobayashi occurs only in the lower part of the C_2 Zone (Westergård, 1946, p. 62). Westergård (1946, p. 61) states that *D. planicauda* (Angelin) is the predominant form in the Andrarum Limestone which corresponds to the C_2 Zone; he also states (p. 62) that *D. planicauda* is "infrequent". Thus, in the above table *D. planicauda bilobatus* is stated to be rare in the C_2 Zone.

also on specimens containing other figured genera. Thus, a representative collection of the Swedish forms of bilobatus and vestgothicus is available for study.

Unfortunately, only two specimens of D. planicauda are available. These are a pygidium (U.S. 290, figured in Westergård, 1946, pl. 8, fig. 23) and a cephalon (U.S. 289, figured in Westergård, 1946, pl. 8, fig. 22). These specimens are figured here as pl. 17, figs. 20, 21, respectively. Thus, no range of variation is seen in planicauda as is in the other two species. This fact is borne in mind in the subsequent discussion although it should be noted that these specimens (i.e., U.S. 289 and U.S. 290) are two of the three figured by Westergård and are presumably typical of the species.

The following features, some previously noted by Westergård or Kobayashi, support or tend to support the hypothesis that the three species concerned represent a continuous evolutionary series:

(a) There is a marked increase in scrobiculation of the cephalic cheeks from the smooth bilobatus to the faintly scrobiculate planicauda to the highly scrobiculate vestgothicus.

(b) The preglabellar median furrow in bilobatus is faint whereas in both other species it is well developed.

(c) The width of the cephalic marginal furrow changes from moderately wide in bilobatus to narrow in vestgothicus, with the furrow of _planicauda_ being of intermediate width. This remark applies only to the Swedish forms. In _vestgothicus_ from Queensland, as figured by Öpik (1961b, pl. 19, figs. 13a, b), the marginal furrow is somewhat wider than in the Swedish forms; it also might be added that the glabella of the Swedish form seems to be comparatively longer than the glabella in the form illustrated by Öpik.

The following features of the species under discussion cast doubt on the validity of the proposed evolutionary series:

(a) The shape of the pygidial axis of _D_. _planicauda_ as compared to those of the other two species. In _D_. _planicauda_ the axis expands markedly at the anterior of the third segment; the axes of both _bilobatus_ and _vestgothicus_ have only a very slight expansion at the anterior of the third axial segment.

(b) The shape of the axial posterior; that of _planicauda_ is broadly rounded, whereas those of _vestgothicus_ and _bilobatus_ are sharply rounded.

(c) The longitudinal section of _planicauda_ (Fig. 31a) is completely different from those of _bilobatus_ (Fig. 31b) and _vestgothicus_ (Fig. 31c) which are very similar to each other. As is seen in Fig. 31a, the posterior axial lobe of _planicauda_ is much more convex than in the other two species.

The convex nature of the posterior lobe, as drawn, is not just an aberration in the one specimen (U.S. 290) at my disposal but is a feature present in most specimens because Westergård (1946, p. 62) states that the axial end-lobe is "very rarely gently depressed in its posterior portion".

(d) The glabellar rear of bilobatus is angular, that of vestgothicus is sub-angular. However, the glabellar rear of planicauda is broadly rounded.

(e) The ratio of the length of the axial ridge to the total length of the pygidium in some specimens of the three species is given below:

bilobatus, 0.28, 0.29

planicauda, 0.39

vestgothicus, 0.32, 0.33

It is obvious that this very small number of measurements is not enough, but if they are in fact a true indication, then it would appear that in this character, as well as those listed above, planicauda is not intermediate between bilobatus and vestgothicus.

The objections, raised above, seem to the author to show that the proposed evolutionary series, Diplagnostus planicauda bilobatus - D. planicauda - D. planicauda vestgothicus, is not valid. However, it seems clear from the above discussion that vestgothicus probably arose from bilobatus; D. planicauda may have arisen from D. planicauda bilobatus independently. Fig. 32 summarizes the proposed evolution of the Swedish species of Diplagnostus.

Diplagnostus humilis (Whitehouse), as described by Öpik (1961b, p. 72), comes from a close but separate location from the form described by Whitehouse (1936, p. 91) as Enetagnostus humilis (see Öpik, 1961b, pp. 46, 73). The author has at his disposal rubber casts of Whitehouse's original material and feels that a comparison is warranted between these specimens and the figures given by Öpik for D. humilis. The casts available are UQ 3192 (a cephalon), UQ 42742 (the holotype cephalon) and UQ 3193 (a pygidium) figured by Whitehouse (1936) on plate 8 as figs. 17, 18, and 19, respectively, and refigured here as pl. 18, figs. 3, 1, and 2, respectively.

The cephala illustrated as humilis by Öpik and Whitehouse are similar. However, there appear to be some differences in the pygidia illustrated as humilis by the two writers. Unfortunately, the pygidium, UQ 3193, is poorly preserved, and a complete comparison cannot be made. The most striking difference is in the length of the pygidial axis. In the specimen figured by Whitehouse the axis stops well short of the collar whereas in the pygidia illustrated by Öpik the axis almost reaches the collar. The pygidial margins of the specimens illustrated by Öpik taper more markedly than those of UQ 3193. Öpik's specimens show a large gap between the collar and the rim; UQ 3193 does not have such a large gap although on the same specimen there is a fragmented pygidium of Diplagnostus with a gap between rim and collar comparable to that illustrated by Öpik. The collar extremities of Öpik's specimens are placed well to the anterior of the border spines; however, in Whitehouse's specimens they appear to be just anterior of the spines.

The differences listed above may be just intraspecific variation or perhaps due to the possibility that the collections of Öpik and Whitehouse were made from rocks of slightly different age. However, in view of the differences noted above, there must be some doubt whether, in fact, the species described by Öpik as Diplagnostus humilis is the same as that described by Whitehouse as Enetagnostus humilis.

The Tasmanian material of Diplagnostus is mostly poorly preserved, and any necessary comments are made after each description.

Diplagnostus geei sp. nov.

pl. 18, figs. 5-8

Material: Three more or less complete specimens and three isolated pygidia are available for description. All specimens have been considerably distorted.

Measurements: UT 89198a, complete specimen, holotype, (E-W distortion), total length, 6.1mm.; cephalon, length, 2.9mm., width, 2.4mm.; pygidium, length (excluding axial half-ring) 2.4mm., width, 2.4mm. UT 89207, pygidium, (N-S distortion), length (without axial half-ring), 2.6mm., width, 3.3mm. UT 92616, pygidium, (intermediate distortion), length (without axial half-ring), 2.9mm., width, 3.3mm.

Diagnosis: *Diplagnostus geei* sp. nov. is a species with a very wide marginal furrow in both the pygidium and the cephalon, especially the latter. The glabellar rear is angulate. The bluntly pointed pygidial axis does not extend to the collar; the pleural areas are separated by a short, well-developed post-axial median furrow. At either extremity, the collar meets the rim a little to the anterior of the small border spines. The collar is arched gently to the posterior except at either end where it is arched gently forward for a very short distance.

Selection of Holotype: Specimen UT 89198a (pl. 18. fig. 5) is selected as the holotype.

Description: The cephalon is a little wider than it is long. The marginal furrow is wide and moderately deep, becoming shallow and very wide at the anterior. The rim is narrow and elevated. The posterolateral spines are short, triangular, upturned and convex. The convex cheeks may be pitted to some extent although the distortion makes such a determination doubtful. The glabella is about two-thirds as long as the cephalon and about one-third the width (measured at the transverse furrow). The axial furrows are narrow and moderately deep; the transverse glabellar furrow is shallow and straight. The moderately sized basal lobes are not well preserved. The preglabellar median furrow probably reaches the border; it is widest and deepest at the posterior. The anterior glabellar segment contains a median sulcus which extends about half the length of the lobe. The glabella widens slightly to the anterior and is widest just to the posterior of the transverse glabellar furrow. The anterior glabellar segment has a length a quarter that of the glabella. In no available specimen does the posterior glabellar segment show much detail. There is probably a median ridge on the posterior glabellar segment.

The pygidium is probably a little wider than it is long. The marginal furrow is wide, becoming very wide near the posterolateral corners; the rim is convex and moderately wide. The posterior border is zonate with the collar reaching the rim at either end. The collar is arched gently to the posterior except at the extremities where it is arched very slightly to the anterior. It meets the rim a little to the anterior of the short border spines. The shoulder furrows are moderately wide and deep; the shoulders are narrow; the fulcra are close to the axis. The pleural areas are smooth. The axis is well defined by moderately deep axial furrows. The axis stops a little distance short of the collar; the axial rear is bluntly pointed. There is a well-defined post-axial median furrow. The axis consists of three (possibly four) segments. It is slightly constricted at the second segment. The anterior pair of segments make up a little less than half the length of the axis, with the anterior of the pair being slightly the shorter (sag.). This pair of segments is outlined by distinct, but poorly developed, transverse furrows which are directed inwards and slightly forwards from the axial furrows. A well-defined axial ridge (about 0.2 the width (tr.) of the axis) extends from the anterior of the axis along the first two axial segments and just onto the third segment. About one-third of the distance along the posterior axial segment from the anterior end there is a suggestion of a pit on either side of the centre of the axis. These may indicate the presence of a fourth axial segment.

Discussion: *Diplagnostus geei* sp. nov. differs from all other species of *Diplagnostus* by the presence of the very wide marginal furrows. This feature is so distinctive in this species that a new species is erected despite the poor quality of the available material.

Occurrence and Age: *Diplagnostus geei* sp. nov. comes from the Que River Beds at lat. 41°34.7'S, long. 145°41.0'E (grid 3710E, 8803N); its age is Middle Cambrian, either of the *Ptychagnostus punctuosus* Zone or the *P. nathorsti* Zone.

Diplagnostus sp. 1

pl. 18, figs. 9-13

Material: One complete specimen, one cephalon and three pygidia are known. They are all poorly preserved.

Measurements: UT 92618, internal mould of complete specimen, (N-S distortion), total length, 2.7mm.; cephalon, length, 1.3mm., width, 2.0mm.; pygidium, length, 1.3mm., width, 2.0mm. UT 88148, cephalon, (E-W distortion), length, 2.5mm., width, 1.9mm. UT 92620, internal mould of pygidium, (intermediate distortion), length, 1.3mm., width, 1.5mm. UT 92619, internal mould of pygidium, (N-S distortion), length (including axial half-ring), 1.8mm., width, 2.8mm.

Description: The moderately convex cephalon is about as wide as it is long. At the anterior the marginal furrow is wide and shallow; it narrows to the posterior. The rim is narrow, elevated and convex. The distortion is such that it cannot be determined if the cheeks are smooth or slightly scrobiculate. The narrow axial furrows are of moderate depth. The glabella has a length about two-thirds that of the cephalon, and at the transverse glabellar furrow it is about 0.3 the width of the cephalon. The anterior glabellar segment is subrectangular with a wide anterior end. There is a small median sulcus at the centre of the front of the anterior glabellar segment. There may be a small preglabellar median furrow immediately in front of the sulcus. The length of the anterior glabellar segment is about 0.25 that of the glabella. The moderately deep transverse glabellar furrow is arched distinctly forward at its centre. There are a pair of deep, short, lateral furrows placed just forward of the centre of the posterior glabellar segment. They run slightly inwards and forwards; in the centre of the glabella between these furrows is a low node. The basal lobes are poorly preserved. The glabellar rear is broadly rounded.

The moderately convex, zonate pygidium is about as wide as it is long. The marginal furrow is narrow and shallow; the rim is nowhere well preserved. The shoulder furrows are narrow and shallow; the shoulders are narrow and raised. The fulcra and articulating device are poorly preserved. The pleural fields are probably smooth. The axis stops a little distance short of the collar; there is a well-developed post-axial median furrow. The axial furrows are narrow and moderately deep. The axial rear is pointed. The axis is slightly constricted at the second axial segment. There is a well-defined anterior transverse axial furrow, each end of which is directed inward and forward. There is a well-defined, low, rounded, central ridge which extends along the first two axial segments and slightly onto the third segment. The posterior transverse axial furrow is directed slightly backwards and inwards from either end. The abaxial sections of the collar are directed to the posterior as in *Diplagnostus planicauda bilobatus*.

Discussion: The poorly preserved nature of the specimens makes a detailed comparison of them with described species impossible. The absence or at most the presence of a poorly defined preglabellar median furrow suggests that the form described above is related to

Diplagnostus planicauda bilobatus. However, no definite assignation can be made and the form described above is referred to as *Diplagnostus* sp. 1.

Occurrence and Age: *Diplagnostus* sp. 1 comes from about 28 metres above the base of the lowest siltstone unit of the Black Hill section of Dundas at lat. 41°50.8'S, long. 145°24.7'E (grid 3466E, 8474N) (RB locality); its age is Middle Cambrian, possibly that of the *Ptychagnostus nathorsti* Zone.

Diplagnostus sp. 2

pl. 18, fig. 14

Material: Only one poorly preserved cephalon UT 92621 is available for study. Both the internal and external moulds are present although only about half the external mould is preserved.

Measurements: On external mould, exposed length, 1.9mm.; on internal mould, length, 1.9mm.; width, 1.9mm.

Description: The strongly convex cephalon is about as wide as it is long. The border is composed of a wide, shallow marginal furrow and a moderately wide, elevated rim. The border narrows to the posterior. The area in front of the glabella is not clearly preserved, but there appears to be a faint preglabellar median furrow at least in the region immediately in front of the glabella. The cheeks seem to be slightly scrobiculate. The basal lobes are small and simple. The glabella is outlined by moderately wide and deep, almost parallel furrows. Just to the posterior of the transverse glabellar furrow, the glabella widens slightly.

The transverse glabellar furrow is not very clearly preserved, but it appears to be shallow, moderately wide, and arched slightly forward. The anterior glabellar segment is almost square. There is a small median sulcus at the front of the anterior glabellar segment. At the transverse glabellar furrow the glabella is just under 0.3 the width of the cephalon. The glabellar length is about 0.65 that of the cephalon. The anterior glabellar segment has a length about 0.3 that of the glabella. No details of the posterior glabellar segment are visible although the glabellar rear is subangular (seen on internal mould).

Discussion: There is only one cephalon of *Diplagnostus* from Sugarloaf Gorge. This specimen does not allow a detailed comparison with described species of *Diplagnostus*. It is referred to here as *Diplagnostus* sp. 2.

Occurrence and Age: *Diplagnostus* sp. 2 comes from Unit 13 of the lower sedimentary sequence of the Radfords Creek Group as exposed along the Gunns Plains Road; its age is late Middle Cambrian, either of the *Lejopyge laevigata* II Zone or the *L. laevigata* III Zone.

Diplagnostus sp. 3

pl. 18, figs. 16-20

Material: One very poorly preserved almost complete specimen, six cephala and six pygidia are available for descriptive purposes. All are poorly preserved.

Measurements: UT 86872g, complete specimen, (E-W distortion), length, 4.3mm.; cephalon, length, 2.1mm., width, about 1.7mm.; pygidium, length, 1.9mm., width, 1.8mm. UT 86872n, flattened cephalon, (N-S distortion), length, 1.5mm., width 2.0mm. UT 92482, pygidium, (N-S distortion), length, 1.5mm., width, 2.0mm. UT 86873a, pygidium, internal mould, (intermediate distortion), length, 1.6mm., width, 1.6mm.

Description: The moderately convex cephalon is probably slightly wider than it is long. The shallow marginal furrow is narrow; the rim is narrow and convex. There is a well-defined preglabellar median furrow which is moderately deep at the posterior but shallows markedly to the anterior. The axial furrows are deep. The cheeks are convex and probably smooth (the preservation makes this difficult to determine, but on most specimens the corrugations appear to be due to distortion effects). The glabella is about three-quarters the length and 0.3 the width of the cephalon. The anterior glabellar segment is subrectangular and contains a narrow sulcus which extends about one-third of the way into the lobe. The transverse glabellar furrow is almost straight; it is arched slightly to the posterior throughout most of its length but is bent slightly forward at its centre. On the posterior glabellar segment is a pair of shallow, lateral furrows which turn inward and forward from points on the axial furrows which are a little to the anterior of the centre of the posterior glabellar segment. There is a high, wide central ridge which extends along the central and anterior parts of the posterior glabellar segment. This ridge is highest at about the centre of the posterior glabellar segment. The glabellar rear is angulate. The basal lobes are small and simple.

The zonate pygidium is probably slightly wider than it is long. There is a narrow marginal furrow and a narrow convex rim which is widest at the posterior. The articulating device is nowhere preserved. The shoulder furrows are narrow and shallow; the moderately geniculate shoulders are narrow and convex; the fulcra are close to the axis. Small border spines are present. The pleural areas are smooth. The pygidial axis has a length about two-thirds that of the pygidium. The narrow axial furrows are of moderate depth. There is a distinct gap between the sharply rounded pygidial posterior and the collar. There may be a faint post-axial median furrow. The narrow, shallow anterior transverse axial furrow is directed inwards and slightly forward from either end. The posterior transverse furrow is poorly developed. The median keel is about a quarter the width of the axis. It extends from the anterior of the axis across the anterior two segments and just onto the posterior axial segment. It is highest and widest near the posterior of the second axial segment. The first two axial segments are of about equal length (sag.) and together make up about 0.4 to 0.45 of the total length of the axis. The axis is slightly constricted at the second axial segment. The collar seems to join the rim at its extremities, which are well to the anterior of the spines.

Discussion: The species of Diplagnostus described above from Christmas Hills differs from D. planicauda vestgothicus (Wallerius) and D. cf. planicauda vestgothicus (Öpik, 1961b, p. 71) in that these species have highly scrobiculate cephala. The pygidial axis of D. planicauda (Angelin) is wider than that of the Christmas Hills form. The preglabellar median furrow of the Diplagnostus described above is better developed than those Diplagnostus sp. 1, and Diplagnostus sp. 2 (described above) and also that of D. planicauda bilobatus Kobayashi. The preglabellar median furrow of D. jarillensis Rusconi is deeper than that of the Christmas Hills form, and jarillensis also has a more rounded glabellar front. The preglabellar median furrow and marginal furrows of D. humilis (Whitehouse) are wider and deeper than those of the species described above. Diplagnostus crassus Öpik differs from the Christmas Hills species in that it has a broadly rounded glabellar rear. Diplagnostus geei sp. nov. differs in that it has wider marginal furrows and also a distinct post-axial median furrow.

Thus, the Diplagnostus found at Christmas Hills differs from all known species. However, there are not enough well-preserved specimens to erect a new species, and it is referred to as Diplagnostus sp. 3.

Occurrence and Age: Diplagnostus sp. 3 comes from the upper fauna at Christmas Hills (lat. 40°54.1'S, long. 144°29.8'E; grid 3075E, 9610N); its age is late Middle Cambrian, either of the Lejopyge laevigata I Zone or the L. laevigata II Zone.

Diplagnostus sp. 4

pl. 18, fig. 15

Material and Comments: Only one poorly preserved, almost complete cephalon, UT 92622, is available. If complete, this specimen would have a length of about 1.3mm. and a width of about 2.0mm. There is a narrow border and a complete, well-developed preglabellar median furrow. Little detail can be seen on the glabella. This cephalon appears to belong in Diplagnostus and is referred to as Diplagnostus sp. 4.

Occurrence and Age: Diplagnostus sp. 4 comes from a black shale at the eastern end of the Summit Cutting of the Comstock tram (lat. 41° 53.8'S, long. 145°18.7'E; grid 3374E, 8412N); its age is late Middle Cambrian.

Genus OEDORHACHIS Resser, 1938

Oedorhachis Resser, 1938, p. 49; Shimer and Shrock, 1944, p. 601; Hupé, 1953, p. 64 (spelt Eodorhachis); Howell, 1959, p. 185; Robison, 1960, p. 12; Poulsen, 1960, p. 12; Öpik, 1967, p. 127.

Type Species: Oedorhachis typicalis Resser, 1938, p. 50, pl. 10, figs. 16, 22, 28.

Diagnosis: The cephalon has a wide marginal furrow and a narrow rim. There is no preglabellar median furrow. The cheeks are smooth. The anterior glabellar segment is wider (tr.) than the posterior glabellar segment. The basal lobes are small and simple; the glabellar rear is angulate.

The zonate pygidium has a wide marginal furrow and a moderately wide rim with a pair of short border spines. The pygidial axis extends to the marginal furrow. It has a slight constriction at the second segment and a considerably expanded posterior axial lobe with a broadly rounded pygidial rear. The pleural areas are smooth.

Discussion: The writer agrees with Öpik (1967, p. 128) that Oedorhachis is not a junior synonym of Acmarhachis as was suggested by Palmer (1962, p. 19) (see above, p. 234). Resser (1938) erected six species of Oedorhachis, but Palmer (op. cit.) has reassigned all but O. typicalis and O. ulrichi to other genera. The author considers that these two species, along with O. australis Poulsen (1960, p. 13) are the only described species which belong in Oedorhachis. A revised generic diagnosis is given above.

<u>Oedorhachis</u> (?) <u>distortus</u> sp. nov.

pl. 19, figs. 4-8

<u>Material</u>: About six cephala and one pygidium are known; all are considerably distorted.

<u>Measurements</u>: Cephala, UT 54944, internal mould, (N-S distortion), length, 5.2mm., width, 4.2mm.; UT 54981, (N-S distortion), length, 3.2mm. Pygidium, UT 92624, (E-W distortion), exposed length, 8.0mm. (complete length probably about 8.5mm.).

<u>Selection of Holotype</u>: The cephalon, UT 54944 (pl. 19, fig. 4), is chosen as the holotype.

<u>Diagnosis</u>: <u>Oedorhachis</u> (?) <u>distortus</u> sp. nov. is a large agnostid with a wide cephalic marginal furrow, a pointed cephalic front, a forward expanded glabella, no preglabellar median furrow, a wide pygidial axis with an expanded posterior segment which reaches the posterior margin, a zonate pygidium with a pair of large knobs on the collar and possibly a trispinose posterior margin.

