LOWER DEVONIAN HETEROSTRACI FROM THE PEEL SOUND FORMATION, PRINCE OF WALES ISLAND, NORTHWEST TERRITORIES

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by

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ABSTRACT

Devonian vertebrate faunas representing Osteostraci, Heterostraci, Arthrodira, Acanthodii and Crossopterygii were obtained from the conglomerate, sandstone and carbonate facies of the Peel Sound Formation of Prince of Wales Island, Arctic Canada. One locality examined in detail shows a conformable passage between the conglomerate facies and the underlying Read Bay Formation. Heterostracan faunules from the basal 450 feet of Peel Sound sandstone and conglomerate include thirteen species representing the families Cyathaspididae, Corvaspididae, Traquairaspididae and Pteraspididae. Included are the new genera *Torpedaspis* and *Pseudotraquairaspis*, and the new species *Traquairaspis rambaldi* and *Pteraspis (Simopteraspis) arctica*. A reconstruction of the cyathaspidid *Torpedaspis* gen. nov. is attempted on evidence from an entire specimen.

Comparison with similar heterostracan faunas elsewhere in the world strongly suggests a Downtonian and Dittonian age for the conglomerate facies; hence the base of the formation at this locality approximates to the Siluro-Devonian boundary. Vertebrate faunas elsewhere suggest a probable Early and Middle Devonian age for the sandstone and carbonate facies.

Heterostraci are common at sixteen stratigraphically separated sandstone horizons. Their distribution suggests that populations occupied a near-shore brackish environment which was repeatedly destroyed by periodic influx of coarse clastics due to rapid but intermittent uplift of the Boothia

Arch.

A progressive facies change and abrupt faunal change from the Ludlovian Read Bay Formation to the Downtonian and Dittonian Peel Sound Formation indicates change from shallow marine conditions (characterized by invertebrates) through transitional marginal brackish conditions (characterized by abundant Heterostraci) to fluviatile conditions.

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I INTRODUCTION

Statement of problem

In 1966 and 1967 field work was undertaken on Prince of Wales Island, Northwest Territories as part of the continuing program of the University of Ottawa Arctic Expedition. In the first season field work was carried out jointly with A.D. Miall, University of Ottawa, who is currently studying the sedimentology of the Peel Sound Formation.

The suspected presence of fossil vertebrates in the predominantly continental Devonian Peel Sound Formation was confirmed. Collecting from nine major localities within an area 128 miles long and 24 miles wide produced collections of fossil vertebrates which far exceed expectation in quality, quantity and preservation. The genera represent the Osteostraci, Heterostraci, Arthrodira, Acanthodii and Crossopterygii. The importance of the unusually fossiliferous faunules was recognized at an early stage for such a concentration of fossil vertebrate assemblages in a small geographical area is exceptional. Smaller vertebrate faunas have been reported from the Canadian Arctic (in particular Somerset Island) but detailed descriptions are not yet available. These faunules thus have considerable stratigraphic significance because reliable palaeontological evidence for the age of the base of the Peel Sound Formation was previously lacking.

In view of the large quantity of material collected, this study is restricted to the fauna of one of the richest localities, Wilson's Gorge (informal name) in southeast Prince of Wales Island (fig.1). This fauna is composed exclusively of Heterostraci; if Osteostraci are present, they occur only as unrecognizable fragments.

The families Cyathaspididae, Traquairaspididae, Corvaspididae and Pteraspididae are represented. Three hundred specimens are described from sixteen stratigraphically separated horizons within the lower 452 feet of the Peel Sound Formation. Elucidation of the age, significance and habitat of these faunas necessitated the description of thirteen species including five new species and two new genera. Comparison of the assemblage with faunas elsewhere, namely northwest and eastern Canada, the United States, Europe, Russia and Spitsbergen, permits the first precise age determination for the local base of the Peel Sound Formation.