<u>Description</u>: The strongly convex cephalon is longer than it is wide. The cephalic front is slightly pointed. There is a wide, moderately deep marginal furrow and a narrow, elevated rim. The cheeks are smooth. The glabella is outlined by deep, moderately wide furrows; it has a length about two-thirds that of the cephalon. The glabella expands slightly to the anterior; the transverse glabellar furrow is arched

slightly to the anterior. The anterior glabellar segment is slightly wider (tr.) than the posterior glabellar segment. The glabellar front is broadly rounded. The glabellar rear is angulate. On the anterior part of the posterior glabellar segment is a pair of shallow lateral furrows. Anterior to these furrows the posterior glabellar segment is slightly widened. To the posterior of these furrows is a low, elongated node. The basal lobes are small and simple.

The solitary pygidium is moderately convex; it has a poorly preserved articulating device and border. The posterior border appears to be zonate with a pair of high knobs on the collar. The lateral border spines are poorly preserved. There is a suggestion of a central marginal spine, but the preservation is too poor to be certain about this point. The small pleural areas are smooth. The axial furrows are narrow and shallow; the axis extends to the marginal furrow. There are at least two and possibly three segments in the anterior part of the axis. At the posterior of the second axial segment is a pair of shallow transverse furrows. The axis is constricted in the region of the second axial segment. A narrow central ridge extends along the first two axial segments and extends some distance past the pair of lateral furrows. There is a suggestion of a short third axial segment in the region of the ridge extension; the preservation does not allow a definite conclusion. There is a wide, moderately deep pit immediately to the posterior of the ridge. The posterior segment of the axis is much expanded and covers much of the acrolobe.

Discussion: This large agnostid probably belongs in a new genus characterized by the features noted in the specific diagnosis. Of previously described genera, *Oedorhachis* Resser, 1938 is the closest. Until a reasonably well-preserved, complete pygidium is available, the species described above will be referred questionably to *Oedorhachis*. The shape of the pygidium of the type species of *Oedorhachis*, *O. typicalis* Resser, is similar to that of *O.* (?) *distortus*. Differences include the pygidial axis of *distortus* being wider than *typicalis* and the presence of large knobs on the collar of *distortus*. There is also the possibility of a third pygidial spine on *O.* (?) *distortus*, whereas *O. typicalis* is bispinose. The cephalon of *distortus* is similar to that of *typicalis* in that it has a wide marginal furrow, an angular rear, an anteriorly expanded glabella and no preglabellar median furrow. The major difference is the pointed cephalic front of *O.* (?) *distortus*. The morphology of *O.* (?) *distortus* indicates that it belongs in the family Diplagnostidae. If, in fact, the anterior part of the pygidial axis is triannulated, then *O.* (?) *distortus* would fit into the Oidalagnostinae as defined by Öpik (1967, p. 134) except that its pygidium does not appear to be scrobiculate. However, until the pygidium of *O.* (?) *distortus* is known properly, the species *distortus* is best compared with *Oedorhachis* which belongs in the Diplagnostinae.

Occurrence and Age: Oedorhachis (?) distortus sp. nov. comes from the Brewery Junction Formation at lat. 41°53.0'S, long. 145°25.6'E (grid 3480E, 8429N) (BJ_2 locality); its age is early Upper Cambrian, either of the Erediaspis eretes Zone or the Cyclagnostus quasivespa Zone.

Oedorhachis (?) sp.

pl. 19, fig. 3

Material: Only one pygidium, UT 92623, is available. It has undergone E-W distortion and has a length (including axial half-ring) of about 2.7mm. and a width of about 1.6mm.

Comments: This pygidium is closely related to that of Oedorhachis (?) distortus sp. nov. It differs from distortus in that the pygidial axis has a slightly pointed rear and does not extend as far to the posterior as does that of distortus. The large collar knobs are well defined, and there is a strong suggestion of a median pygidial marginal spine, but the margin is too poorly preserved to be sure of this point.

Occurrence and Age: Oedorhachis (?) sp. comes from the lower fauna of the siltstone and shale unit exposed in Barkers Creek (Black Hill section, Dundas) at lat. 41°51.3'S, long. 145°26.1'E (grid 3487E, 8463N); its age is early Upper Cambrian, possibly that of the Cyclagnostus quasivespa Zone.

Subfamily OIDALAGNOSTINAE Öpik, 1967

The Subfamily Oidalagnostinae was defined by Öpik (1967, p. 134). A new genus, *Buckagnostus* is herein included in this subfamily. The author feels that character (2) of the subfamily (see Öpik, *op. cit.*) should read, "the median depression in the pygidial collar" rather than "median gap". This is because there is no distinct break in the collar of any known species of either *Buckagnostus* or *Oidalagnostus* such as there is in *Aspidagnostus*.

Genus OIDALAGNOSTUS Westergård, 1946

Oidalagnostus Westergård, 1946, p. 65; Hupé, 1953, p. 63; Howell, 1959, p. 175; Pokrovskaya, 1960a, p. 57; Öpik, 1967, p. 134.

Type Species: *Oidalagnostus trispinifer* Westergård, 1946, p. 65, pl. 9, figs. 4-7.

Discussion: Öpik (1967, p. 134) has discussed fully the generic concept of *Oidalagnostus*. The Tasmanian form noted below adds nothing to this concept.

The author has at his disposal rubber casts of the two pygidia of *O. trispinifer* figured by Westergård. They are specimens Riks 357 and Riks 358 figured by Westergård as pl. 9, figs. 6 and 7 respectively; Riks 357, (pl. 19, figs. 9, 10, herein), the holotype, is an exfoliated specimen, and thus shows the internal anatomy better than does Riks 358, (pl. 19, fig. 11, herein), which has the original test preserved.

An inspection of Riks 357 (pl. 19, figs. 9, 10) reveals the presence of a long, low, rounded ruga on each pleural area. These rugae extend from near the junction of the two lateral bosses to a point near the anterolateral corners. These photographs also show that the pleural areas are much more pitted on the abaxial sides of these rugae than on the adaxial side. An inspection of the pygidium of O. personatus Öpik (1967, pl. 54, fig. 8) shows what appears to be similar rugae. This type of pygidial caecal arrangement may be indicative of Oidalagnostus.

Both members of the Subfamily Oidalagnostinae show a similar evolutionary trend in regard to their lateral bosses. Oidalagnostus personatus Öpik from the Queensland Lejopyge laevigata II Zone has one pair of lateral bosses on the third axial annulation. The younger O. trispinifer Westergård has two well-developed lateral bosses on the posterior part of the pygidium. In Queensland O. trispinifer extends from the highest Middle Cambrian Lejopyge laevigata III Zone to the Mindyallan Cyclagnostus quasiverspa Zone. In Sweden trispinifer is found in the upper part of the Swedish Lejopyge laevigata Zone.

The older species of Buckagnostus, i.e., B. debori, from the lower fauna at Christmas Hills is of about Lejopyge laevigata I age and has no distinct lateral bosses on the third pygidial axial annulation. In contrast, the younger, B. compani, (about Lejopyge laevigata III age), from near St. Valentines Peak has distinct lateral bosses on the third pygidial axial annulation. Thus, in the known species of Buckagnostus and Oidalagnostus there is a trend to increase the differentiation of the lateral bosses in the younger species.

The close similarity of the pygidial structure of Buckagnostus and Oidalagnostus makes it appear probable that Oidalagnostus arose from Buckagnostus or a Buckagnostus-like agnostid by extension of the pygidial rim into a median spine.

Oidalagnostus sp.

pl. 19, figs. 12, 13

Several very poorly preserved pygidia of Oidalagnostus are known from the BJ_2 locality in the Brewery Junction Formation near Dundas. They appear to have two pairs of lateral bosses on the pygidium in a similar position to those in O. trispinifer. However, the specimens are so poor that they are simply referred to Oidalagnostus sp.

Oidalagnostus has been reported from the Barkers Creek area by Banks, 1956 (p. 174). This is presumably the form referred to by Öpik (1967, p. 134) as O. trispinifer from Tasmania "in the Zone of Glyptagnostus stolidotus." However, Oidalagnostus was not relocated in the Barkers Creek area.

Occurrence and Age: Oidalagnostus sp. comes from the Brewery Junction Formation at lat. 41°53.0'S, long. 145°25.6'E (grid 3480E, 8429N) (BJ_2

locality); its age is early Upper Cambrian, either of the Erediaspis eretes Zone or the Cyclagnostus quasivespa Zone.

Genus BUCKAGNOSTUS nov.

The type species of Buckagnostus is B. debori sp. nov.

Diagnosis: Buckagnostus has a cephalon with smooth cheeks, a wide marginal furrow and a wide, convex, elevated rim. There is usually an incomplete preglabellar median furrow; the axial furrows are deep; the transverse glabellar furrow is shallow. There are simple basal lobes, an angular glabellar rear and small, wide posterolateral spines. The posterior glabellar segment has an anterocentrally placed, elongated node.

The zonate pygidium has a wide border with a pair of small border spines. There is sometimes a transversely elongated pair of knobs on the collar directly behind the axis; the knobs are separated by a low depression. The axis extends to the collar; it is divided into two parts by a pair of broad and deep transversely elongated pits found in the posterior part of the axis. To the anterior of these pits there are three axial segments. On the anterior three segments is an elongated ridge, which is much lower on the third segment than on the anterior pair. The axis widens considerably to the posterior of the second axial segment and is widest near the transverse pits. There is a low intranotular axis in the wide posterior segment of the axis.

Discussion: *Buckagnostus* has a zonate pygidium and is rather similar to *Oidalagnostus*. The genera are differentiated by the fact that *Buckagnostus* has two border spines whereas *Oidalagnostus* has a trispinose pygidium. *Buckagnostus compani* sp. nov., described below, from near St. Valentines Peak has gently pitted pleural fields. The diagnosis given above and this latter fact show that *Buckagnostus* clearly belongs in the Subfamily Oidalagnostinae as defined by Öpik (1967, p. 134).

Buckagnostus debori sp. nov.

pl. 19, figs. 14, 15; pl. 20, figs. 1-15; pl. 21, figs. 1-6

Material: The illustrated specimens are selected from the hundreds of available specimens.

Measurements: Cephala: UT 86877e (two individuals), (a) (E-W distortion), length, 3.9mm., width, 3.3mm.; (b) (intermediate distortion), length, 4.7mm., width, 4.7mm. Pygidia: UT 86869e, (N-S distortion), length, 4.3mm., width, 5.3mm.; UT 86583, (N-S distortion), length, 3.3mm., width, 4.5mm.; UT 92467, (E-W distortion), length, 4.5mm., width, 4.1mm.

Selection of Holotype: UT 86869e, (pl. 20, fig. 6), a pygidium, is selected as the holotype.

Diagnosis: *Buckagnostus debori* sp. nov. is a species in which the cephalon has a preglabellar median furrow which is usually incomplete.

There is a shallow transverse glabellar furrow, an angular glabellar rear and large simple basal lobes. The zonate pygidium may have a very low pair of transversely elongated knobs on the collar. The pleural areas are smooth. The broadly rounded pygidial axis extends slightly onto the posterior marginal furrow. There is a centroposteriorly placed transverse furrow which has a pair of pits, one on either side of a low central rise. This furrow does not quite extend right across the axis and at either extremity is distinctly separated from the axial furrow.

Description: The convex cephalon is about as wide as it is long. The border is wide at the anterior and narrows markedly to the posterior. The rim is wide, convex, and elevated at the anterior, becoming narrow to the posterior. The marginal furrow is moderately deep. It is wide at the anterior, becoming narrow at the posterior. The cephalon has subparallel margins in its posterior half and a broadly rounded anterior outline. The glabella is outlined by deep, wide axial furrows. It is about 0.7 the length of the cephalon. The glabellar front is perhaps slightly pointed. The preglabellar median furrow is generally incomplete being widest and deepest at the posterior and fading to the anterior. The glabellar rear is angulate. The basal lobes are large and simple and extend about one-third of the way to the glabellar front. From the anterior ends of the basal lobes to the shallow transverse glabellar furrow, the glabella is parallel sided with a slight increase in width of the axis just behind the furrow. The transverse glabellar furrow is slightly arched to the posterior. There is a long, narrow, centroanteriorly placed node on the glabella. At the transverse glabellar furrow the glabella is just under 0.3 the width of the cephalon. The glabella stands out distinctly above the smooth cheeks. There is no connective band behind the glabella. The posterolateral spines are short, wide, and blunt and arise from wide bases.

The zonate, gently convex, pygidium appears to have smooth pleural fields and is probably slightly wider than it is long. It has a subrectangular outline. The border is wide with a wide, elevated, convex rim which narrows quite considerably to the anterior. The marginal furrows are wide and moderately deep. The shoulder furrows are a little narrower than the marginal furrows. The moderately geniculate shoulders are strongly elevated; the fulcra occur about mid-way between the abaxial acrolobe margin and the axial furrows. The moderately sized facets are gently concave. The articulating device consists of a wide, deep articulating furrow which is curved smoothly and is arched posteriorly and a narrow, elevated half-ring. Two small border spines are present.

The convex posterior rim, between the spines, is evenly curved but does not stand out as markedly as do the lateral rims. There is a narrow, shallow, crescentic furrow between the rim and the collar. The collar and the rim join at their abaxial extremities to form slightly thickened abaxial rim portions. The collar is sometimes slightly depressed at its mid-point. On either side of this depression (if present) the collar may be slightly thickened and elevated to form a pair of weak, transversely elongated knobs. The thickening of the collar is present on most specimens, but the central depression in the collar is seen on only about 15% of the specimens. The collar is markedly lower at its abaxial ends than on and near the knobs. The posterior marginal furrow is curved gently to the posterior at its mid-region where the axis protrudes slightly to the posterior of the pleural fields.

The pygidial axis is outlined by moderately wide and deep furrows and stands out distinctly above the pleural fields. It is divided into two parts by what appears in many specimens to be a broad transverse pygidial furrow, which is present at the posterior end of the axis about 0.5 to 0.55 of the distance from the anterior to the posterior of the pygidium. This feature does not extend abaxially to the axial furrows and in fact is a pair of "clavagnostid" pits as described below. The anterior half of the axis has almost parallel axial furrows and three annulations, the anterior two of which are outlined by widening of the axis around each annulation. From the posterior end of the second annulation the axis expands evenly until it is widest in the region of the clavagnostid pits. The axis then contracts to a broadly rounded posterior which extends slightly onto the posterior marginal furrow. On the three anterior annulations there is a prominent elongated median ridge just under a third the width of the axis. The ridge is best developed on the two anterior annulations and is outlined by shallow longitudinal furrows. On the third annulation the ridge is less elevated than it is on the two anterior annulations and extends slightly onto the transverse furrow. The "transverse furrow" has a raised central region immediately behind the node with small clavagnostid pits on either side.

There are notular lines on the posterior axial lobe. These are not visible on all specimens. On UT 92480 (pl. 20, fig. 13) one of the largest available specimens, these notular lines have been accentuated by distortion and occur as distinct furrows. The intranotular axis is very slightly set above the extranotular axis.

Discussion: *Buckagnostus debori* sp. nov. is compared with *B. compani* in the discussion on the latter species. There is some intraspecific variation in *B. debori*, e.g., the pygidial collar on some specimens is wider (tr.) than on others. As noted in the description, the central collar depression is present in only about 15% of the specimens. The pygidial rear of some specimens is much more broadly rounded than on others even when the effects of distortion are taken into account. The preglabellar median furrow is well developed on some specimens and almost absent on others. In the immature pygidium, UT 86877d (pl. 21, figs. 4, 5), the clavagnostid pits are placed further to the posterior than in more mature specimens.

Occurrence and Age: *Buckagnostus debori* sp. nov. comes from both the lower and upper faunas at Christmas Hills (lat. 40°54.1'S, long. 144°29.8'E; grid 3075E, 9610N); its age is late Middle Cambrian, probably of the *Lejopyge laevigata* I Zone, or of the *L. laevigata* II Zone.

Buckagnostus compani sp. nov.

pl. 21, figs. 7-14; pl. 22, fig. 1

Material: Apart from the illustrated material there are a total of about twenty cephala and pygidia available for descriptive purposes. The description is based mainly on the illustrated specimens.

Measurements: Cephala: UT 92709, (N-S distortion), length, 4.0mm., width, 5.7mm.; UT 92711, (intermediate distortion), length, 4.1mm., width, 4.7mm. Pygidia: UT 92700, internal mould, (E-W distortion), length, 4.3mm., width, 4.1mm.; UT 92724, (N-S distortion), length, 2.4mm., width, 3.0mm.; UT 92711, (intermediate distortion), length, 4.2mm., width, 4.3mm.

Selection of Holotype: A pygidium, UT 92724 (pl. 21, fig. 14), is selected as holotype.

Diagnosis: *Buckagnostus compani* sp. nov. is a species with a highly convex cephalon, a very faint transverse glabellar furrow, moderately sized basal lobes, and a short, shallow preglabellar median furrow. The zonate pygidium has a pair of transversely elongated knobs on the collar, which is only a little wider than the axial posterior. The third axial segment has a distinct lateral boss at either extremity; they slightly protrude into the pleural areas. The pleural areas are gently pitted, particularly opposite the third axial segment. There is a posterocentrally placed transverse furrow which has a pair of pits on either side of a low central rise. This furrow shallows abaxially. The posterior axial segment is subsquare.

Description: The strongly convex cephalon is about as wide as it is long. The marginal furrow is wide and shallow; the elevated convex rim is of moderate width. The glabella is outlined by moderately deep axial furrows; it is divided by a very shallow transverse glabellar furrow which in most specimens is a change of slope rather than a distinct furrow. There is a very shallow preglabellar median furrow which does not extend to the marginal furrow. The glabella has a length about two-thirds that of the cephalon; it has a broadly rounded anterior. The anterior glabellar segment has a length about one-quarter that of the glabella. There is a narrow, elongated node at the anterior end of the posterior glabellar segment. The glabellar rear is angular although in some specimens it appears rounded unless a close inspection is made. The intermediate sized basal lobes do not meet beneath the posterior end of the glabella.

The strongly convex, zonate pygidium is about as wide as it is long. The rim is elevated, gently convex and moderately wide at the posterior but narrows markedly to the anterior. The marginal furrow is wide and deep. The shoulder furrows are of moderate width and depth. The slightly geniculate shoulders are narrow and elevated; the fulcra are abaxially placed near the centre of the shoulders. The agnostoid articulating device includes a wide articulating furrow which is arched to the posterior; the half-ring is fairly long (sag.) and is arched to the posterior at its centre. There are small border spines. The posterior rim between the posterolateral spines is slightly convex with a narrow, shallow furrow between the rim and the collar. The collar has a width only a little greater than that of the pygidial rear. It has two transversely elongated knobs which are separated by a small saddle.

The pygidial axis is divided into two parts by a broad transverse pygidial furrow which occurs slightly to the posterior of the centre of the axis. This furrow is basically a pair of large pits separated by a small, central, higher area; the abaxial ends of the furrow are shallow and curve slightly to the posterior. The axis is outlined by broad, moderately deep axial furrows. Overall the axial furrows are parallel; there is a slight constriction at the second axial segment, and a slightly expanded posterior axial segment. The anterior portion of the axis contains three segments of approximately equal length. The third segment has a small lateral boss at either extremity. These bosses protrude slightly into the pleural areas, and the axis is widest at this point. A prominent median ridge, about one-third the width of the axis, extends the length of the three anterior segments. It is composed of three connected large nodules and is most prominent on the second annulation where it is outlined by prominent longitudinal furrows. There is a steep drop from the second segment nodule down to the third segment nodule. The ridge has a short posterior extension from the third segment onto the wide, deep transverse furrow. This extension is mirrored on the enlarged subsquare posterior pygidial segment. The posterior segment has two faint ridges extending longitudinally in the position where notulae would be expected. Between these ridges the intranotular axis stands out very slightly above the extranotular axis and extends slightly but distinctly further towards the collar than does the extranotular axis. The axis extends slightly further to the posterior than do the pleural areas. The pleural areas of some specimens are slightly pitted.

Discussion: *B. compani* sp. nov. differs from *B. debori* sp. nov. in that it has smaller basal lobes, a less distinct transverse glabellar furrow and a less well-developed preglabellar median furrow. The third pygidial segment has a distinct pair of lateral bosses which is not the case in *B. debori*. The pleural areas of *compani* may be slightly pitted; those of *debori* are smooth. The transverse pygidial furrow is bigger in *compani* than *debori*. The collar of *compani* is not as wide (tr.) as that of *debori*, but the knobs are more distinct.

Occurrence and Age: *Buckagnostus compani* sp. nov. comes from the main fauna in the St. Valentines Peak area near lat. 41°21.6'S, long. 145° 44.3'E (grid 3758E, 9064N); its age is of either late Middle Cambrian, *Lejopyge laevigata* III Zone or the Middle Cambrian/Upper Cambrian Passage Zone.

Buckagnostus sp.

pl. 22, fig. 2

A single specimen UT 92625 comprising a poorly preserved almost complete agnostid is known from the upper part of unit 15 of the Sugarloaf Gorge section (lower sedimentary sequence, Radfords Creek Group). The wide borders, the elongated node on the anterior of the posterior glabellar segment, the zonate pygidium and the posterocentrally placed transverse pygidial axial furrow indicate that this specimen belongs in *Buckagnostus*.

It differs from both *B. debori* and *B. compani* in that the posterior pygidial axial lobe is more expanded than in either of these species. Consequently the width of the posterior part of the pleural areas is much smaller than in either *debori* or *compani*. However, the specimen is not well enough preserved to allow the erection of a new species, and it is termed *Buckagnostus* sp.

Occurrence and Age: *Buckagnostus* sp. comes from Unit 15 of the lower sedimentary sequence of the Radfords Creek Group as exposed along the Gunns Plains Road; its age ~~is either~~ may be of the *Lejopyge laevigata* II Zone or the *L. laevigata* III Zone.

Subfamily AMMAGNOSTINAE Öpik, 1967

Genus AMMAGNOSTUS Öpik, 1967

Ammagnostus Öpik, 1967, p. 137

Diagnosis: See Öpik, 1967, p. 137.

Type Species: *Ammagnostus psammius* Öpik, 1967, p. 139, pl. 55, fig. 3; pl. 66, figs. 1-4; text fig. 40.

Ammagnostus (?) sp.

pl. 22, figs. 3-5

Material: One internal mould of a cephalon and four pygidia are available. All specimens are considerably distorted.

Measurements: Cephalon, UT 92626, internal mould, (E-W distortion), length, 2.7mm. Pygidium, UT 92628, (intermediate distortion), length (without axial half-ring), 2.7mm., width, 2.7mm.

Description: The moderately convex cephalon has a moderately wide anterior border which narrows to the posterior. The rim is narrow and convex;

the narrow marginal furrow is moderately deep. The cheeks are smooth. There may be a short, shallow preglabellar median furrow, but this feature could also be due to distortion. The glabella has a length about 0.7 that of the cephalon. The glabellar region is poorly preserved. The glabellar rear is rounded. The basal lobes are small and simple.

The pygidium has a very wide border, composed of a narrow, shallow marginal furrow and a very wide, almost flat rim. There are no border spines; the shoulder regions and the articulating device are nowhere well preserved. The wide convex axis stands well above the small pleural regions. The axial furrows are narrow and moderately deep. The axis is somewhat expanded toward the well-rounded posterior; it reaches the marginal furrow. The axial details are obscured by distortion, but it is clear that there are no prominent transverse axial furrows.

Discussion: The cephalon and pygidium described above all come from the same locality and are tentatively placed in the same species. The material is too poorly preserved to be assigned to a previously described agnostid species or to be the basis of a new species. This species is questionably assigned to *Ammagnostus* because of the combination of a cephalon with a well-rounded glabellar rear, narrow border, a short or absent preglabellar median furrow, and a pygidium which has a wide somewhat expanded axis with a very wide, almost flat rim. The pygidium of

Amagnostus (?) sp. does not have border spines and may not have constricted acrolobes as do all of the species of Ammagnostus described by Öpik (1967). Further and better specimens of Ammagnostus (?) sp. are required before a definite generic and specific assignation can be made.

Occurrence and Age: Ammagnostus (?) sp. comes from the Brewery Junction Formation at lat. 41°52.8'S, long. 145°25.0'E (grid 3471E, 8434N) (FE_1 locality); its age is early Upper Cambrian, probably that of the Glyptagnostus stolidotus Zone.

Genus KORMAGNOSTUS Resser, 1938

Synonymy: See Palmer, 1954, p. 59. In addition, see Hupé, 1953, p. 65; and Howell, 1959, p. 185.

Diagnosis: See Palmer, 1954, p. 59.

Type Species: Kormagnostus simplex Resser, 1938, p. 49, pl. 9, figs. 11-13.

cf. Kormagnostus sp.

pl. 22, figs. 6, 7

Material: Two badly distorted complete specimens, UT 92629, UT 92630, are known only from their internal moulds. One badly distorted external mould of a cephalon (UT 89198) is known.

Measurements: UT 92630, E-W distortion, total length, 6.1mm.; cephalon, length, 3.0mm., width, about 2.3mm.; pygidium, length (without articulating half-ring), 2.5mm., width, about 2.0mm. UT 92629, N-S distortion, total length, 3.9mm., cephalon, length, 1.8mm., width, 2.3mm.; pygidium, length (without articulating half-ring), 1.6mm., width, 2.6mm.

Description: The cephalon is about as wide as is long with a narrow, weakly convex rim and a marginal furrow of moderate width. The acrolobe is unconstricted. The monolobed glabella is outlined by moderately deep and wide dorsal furrows. Its length is probably about half that of the cephalon, and its width about one-third that of the cephalon. The glabella has an elongated oval shape with a bluntly rounded anterior end and possibly a subangular rear. It is difficult to be certain of this last point due to the distortion. The basal lobes are small and simple with the exact nature of their relationship beneath the glabellar rear not being clear. It is probable that they are separate entities. The cheeks are smooth. No other cephalic details are visible.

The pygidium is about as wide as it is long with a moderately wide marginal furrow and a moderately wide rim, both of which narrow slightly to the anterior. The shoulder furrows are moderately deep. The shoulders are well rounded; the fulcra are probably adaxially placed. The acrolobes may be slightly constricted. The articulating device is not visible.

The axis is outlined by narrow axial furrows. It is very wide, being about 0.6 the width of the pygidium at its anterior. The axis is very slightly constricted a little to the posterior of the anterior margin. From this constriction the axis expands posteriorly and the axial furrows meet the marginal furrow at a low angle about two-thirds of the distance from the pygidial anterior to the well-rounded pygidial posterior. The pleural lobes are small, smooth and subtriangular. There may be a small node on the central anterior portion of the axis, but this is difficult to ascertain due to the poor preservation.

Discussion: The species described above probably represents a new genus. However, as the specimens concerned are so poorly preserved, and the fact that the two complete specimens are only known as internal moulds makes the erection of a new genus undesirable. This is deferred until more and better material is available.

This species is related to *Kormagnostus* by virtue of its very wide pygidial axis, the probable constriction of the pygidial acrolobe combined with the non-constriction of the cephalic acrolobe, and the wide pygidial border. It is referred to as cf. *Kormagnostus* sp. However, where the transverse glabellar furrow of *Kormagnostus* is straight, the glabellar front of cf. *Kormagnostus* sp. is well rounded. Whether in fact the transverse glabellar furrow of cf. *Kormagnostus* sp. is effaced or represented by the apparent glabellar front cannot be determined from the available material. *Kormagnostus* also differs from cf. *Kormagnostus* sp. in that the latter has a much wider pygidial axis. As with Kormagnostus, cf. Kormagnostus sp. belongs in the Ammagnostinae, and since it belongs in either the Ptychagnostus punctuosus or the P. nathorsti Zone, it is the oldest known member of the subfamily. It is possible that cf. Kormagnostus sp. or a similar form is ancestral to Kormagnostus.

Occurrence and Age: cf. Kormagnostus sp. comes from the Que River Beds at lat. 41°34.7'S, long. 145°41.0'E (grid 3710E, 8803N); its age is Middle Cambrian, of the Ptychagnostus punctuosus Zone or the P. nathorsti Zone.

Genus DENAGNOSTUS nov.

Denagnostus is a monotypical genus with D. keithi sp. nov. as the type species.

Diagnosis: Denagnostus is a genus with an almost effaced, gently convex cephalon, which has a subelliptical outline and a straight posterior margin. The posterior part of the glabella is faintly outlined. It has a rounded glabellar rear, a centrally placed glabellar node and a wide anterior border which narrows posteriorly and disappears about halfway to the posterior margin. The pygidium is slightly more convex than the cephalon; it has a wide border, very small border spines and a faint ridge around the centre of the posterior border. The faintly outlined axis has two small anterior segments and a long slightly expanded posterior lobe which reaches the posterior marginal furrow and has a small terminal node. There is a low elevated node on the second axial segment.

Discussion: Denagnostus is placed tentatively in the Ammagnostinae. It conforms with the concept of this subfamily as diagnosed by Öpik (1967, p. 137). Denagnostus, in common with Ammagnostus, has a cephalon with an unconstricted acrolobe and a pygidium with a faintly constricted acrolobe (in some specimens). The pygidial border of Denagnostus is wide as specified in the subfamilial diagnosis. The cephalic border disappears about half-way to the cephalic posterior, a fact which could be considered as being in accord with the subfamilial diagnosis. The pygidial axis of Denagnostus has a similar shape to that of Ammagnostus. This is best seen in the internal mould of UT 89443 (pl. 22, fig. 13). However, there appear to be only two anterior pygidial axial segments in Denagnostus keithi sp. nov. as compared with the three in Ammagnostus. A feature against the inclusion of Denagnostus in the Ammagnostinae is the low ridge around the posterior border of Denagnostus. If this ridge is interpreted to be related to the pygidial collar of Diplagnostus and other genera, then the pygidium of Denagnostus is zonate. In this case Denagnostus would not belong in the Ammagnostinae but rather in some other subfamily of the Diplagnostidae.

Differential Diagnosis: Denagnostus is much more effaced than other members of the Ammagnostinae. The wide anterior cephalic border which disappears about half-way back to the posterior margin differentiates *Denagnostus* from all other agnostid genera.

Denagnostus keithi sp. nov.

pl. 22, figs. 8-13

Material: One reasonably well-preserved cephalon, two partially preserved pygidia as external moulds, and several reasonably preserved internal moulds of both cephala and pygidia are available.

Diagnosis: See generic diagnosis.

Selection of Holotype: The cephalon UT 88463 (pl. 22, fig. 8) is selected as the holotype because it is the best preserved cephalon.

Measurements: Cephalon, UT 88463, length, 4.0mm., width, 4.0mm.; UT 88511 and UT 88495, external and internal moulds respectively of the same pygidium, length (without axial half-ring), 4.7mm., width, 4.0mm.; UT 89443, internal mould of pygidium, length (including axial half-ring), 4.5mm., width, 4.7mm.

Description: The gently convex cephalon is about as wide as it is long with an almost straight posterior margin. The margins of the cephalon diverge anteriorly up to a point just under half-way to the anterior of the cephalon; from this point the margins converge to give the anterior margin a subelliptical outline.

The border, if present, is not visible in the posterior half of the cephalon, except for short posterolateral spines which are separated from the acrolobe by narrow, shallow posterior border furrows. The border appears about half-way along the cephalic margins and widens markedly to the anterior of the cephalon where it is quite wide. It is composed of a narrow, shallow marginal furrow and a wide, almost flat rim.

The glabella is only faintly outlined at the posterior; it is markedly convergent to the anterior and fades out in that direction. The basal lobes are of moderate size (see pl. 22, fig. 8); the glabellar rear is rounded. To the anterior of the basal lobes, the glabella tapers to a broadly rounded front which can only be seen faintly in some specimens and not at all in others. The glabella has a length about two-thirds that of the cephalon. There is a small node at about the centre of the glabella.

The pygidium is probably a little longer than it is wide. The pygidium is slightly more convex than the cephalon. The acrolobe is slightly constricted in some specimens; this feature is best seen on the internal mould of specimen UT 89443 (pl. 22, fig. 13).

The border is very wide at the posterior, becoming narrower to the anterior. The marginal furrow is wide and shallow; the rim is wide and almost flat at the posterior, becoming narrow and more elevated to the anterior. There are very small border spines which are more of a break in the marginal slope than distinct spines. Around the centre of the posterior border, paralleling the acrolobe margin, is a low ridge which meets the margin a little to the anterior of the border spines. This ridge appears to reflect the outline of the cephalic border. The shoulder furrows are narrow and shallow, becoming more so adaxially. The shoulders are narrow, elevated and convex. Neither the facets nor the fulcra can be seen on the available specimens. The articulating device is nowhere completely preserved; the articulating furrow is of moderate depth and width with a shallow articulating recess.

At the anterior the axis has a width about 0.45 that of the pygidium. The anterior pair of axial segments are outlined by narrow, shallow axial furrows. Both segments are short (sag.); the more posterior of the pair is slightly narrower (tr.) than the other. There are very faint traces of a transverse axial furrow between the two anterior segments and also between the second segment and the posterior axial lobe. There is a low, elongated node at the centre of the second segment.

The long posterior axial lobe is only very faintly outlined; it is slightly expanded and just reaches the posterior marginal furrow. There is a small terminal node at the very posterior of the posterior lobe. There is some suggestion of an intranotular axis, but the preservation is not good enough to be certain of this feature. The pleural areas are smooth.

<u>Occurrence and Age</u>: <u>Denagnostus</u> <u>keithi</u> sp. nov. comes from the upper part of the Singing Creek Siltstone in the Denison Range area; its age

is Upper Cambrian, probably that of either the *Dunderbergia* Zone or the *Elvinia* Zone.

Family DIPLAGNOSTIDAE, subfamiliae suae

Genus AGNOSTASCUS Öpik, 1967

Agnostascus Öpik, 1967, p. 147.

Type Species: *Agnostascus gravis* Öpik, 1967, p. 147, pl. 61, figs. 1-4, text fig. 38.

Diagnosis: See Öpik, 1967, p. 147.

Discussion: The five Tasmanian forms described below are all poorly preserved and rarely found at their respective localities. They are all questionably referred to *Agnostascus* although only *Agnostascus* (?) sp. 1 has reasonably narrow borders as required by the generic diagnosis. However, as far as can be ascertained from the limited material available, the forms described below as *Agnostascus* (?) sp. 2, *A*. (?) sp. 3, *A*. (?) sp. 4 and *A* (?) sp. 5 fit more closely into the generic concept of *Agnostascus* than in any other genus. More and better preserved material must be found before any of the Tasmanian species can be definitely assigned to *Agnostascus* or be the basis of a new species.

Agnostascus (?) sp. 1

pl. 22, figs. 14-16

Material: One poorly preserved, partial cephalon (UT 92631) and one poorly preserved pygidium (UT 24542) are available. The pygidium has a length of 3.3mm. (excluding the articulating half-ring) and a width of 3.3mm.

Description: The cephalon has a constricted acrolobe. At the anterior the rim is narrow and elevated and the marginal furrow is of moderate width. Both narrow to the posterior. There is a shallow transverse glabellar furrow. The anterior glabellar segment has a length about 0.3 that of the glabella. There is probably a preglabellar median furrow. There is a node placed well forward on the posterior glabellar segment. The basal lobes are small. No other glabellar details can be seen.

The border details of the strongly convex pygidium are not entirely clear. There is a narrow to moderately wide marginal furrow and a narrow rim. The preservation is such that border spines, if present, cannot be seen. The acrolobe is constricted. The wide trisegmented axis has a broadly rounded rear and extends the full length of the acrolobe. The posterior lobe is slightly expanded. The axis is slightly constricted at the second axial segment. There are no transverse axial furrows; the axial furrows are narrow and deep. There is a low, elongated node on the second segment.

Discussion: *Agnostascus* (?) sp. 1 is quite similar to *A. gravis* Öpik as far as can be seen. The pygidial axis of *gravis* is a little narrower than that of *A.* (?) sp. 1.

Occurrence and Age: *Agnostascus* (?) sp. 1 is known from the lower sedimentary succession of the Radfords Creek Group as exposed on an old timber track along the west side of Sugarloaf Gorge, lat. 41° 15.4'S, long. 146°04.2'E. Its age is probably either late Middle Cambrian, *Lejopyge laevigata* III Zone or the Middle Cambrian/Upper Cambrian Passage Zone.

Agnostascus (?) sp. 2

pl. 23, figs. 1, 2

Material: Two pygidia preserved as internal moulds are available. One of these (UT 92721) is reasonably well preserved, and the other (UT 92682) is poorly preserved. Specimen UT 92721 has a length of 4.3mm. (including the articulating half-ring) and a width of 4.3mm. Specimen, UT 92682 has a length of 3.3mm. without the articulating device.

Description: The pygidia of this form are strongly convex and have constricted acrolobes. The marginal furrow is wide (exaggerated in available specimens due to the fact that they are internal moulds), and the rim narrow and elevated. Short border spines are placed opposite the well-rounded posterior of the trisegmented pygidial axis. The axis extends the full length of the acrolobe. The two anterior axial annulations are outlined by faint transverse furrows and nicks in the lateral axial margins. There is a low, elongated node extending the full length of the second axial segment. The axis is slightly constricted at the second axial segment; the posterior segment is somewhat expanded; the pleural areas are smooth. The axis is outlined by deep axial furrows.

Discussion: The width and depth of the furrows are exaggerated in internal moulds, and it is difficult to deduce the correct width and depth of the marginal furrows of the pygidia of Agnostascus (?) sp. 2. The transverse axial furrows of Agnostascus (?) sp. 2 are more pronounced than those of A. gravis Öpik. The pygidial axial node of A. sp. aff. gravis (Öpik, 1967, p. 148, pl. 61, figs. 5, 6) is placed further to the posterior than that of A. (?) sp. 2.

Occurrence and Age: Agnostascus (?) sp. 2 comes from near St. Valentines Peak at lat. 41°21.6'S, long. 145°44.3'E and also at lat. 41°21.4'S, long. 145°44.6'E; its age is close to the Middle Cambrian-Upper Cambrian boundary.

Agnostascus (?) sp. 3

pl. 23, fig. 3

Material: One moderately preserved pygidium, UT 92599, of length, 4.0mm. (including axial half-ring) is known.

Discussion: This pygidium shows angulate fulcral points and large slightly concave facets. It is similar to Agnostascus (?) sp. 2 and may be the same species, but until further specimens are found, no firm decision can be made.

Occurrence and Age: *Agnostascus* (?) sp. 3 comes from the upper sedimentary sequence of the Radfords Creek Group as exposed near a quarry near Riana at lat. 41°13.0'S, long. 146°00.2'E (grid 4004E, 9240N). It is found above the main fossil band of this quarry; its age is early Upper Cambrian, Mindyallan Stage.

Agnostascus (?) sp. 4

pl. 23, figs. 4-6

Material: Three pygidia, all of which are poorly preserved, are available for description.

Measurements: UT 92632, (internal mould), pygidium, length (including axial half-ring), 2.1mm., width, about 2.0mm.

Description: The moderately convex pygidium is about as wide as it is long. At the posterior the shallow marginal furrow is moderately wide as is the gently convex rim; both narrow to the anterior. There are angulate posterolateral corners rather than distinct spines. The shoulder furrows are narrow and shallow; the articulating furrow is shallow and arched gently to the posterior.

The wide axis has no transverse furrows. The posterior half of the axis is slightly expanded. The axis stands out well above the smooth pleural areas. The axial rear is well rounded. There is a low slightly elongated node placed only a little forward of the axial centre.

Discussion: This species, referred to as *Agnostascus* (?) sp. 4, like the other Tasmanian forms referred to *Agnostascus* (?), has a wider pygidial border than the type species, *A. gravis*. The pygidial axial node of *Agnostascus* (?) sp. 4 is placed much further to the posterior than that of *A. gravis*, *A.* sp. aff. *gravis* or any of the other Tasmanian forms. The pygidial axis of *Agnostascus* (?) sp. 4 is not as wide as those of *A.* (?) sp. 1, *A.* (?) sp. 2, *A.* (?) sp. 3, or *A.* (?) sp. 5.

Occurrence and Age: *Agnostascus* (?) sp. 4 comes from the Brewery Junction Formation at lat. 41°52.9'S, long. 145°25.6'E (BJ_1 fauna); its age is early Upper Cambrian, either the *Erediaspis eretes* Zone or the *Cyclagnostus quasivespa* Zone.

Agnostascus (?) sp. 5

pl. 23, figs. 7-9

Material: Two cephala and one pygidium, all of which are poorly preserved, are available for inspection.

Measurements: UT 92634, cephalon, length, about 3.2mm. UT 92635, pygidium, length (including axial half-ring), 3.4mm.

Description: The moderately convex cephalon is probably about as wide as it is long. There is a moderately wide, shallow marginal furrow and a narrow, convex rim, both of which narrow to the posterior. There is a wide, deep preglabellar median furrow. The cheeks are smooth; the basal lobes are small. The glabella is outlined by wide, shallow furrows. It has a length about two-thirds that of the cephalon. The shallow transverse glabellar furrow is arched gently to the posterior. The anterior glabellar segment has a length about one-third that of the cephalon. The glabellar rear is probably subangular.

The pygidium has a wide, rather flat border, with the rim only slightly elevated above the marginal furrow. The acrolobe is constricted. Neither the posterolateral regions nor the shoulder regions are clearly visible. The articulating furrow is shallow; the articulating half-ring is short (sag.). The wide axis stands well above the small, smooth pleural areas. The posterior rear is very broadly rounded. There is an elongated axial node on the second axial segment. The anterior pair of axial segments is outlined by slight indentations in the axial margins.

Discussion: This form, referred to as *Agnostascus* (?) sp. 5, is similar to both *A.* (?) sp. 2 and *A.* (?) sp. 3 although better preservation is required before determining if, in fact, these forms are conspecific.

Occurrence and Age: *Agnostascus* (?) sp. 5 comes from the Brewery Junction Formation at lat. 41°52.9'S, long. 145°25.6'E (BJ_1 fauna); its age is early Upper Cambrian, either of the *Erediaspis eretes* Zone or the *Cyclagnostus quasivespa* Zone.

Subfamily PSEUDAGNOSTINAE Whitehouse, 1936

Genus PSEUDAGNOSTUS Jaekel, 1909

Synonymy: See Palmer, 1968, p. 29, for pre-1968 synonymy. Öpik, 1967, p. 149, has since discussed the genus.

Type Species: *Agnostus cyclopyge* Tullberg, 1880, p. 26, pl. 2, fig. 15.

Discussion: Öpik (1963, p. 48 and 1967, p. 149) has discussed the generic concept of *Pseudagnostus* in considerable detail. The Tasmanian forms do not add anything to those discussions. Each Tasmanian form is discussed after its description.

Pseudagnostus corbetti sp. nov.

pl. 23, figs. 10-19

Material: Four cephala and six pygidia are chosen for descriptive purposes from the many available specimens.

Measurements: Cephala: UT 88499, length, 3.1mm., width, about 3.3mm.; UT 88370, length, about 3.1mm., width, about 3.5mm. Pygidia: UT 88353, length (without articulating half-ring), 2.9mm.; UT 88442, length (including articulating half-ring), 2.8mm.

Selection of Holotype: The pygidium, UT 88353, (pl. 23, fig. 14) is selected as holotype.