Access, method of travel and special problems

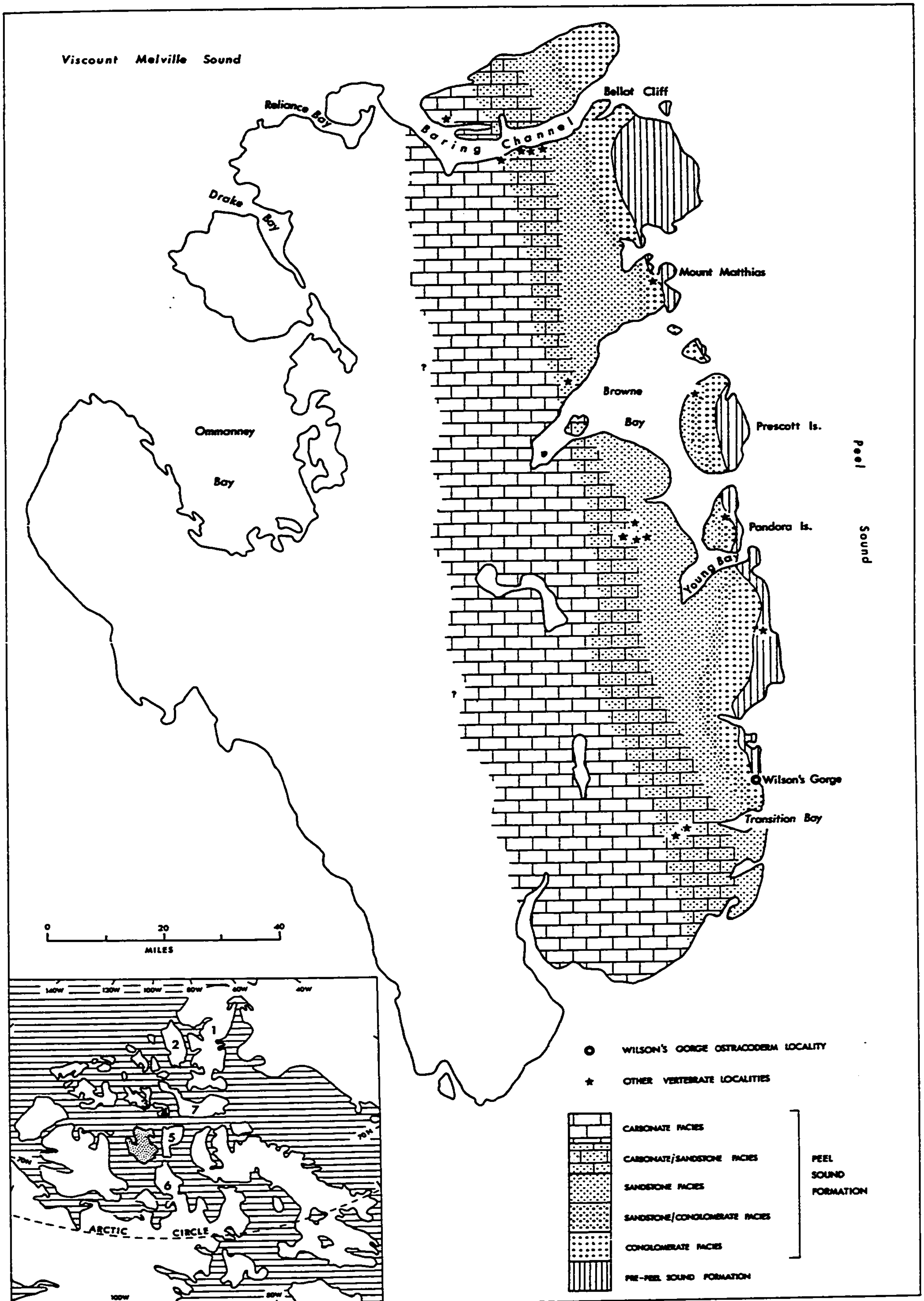
Prince of Wales Island is situated in the Canadian Arctic Archipelago at latitude 73 degrees North and longitude 98 degrees West (fig.1). Access is from Resolute Bay, Cornwallis Island, by chartered Otter or Beaver aircraft equipped with balloon tyres for landing on a wide range of arctic terrain. Travel from aircraft-supported base camps was by Snowcruiser early in the season and on foot thereafter.