Diagnosis: *Pseudagnostus corbetti* sp. nov. is a species with unconstricted or barely constricted acrolobes. The cephalic dorsal furrows are wide and shallow. The preglabellar median furrow fades slightly to the anterior. The faint transverse glabellar furrow is V-shaped. The glabellar rear is subangular. There is a low, elongated glabellar node. The second transverse pygidial axial furrow is shallow; the anterior furrow is almost obsolete. There is a long, wide node on the second axial segment which extends slightly beyond the second transverse furrow. The short border spines are placed a little to the anterior of the well-rounded axial posterior. The accessory furrows, if continued across the margin, would meet the pygidial margin a little to the posterior of the spines. The shoulders are strongly geniculate.

Description: The cephalon is slightly wider than it is long, with a somewhat flatly rounded anterior margin and very slightly divergent posterior lateral margins. The rim is wide and slightly elevated. The marginal furrow is wide and moderately deep. Both the rim and the marginal furrow narrow markedly to the posterior. The acrolobe appears unconstricted in some specimens and very slightly constricted in others; it has a length about seven-eights that of the cephalon. The glabella has an elongated oval shape and is outlined by wide, shallow axial furrows. The glabella has a length about two-thirds that of the cephalon; the glabellar rear is subangular. The cheeks are smooth and separated at the anterior by a well-defined shallow preglabellar furrow, which shallows to the anterior. The simple, moderately sized basal lobes are connected by a very narrow connecting band. There is a faintly outlined V-shaped transverse glabellar furrow. There is an elongated narrow node in the centre of the glabella. A pair of faint glabellar furrows extend forwards and inwards toward the anterior end of the node from about halfway along the glabella.

The gently convex pygidium is slightly wider than it is long. The lateral margins diverge slightly to a point about halfway between the anterolateral corners and the short border spines. The marginal furrow is wide and shallow; the rim is almost flat; both the rim and furrow narrow markedly to the anterior. The shoulder furrows are narrow and shallow; the shoulders are narrow, elevated and strongly geniculate. The fulcral points are about midway between the axial furrows and the edge of the pygidium. There is a wide, shallow articulating furrow which is arched to the posterior and a short (sag.) elevated articulating half-ring. The anterior part of the axis is outlined by moderately wide, shallow axial furrows which converge slightly away from the anterior margin. The second axial segment is about twice as long (sag.) and slightly narrower (tr.) than the first axial segment. There is a strong elongated node on the second axial segment. The node extends over the second transverse axial furrow and just onto the third axial segment. The rather shallow posterior transverse axial furrow is directed inwards and slightly backwards from each end. The anterior transverse axial furrow is almost obsolete. The well-developed accessory furrows fade slightly to the posterior. If continued across the border, they would strike the margin a little to the posterior of the border spines. The spines are placed a little to the anterior of the axial rear and posterior to where the accessory furrows meet the marginal furrows. There is a suggestion of a terminal axial node on some specimens, but in specimens where the pygidial rear is clearly preserved, no such node is present.

Discussion: When compared to previously described species, *Pseudagnostus corbetti* sp. nov. appears to be closest to *P. rotundatus* Lermontova (1940, p. 125, pl. 49, fig. 12, 12a-c). Both *P. corbetti* and *P. rotundatus* have a V-shaped transverse glabellar furrow, short pygidial border spines and a large, elongated node on the second pygidial axial segment. The accessory furrows of *P. rotundatus* are a little more effaced than those of *P. corbetti*, and if continued across the border would cut the pygidial margin to the anterior of the border spines, whereas the accessory furrows of *corbetti* would cut the margin to the posterior of the spines.

Occurrence and Age: *Pseudagnostus corbetti* sp. nov. comes from the upper part of the Singing Creek Siltstone in the Denison Range area; its age is Upper Cambrian, probably that of either the *Dunderbergia* Zone or the *Elvinia* Zone.

Pseudagnostus cf. *corbetti*

pl. 23, fig. 20

One pygidium, UT 88478, length (including axial half-ring), 3.6mm. and width, about 3.7mm., is associated with *Pseudagnostus corbetti* sp. nov. This pygidium has similar axial features to *P. corbetti* although the axial node is not as pronounced as that of *P. corbetti*. However, the pygidial margins of this specimen are markedly tapered; the border spines are set opposite the axial rear and are much closer together than in *Pseudagnostus corbetti*. The rim is narrower than that of *P. corbetti*. The similarity in axial characteristics and the fact that there is only one known specimen of this type raises the possibility that specimen UT 88478 is an aberrant pygidium of *Pseudagnostus corbetti*. However, for the time being it is referred to *Pseudagnostus* cf. *corbetti*.

Occurrence and Age: *Pseudagnostus* cf. *corbetti* comes from the upper part of the Singing Creek Siltstone in the Denison Range area; its age is Upper Cambrian, probably that of either the *Dunderbergia* Zone or the *Elvinia* Zone.

Pseudagnostus sp. aff. *P. ampullatus* Öpik

pl. 24, figs. 1-5

Pseudagnostus ampullatus Öpik, 1967, p. 150, pl. 61, figs. 7-11, text fig. 45.

Diagnosis: See Öpik, 1967, p. 151.

Material: Several reasonably well-preserved individual cephala and pygidia are available. No complete specimen is known, but the faunal association leaves little doubt that the cephala and pygidia described below belong to the same species. Unfortunately, the one reasonably complete pygidium is known only from the internal mould.

Measurements: Cephalon, UT 92590, (intermediate distortion), length, about 1.5mm., width, about 1.4mm.; pygidium, UT 92592, internal mould, (N-S distortion), length (without articulating half-ring), 2.0mm.

Description: The strongly convex cephalon is about as wide as it is long. The posterior part of the cephalon is never fully exposed. The cephalic margins appear to converge to the anterior; the anterior cephalic margin is quite flatly rounded. The border widens slightly where the lateral and anterior margins meet to give distinct "antero-lateral corners". There is a narrow, moderately deep marginal furrow and a wide, convex, elevated rim. The rim widens slightly at the "anterolateral corners", which are accentuated by distortion.

The cheeks are smooth and placed well above the border; there is a shallow preglabellar median furrow which fades to the anterior and does not always reach the marginal furrow. The strongly convex glabella stands out well above the cheeks; it has a length about 0.65 that of the cephalon. The anterior glabellar segment has a length about one-third that of the glabella. The glabella has a very slightly pointed anterior end. The transverse glabellar furrow is wide, moderately deep and arched slightly to the posterior. The basal lobes appear to be small and simple. The glabellar rear is not seen. Toward the anterior end of the posterior glabellar segment is a pair of shallow, wide lateral glabellar furrows which run inward and slightly forwards from the axial furrows. Between the two lateral furrows and the transverse glabellar furrow the glabella is slightly expanded. Just behind the two lateral furrows is a well-developed, central, elongated node.

The strongly convex pygidium is about as wide as it is long. There is a moderately deep, wide marginal furrow. The lateral rims are wide, elevated and flat at the posterolateral corners but become quite narrow to the anterior. The lateral margins converge considerably from the anterior along to the position of the short border spines which are placed a little to the posterior of the broad axial rear. The posterior rim is wide, elevated and flat. The posterior margin has a gently curved outline.

The shoulder furrows are wide and deep. The shoulders are narrow and elevated; the facets are large and flat. The fulcra are adaxially placed. The articulating device is seen only in internal moulds (not figured). The elevated, somewhat convex, articulating half-ring is long (sag.) at the centre and narrow at its extremities.

It extends almost the full width of the axis. At its midpoint it is arched to the posterior. The wide articulating furrow also arches to the posterior; there are two deep areas at either end of the articulating furrow separated by a high, well-rounded central region.

The very wide, strongly convex axis extends the full length of the acrolobe. There are narrow, deep axial furrows in the anterior part of the axis and narrow, deep accessory furrows in the posterior part of the pygidium. The pleural fields are smooth and separate; they narrow markedly to the posterior and curve around the pseudolobe posterior but do not meet behind the axis. From the anterior margin the axis narrows slightly around the very short (sag.) anterior axial segment, which is delineated by short furrows near the axial margins. Along the second axial segment the axis is parallel-sided and at its narrowest. At the posterior of the second axial segment is a very shallow transverse axial furrow which extends across the axis. There is a strong elongated node on the second axial segment; the node is highest at the posterior. The pseudolobe is not greatly expanded.

Discussion: The species described above is referred to *Pseudagnostus* sp. aff. *P. ampullatus* Öpik because the posterior portions of the pleural areas tend to curve around the posterior of the pseudolobe. This feature is seen better on some specimens than others, e.g., in

UT 92591 (pl. 24, fig. 4) there is practically no sign of the pleural areas curving around the pseudolobe. However, in UT 92592 (pl. 24, fig. 5) and other specimens (not figured) pleural areas extend a considerable distance around the pseudolobe posterior. In no known specimen do the accessory furrows meet as in Pseudagnostus ampullatus Öpik. The pygidial border spines of both Pseudagnostus ampullatus and P. sp. aff. P. ampullatus are found opposite the axial rear. The preglabellar median furrow of P. sp. aff. P. ampullatus usually extends to the marginal furrow, whereas that of P. ampullatus does not. A further difference is that the "anterolateral corners" of P. sp. aff. P. ampullatus are much more pronounced than those of P. ampullatus. As noted by Öpik (1967, p. 151), Pseudagnostus canadensis (Billings) also has confluent accessory furrows. Pseudagnostus canadensis also shows distinct "anterolateral corners" (Rasetti, 1944, pl. 36, fig. 10). A further similarity between Pseudagnostus sp. aff. P. ampullatus with both P. ampullatus and P. canadensis is that it has decidedly curved, deep accessory furrows.

Until more complete cephala and pygidia are known, Pseudagnostus sp. aff. P. ampullatus cannot be described as a new species.

Occurrence and Age: Pseudagnostus sp. aff. P. ampullatus Öpik comes from the upper sedimentary sequence of the Radfords Creek Group as exposed near Riana in a quarry at lat. 41°13.0'S, long. 146°00.2'E (grid 4004E, 9240N) and also within 120 metres of the base of the Junee Group at lat. 41°12.7'S, long. 146°00.0'E (grid 4000E, 9250N); its age is early Upper Cambrian, Mindyallan Stage.

Pseudagnostus sp. 1

pl. 24, figs. 6-9

Material: Two cephala and two pygidia are available. All specimens are poorly preserved, considerably distorted external moulds.

Measurements: Cephala, UT 92638, (intermediate distortion), length, 2.3mm.; UT 92636, (intermediate distortion), length, 3.0mm.; width, 3.4mm. Pygidium, UT 92639, (N-S distortion), length, about 2.6mm., width, about 3.9mm.

Description: The cephalon is about as wide as it is long. There is a narrow, shallow marginal furrow and a convex, elevated rim. The posterolateral areas are absent in both specimens. The cheeks are smooth; the glabella is outlined by moderately deep and wide axial furrows. There may be a faint preglabellar median furrow for a short distance immediately in front of the glabella, but this feature (on UT 92636, pl. 24, fig. 6) may be due to distortion effects.

The glabella, which stands well above the cheeks, has a length about two-thirds that of the cephalon. The basal lobes are simple; the glabellar rear is subangular (although in UT 92638, pl. 24, fig. 8, it appears rounded due to distortion effects). The glabellar front is broadly rounded. There is a very shallow transverse glabellar furrow which is arched to the posterior. The anterior glabellar segment has a length about 0.25 that of the glabella. There is a waist at about the centre of the glabella; from the waist, wide, shallow furrows are directed inwards and slightly forwards and almost meet at the centre of the glabella. Immediately behind the waist is a low centrally placed node.

The pygidium is probably about as wide as it is long. There is a moderately wide, shallow marginal furrow and a narrow, gently convex rim both of which narrow considerably to the anterior. Border spines are probably present but cannot be seen clearly on the available material. Neither the shoulder regions nor the articulating device are visible.

The anterior pair of axial segments are short. The anterior transverse axial furrow is obsolete. The wide, shallow posterior transverse axial furrow is directed inwards and backwards from the axial furrow. There is a well-developed node on the second axial segment. The accessory furrows are straight and fade to the posterior and are barely visible where they meet the marginal furrow at points a little to the posterior of where the border spines are probably present.

Discussion: This species is too poorly preserved to compare with any known species of *Pseudagnostus*. It is referred to as *Pseudagnostus* sp. 1.

Occurrence and Age: *Pseudagnostus* sp. 1 comes from about 200 metres below the top of the Climie Formation at lat. $41^{\circ}54.2'$S, long. 145° $24.2'$E (grid 3460E, 8405N); its age is the later part of the Upper Cambrian (zone indeterminate).

Pseudagnostus sp. 2

pl. 24, figs. 10-18

Material: Seven cephala and four pygidia are available for description. All are poorly preserved and considerably distorted.

Measurements: Cephalon, UT 92627, (intermediate distortion), length, 1.3mm., width, 1.3mm.; pygidium, UT 92613, (N-S distortion), length (including axial half-ring), 2.8mm., width, 3.0mm.

Description: The strongly convex cephalon is about as wide as it is long. There is a narrow marginal furrow and a narrow, convex rim. The cheeks are smooth. There is an incomplete preglabellar median furrow, which extends only a short distance in front of the glabella. The glabella has a length about 0.7 that of the cephalon. The axial furrows are narrow and moderately deep. The shallow, narrow transverse glabellar furrow is arched to the posterior. Immediately to the posterior of this furrow the glabella is slightly expanded. The posterior glabellar segment has a distinct waist. The basal lobes are small and simple. The shape of the glabellar rear is uncertain. The highest point of the glabella is near its posterior; the presence of a node is uncertain.

The very convex pygidium is about as wide as it is long. It has markedly convergent lateral margins. The wide rim is almost flat; the marginal furrow is shallow. There may be very small border spines placed opposite the axial rear. The shoulder furrows are narrow and shallow; the shoulders are low; the fulcra are placed adaxially. The articulating half-ring is narrow; the articulating furrow is wide with small depressions at either end.

Except for indentations in the well-developed axial furrows the anterior pair of axial segments is poorly defined. An elongated node extends over both segments and is particularly prominent on the second segment. The well-developed, almost straight accessory furrows curve slightly inwards at their posterior ends. They meet the marginal furrow well forward of the broadly rounded axial rear.

Discussion: This species, referred to as *Pseudagnostus* sp. 2, is too badly preserved to be assigned to a described species or to be the basis of a new species. *Pseudagnostus* sp. 2 is probably best compared with *P. bulgosus* Öpik, 1967. The overall appearance of the two forms is similar. However, *P. bulgosus* does not have a preglabellar median furrow; it has a wider cephalic border, and the accessory furrows meet the marginal furrows further forward than in *Pseudagnostus* sp. 2.

Occurrence and Age: *Pseudagnostus* sp. 2 is found in (a) the siltstone and shale unit of the Black Hill section, Dundas, exposed at lat. 41°

51.4'S, long. 145°25.1'E (grid 3472E, 8462N) (GP_1 fauna) and (b) Brewery Junction Formation at lat. 41°52.8'S, long. 145° 25.0'E (grid 3471E, 8434N) (FE_1 fauna); its age is early Upper Cambrian, probably the Glyptagnostus stolidotus Zone.

Pseudagnostus sp. 3

pl. 24, fig. 19

One poorly preserved pygidium (UT 92570) is referred to here as Pseudagnostus sp. 3

Pseudagnostus sp. 4

pl. 24, fig. 20

A poorly preserved cephalon (UT 92648) is referred with some doubt to Pseudagnostus sp. 4. Neither Pseudagnostus sp. 3 or P. sp. 4 is preserved well enough to warrant description or comment, and these species are simply recorded as being present.

Occurrence and Age: Pseudagnostus sp. 3 and P. sp. 4 come from west of Birch Inlet from near lat. 42°27.2'S, long. 145°21.1'E (grid 3417E, 7735N); their age is the late Upper Cambrian, Prosaukia-Ptychaspis Zone.

Pseudagnostus sp. 5

pl. 24, fig. 21

One reasonably preserved pygidium (UT 54957) is known from the BJ_2 locality of the Brewery Junction Formation near Dundas. It cannot be placed into any existing species and is referred to here as Pseudagnostus sp. 5

Occurrence and Age: Pseudagnostus sp. 5 comes from the Brewery Junction Formation at lat. 41°53.0'S, long. 145°25.6'E (grid 3480E, 8429N) (BJ_2 locality); its age is early Upper Cambrian either of the Erediaspis eretes Zone or the Cyclagnostus quasivespa Zone.

Subfamily GLYPTAGNOSTINAE Whitehouse, 1936

Genus GLYPTAGNOSTUS Whitehouse, 1936

Glyptagnostus Whitehouse, 1936, p. 101; Kobayashi, 1939, p. 155; 1949, p. 1; Shimer & Shrock, 1944, p. 600; Westergård, 1947, p. 5; Hupé, 1953, p. 63; Pokrovskaya, 1960a, p. 60; Öpik, 1961a, p. 428; 1963, p. 38; 1967, p. 167; Palmer, 1962, p. 15; 1968, p. 27.

Type Species: Glyptagnostus toreuma Whitehouse (1936, p. 102, pl. 9, figs. 17-20) = Agnostus reticulatus Angelin (1851, p. 8, pl. 6, fig. 10).

Diagnosis: See Palmer, 1962, p. 15.

Discussion: Öpik (1961a) and Palmer (1962) have discussed Glyptagnostus in considerable detail. Some aspects of Palmer's work are discussed below in the discussion of Glyptagnostus reticulatus (Angelin). Öpik (1967, p. 169) erected Lispagnostus as a new subgenus within Glyptagnostus. Öpik (op. cit.) had only one cephalon at his disposal. The writer considers that more material is required before the erection of a new subgenus can be justified.

Glyptagnostus reticulatus (Angelin)

pl. 25, figs. 1-9

Synonymy: See Palmer, 1968, p. 27.

Diagnosis: See Palmer, 1962, p. 18.

Material: Two almost complete specimens and several individual cephala and pygidia are available. All specimens are reasonably well preserved.

Discussion: Glyptagnostus reticulatus (Angelin) has been known from the Huskisson River area for a number of years (e.g., Öpik, 1951b; Banks, 1956, 1962a; Blissett, 1962). The exceedingly flattened nature of most of the Huskisson River specimens makes it a little difficult to compare them with those illustrated from other parts of the world. Even the flattened specimen of G. reticulatus from Queensland, illustrated by Öpik (1963, pl. 2, fig. 6), appears to show more convexity than most of the Tasmanian specimens. Apart from this factor the Huskisson River specimens are a little distorted. One pygidium (UT 89517c) and three cephala (UT 89517a, b, d) are distinctly more convex than the other specimens (see pl. 25, figs. 8, 9, 7, 3, respectively), and it can be seen that the convexity slightly alters the overall appearance of the specimens. The Huskisson River forms clearly belong to G. reticulatus (Angelin) rather than G. stolidotus Öpik. There are three described subspecies of G. reticulatus, viz: G.r.

nodulosus Westergård, 1947, *G.r. reticulatus* (Angelin) and *G.r. angelini* (Resser). The latter two subspecies were erected by Palmer (1962), with *angelini* being slightly older than *reticulatus*.

Palmer (1962, p. 18) states that one of the diagnostic features of *G.r. reticulatus* is that the length of the third pygidial axial lobe (Lb_3) averages more than 0.7 the length (Lb_2) of the second pygidial axial node, whereas one of the diagnostic features of *angelini* is that Lb_3 averages less than 0.7 Lb_2. His equations for plots of Lb_3 v. Lb_2 for both *reticulatus* and *angelini* are as follows:

G.r. angelini $Lb_3=0.69Lb_2+0.14$ (N = 36; r = 0.91)

G.r. reticulatus $Lb_2=0.70Lb_2-0.09$ (N = 14; r = 0.86)

Palmer apparently derives this diagnostic feature from the slopes of the lines drawn from the above equations. It is doubtful if this is a valid deduction due to the fact that the two slopes are almost equal. Dr. S. Morris, Department of Mathematics, University of Adelaide, supports this statement.

It should also be noted that the areas occupied by the points representing the two subspecies overlap to some extent (see Palmer, 1962, fig. 11). A further point is that in three of the thirty-five points plotted by Palmer for *G.r. angelini* $Lb_3 \geq .70$ and in *G.r. reticulatus* $\frac{Lb_3}{Lb_2} < 0.7$ in two of the fourteen plotted points. Thus, it is doubtful if the relative lengths of the third and second pygidial axial lobes should be used as a diagnostic feature.

However, it is true that in general $\frac{Lb_3}{Lb_2}$ is greater in *G.r. reticulatus* than in *G.r. angelini*. This can be seen very clearly on figure 11 of Palmer (1962) and may be demonstrated by means of a "Student's 't' test". Using this test on a null hypothesis that the populations of the supposedly different subspecies in fact belong to the same population, a value of t = 7.89 was obtained (see Appendix 1 for calculations). The tables of Simpson *et al*. (1960, p. 422) indicate that the probability that the two samples belong to the same population is less than 0.001. This implies that the two subspecies, as recognized by Palmer, do, in fact, generally differ in the ratio of the lengths of the second and third pygidial axial lobes, but, as noted above, it is a general rather than a diagnostic feature.

A second difference between *G.r. reticulatus* and *G.r. angelini* noted by Palmer is that in the former the posterior part of the axis usually has well-developed, longitudinal furrows outlining lateral lobes whereas in *angelini* these longitudinal furrows are poorly developed. Again this is a general feature used to assist in diagnosing the differences between the two subspecies rather than a completely diagnostic feature. Palmer (*op. cit.*, fig. 11 and p. 18) indicates that there is an evolutionary sequence within G. reticulatus, with G.r. angelini being the older morphologic extreme and G.r. reticulatus being the younger morphologic extreme. He also notes that there is "complete stratigraphic gradation between the two morphologic extremes." It would seem that Palmer has shown a valid evolutionary series within G. reticulatus.

In such circumstances (where complete gradation can be shown) it seems doubtful to the writer whether in fact new subspecies and formal diagnoses should be set up. Rather in would seem better to do what Palmer (op. cit., p. 18) has, in fact, done in his discussion and indicate what features change, how they change, and the relationship between the changes of different morphologic features. This seems more realistic as it looks at the evolving animals rather than putting them in arbitrarily defined classificatory "boxes".

The Huskisson River specimens agree reasonably closely with the form described by Palmer as G.r. reticulatus.

Occurrence and Age: Glyptagnostus reticulatus (Angelin) comes from unit 18 of the Huskisson River Group at lat. 41°45.1'S, long. 145° 27.2'E; its age is early Upper Cambrian, either the Glyptagnostus reticulatus - Olenus ogilviei Zone or the G. reticulatus - Proceratopyge nectans Zone.

Genus AGNOSTARDIS Öpik, 1963

Agnostardis Öpik, 1963, p. 39; 1967, p. 166.

Diagnosis: See Öpik, 1963, p. 40.

Type Species: Agnostardis amplinatus Öpik, 1963, p. 40, pl. 3, figs. 1-8, text figs. 8, 9.

Agnostardis sp. 1

pl. 26, figs. 1-6

Material: The available material consists of several poorly preserved specimens, including one almost complete specimen as well as individual cephala and pygidia.

Discussion: The material is too poorly preserved to be described in detail. The specimens figured clearly belong to the genus Agnostardis as diagnosed by Öpik (1963, p. 40). The only comment that should be made is that there appears to be considerable variation in the length of the pygidial axis as shown by the various specimens all of which come from the one locality. Until better material is found, all specimens from this locality are placed tentatively in the one species referred to here as Agnostardis sp. 1. Öpik (1967, p. 32) records Agnostardis amplinatus from what he called the Comet Slate. He does not state the locality of this occurrence, but it is probably from a similar horizon to Agnostardis sp. 1 (Gatehouse, pers. comm.).

Occurrence and Age: Agnostardis sp. 1 comes from the upper fauna of the siltstone and shale unit exposed in Barkers Creek (Black Hill section, Dundas) at lat. 41°51.4'S, long. 145°26.1'E (grid 3487E, 8462N); its age is early Upper Cambrian, the *Glyptagnostus stolidotus* Zone.

Agnostardis sp. 2

pl. 26, figs. 7, 8

Material: Two poorly preserved pygidia are known from Tom Creek. One specimen, UT 54928, is an external mould and the other, UT 54926, is an internal mould.

Discussion: Both specimens are tentatively referred to as *Agnostardis* sp. 2 although there appear to be considerable differences in the shape of the pygidial axes. However, the pygidia of *Agnostardis amplinatus*, illustrated by Öpik (1963, pl. 3), show considerable intra-specific variation as well as having different appearances depending on the preservation.

Unlike all illustrated pygidia of *Agnostardis amplinatus* there does not appear to be a well-developed post-axial median furrow in UT 54926 (pl. 26, fig. 8). The pygidial axis in specimen UT 54926 is much narrower than that in specimen UT 54928 (pl. 26, fig. 7). The junction of the middle axial segment and the posterior bulb in specimen UT 54928 is placed further back than in any other illustrated specimen of *Agnostardis* although there does appear to be considerable variation in the position of this point in *Agnostardis amplinatus* (see Öpik, 1963, pl. 3; Öpik, 1967, pl. 67).

Until further and better specimens are obtained from the Tom Creek locality, the two specimens, UT 54926 and UT 54928, are referred to Agnostardis sp. 2 although it is recognized that they may belong in different species.

Occurrence and Age: Agnostardis sp. 2 comes from a siltstone bed in Tom Creek near lat. 41°55.5'S, long. 145°26.3'E (grid 3491E, 8378N); its age is early Upper Cambrian, that of Glyptagnostus stolidotus Zone.

Agnostardis sp. 3

pl. 26, fig. 9

Material and Comments: Only one internal mould of a pygidium is available. This pygidium, UT 54730, has undergone intermediate type distortion. It has a length (including the axial half-ring) of 4.6mm. and a width of 6.0mm.

This pygidium is rather similar to Agnostardis amplinatus Öpik but has a wider border than most specimens of A. amplinatus as figured by Öpik (1963, pl. 3, and 1967, pl. 67). However, the pygidium figured by Öpik (1963, pl. 3, fig. 4) has a border of similar width to the specimen concerned. Until better material is recovered, this pygidium, UT 54730, will be referred to as Agnostardis sp. 3. One possible difference between Agnostardis amplinatus and A. sp. 3 is the apparent lack of a post-axial median furrow in the latter. Unfortunately, a low "tectonic ridge" crosses this part of the only available pygidium and no firm decision can be made.

Occurrence and Age: Agnostardis sp. 3 is found in the siltstone and shale unit of the Black Hill section, Dundas, exposed at lat. $41^{o}51.4'S$, long. $145^{o}25.1'E$ (grid 3472E, 8462N)(GP_1 locality); its age is early Upper Cambrian, probably that of the Glyptagnostus stolidotus Zone.

Family and Subfamily, Indet.

Agnostid, gen. et sp. indet. no. 1

pl. 26, figs. 10, 11

Material: Two badly distorted enrolled specimens are available for description. UT 92654 shows the pygidium, and UT 92653 exhibits the cephalon.

Description: The cephalon UT 92653 is about 5.5mm. long and 6.0mm. wide. It is subquadrate with an apparently entirely effaced surface. The border area is of moderate width with a shallow marginal furrow and an elevated rim. The specimen is so badly deformed that no more can be seen.

The pygidium probably had a subquadrate outline. The border is of moderate width but details of the rim are obscured by deformation; the marginal furrow is probably narrow. The axis is fairly well outlined at the anterior by deep dorsal furrows which fade to the posterior. At the anterior margin the width of the axis is about half that of the pygidium. The axis narrows posteriorly until it is narrowest (about 3/8 the width of the pygidium) approximately .25 of the distance to the posterior margin. To the posterior of the narrowest point the axis widens slightly and fades out. The pleural fields are smooth.

Discussion: The size and high degree of effacement of this species suggest affiliation with *Grandagnostus*. However, until better species are found, it will be referred to as Agnostid, gen. et sp. indet. no. 1.

Occurrence and Age: Agnostid, gen. et sp. indet. no. 1 comes from the Que River Beds at lat. 41°34.7'S, long. 145°41.0'E (grid 3710E, 8803N); its age is Middle Cambrian, either the *Ptychagnostus punctuosus* Zone or the *P. nathorsti* Zone.

Agnostid, gen. et sp. indet. no. 2

pl. 26, figs. 12, 13

Material: Two incomplete pygidia are available for inspection.

Measurements: The larger pygidium, UT 92733, (N-S distortion) has a length (without the articulating half-ring) of 1.7mm. and a width of 2.0mm.

Remarks: These pygidia appear to be of a similar type to those described by Rasetti, 1967, p. 38, as Agnostida, pygidium, no. 1. The Tasmanian specimens do not show the articulating device, and the shoulder area is seen only in the smaller specimen. These specimens do not permit anything to be added to or any comment to be made on the discussion given by Rasetti (*op. cit.*). Rasetti's specimens are associated with

Centropleura and are hence of a similar but slightly older age to the two pygidia from St. Valentines Peak. These pygidia are referred to here as Agnostid, gen. et sp. indet. no. 2.

Occurrence and Age: Agnostid, gen. et sp. indet. no. 2 comes from the main fauna in the St. Valentines Peak area near lat. 41°21.6'S, long. 145°44.3'E (grid 3758E, 9064N); its age is either late Middle Cambrian, the *Lejopyge laevigata* III Zone or the Middle Cambrian/Upper Cambrian Passage Zone.

Agnostid, gen. et sp. indet. no. 3

pl. 26, figs. 14, 15

Material: Two pygidia, UT 92690 and UT 92691, are available for description. UT 92691 is well preserved, and the following description is based almost entirely on that specimen.

Description: The pygidium is about as wide as it is long. It has a convex anterior end and a flat posterior. The acrolobes are unconstricted; the border is wide with a wide convex elevated rim which becomes less convex and quite narrow to the anterior. The rim has a low posterior median salient. The marginal furrow is wide and of moderate depth. The shoulder areas are poorly preserved, but the shoulder furrows are narrow and shallow; the shoulders appear to be low and convex with no geniculation. The fulcra seem to be very close to the axis, which is outlined by wide, moderately deep, axial furrows.

The axis is wide at the anterior and tapers fairly evenly to the posterior with a slight constriction about one-third of the distance to the sharply rounded posterior. Immediately to the posterior of the axis there is a large depression caused by the meeting of the axial furrows and the posterior marginal furrow. There are no border spines. The pleural fields are smooth. There is a small axial node placed just to the anterior of the axial constriction. No details of the articulating device are visible.

Discussion: As far as I can determine, these pygidia have no affiliation with any known agnostid genus or species. They are referred to as Agnostid, gen. et sp. indet. no. 3.

Occurrence and Age: This species comes from the main fauna in the St. Valentines Peak area near lat. 41°21.6'S, long. 145°44.3'E (grid 3758E, 9064N); its age is either late Middle Cambrian, the *Lejopyge laevigata* III Zone or the Middle Cambrian/Upper Cambrian Passage Zone.

Agnostid, gen. et sp. indet. no. 4

pl. 26, figs. 16-18; pl. 27, figs. 1-8

Material: Numerous poorly preserved cephala and pygidia are available. Two poorly preserved complete specimens are known (UT 88620 and UT 92470).

Measurements: UT 86620, complete specimen, (N-S distortion), total length, 7.6mm.; cephalon, length, 3.5mm.; width, 3.4mm.; pygidium, length (without articulating half-ring), 3.3mm., width, 3.5mm. UT 92470, complete specimen, (E-W distortion), total length, 6.7mm.; cephalon, length, 3.0mm., width, 2.3mm.; pygidium, length (without articulating half-ring), 2.9mm., width, about 2.5mm.

Description: The moderately convex cephalon is probably about as wide as it is long. When undistorted it would have had a subcircular outline with a straight posterior margin; the cephalon is widest near the posterior end about .25 of the distance to the broadly rounded anterior margin. The narrow border is rarely visible due to the overhanging acrolobe margins. Apart from faint traces of a slightly elevated rounded glabellar rear, the cephalon is smooth.

The pygidium is probably slightly longer than it is wide. There is a wide, gently convex, elevated rim, which narrows considerably to the anterior and a narrow, shallow marginal furrow. The shoulder and marginal furrows meet at an angle of just over 90°. The shoulders are narrow and elevated. The articulating device consists of a narrow (sag.), moderately convex articulating half-ring which is arched gently forward and a moderately deep articulating furrow which is also arched forward. The only dorsal features on the acrolobe are shallow axial furrows at the anterior end of the pygidium where the axis has a width about 0.4 that of the pygidium.

Discussion: This effaced agnostid cannot be placed with certainty into any genus as all specimens have been considerably crushed and distorted.

The pygidial border is wide, thus excluding Lejopyge; it may be a species of either Grandagnostus or Pseudophalacroma. The high degree of effacement and poor preservation makes detailed classification out of the question. This species is referred to as Agnostid, gen. et sp. indet. no. 4.

Occurrence and Age: This species comes from the upper fauna at Christmas Hills (lat. 40°54.1'S, long. 144°29.8'E; grid 3075E, 9610N); its age is late Middle Cambrian, either the Lejopyge laevigata I Zone or the L. laevigata II Zone.

Agnostid, gen. et sp. indet. no. 5

pl. 27, figs. 9, 10

Material: Two pygidia (UT 92655, UT 92656), probably belonging to Hypagnostus sp., are known from the RB locality (see discussion of Hypagnostus sp., p. 143).

Description: UT 92655 has undergone N-S distortion; it is 1.8mm. long and 2.1mm. wide. There is a narrow, moderately deep marginal furrow and a wide, elevated, almost flat rim. Neither the articulating device nor the shoulder areas are preserved. The pleural areas are probably smooth. The axis is outlined by wide, moderately deep furrows, which are subparallel for about 0.75 of the axial length. The axial posterior is angular. There is a well-developed post-axial median furrow. The axis has a length about 0.7 that of the pygidium and about 0.85 that of the acrolobe. The trisegmented nature of the axis is picked out by faint lateral notches. The two anterior segments have about the same length (sag.) although the anterior segment is slightly the wider (tr.). The combined length of the two anterior segments is about three-eights that of the axis.

Occurrence and Age: This species, referred to Agnostid, gen. et sp. indet. no. 5, comes from about 28 metres above the base of lowest siltstone unit of the Black Hill section near Dundas at lat. 41°50.8'S, long. 145°24.7'E (grid 3466E, 8474N)(RB locality); its age is Middle Cambrian, possibly the *Ptychagnostus nathorsti* Zone.

Agnostid, gen. et sp. indet. no. 6

pl. 27, fig. 11

Material: Three poorly preserved pygidia are available from the RB locality, Black Hill section, Dundas. Only the best preserved of these, UT 88132, is figured.

Description: The pygidium is probably about as wide as it is long. There is a moderately deep marginal furrow and a flatly convex, wide rim. There are border spines of indeterminate length. The pleural fields are probably smooth. The wide axis, which extends the entire length of the acrolobe, is outlined by narrow, shallow furrows. The axial rear is pointed. The axis shows no sign of transverse axial furrows. The axis is widest at a point about 0.6 of the distance from its anterior to its posterior, where it has a width about 0.5 that of the pygidium. The axis is slightly constricted in the expected position of the second axial segment. There is a large, circular node on the second axial segment.

Discussion: These pygidia may belong in Peronopsis (see discussion of Hypagnostus sp., p. 143).

Occurrence and Age: This species, referred to Agnostid, gen. et sp. indet. no. 6, comes from about 28 metres above the base of lowest siltstone unit of the Black Hill section near Dundas at lat. 41°50.8'S, long. 145°24.7'E (grid 3466E, 8474N)(RB locality); its age is Middle Cambrian, possibly the Ptychagnostus nathorsti Zone.

Agnostid, gen. et sp. indet. no. 7

pl. 27, figs. 12-14

Material: Three poorly preserved, external moulds of incomplete pygidia are known.

Description: The most complete pygidium, UT 92657, (intermediate distortion) has a length (including axial half-ring) of about 3.2mm. The pygidium is probably about as wide as is long. The posterior border is moderately wide with a moderately wide, shallow marginal furrow and a narrow, gently convex rim. Small border spines are placed opposite the well-rounded pygidial rear. The lateral rim and marginal furrow narrow to the anterior. The shoulder areas and articulating device are nowhere clearly preserved.

The trilobate axis has two short (sag.) anterior lobes and a long, slightly expanded end-lobe, which just reaches the marginal furrow. The anterior pair of lobes have a combined length about 0.4 that of the axis. The axial furrows are wide and moderately deep at the anterior but fade out almost completely along the posterior half of the axis. The posterior of the axis is well rounded with a small terminal node. The axis is slightly constricted at the second axial lobe. The first transverse axial furrow is obsolete. There is a long, low central ridge which extends the full length of the first and second axial lobes and is highest at its posterior. It extends slightly onto the transverse axial furrow, which separates the second lobe from the posterior lobe. From either end this furrow is directed inwards and slightly backwards. The pleural areas are smooth and are separated at the posterior by the tip of the axial lobe.

Discussion: There is no known cephalon with which these poorly preserved pygidia can be linked, and until such a cephalon is found, their taxonomic position must remain open.

Occurrence and Age: This species, referred to Agnostid, gen. et sp. indet. no. 7, comes from about 200 metres below the top of the Climie Formation at lat. 41°54.2'S, long. 145°24.2'E (grid 3460E, 8405N); its age is the later part of the Upper Cambrian (zone indeterminate).

Agnostid, gen. et sp. indet. no. 8

pl. 27, fig. 15

Material: One well-preserved, incomplete cephalon, UT 89438b, of length 3.9mm. is known.

Description: At the anterior there is a wide, shallow marginal furrow and a wide, gently convex, elevated rim. The lateral borders are not visible. As far as can be seen, the acrolobes are unconstricted. There are wide posterior borders with narrow spines arising from near the posterolateral corners; the spine length is not known, but it is of at least moderate length. The cheeks are smooth. The deep, wide preglabellar median furrow flares slightly forward. The glabella is long, parallel-sided and is outlined by deep, wide dorsal furrows. The glabella has a length about 0.7 that of the cephalon. The glabellar front is evenly rounded. The straight, shallow, transverse glabellar furrow is very shallow at the centre. The anterior glabellar segment has a length one-third that of the glabella. There is no distinct glabellar node although this may be a function of preservation.

Towards the anterior end of the posterior glabellar segment is a pair of faint short lateral furrows which run inwards and forwards. The glabellar rear is very broadly rounded. The small basal lobes are connected by a wide connecting band. The cephalo-thoracic aperture is present at the posterior of the connecting band.

The anterior ends of the basal lobes appear to be connected to the cheeks. In both basal lobes the abaxial furrow outlining the lobe shallows markedly at the anterior; the left-hand lobe in particular seems connected to the cheek.

Discussion: This cephalon cannot be placed in any particular genus. The combination of a wide border, a preglabellar median furrow which flares at the anterior, a parallel-sided glabella, a straight shallow transverse glabellar furrow, a broadly rounded glabellar rear, moderately long posterolateral spines, a wide connecting band between the small basal lobes and the apparent connection of the anterior part of the basal lobes to the cheeks is unique as far as the author is aware. However, in view of the fact that the cephalon is incomplete and that the pygidium is unknown, a new genus or a new species is not erected.

Occurrence and Age: This species, referred to Agnostid, gen. et sp. indet. no. 8, comes from the upper part of the Singing Creek Siltstone in the Denison Range area; its age is Upper Cambrian, probably either the *Dunderbergia* Zone or the *Elvinia* Zone.

Agnostid, gen. et sp. indet. no. 9

pl. 27, figs. 16, 17

Material and Comments: One external mould of a cephalon and an internal mould of a pygidium are available. Both specimens are very poorly preserved. The cephalon, UT 92660, has an approximate length of 1.5mm., and the pygidium, UT 92661, has an approximate length of 2.2mm.

Little can be seen in the cephalon except that the border is narrow and the glabella is distinctly outlined. The pygidium is somewhat better preserved. The border is wide; there may be short border spines present. The wide axis is well defined by axial furrows. It extends the full length of the acrolobe and has a well-rounded rear. The pleural areas are small. The posterior axial lobe is slightly expanded.

The cephalon and pygidium noted above were found at the same stratigraphic level. They are the only agnostids known from this locality and are placed together for the time being. The material is much too poor to allow a generic designation to be made although it is possible that the pygidium belongs to *Agnostoglossa* or a related genus.

Occurrence and Age: This species referred to Agnostid, gen. et sp. indet. no. 9, comes from a mudstone in McLeans Creek at lat. 41°55.3'S, long. 145°17.5'E (grid 3375E, 8381N); its age is probably Upper Cambrian.

Agnostid, gen. et sp. indet. no. 10

pl. 27, fig. 18

One poorly preserved partial pygidium, UT 92662, is available. Its exposed length is 1.1mm.; the total length would be about 1.2mm. As far as can be determined, it has a similar overall appearance to a pygidium of *Agnostus* except that it has a post-axial median furrow, a feature not seen in *Agnostus*. Until further and better specimens are located, this pygidium must be classed as gen. et sp. indet.

Occurrence and Age: This species, referred to Agnostid, gen. et sp. indet. no. 10, is found in the Brewery Junction Formation at lat. 41^{o} 52.8'S, long. 145^{o}25.0'E (grid 3471E, 8434N) (FE_1 locality); its age is probably early Upper Cambrian, the *Glyptagnostus stolidotus* Zone.

Agnostid, gen. et sp. indet. no. 11

pl. 27, fig. 19; pl. 28, figs. 1-12

Material: Numerous poorly preserved individual cephala and pygidia are known.

Measurements: Cephalon, UT 92664, (E-W distortion), length, 2.7mm., width, about 1.9mm. Pygidia, UT 92663, (intermediate distortion), length (including axial half-ring), 4.3mm., width, 3.8mm.; UT 92670, (E-W distortion), length (including axial half-ring), 2.8mm., width, 2.2mm.

Description: The moderately convex cephalon has a moderately wide anterior border which narrows to the posterior. There is a shallow marginal furrow and a wide, almost flat rim, which narrows markedly to the posterior. There are short posterolateral spines. With the exception of faint traces of the very posterior regions of the glabella, the rest of the cephalon appears to be effaced.

The moderately convex pygidium has a wide border which, in contrast to the cephalic border, narrows only slightly to the anterior. The wide, shallow marginal furrow merges into the slightly elevated rim.

The acrolobe margins are steep. The shallow shoulder furrows narrow adaxially. The shoulders are narrow; the fulcra are placed adaxially. There is a narrow articulating furrow which is markedly depressed at either end. The articulating half-ring is short (sag.) and convex. The acrolobes are largely effaced with a very prominent somewhat elongated node placed somewhat to the anterior of the centre of the pygidium.

Discussion: This species is placed in the category of genus and species undetermined. The combination of considerably distorted specimens and an effaced agnostid makes positive or even tentative identification at both the generic and specific level impossible.

Occurrence and Age: This species, referred to Agnostid, gen. et sp. indet. no. 11, is found in (a) the siltstone and shale unit of the Black Hill section, Dundas exposed at lat. 41°51.4'S, long. 145°25.1'E (grid 3472E, 8462N), (GP_1 locality) and (b) Brewery Junction Formation at lat. 41°52.8'S, long. 145°25.0'E (grid 3471E, 8434N)(FE_1 locality); its age is early Upper Cambrian, probably the *Glyptagnostus stolidotus* Zone.

Suborder EODISCINA Kobayashi, 1939

Family PAGETIIDAE Kobayashi, 1935

Genus OPSIDISCUS Westergård, 1949

Opsidiscus Westergård, 1949, p. 606; Rasetti, 1952, p. 436; 1966b, p. 8; Howell, 1959, p. 188; Pokrovskaya, 1960a, p. 56; Kobayashi, 1962, p. 21;

Rushton, 1966, p. 11; Palmer, 1968, p. 38; Poletaeva and Romanenko, 1970, p. 73.

Aulacodiscus Westergård, 1946, p. 26; Shaw, 1950, p. 588; Hupé, 1953, p. 59.

Type Species: Aulacodiscus bilobatus Westergård, 1946, p. 26, pl. 1, figs. 16-22.

Description: Opsidiscus is a pagetiid trilobite with two thoracic segments and a closely spaced fine granulation on the dorsal surface. This granulation is not visible on most photographs. The moderately convex cephalon is wider than is long (excluding the occipital spine). The rim is moderately wide at the anterior but narrows to the posterior. The shallow marginal furrow has a variable number of pits or transverse furrows in its anterior region. There is a small depressed area immediately in front of the glabella. The glabella extends about 0.75 the length of the cephalon (excluding the occipital spine); it is outlined by wide, deep furrows and tapers slightly to the anterior. A weakly to well-developed anterior transverse glabellar furrow separates off an anterior glabellar lobe. An occipital spine is present. The eye ridges are well defined to not present. There are well-defined schizochroal eyes, or large "eye tubercles", in a similar position near the edge of the cephalon. There are no facial sutures.

The moderately convex pygidium has a narrow border and is wider than it is long. The axis is outlined by moderately deep furrows which shallow to the posterior. It does not quite reach the posterior border. There is a large, crescentic shaped articulating half-ring. The axis consists of three to five segments plus a terminus. The two segments immediately in front of the terminus are fused and may bear a spine. The only sign of pleural segmentation is close to the axis.

Discussion: The above generic description is based on a study of the figures of Opsidiscus bilobatus (Westergård) (Westergård, 1946, pl. 1, figs. 16-22), O. altaicus Poletaeva (Poletaeva and Romanenko, 1970, pl. 10, figs. 1-5, text fig. 2), O. depolitus Romanenko (Ibid, pl. 10, figs. 6-9, text fig. 3), the specimens of O. argusi described here and two rubber casts of O. bilobatus. These casts, US 274 and US 275, are the holotype cephalon and a pygidium figured by Westergård, 1946, pl. 1, figs. 21, 22, respectively. They are refigured here as pl. 31, figs. 1, 2, respectively.

This generic description differs in some respects from that given by Westergård (1946, p. 27) for the type species Opsidiscus bilobatus. The first difference is the very fine granulation of the test noted above. This feature is not noted by Westergård with respect to the type species, but an inspection of the rubber casts of O. bilobatus reveals that a fine granulation is present.

The pygidial axes of the other three species are better known than that of bilobatus, and it is on these three species that the axial description is mostly based. The most important difference between the above description and that originally given for O. bilobatus is the mention of schizochroal eyes. These are known to date only in the new species, Opsidiscus argusi, described below. Only large "tubercles" are seen in the eye position of the other three species. The eye tubercles on the rubber cast of the holotype cephalon of O. bilobatus were closely inspected. They are poorly preserved, and as shown in pl. 29, fig. 7, they possess fine granules which could possibly be interpreted as eye lenses. However, they bear no resemblance to the well-defined schizochroal eyes of O. argusi and are rather unconvincing. It is possible that the eyes were present and have not been preserved. This suggestion is supported by the fact that in the more poorly preserved specimens of O. argusi no lenses are seen on the eye surfaces, which have a similar appearance to the "eye tubercles" of O. bilobatus.

Classification and Relationships of Opsidiscus: In discussing this subject a brief nomenclatural observation must be made. The writer found that, in searching the literature on this and related topics, the term eodiscid is used to refer to either the suborder Eodiscina as a whole (i.e., including both the families Eodiscidae and Pagetiidae) or solely to members of the family Eodiscidae. This can be very confusing, and in the following discussion the term eodiscid is restricted to members of the family Eodiscidae. Where reference is made to the suborder, then the term Eodiscina is used.

Westergård (1946, p. 22) considered that Opsidiscus was the link between the pagetiids and the eodiscids in that it has a pair of tubercles (homologous with pagetiid eyes) and lacks facial sutures. However, this suggestion is ruled out by the fact that the first appearance of Opsidiscus is later than the last appearance of the eodiscids. Westergård (1946, p. 28) also noted the close similarity between Opsidiscus and Pagetia and considered Opsidiscus to be a descendant of Pagetia. Westergård (op. cit., p. 22) included both the eodiscids and the pagetiids in the family Eodiscidae and suggested that a further breakdown into subfamilies, Pagetiinae and Eodiscinae, was unnecessary, partly due to the presence of the supposed intermediate form Opsidiscus. Westergård (1946) discussed Opsidiscus under his original generic designation, Aulacodiscus. However, Westergård (1949) realized that this name was preoccupied and replaced it with Opsidiscus.

The classification of Hupé (1953) for the eodiscids and pagetiids is quite complicated. It includes the new family Aulacodiscidae, thus raising the preoccupied generic name to familial level. Howell (1959) proposed that the suborder Eodiscina be divided into two families, (1) the Eodiscidae, without facial sutures and usually without eyes, and (2) the Pagetiidae, with eyes and facial sutures. He placed Opsidiscus in the Eodiscidae, presumably because of the lack of facial sutures. The classification of Pokrovskaya (1960a) is basically the same as that of Howell, in that she recognizes the families Eodiscidae and Pagetiidae within the superfamily Eodiscoidea. However, she adds a third family, Opsidiscidae Hupé, 1953, in which she places Opsidiscus. Prior to this Pokrovskaya (1959) included a new genus Tannudiscus in the Opsidiscidae, a move followed by Kobayashi (1962) and Repina (1964). However, as pointed out by Rushton (1966, p. 22) and Rasetti (1966b, p. 10), Tannudiscus is not related to Opsidiscus and belongs in the Eodiscidae. Rasetti (1966b, p. 10) states that Opsidiscus could be referred to either the Pagetiidae or the Eodiscidae. Poletaeva and Romanenko (1970) retain Opsidiscus in the Opsidiscidae.

Palmer (1968, p. 38) described a new genus, Yukonia, from the early Cambrian of Alaska. This genus has three thoracic segments, an unfurrowed glabella, prominent eyes and eye lines, fused facial sutures and a smooth test. As suggested by Palmer, Opsidiscus and Yukonia are probably not closely related, although he tentatively includes Yukonia in the Pagetiidae because of its well-developed eyes and eye ridges.

The discovery of well-preserved eyes in Opsidiscus argusi sp. nov. indicates that Opsidiscus differs considerably from any known genus of the Eodiscidae and cannot be included in that family as was done by Howell (1959). *Opsidiscus argusi* sp. nov. is very similar to some species of *Pagetia* as illustrated by Rasetti (1966a). Apart from the lack of facial sutures, *Opsidiscus argusi* corresponds well to *Pagetia* as defined by Rasetti (1966a). This fact, along with the reasonable presumption that *Opsidiscus* must have been able to moult quite easily without the presence of facial sutures, suggests to the writer that the absence of facial sutures in *Opsidiscus* is not sufficient to be the basis of a familial separation between *Opsidiscus* and the Pagetiidae. This placing of *Opsidiscus* in the Pagetiidae dissolves the necessity for a separate family, the Opsidiscidae.

Whether *Opsidiscus* evolved directly from *Pagetia*, as suggested by Westergård (1946, p. 22), cannot be determined from the Tasmanian faunas. However, Mr. P. Jell (pers. comm., March, 1971) states he will soon be in a position to publish an evolutionary sequence showing that *Opsidiscus* is descended from the pagetiids in the Cambrian faunas of northern Australia. This suggestion is supported by the presence of schizochroal eyes in both *Opsidiscus argusi*, as described below, and *Pagetia ocellata* Jell, 1970.

Opsidiscus argusi sp. nov.

pl. 28, figs. 16-19; pl. 29, figs. 1-6, 8-18

Material: The available material includes two reasonably well-preserved, complete specimens as well as about ten individual cephala and six individual pygidia, some of which are very well preserved.

Selection of Holotype: The almost complete specimen on catalogue number UT 92011, and figured as pl. 29, fig. 1, is designated as the holotype.

Diagnosis: Opsidiscus argusi sp. nov. is a species with numerous large pustules on the dorsal surface of both the cephalon and the pygidium. The pustules on the thoracic segments are smaller and much less numerous. There are well-defined schizochroal eyes of about seventeen lenses. The palpebral lobes are well defined. There is a well-developed, wide, shallow transverse glabellar furrow and a long occipital spine. The pygidial axis consists of five segments and a terminus. The fourth and fifth segments are fused and bear a spine.

Description: Closely spaced, very small granules cover the exoskeleton surface.

The moderately convex cephalon is distinctly wider than it is long; it has a semielliptical outline; the margins diverge slightly away from the straight posterior margin and converge around the anterior margin. The shallow, wide anterior border furrow narrows posteriorly. The anterior border of some specimens has six to eight pits or radial grooves. There is a convex, narrow posterior border and a narrow, shallow posterior border furrow; both fade adaxially.

The border is variable. The rim may be almost flat or markedly convex. Convexity of rim and development of pits and radial grooves show a continuous range of variation and is believed to reflect intra-specific variation rather than the existence of two or more species.

The moderately convex glabella tapers very slightly to the bluntly rounded anterior. It extends about 0.75 the length of the cephalon. There are wide, deep axial furrows. Immediately in front of the glabella is a deep preglabellar depression connected to the border furrow. The cephalic margin is slightly depressed and indented immediately in front of the preglabellar depression. Towards the glabellar anterior (about one-third of the distance towards the posterior) is a well-developed, wide, shallow transverse glabellar furrow. Eye ridges meet the glabellar furrows just to the anterior of the transverse glabellar furrow.

The occipital ring is slightly wider than the rest of the axis. The occipital furrow has deep lateral notches and a shallow mid-section. These pronounced notches give lateral parts of the occipital ring a rib-like appearance. Between the occipital ring and the transverse glabellar furrow are two glabellar segments separated by faintly impressed lateral notches which are rarely connected by a very faint furrow. A long, strong, posteriorly directed occipital spine is not usually preserved except for a large spine base. The length of the spine preserved in UT 92000 (pl. 29, fig. 18) indicates that the spine extended over the thorax and possibly over the pygidial anterior.

The pleural areas are strongly convex. Eye ridges are well developed in some specimens, e.g., UT 92009 (pl. 29, fig. 12), but in others they are either poorly developed or not developed at all, e.g., UT 92005 (pl. 29, fig. 16). Prominent, convex, small palpebral lobes are slightly elevated above the palpebral areas. Poorly developed palpebral furrows are present in some specimens, but usually the palpebral lobe and the palpebral area are continuous. The ocular surface of each schizochroal eye is curved gently outwards. Each eye, when complete, possesses about 16 or 17 lenses. Facial sutures are absent; the fixigenae and librigenae are fused into a single test.

As well as the very small granules scattered all over the surface, there are large pustules scattered over the cephalon. On the glabella these are usually placed near the lateral margins, with a pair on the first glabellar segment and three evenly spaced pairs on the rest of the glabella. Each well-preserved cephalon has a row of about seven pustules on the pleural areas, close to and parallel with the axial furrows. Other pustules tend to occur in irregular rows, parallel to either the glabella or to the cephalic margins.

The doublure is partly exposed on one specimen, (UT 92006, pl. 29, fig. 5). On the edge of the border of this specimen, where it starts to turn down to form the doublure, there are well-preserved terrace lines consisting of small rows of granules. These also occur on the doublure, the width of which cannot be determined.

Neither rostral plate nor hypostome is known.

The two thoracic segments are moderately well preserved in only two specimens. The anterior segment is a little larger than the posterior segment. Each pleura of the anterior segment has two distinct areas; a small, tumid anteroadaxially placed area with a distinct pustule, and a much larger adaxial area which includes the wide, shallow pleural furrow (see pl. 29, fig. 11). The pleural furrow emerges from the adaxial area; it deepens abaxially and runs outwards and slightly backwards. The anterior and posterior edges of the outer area are raised well above the furrow and possess small pustules. The pleural extremities of the anterior segment are directed outwards and backwards for the anterior two-thirds of the segment and inwards for the rest. The available posterior thoracic segments are not as well preserved as the anterior segments. The axial region of the posterior segment bears a median-sized spine base. The pleural furrows shallow adaxially; they widen and deepen abaxially. There are small pustules on raised areas on either side of the furrow.

The moderately convex pygidium has a semicircular outline. At the posterior, the border is very narrow. The border furrow is shallow and moderately wide; the edges of the pleural regions are very steep; the posterior margin of the pygidium is slightly indented immediately behind the axis. The anterior border is convex and moderately wide; it is widest near the centroadaxially placed fulcral points. The anterior border furrow is shallow and wide; it widens slightly abaxially. There are large concave facets (seen only in internal moulds). There is a prominent crescentic, strongly convex, long (sag.) articulating half-ring. The articulating furrow is wide and almost straight; it is shallow at the centre and deeper at either end.

The axis is outlined by moderately wide, deep furrows which shallow posteriorly; the axis tapers evenly to a rounded posterior and stands out well above the pleural areas. The axis does not quite reach the border furrow; it consists of five segments and a terminus. The first three segments are quite convex; each bears a central, median sized pustule flanked by two smaller ones. Transverse furrows which separate these segments are deep laterally and shallow at the centre. The fourth and fifth segments are fused and bear a large spine base. In specimen UT 92003 the lower part of the spine is preserved (pl. 29, fig. 10). The spine probably was directed upwards and backwards. The terminus is short; it bears two small pustules.

The pleural fields are highly pustulate. There is a weak segmentation on the pleural fields with about four discernable segments faintly delineated by small notches on the abaxial margins of the axial furrows. On the pleural fields, the first two pleural segments are outlined in each case by two rows of pustules orientated transverse to the axis. These rows run outwards and backwards from the axis. There is less organization of the smaller pustules towards the pygidial posterior. The doublure is not seen.

Discussion: The large pustules over the surface of both the pygidium and the cephalon, as well as the presence of well-developed schizochroal eyes and palpebral lobes, differentiate *Opsidiscus argusi* sp. nov. from other species of *Opsidiscus*. The cephalic pleural regions of *O. argusi* curve further around the front of the glabella than in *O. bilobatus*, which gives the preglabellar depression of *argusi* more the look of a furrow than in *bilobatus*. *Opsidiscus argusi* has a much better developed transverse glabellar furrow than has *O. depolitus*. The occipital spine of *O. altaicus* is wider than that of *O. argusi*. The pygidial axis of *O. argusi* is narrower and more clearly sgemented than that of *O. altaicus*.

Occurrence and Age: *Opsidiscus argusi* sp. nov. comes from the main fauna in the St. Valentines Peak area near lat. 41°21.6'S, long. 145°44.3'E (grid 3758E, 9064N); its age is either late Middle Cambrian, the *Lejopyge laevigata* III Zone or the Middle Cambrian/Upper Cambrian Passage Zone.

POLYMERID TRILOBITES

Only two polymerid trilobites are described in detail. Unless otherwise stated, the morphological nomenclature used in these descriptions is the same as that used in Moore (1959). Many generic identifications of polymerid trilobites have been given in the stratigraphic section of this thesis. In order to substantiate some of these identifications, photographs of some of the polymerid trilobites are included in plates 31-33.

Order PTYCHOPARIIDA Swinnerton, 1915

Suborder PTYCHOPARIINA Richter, 1933

Superfamily BURLINGIACEA Walcott, 1908

Family BURLINGIIDAE Walcott, 1908

Genus SCHMALENSEEIA Moberg, 1903

Schmalenseeia Moberg, 1903, p. 93; Westergård, 1922, p. 119; 1929, p. 8; 1948, p. 3; Hupé, 1955, p. 198; Poulsen, 1959, p. 293; Chernysheva, 1960b, p. 130; Lazarenko, 1960, p. 253.

Type Species: Schmalenseeia amphionura Moberg, 1903, p. 93, pl. 4, figs. 1-4, 7-10.

Discussion: Westergård (1948, p. 3) placed Schmalenseeia along with Burlingia in the family Burlingiidae Walcott, 1908. Hupé (1955) and Poulsen (1959) agreed with this grouping, but Chernysheva (1960b) also included Fissocephalus in the Burlingiidae. However, this is an error and Fissocephalus belongs in the family Harpididae Whittington, 1950 (Whittington, 1959, p. 418).

Prior to the description of Schmalenseeia gostinensis (see below), there were only three described species placed in Schmalenseeia. These were the type species S. amphionura Moberg, 1903 from Sweden (lowest part of the Agnostus pisiformis Zone), S. acutangula Westergård, 1948 (Zones of Ptychagnostus atavus, Hypagnostus parvifrons and Ptychagnostus punctuosus of Sweden) and S. spinulosa Lazarenko, 1960 from the Agnostus pisiformis Zone of the North Siberian Platform.

Schmalenseeia amphionura Moberg, as illustrated in Chernysheva (1960a, pl. 3, fig. 4), from eastern Siberia is different from S. amphionura Moberg, as illustrated by Westergård, 1922 (pl. 1, fig. 19). One difference is that the palpebral area of the form illustrated by Westergård is much narrower than that in the form illustrated by Chernysheva. A second difference is that the anterior thoracic segment in the Siberian form is curved markedly to the anterior, whereas in the Swedish form the anterior thoracic segment has a nearly straight anterior margin and a posterior margin which is curved to the posterior. The anterior glabellar lobe is much larger in the Swedish form than in that illustrated by Chernysheva; the preglabellar ridge in the latter appears to be much more pronounced than in the former. Although the specimen of S. amphionura, illustrated by Westergård (1922, pl. 1, fig. 19), is a young individual (Westergård, 1948, p. 4), the differences noted above seem much too pronounced to be accounted for by changes during growth. Thus, the Siberian form is a different species from S. amphionura and is in need of revision.

The availability of a rubber cast, US 256 (pl. 28, fig. 13 herein), of the specimen of Schmalenseeia amphionura, which was illustrated by Westergård (1922, pl. 1, fig. 19), reveals that in fact this figure has been printed the wrong way around. A further point is that Westergård's figure has been retouched resulting in the preglabellar ridge showing out much more prominently in the illustration than it does in the specimen. However, a previously unfigured rubber cast, US 257 (pl. 28, fig. 14 herein), of S. amphionura has a more prominent ridge than the figured specimen. Another result of the retouching has been to show the posterior cranidial margin as straight, whereas in US 256 the posterolateral corners are slightly, but distinctly, turned to the posterior.

The cranidia of Schmalenseeia acutangula, as illustrated by Westergård, 1948 (pl. 1, figs. 2, 3, 5, 6), appear to include two separate forms. These are form (1), represented in figures 2 and 3, and form (2), as shown in figures 5 and 6. In form (2) the free cheeks are bigger in proportion to the size of the cranidium than in form (1).

The transverse glabellar furrows in form (1) extend from the lateral margins of the glabella towards the centre of the glabella, but in form (2) they appear more as shallow depressions and do not extend from the lateral margins but commence some distance inside them. A detailed comparison between forms (1) and (2) is difficult because of the poor reproductions of figures 2 and 3 and the lack of pygidia of form (2). The palpebral lobe in form (2) is much larger than in form (1), and it appears to be narrower in comparison with the glabellar width. Figures 5 and 6 have the appearance of internal moulds, but no mention is made about this point in Westergård's text.

The cranidium of form (2) of _acutangula_ is so markedly different from that of _Schmalenseeia amphionura_ that it cannot be included in the same genus. The glabella of form (2) is much larger in relation to the cranidium than that of _amphionura_. The glabellar furrows of form (2) do not reach the lateral glabellar margins, whereas those of _amphionura_ are deepest near the glabellar margins. Neither forms (1) or (2) of _acutangula_ have the preglabellar longitudinal ridge of _amphioura_ and other species of _Schmalenseeia_. It cannot be determined from Westergård's figures whether in fact forms (1) and (2) of _acutangula_ as discussed above belong in the same genus. In any case the specimens illustrated and described by Westergård (1948) as _Schmalenseeia acutangula_ are in need of revision.

If both forms (1) and (2) of acutangula are removed from Schmalenseeia, then this genus, as far as is known, is restricted to the lowest Upper Cambrian (Siberia and Sweden) and to the highest Middle Cambrian or Middle/Upper Cambrian transition beds (Tasmania). With the Tasmanian discovery, Schmalenseeia is now known from three widely separated parts of the globe (Tasmania, Siberia and Sweden). It is very small for a polymerid trilobite with the complete Schmalenseeia spinulosa, figured by Lazarenko, 1960 (pl. 53, fig. 18) and refigured here (pl. 28, fig. 15), having a length of only 7.7mm. The very small size of Schmalenseeia, its lack of convexity, and its widespread distribution probably indicate that it led a pelagic existence. Because of its size and lack of convexity, Schmalenseeia is difficult to see in the rock, and it can be expected that further examples of this genus will be found in scattered locations around the world. The nomenclature of the facial suture given below is similar to that of Hupé (1953, text fig. 37).

Schmalenseeia gostinensis sp. nov.

pl. 29, figs. 19-22

Material: Only two specimens are available, one of which is the holotype (UT 92012), which is a moderately well-preserved cranidium, about two-thirds of which is present. The complete cranidium would have a length of about 1.25mm. and a width of about 2.3mm. The other specimen, UT 92013, is one in which part of the thorax and all of the pygidium is known, although only part of the pygidium is preserved as the external mould. The combined thorax and pygidium of UT 92013 would have a minimum length of 3.0mm. Associated with this partial thorax and pygidium is a partial cranidium which is preserved only in the internal mould (see pl. 29, fig. 21). It is possible that this cranidium belongs with the associated thorax-pygidium. Internal and external moulds of both specimens are available.

Diagnosis: *Schmalenseeia gostinensis* sp. nov. has a pronounced posterior marginal furrow on the fixed cheek, short genal spines, and a dome-shaped anterior glabellar segment which bears a large node. From this node emerges a distinct ridge which extends to the centre of the anterior cranidial margin. The occipital ring has a well-developed node or spine base. There is a total of at least eighteen thoracic and pygidial segments. The pleurae are flat, with a narrow ridge along both the anterior and posterior margins. There are short pleural spines. The pygidium has no distinguishable border.

Description: The complete cephalon would have a semicircular outline and be almost twice as wide as it is long. The cranidium is almost flat, except for the elevated glabella and the palpebral lobes. The librigenae (so far unknown) are probably flat. There is no frontal border.

The posterior margin is almost straight across the base of the occipital ring. The adaxial parts of the margin are arched slightly to the posterior; the abaxial parts are arched slightly to the anterior, terminating in short genal spines. Each posterior border furrow is located a little distance anterior of the posterior margin; it extends from near the occipital furrow to close to the tip of the genal spine. The posterior border areas are raised slightly above the level of the posterior areas of the fixigenae.

The facial sutures are proparian and burlingiiform. The posterior end of each facial suture cuts the lateral cephalic margin about one-third of the distance from the genal spine to the cranidial front. From this point (ω) the facial suture runs at about 90° to the cephalic margin. The "posterior" section of the facial suture is straight except for the most adaxial part which curves around until the very end of it is directed inwards and forwards. At this point (ϵ), the facial suture is very close to the glabella. From ϵ, the suture is curved gently forwards and outwards, up to a point about 0.4 of the distance along the palpebral lobe from where it curves gently inwards and forwards to γ. γ is close to the glabella and opposite the centre of the anterior glabellar segment. From γ to α, the facial suture is straight; it meets the cranidial margin at about 90°.

The posterior areas of the fixigenae are large, flat and narrow (exsag.) near the glabella. The palpebral areas are small and flat; there are prominent, long, narrow, steep palpebral lobes and moderately wide, shallow palpebral furrows. There is a small knob at the anterior of each palpebral lobe; there may be a smaller knob at the posterior end, but this cannot be determined with certainty.

The frontal area is large, flat, and featureless except for a pronounced ridge which commences at a centrally placed node on the anterior glabellar segment and continues to the midpoint of the anterior cephalic margin. This ridge becomes narrower and lower towards the cranidial front; at the posterior it is bounded by faint furrows.

The glabella stands well above the fixigenae; it consists of four segments, plus the occipital ring, which appears to be an integral part of the glabella and is described as such. The length and width of the glabella are respectively about two-thirds and one-third those of the cranidium. From the occipital ring, the glabella tapers to the third glabellar segment; the second glabellar segment is slightly wider than the third segment. The glabellar front is subangular; the glabellar furrows are deep. The frontal glabellar segment has a length about one-third that of the glabella. The first pair of glabellar furrows commence very close to, and just to the posterior of, the knobs at the anterior ends of the palpebral lobes. They are directed inwards and backwards quite markedly and are arched adaxially. In the centre of the subelliptical dome, which is the anterior glabellar segment, there is a large node from which runs the ridge across the frontal area. The second glabellar segment may have a small central node, but further specimens will be required to confirm this point.

The second pair of glabellar furrows curve gently inwards and backwards; they are deepest adaxially with distinct pits near the abaxial extremities as is the case in the other glabellar furrows and the occipital furrow. These pits probably represent muscle attachments. The posterior pair of glabellar furrows run almost straight across the glabella and meet in the middle. The occipital ring is narrow (sag.) with a well-developed node or spine base on the anterior part of the central region. The wide, deep occipital furrow is separated at the centre by the node.

The thorax has at least nine, and possibly twelve or more segments. As noted above, only one partial thorax is available. The axial region is not present except for what are probably the last two or three segments. The narrow axis is raised slightly above the pleural areas. Along the anterior margin of the axis of each known thoracic segment is a low convex ridge which is the axial half-ring. All known thoracic and pygidial segments are narrow (sag.). Immediately behind the axial half-ring is a relatively wide furrow which is of moderate depth abaxially; it shallows adaxially where it is interrupted by a low hemispherical node. There is a low ridge along the posterior margin of the axis.

The thoracic pleurae are basically flat with low, narrow, convex ridges along the anterior margins; there is a somewhat higher, narrow, convex ridge along the posterior margins. There is a small transversely elongated depression anterolaterally placed on each pleura. From these depressions, poorly defined, shallow pleural furrows run outwards and backwards until they meet the posterior pleural ridges about one-third of the distance to the segment margins. For the rest of its course, each furrow runs just in from the posterior ridges. The pleural furrows are narrower and better defined abaxially.

The pleural margins make an angle of about 120° with the anterior border; they are straight and end in very short pleural spines. The pleurae widen slightly abaxially. On the most anterior pleural segment present on specimen UT 92013 the anterior margin is curved; its outline is concave to the anterior (pl. 29, figs. 21, 22). In the more posterior segments the margins gradually straighten until in the most posterior segment, which can be definitely assigned to the thorax, the curvature is slightly in the reverse sense.

On the available specimen it is impossible to determine the junction between thorax and pygidium. The pygidial axial region is similar to that of the thorax. The pointed pygidial axis terminates some distance in front of the broadly rounded pygidial margin. There is no distinguishable pygidial border. In the posterior part of the axis, the central axial nodes tend to merge to give the appearance of a ridge.

Near the thoracic posterior there is a slight posterior geniculation where the posterior axial ridges continue onto the posterior pleural ridges. This feature becomes more pronounced to the posterior until, on the third last pygidial segment, these ridges are aligned almost parallel to the axis. On the last two segments the pleural ridges are directed inwards and backwards. The available specimen has a total of at least eighteen thoracic and pygidial segments.

Discussion: *Schmalenseeia gostinensis* sp. nov. differs from all other described and illustrated forms of *Schmalenseeia* in that it has a pronounced posterior marginal furrow on the fixigenae.

S. gostinensis is probably closest to "*S. amphionura*", as illustrated by Chernysheva (1960a, pl. 3, fig. 4), because the latter appears to have faint posterior marginal furrows on the fixigenae. However, *S. gostinensis* differs from this form in that the anterior glabellar lobe of *gostinensis* is much more pronounced, the posterolateral limbs of the fixigenae are much bigger and it has more thoracic and pygidial segments. *Schmalenseeia gostinensis* differs from *S. amphionura*, as illustrated by Westergård (1922, pl. 1, fig. 19), in the much more pronounced preglabellar ridge that the former possesses (see pl. 28, figs. 13, 14 herein). *S. amphionura* does not possess the well-developed node at the most anterior glabellar segment as does *S. gostinensis*. A third difference is that the anterior thoracic segments in *gostinensis* are curved to the anterior, whereas those of *amphionura* are straight or curved to the posterior.

Schmalenseeia gostinensis differs from *S. spinulosa* Lazarenko in that the latter has pronounced axial spines or at least large nodes on each glabellar segment; the posterior cranidial margin of *spinulosa* is much more curved forward than in *gostinensis*; the glabella of *spinulosa* tapers more than that of *gostinensis*, and the most anterior glabellar lobe in the latter is slightly bigger than that of *spinulosa*. Although one and probably both forms of *Schmalenseeia acutangula*, as described by Westergård (1948), do not belong in *Schmalenseeia* (see above), they are briefly compared with *S. gostinensis* for the sake of completeness. *S. gostinensis* differs from both forms of *acutangula* in that it has a distinct preglabellar median ridge and that its palpebral areas are comparatively much larger. The glabella of *gostinensis* does not extend as far forward as that of either form of *acutangula*. *S. gostinensis* also differs from form (1) of *acutangula* in that the anterior thoracic segments of the latter are curved to the posterior.

Occurrence and Age: *Schmalenseeia gostinensis* sp. nov. comes from the main fauna in the St. Valentines Peak area near lat. 41°21.6'S, long. 145°44.3'E (grid 3758E, 9064N); its age is either late Middle Cambrian the *Lejopyge laevigata* III Zone or the Middle Cambrian/Upper Cambrian Passage Zone.

Superfamily PTYCHOPARIACEA Matthew, 1887

Family PAPYRIASPIDIDAE Whitehouse, 1939

Genus PIANASPIS Saito and Sakakura, 1936

Synonymy: See Chernysheva, 1970, p. 123.

Type Species: *Pianaspis kodairai* Saito and Sakakura, 1936, p. 114, pl. 8, figs. 1-3.

Diagnosis: See Chernysheva, 1970, p. 124.

Discussion: Chernysheva (1970) reviewed *Pianaspis*. She placed *Tosotychia* Öpik in synonymy with *Prohedinia* Lermontova and Chernysheva and *Prohedinia* in synonymy with *Pianaspis*. Öpik (pers. comm.) agrees that *Tosotychia* is a junior synonym of *Prohedinia*. Chernysheva had at her disposal numerous examples of *Prohedinia attenuata*, the type species of *Prohedinia*, but had no specimens of *Pianaspis kodairai*. The photographs of *Pianaspis kodairai* shown in Saito and Sakakura (1936, pl. 8, figs. 1-3) are not particularly clear. It seems to me that Chernysheva should have obtained actual specimens of *P. kodairai* before placing *Prohedinia* (and thus *Tosotychia*) in synonymy with *Pianaspis*. Until such time as a detailed comparison of actual specimens of *Prohedinia atenuata* and *Pianaspis kodairai* is made, the synonymy of *Prohedinia* and *Pianaspis* must be accepted with some reservations.

Öpik (1961b, p. 148ff.) discussed the Papyriaspididae at length, especially the genera *Papyriaspis*, *Tosotychia* (=*Pianaspis*) and *Chancia*.

He distinguished the Papyriaspididae from the Ptychopariidae on the single criterion that the former family has more than sixteen thoracic segments. The form described below has an incomplete thorax (only eight segments preserved) and thus cannot be placed in either the Papyriaspididae or the Ptychopariidae on this basis. Öpik (op. cit.) placed the Papyriaspididae in the Ptychopariacea rather than in the Dikelocephalacea as was done in Moore (1959). Öpik's classification is followed here.

The cranidium is reasonably well preserved, and a combination of the characteristics of the cranidium and the thorax indicate that this form is related to Pianaspis sors (Öpik). Recorded differences are not considered great enough to distinguish it on a generic level from Pianaspis sors. However, the number of thoracic segments in the new species, leveni, is unknown, and thus it is only tentatively assigned to the genus Pianaspis.

Pianaspis (?) leveni sp. nov.

pl. 30, figs. 1-12, text fig. 33

Material: One almost complete cranidium, two partial cranidia (one of which is known as the internal mould), part of eight thoracic segments and one partial free cheek are reasonably well preserved. There are three hypostoma and a specimen with a partial cranidium and the two anterior thoracic segments. These are poorly preserved. There are also some isolated cranidial and thoracic segments. All specimens come from the one horizon, and because there are no other polymerids known from this section, all specimens are placed in the one species.

Measurements: Holotype cranidium (UT 92671), lengths, total 10mm.; axial lobe, 7.1mm.; preglabellar area, 2.9mm.; widths, glabella (anterior), 3.8mm.; glabella (posterior), 4.2mm.; across palpebral lobes, 13.5mm. Thoracic segments (UT 92671), total length of the eight thoracic segments, 10.6mm. Hypostome (UT 92674) (pl. 30, fig. 8), exposed length, 3.2mm.

Selection of Holotype: The cranidium (UT 92671) (pl. 30, figs. 1-5) is chosen as the holotype.

Diagnosis: *Pianaspis* (?) *leveni* sp. nov. has a slightly tapered glabella, abaxially curved anterior facial sutures, gently curved posterior facial sutures, and prominent, narrow, elevated eye ridges. The anterior glabellar border is slightly to strongly elevated above the preglabellar field. There is a wide (tr.), narrow (sag.) plectrum. On the palpebral area of each fixed cheek, immediately adjacent to the palpebral lobe, is a low dome-like structure. The wide, deep almost straight posterior border furrow widens and deepens abaxially; the axial glabellar furrows are deep. Genal caeca are seen clearly only on the preglabellar field and on the frontal areas of the fixigenae. There is no occipital spine; there are no thoracic axial spines; the pleural spines are of moderate length.

Description

Cranidium: The cranidium is about twice as wide as it is long. The axial lobe has a length about two-thirds that of the cranidium; it is quite convex and stands out well above the rest of the cranidium, which is either gently convex or gently concave. The fixed cheeks are wide; the palpebral areas of the fixed cheeks have about the same width as the glabella.

From the posterior end of the palpebral lobes the posterior branches of the facial sutures diverge greatly. Close to the posterior end of each posterior branch, the facial suture has a very slightly convex (in an abaxial direction) outline. The centroanterior part of the posterior branches are almost straight; in the posterior part of the posterior branches they are curved strongly backwards.

The anterior sections of the facial suture are gently curved. From the anterior ends of the palpebral lobes the sutures diverge slightly up to a point about one-third of the distance to the marginal furrow; from this point they converge gently to the marginal furrow. On the anterior border the facial sutures converge strongly; each branch of the facial suture cuts the frontal margin a little over half-way to the median line from the points where they cut the marginal furrow.

The palpebral lobes, situated opposite the centre of the axial lobe, are poorly preserved in all specimens and have a length about 0.35

that of the glabella. They are gently convex and slope at a high angle into the wide, shallow palpebral furrows. The palpebral furrows are a continuation of narrow furrows which occur immediately to the posterior of the eye ridges throughout the entire length.

The narrow, elevated eye ridges are quite prominent. They appear to be single except in the adaxial region of the left hand eye ridge of UT 92671 (pl. 30, fig. 2) where there appear to be signs of a furrow between two separate ridges. They are directed slightly backwards from the glabella. The eye ridges are straight except at either end; the adaxial ends are curved forward and in the axial furrow the extreme end of the ridges are almost parallel to the glabella; they meet the axial furrows just to the anterior of the most anterior glabellar furrows. The abaxial end of each ridge has a sharp backward bend in it before merging with the palpebral lobe. In this bend the elevation of the ridge is markedly increased.

The preglabellar field has a length about 0.2 that of the cranidium. The anterior border is slightly elevated in some specimens, but strongly elevated in others above the preglabellar field; it is separated from both the preglabellar field and the anterior area of the fixed cheeks by a shallow marginal furrow. The anterior border in its central region is slightly lower than it is abaxially. Across the preglabellar field the marginal furrow is deflected backwards to form a wide (tr.) but narrow (sag.) plectrum. The anterior areas of the fixed cheeks are gently convex and are highest posterolaterally. They slope gently down to the preglabellar field and the marginal furrow.

Immediately to the adaxial of the palpebral lobes, the palpebral areas of the fixed cheeks are strongly convex and form low dome-like structures. On the fixed cheeks (adjacent to the glabella) extending from near the 2p glabellar furrows to the posterior margin of the cranidium are low raised areas which widen backward and rise to a low maximum toward the posterior. Apart from these features the palpebral areas of the fixed cheeks are almost flat or slightly concave; these concave areas extend posteriorly across the posterior areas of the fixigenae to the posterior marginal furrows, becoming narrower and shallower to the posterior. The rest of each fixed cheek between this depressed area, the posterior branch of the facial suture and the posterior border furrow is almost flat except at the extremities where it slopes away.

The posterior border furrows are almost straight, wide and deep, becoming wider and deeper abaxially. The posterior borders are narrow becoming wider abaxially. On the fixed cheek there are small granules scattered over the surface.

The occipital ring is short (sag.), elevated and gently convex. The occipital furrow is wide and moderately deep being slightly deeper at the lateral extremities, which are directed strongly to the anterior. Overall the glabella tapers slightly forward; at its flatly rounded anterior end it has a width about 0.9 that at the posterior.

The glabella is outlined by narrow axial furrows which deepen to the anterior. The furrows are deepest where the eye ridges meet them. To the anterior of this point the furrows shallow markedly and only extend a little way around the front of the glabella.

There are four pairs of glabellar furrows. The most posterior pair (1p) meet the axial furrows about half way from the occipital furrow to the points where the eye ridges meet the axial furrows. They are deep, bifurcating and directed inward and very strongly backwards. The more posterior branches of the bifurcating pairs are much the deeper of the two; the posterior branches almost meet across the top of the posterior end of the glabella.

The second pair of glabellar furrows (2p) are directed inwards and backwards, but not as markedly as in 1p. They arise from about half way between where the eye ridges meet the axial furrows and the point where the 1p furrows meet the axial furrows. The 2p furrows are wide and deep but not as deep as the 1p furrows.

The third pair of lateral glabellar furrows (3p) occur as medium sized shallow depressions which do not reach the axial furrows. The fourth pair of lateral glabellar furrows (4p) occur as small indentations in the glabellar margin immediately to the posterior of where the eye ridges meet the axial furrows. The 3p and 4p furrows have a similar arrangement to that figured for the two anterior glabellar furrows of Pianaspis sors (Öpik) in Öpik, 1961b (fig. 50). Between the points where the eye ridges meet the axial furrows and where the 2p furrows meet these furrows the glabella appears to be slightly but distinctly expanded. This is especially evident in specimen UT 92671 (pl. 30, fig. 1). This feature does not appear to be present in UT 92673 (pl. 30, fig. 7). However, as UT 92671 is the better preserved specimen, it is considered that this feature is present in the species.

Genal caeca are seen clearly on the cranidium only on the preglabellar field and the frontal area of the fixigenae. The caeca have a reticulate pattern and are more prominent in front of the eye ridges than in front of the glabella where they are weak. In UT 92671 there is a very faint reticulation visible on the right hand palpebral area immediately to the posterior of the eye ridge. This cannot be seen in the photographs.

Free Cheek: Only one partially preserved free cheek is available. It is gently convex. The marginal region is poorly preserved, but there is a shallow, narrow marginal furrow and a border which is only slightly elevated above the furrow. There is a long genal spine as a continuation of the border. Genal caeca which radiate from the eye region are faintly visible.

Hypostome: No complete hypostome is available; most of the following description is based on the best preserved hypostome (pl. 30, fig. 8).

The strongly convex hypostome, when complete, is probably as wide (across the anterior wings) as is long. Most of the hypostome consists of the strongly convex median body. The border furrow is narrow and of moderate depth, except across the anterior end where it is shallow. The border is of moderate width. The anterior border is flat; the rest of the border appears to be convex and slightly elevated. The anterior wings are large, flat and triangular. Maculae are absent.

Thorax: The total number of thoracic segments is unknown. The most complete specimen of a thorax has only eight segments. The following description is based on these segments.

The axial region of each segment has a width about one-fifth that of the segment (including spines). The articulating device is not seen in any specimen. The axis is strongly convex. Across the anterior end of each segment there is a shallow concave furrow which narrows and deepens abaxially with small pits close to the axial furrows. The posterior part of the axis is slightly elevated and quite convex. Separating the axis from the pleurae are narrow axial furrows which have shallow axial sockets at the posterior and shallow anteriorly.

Each pleural segment is almost flat with a moderately deep pleural furrow which is directed abaxially and posteriorly. The furrow is close to the anterior margin adaxially, but in the abaxial third it tends to be close to the centre of the segment. It widens slightly abaxially, up to the base of the spine; the pleural furrows extend slightly into the base of the spine. Each spine is directed strongly to the posterior and is of moderate length. There is a gentle slope from the main part of the pleural segment down to the spine. The posterior flange is very narrow. There are no signs of pleural caecae.

Pygidium: This is unknown.

Discussion: *Pianaspis sors* (Öpik) is the best illustrated and described species of *Pianaspis*. For this reason *Pianaspis* (?) *leveni* is compared in detail with *P. sors*.

Pianaspis (?) *leveni* sp. nov. differs from *P. sors* in that it has no thoracic axial spines, and the pleural spines of *leveni* are decidedly longer than in *sors*. The genal spines in *leveni* are longer than those of *sors*. There is no occipital spine in *leveni* as there is in *sors*. The axial glabellar furrows of *leveni* are deeper than those of *sors*. In marked contrast to the situation in *sors*, there is very little sign of genal caeca to the posterior of the eye lines on *leveni* although this could be due to the preservation of *leveni*. The 1p and 2p furrows of *leveni* are directed more sharply to the posterior than in *sors*. The eye ridges in the latter are double whereas in *leveni* they appear to be single except in the case of UT 92671 mentioned in the description. *P. sors* has a posterior and an anterior parafrontal band; *P.* (?) *leveni* has neither of these features.

The anterior branches of the facial sutures of leveni diverge slightly to the anterior of the palpebral lobe and then converge in a smooth curve to the anterior marginal furrow. Those of sors are sub-parallel according to Öpik (1961b, p. 162 and fig. 50). However, an inspection of the photographs of P. sors (Öpik, op. cit. pl. 15, figs. 1, 2, 3) indicate that they are somewhat convergent.

The glabella of Pianaspis (?) leveni is not as tapered as that of either P. attenuata or P. sors but is similar to P. kodairai in this respect. The 1p glabellar furrows of P. (?) leveni are directed more sharply to the posterior than are those of either P. attenuata or P. kodairai. The anterior cranidial border of P. (?) leveni narrows markedly in an abaxial direction as does that of P. sors; in both P. attenuata and P. kodairai there is little change in width along the anterior cranidial border. P. sibirica Solovjev differs from other species of Pianaspis in having a very narrow preglabellar field.

The writer agrees with Chernysheva (1970) that Prohedinia brevifrons Palmer (1968, p. 69, pl. 5, fig. 9) does not belong in Pianaspis. Chancia palliseri (Walcott) included by Palmer (1968, p. 69) in Prohedinia does not belong in Pianaspis; it has only two pairs of glabellar furrows (Rasetti, 1951, p. 214) as compared with the four of Pianaspis. The cranidium, doubtfully assigned to Chancia odarayensis by Rasetti (1951, pl. 33, fig. 15) and included by Palmer (op. cit.) in Prohedinia, seems close to *Pianaspis*. This specimen, which has four pairs of glabellar furrows, appears to have a caecal pattern in front of the eye ridges (Rasetti, 1951, pl. 33, fig. 15) although Rasetti does not mention this in his description.

Occurrence and Age: *Pianaspis* (?) *leveni* sp. nov. comes from Unit 13 of the lower sedimentary sequence of the Radfords Creek Group as exposed along the Gunns Plains Road; its age is either of the *Lejopyge laevigata* II Zone or the *L. laevigata* III Zone.

GENERAL CONCLUSIONS

The taxonomic and biostratigraphic studies of Tasmanian Middle and Upper Cambrian trilobites carried out in this project have led to the first well-documented correlations of the fossiliferous Tasmanian Cambrian sequences, both within Tasmania and with other Australian and overseas sequences. Three non-agnostid and over ninety agnostid species are described and illustrated in this thesis. Five genera and twenty-five species are new. Table 10 (included in the back pocket of Volume 2) shows the time distribution of the trilobites described herein. The stratigraphic and palaeogeographical conclusions which were reached largely by means of the study of Tasmanian agnostid trilobites have been discussed and summarized above (pp. 87-93).

The use of rubber casts of previously described and figured trilobite species, along with the discovery and recognition of new Tasmanian species and genera, has led to substantial revisions of several trilobite genera and species. These include species of the agnostid genera Diplagnostus Jaekel, Lejopyge Hawle and Corda, Clavagnostus Howell, Grandagnostus Howell and other effaced agnostids, and the non-agnostid genera Opsidiscus Westergård and Schmalenseeia Moberg. It is recommended that this approach of comparison of new material with casts (or, if possible, actual specimens) of previously described material should be used where possible in order to facilitate description and redescription. The conclusions pertaining to each particular genus or species are discussed in the appropriate section.

The classification of agnostid trilobites proposed by Öpik (1967) is preferred to previous agnostid classifications because it seems more objective and consistent than earlier classifications. In the course of this study the only part of Öpik's classification found to be unsatisfactory was with respect to the shape of the glabellar rear. It is recommended that this criterion should not be used in first order agnostid classification. It is found that the suggestion of Robison (1964a), that an enrolled condition may have been the normal mode of life of agnostid trilobites, cannot be substantiated.

Two, and possibly three, distinct agnostid assemblages are recognized in the Middle and early Upper Cambrian sequences of Tasmania. These are (1) an agnostid assemblage in which polymerid trilobites are absent, rare or present as thanatocoenotic fossils, (2) a ptychagnostid--non-nepeid assemblage which could be considered as a variation of assemblage (1) and (3) a nepeid-clavagnostid-peronopsid assemblage which does not contain ptychagnostids. It is proposed that assemblage (1) was essentially an open sea fauna with assemblages (2) and (3) occurring progressively closer to the shore.

The presence of particular species of *Ptychagnostus*, *Lejopyge* and *Hypagnostus* in assemblages (1) and (2) (interpreted as essentially open sea faunas) and their absence in assemblage (3) (interpreted as a nearer shore assemblage) probably explains why species of these genera had a world-wide distribution in the Middle Cambrian and why they are good zone fossils in widely scattered parts of the world (e.g., Sweden, Queensland). Agnostid species found in assemblage (3) are probably of more use in making local correlations.

APPENDIX 1

Appendix 1 contains the tables and calculations used to derive the value of "t" in the "Student's 't' Test" noted in the discussion on _Glyptagnostus reticulatus_ (see p. 355). The values of Lb_2 and Lb_3 shown in the tables below were taken directly from Palmer (1962, fig. 11). It will be noted that in the case of _Glyptagnostus reticulatus angelini_, Palmer has N=36 although only 35 points are plotted on his fig. 11 and used in my calculations. Presumably two specimens had the same dimensions for Lb_2 and Lb_3. However, this should not effect the results of the subsequent calculations to any significant extent.

(a) Calculations for Glyptagnostus reticulatus angelini.

(Na=35)

Lb_3(mm)	Lb_2(mm)	Lb_3/Lb_2	$(Lb_3/Lb_2)^2$
.19	.50	.38	.1444
.24	.55	.44	.1936
.26	.56	.46	.2116
.24	.60	.40	.1600
.26	.61	.43	.1849
.40	.75	.53	.2809
.45	.75	.60	.3600
.40	.80	.50	.2500
.40	.86	.47	.2209
.34	.86	.40	.1600
.36	.87	.41	.1681
.50	.86	.58	.3364
.50	.90	.56	.3136
.60	.91	.66	.4356
.44	.96	.46	.2116
.50	.95	.53	.2809
.48	.97	.49	.2401
.51	.97	.53	.2809
.60	.96	.62	.3844
.65	1.01	.64	.4096
.79	1.01	.78	.6084
.74	1.06	.70	.4900
.49	1.11	.44	.1936
.63	1.12	.56	.3136
.65	1.11	.59	.3481
.66	1.12	.59	.3481
.75	1.26	.60	.3600
.85	1.31	.65	.4225
.80	1.36	.59	.3481
.74	1.37	.54	.2916
.65	1.42	.46	.2116
.79	1.42	.56	.3136
1.09	1.46	.75	.5625
.89	1.51	.59	.3481
.75	1.52	.49	.2401

$$\sum \frac{Lb_3}{Lb_2} = 18.98 \qquad \sum\left(\frac{Lb_3}{Lb_2}\right)^2 = 10.6274$$

Mean $\frac{Lb_3}{Lb_2} = \frac{18.98}{35} = .5423$

If Sa is standard deviation then

$$Sa^2 = \frac{\sum\left(\frac{Lb_3}{Lb_2}\right)^2 - \frac{\left(\sum\frac{Lb_3}{Lb_2}\right)^2}{Na}}{} = \frac{10.6274 - \frac{360.240}{35}}{35 - 1}$$

$$= .00985$$

(b) Calculations for Glyptagnostus reticulatus reticulatus.
(Nr=14)

Lb_3(mm)	Lb_2(mm)	Lb_3/Lb_2	$(Lb_3/Lb_2)^2$
.54	.75	.72	.5184
.60	.75	.80	.6400
.54	.85	.64	.4096
.60	.85	.71	.5041
.79	.86	.92	.8464
.79	.91	.87	.7569
.65	.96	.68	.4624
.74	.96	.77	.5929
.75	.97	.77	.5929
.79	.96	.82	.6724
.84	.96	.88	.7744
.84	1.01	.83	.6889
.84	1.11	.76	.5776
1.09	1.51	.72	.5184

$\sum\frac{Lb_3}{Lb_2} = 10.89$ $\sum\left(\frac{Lb_3}{Lb_2}\right)^2 = 8.5553$

Mean $\frac{Lb_3}{Lb_2} = \frac{10.89}{14} = .7779$

If Sr is the standard deviation of sample then

$$Sr^2 = \frac{\sum\left(\frac{Lb_3}{Lb_2}\right)^2 - \frac{\left(\sum\frac{Lb_3}{Lb_2}\right)^2}{Nr}}{Nr - 1}$$

$$= \frac{8.5553 - 8.4709}{13}$$

$$= .00649$$

(c) Calculations of "t"

$$t = \frac{\left(\text{Mean } \frac{Lb_3}{Lb_2} \text{ retic} - \text{Mean } \frac{Lb_3}{Lb_2} \text{ ang}\right)\sqrt{\frac{NrNa}{Nr + Na}}}{\sqrt{\frac{(Nr - 1)\ Sr^2 + (Na - 1)\ Sa^2}{Na + Nr - 2}}}$$

$$= \frac{(.7779 - .5423)\sqrt{\frac{490}{49}}}{\sqrt{\frac{13 \times .00649 + 34 \times .00985}{47}}}$$

$$= 7.888$$

APPENDIX 2

Appendix 2 is a catalogue of the rubber casts of specimens referred to in this thesis which have been described and figured by earlier workers. The reference numbers used here are the same as those on the rubber casts and, with the exception of the specimens of Diplagnostus humilis (Whitehouse), bear no relationship to the numbering of the original specimens.

Reference Number	Figuring in this thesis	Identification and Remarks
US 595	pl. 14, fig. 18	specimen described and figured by Poulsen (1960, p. 13, pl. 1, fig. 13) as the type pygidium of Peronopsis ultima; shown in this thesis to be a cephalon, probably of Clavagnostus chipiquensis (Rusconi)
US 588	pl. 14, fig. 19	pygidium of Clavagnostus chipiquensis (Rusconi) figured by Poulsen (1960, p. 9, pl. 1, fig. 14)
Riks 105, 106	not figured	pygidia of Hypagnostus brevifrons (Angelin), figured in Westergård as pl. 5, fig. 27 and pl. 5, fig. 26 respectively
Prague 11	pl. 9, fig. 2	Phalagnostus prantli Snajdr, complete holotype, figured by Snajdr, 1958, pl. 6, fig. 1

Reference Number	Figuring in this thesis	Identification and Remarks
Prague 10	pl. 9, fig. 3	Phalagnostus nudus Beyrich, enrolled specimen figured by Snajdr, 1958, pl. 5, fig. 9.
Riks 418	pl. 10, fig. 2	Lejopyge laevigata (Dalman), figured by Westergård, 1946, pl. 16, fig. 9.
Riks 458	pl. 10, fig. 3	Lejopyge laevigata (Dalman) cephalon figured by Westergård, 1946, pl. 13, fig. 24
Riks 36	pl. 10, fig. 4	Lejopyge laevigata (Dalman), cephalon figured by Westergård, 1946, pl. 13, fig. 22
Riks 455	pl. 10, fig. 5	spinose cephalon associated with the pygidia of Lejopyge laevigata armata (Linnarsson) figured by Westergård, 1946, pl. 13, figs. 30, 31.
Riks 402	pl. 10, fig. 6	holotype cephalon of Lejopyge laevigata perrugata Westergård (1946, pl. 14, fig. 2)
Riks 399	pl. 10, fig. 7	cephalon of Lejopyge laevigata rugifera Westergård (1946, pl. 14, fig. 3)
Riks 399	pl. 10, fig. 8	cephalon associated with the cephalon of Lejopyge laevigata rugifera figured herein as pl. 10, fig. 7
Riks 457	pl. 10, figs. 9, 10	pygidium of Lejopyge laevigata (Dalman) figured in Westergård, 1946, pl. 13, fig. 25

Reference Number	Figuring in this thesis	Identification and Remarks
Riks 460	pl. 10, fig. 11	pygidium of Lejopyge laevigata (Dalman) figured in Westergård, 1946, pl. 13, fig. 26
Riks 458	pl. 10, fig. 12	small pygidium associated with the pygidium of Lejopyge laevigata (Dalman) figured in this thesis as pl. 10, fig. 13
Riks 458	pl. 10, fig. 13	pygidium of Lejopyge laevigata (Dalman) figured by Westergård, 1946, pl. 13, fig. 24.
Riks 456	pl. 10, fig. 14	small pygidium of Lejopyge laevigata (Dalman) associated with the pygidium of L. laevigata figured here as pl. 11, figs. 1, 2
Riks 456	pl. 11, figs. 1, 2	pygidium of Lejopyge laevigata (Dalman) figured by Westergård, 1946, pl. 13, fig. 20
Riks 37	pl. 11, figs. 3, 6	pygidium of Lejopyge laevigata (Dalman) figured by Westergård, 1946, pl. 13, fig. 23
Riks 455	pl. 11, figs. 4, 5	pygidium of Lejopyge laevigata armata (Linnarsson) figured by Westergård, 1946, pl. 13, fig. 31
Riks 455	pl. 11, figs. 7, 8	pygidium of Lejopyge laevigata armata (Linnarsson) figured by Westergård, 1946, pl. 13, fig. 30

Reference Number	Figuring in this thesis	Identification and Remarks
Riks 402	pl. 11, figs. 9, 10	pygidium associated with the cephalon of *Lejopyge laevigata perrugata* Westergård, figured here as pl. 10, fig. 6
Riks 399	pl. 11, figs. 11, 12	pygidium associated with the cephalon of *Lejopyge laevigata rugifera* Westergård, figured here as pl. 10, fig. 7
Riks 288	pl. 14, fig. 14	cephalon of *Clavagnostus sulcatus* Westergård figured in Westergård, 1946, pl. 4, fig. 23
Riks 289	pl. 14, fig. 15	holotype cephalon of *Clavagnostus sulcatus* Westergård figured in Westergård, 1946, pl. 4, fig. 25
Riks 33	pl. 14, fig. 16	cephalon of *Clavagnostus repandus* (Westergård) figured in Westergård, 1946, pl. 4, fig. 21
Riks 34	pl. 14, fig. 17	pygidium of *Clavagnostus repandus* (Westergård) figured by Westergård, 1946, pl. 4, fig. 22
Riks 350	pl. 17, fig. 15	cephalon of *Diplagnostus planicauda bilobatus* Kobayashi figured by Westergård, 1946, pl. 8, fig. 14

Reference Number	Figuring in this thesis	Identification and Remarks
Riks 349	pl. 17, fig. 16	neotype cephalon of *Diplagnostus planicauda bilobatus* Kobayashi figured by Westergård, 1946, pl. 8, fig. 16
Riks 350	pl. 17, fig. 17	pygidium of *Diplagnostus planicauda bilobatus* Kobayashi figured by Westergård, 1946, pl. 8, fig. 17
Riks 348	pl. 17, fig. 18	pygidium of *Diplagnostus planicauda bilobatus* Kobayashi figured in Westergård, 1946, pl. 8, fig. 19
Riks 350	pl. 17, fig. 19	cephalon incorrectly figured by Westergård, 1946, pl. 8, fig. 15 as *Diplagnostus planicauda bilobatus* Kobayashi (see p. 284 herein)
Riks 290	pl. 17, fig. 20	pygidium of *Diplagnostus planicauda* (Angelin) figured by Westergård, 1946, pl. 8, fig. 23
Riks 289	pl. 17, fig. 21	cephalon of *Diplagnostus planicauda* (Angelin) figured by Westergård, 1946, pl. 8, fig. 22
Riks 354	pl. 17, fig. 22	cephalon of *Diplagnostus planicauda vestgothicus* (Wallerius) figured by Westergård, 1946, pl. 8, fig. 26

Reference Number	Figuring in this thesis	Identification and Remarks
Riks 353	pl. 17, fig. 23	pygidium of Diplagnostus planicauda vestgothicus (Wallerius) figured by Westergård, 1946, pl. 8, fig. 27 other cephala and pygidia (unfigured by Westergård) of vestgothicus are also available on Riks 353
UQ 42742	pl. 18, fig. 1	holotype cephalon of Diplagnostus humilis (Whitehouse) figured by Whitehouse, 1936, pl. 8, fig. 18
UQ 3193	pl. 18, fig. 2	pygidium of Diplagnostus humilis (Whitehouse) figured by Whitehouse, 1936, pl. 8, fig. 19
UQ 3192	pl. 18, fig. 3	cephalon of Diplagnostus humilis (Whitehouse) figured by Whitehouse, 1936, pl. 8, fig. 17
Cop. 8	pl. 18, fig. 4	cephalon of Diplagnostus jarillensis Rusconi figured by Poulsen, 1960, pl. 1, fig. 9
Rusconi 18208	pl. 19, fig. 1	holotype cephalon of Lotagnostus atenuatus (Rusconi), described by Rusconi (1955) as Goniagnostus atenuatus
Rusconi 18208	pl. 19, fig. 2	pygidium of Lotagnostus atenuatus (Rusconi) associated with cephalon listed above
Riks 357	pl. 19, figs. 9, 10	holotype pygidium of Oidalagnostus trispinifer Westergård figured by Westergård 1946, pl. 9, fig. 6

Reference Number	Figuring in this thesis	Identification and Remarks
Riks 358	pl. 19, fig. 11	pygidium of *Oidalagnostus trispinifer* figured by Westergård, 1946, pl. 9, fig. 7
US 256	pl. 28, fig. 13	almost complete specimen of *Schmalenseeia amphionura* Moberg figured in Westergård, 1922, pl. 1, fig. 19; Westergård's figure is printed back to front.
US 257	pl. 28, fig. 14	previously unfigured specimen of *Schmalenseeia amphionura* Moberg from Sweden
Photograph only	pl. 28, fig. 15	photograph of *Schmalenseeia spinulosa* Lazarenko, figured by Lazarenko, 1960, pl. 5, fig. 18
US 274	pl. 29, fig. 7 pl. 31, fig. 1	holotype cephalon of *Opsidiscus bilobatus* (Westergård), figured by Westergård, 1946, pl. 1, fig. 21
US 275	pl. 31, fig. 2	pygidium of *Opsidiscus bilobatus* (Westergård), figured by Westergård, 1946, pl. 1, fig. 20
Riks 88	not figured	cephalon of *Grandagnostus glandiformis* (Angelin) figured by Westergård, 1946, pl. 15, fig. 4 as *Phalacroma glandiforme*
Riks 372	not figured	pygidium of *Ptychagnostus stenorrhachis* (Grönwall) figured by Westergård, 1946, pl. 10, fig. 4

Reference Number	Figuring in this thesis	Identification and Remarks
Riks 445	not figured	pygidium of <u>Ptychagnostus scanensis</u> Westergård figured by Westergård, 1946, pl. 12, fig. 17

Rubber casts of the specimens listed below, although not referred to by number in the text, were used in the revision of the effaced agnostids given on pages 148 to 156. All plate and figure numbers refer to Westergård (1946); the generic and specific names are those given by Westergård.

<u>Phalacroma glandiforme</u> (Angelin), cephala: pl. 15, figs. 4, 5a-b, 6a-b (lectotype), 15, 16; pl. 16, fig. 1; pygidia: pl. 15, figs. 7, 10a-b, 12, 14; pl. 16, fig. 2

<u>Phalacroma marginatum</u> (Brögger), cephala: pl. 14, figs. 20, 23, 24; pygidia: pl. 14, figs. 22, 26, 27, 28, 29; pl. 15, fig. 2

<u>Phalacroma resectum</u> (Grönwall), pygidium: pl. 14, fig. 19a-b

<u>Phalacroma scanicum</u> (Tullberg), pygidia: pl. 14, figs. 17, 18

<u>Phoidagnostus bituberculatus</u> (Angelin), cephala: pl. 14, figs. 10, 12; pygidia: pl. 14, figs. 11, 14

Rubber casts of most of the specimens of <u>Ptychagnostus atavus</u> (Tullberg), <u>P. punctuosus affinis</u> (Brögger) and <u>P. punctuosus</u> (Angelin) figured by Westergård (1946, pls. 11, 12) were available to the author (see p. 183).

Rubber casts of the specimens of *Ptychagnostus nathorsti* figured by Westergård (1946, pl. 12, figs. 14-16) were also available (see p. 203).

APPENDIX 3

GLOSSARY

Explanation of New Names of Fossils

argusi (Opsidiscus): Refers to the discovery of well-developed eyes in this species.

banksi (Valenagnostus): After Mr. M.R. Banks, Reader in Geology, University of Tasmania.

Birchagnostus: After Birch Inlet in western Tasmania.

brittoni (Valenagnostus): Refers to Brittons Swamp near Christmas Hills.

Buckagnostus: After John Buckley who collected many important specimens from Christmas Hills.

buckleyi (Ptychagnostus): After John Buckley.

burnsi (Clavagnostus): After Dr. K.L. Burns, who discovered the main Riana localities.

compani (Buckagnostus): Refers to the Companion River.

corbetti (Pseudagnostus): After Dr. K.D. Corbett, who discovered the Denison Range faunas.

debori (Buckagnostus): After John Buckley's daughter, Deborah.

Denagnostus: After the Denison Range.

distortus (Oedorhachis?): Refers to the distorted nature of the specimens.

ekip (_Peronopsis_): After Mr. G. Pike, who discovered the main fauna near St. Valentines Peak.

geei (_Diplagnostus_): After Dr. C.E. Gee, who worked with the author in the Que River area.

gostinensis (_Schmalenseeia_): After Dr. V.A. Gostin, who translated some of the Russian literature.

gullini (_Peronopsis_): After Mr. A.B. Gulline, who discovered the faunas at Christmas Hills.

hodgei (_Ptychagnostus_): Refers to the Hodge (=Razorback) Mine near Dundas.

inara (_Pseudoclavagnostus_): Anagram of Riana.

inleti (_Birchagnostus_): After Birch Inlet.

keithi (_Denagnostus_): After Dr. Keith Corbett.

leveni (_Pianaspis_?): Refers to the Leven River.

milli (_Clavagnostus_): Refers to the old timber mill close to the main Christmas Hills fossil locality.

murchisoni (_Ptychagnostus_?): Refers to the Murchison Highway.

nevel (_Pseudoclavagnostus_): Anagram of Leven.

Pseudoclavagnostus: Refers to the _Clavagnostus_-like cephalon of this genus.

rawlingi (_Clavagnostus_): After Rawlings Road in the St. Valentines Peak area.

riani (Aspidagnostus): After the village of Riana.

rubenacha (Ptychagnostus): After Mr. M.J. Rubenach who discovered the locality containing this fossil.

sisponorep (Pseudoclavagnostus): Peronopsis spelt backwards; refers to Peronopsis-like pygidium of this species.

Valenagnostus: Refers to St. Valentines Peak.

APPENDIX 4

PUBLICATIONS

This appendix includes reprints of papers produced in the course of this study. These publications are Gee *et al*. (1970), Jago and Buckley (1971), and Jago (1972). The first two papers are included in the pocket at the back of Volume 2. The last paper will not appear until mid-1972; a copy of the abstract is included here. The rest of this paper is composed essentially of the descriptions and discussions of the trilobites referred to in this thesis as *Opsidiscus argusi* sp. nov. and *Schmalenseeia gostinensis* sp. nov.

ABSTRACT OF JAGO (1972)

The first published descriptions of Tasmanian Cambrian trilobites are given. Two new species, *Opsidiscus argusi* and *Schmalenseeia gostinensis*, are described from a fauna, the age of which is probably either that of the latest Middle Cambrian *Lejopyge laevigata* III Zone or the Middle Cambrian/Upper Cambrian Passage Zone. *Opsidiscus argusi* has well developed schizochroal eyes, recorded for the first time in this genus. The genera *Opsidiscus* and *Schmalenseeia* are reviewed. *Opsidiscus* is placed in the Pagetiidae. *Schmalenseeia acutangula* Westergård is in need of revision and should be removed from *Schmalenseeia*.

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