Special problems encountered were those expected in Arctic latitudes, viz. difficulty of access and transportation

Figure 1. Prince of Wales Island, Northwest Territories. Map showing location, geology and vertebrate localities. Geology after Miall (Broad, Dineley and Miall, 1968).

Key to index map.
1 : Ellesmere Island
2 : Axel Heiberg Island
3 : Bathurst Island
4 : Cornwallis Island
5 : Somerset Island
6 : Boothia Peninsula
7 : Devon Island

Prince of Wales Island stippled.



Viscount Melville Sound
Reliance Bay
Baring Channel
Bellot Cliff
Drake Bay
Mount Matthias
Browne Bay
Prescott Is.
Ommanney Bay
Peel Sound
Pandora Is.
Young Bay
Wilson's Gorge
Transition Bay
0 20 40
MILES
140W 120W 100W 80W 60W 40W
70°N
ARCTIC CIRCLE
100W 80W
1
2
5
6
7
WILSON'S GORGE OSTRACODERM LOCALITY
OTHER VERTEBRATE LOCALITIES
CARBONATE FACIES
CARBONATE/SANDSTONE FACIES
SANDSTONE FACIES
SANDSTONE/CONGLOMERATE FACIES
CONGLOMERATE FACIES
PRE-PEEL SOUND FORMATION
PEEL SOUND FORMATION

Fig. 1.

adverse climate, snow cover and widespread felsenmeer. It should be noted that the shallow depth of permafrost sometimes limited the extraction of material from outcrop. The use of a portable 2-stroke rock saw facilitated the trimming of specimens and minimized breakage.

Acknowledgements

Financial support from the Department of Indian Affairs and Northern Development, the National Research Council of Canada, the Geological Survey of Canada, the National Museum of Canada and the Defence Research Board is gratefully acknowledged. Thanks are also due to Sproule Projects Ltd. for facilities provided and to Outboard Marine Ltd. for loan of Snowcruisers.

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II REGIONAL STRATIGRAPHY AND PREVIOUS WORK

Introduction

Somerset and Prince of Wales Islands lie astride the Boothia Arch or Uplift, a northerly projection of the Precambrian Shield which extends about 400 miles across the stable region (Kerr and Christie, 1965). To the south it includes Boothia Peninsula while its northern extremity underlies the miogeosynclinal sediments of Cornwallis Island (fig.1).

Uplift along the Boothia Arch has occurred intermittently since the Precambrian and is reflected by the partly clastic nature of the Palaeozoic sediments in the Boothia Region. On the flanks of the Boothia Arch rocks of Proterozoic age include the Aston Formation, an assemblage of quartzitic sands with minor shales and conglomerate and the Hunting Formation, consisting of dolomite, argillaceous dolomite and minor sandstone.

The basal Palaeozoic rocks of the Boothia Region are unnamed Middle Cambrian clastic dolomites, sandstone with minor dolomitic intraformational breccia, and conglomerate. Overlying this is an unnamed Lower and Middle Ordovician unit, predominantly dolomitic with minor sandstone and apparently equivalent to the Cornwallis Formation (table 1). The overlying Ordovician and Silurian Allen Bay Formation is primarily dolomitic and apparently represents biostromal reefs. The conformably overlying Silurian

Read Bay Formation is described below.

Renewed uplift of the Boothia Arch during the Early Devonian considerably influenced local sedimentation, producing on Boothia Peninsula and Somerset and Prince of Wales Islands a varied but predominantly clastic syntectonic succession called the Peel Sound Formation.

Below is a summary of previous work on the Peel Sound Formation and the underlying Read Bay Formation on Prince of Wales Island, with additional information from adjacent Somerset and Cornwallis Islands where relevant (see table 1).

Read Bay Formation

Description. The type section of the Read Bay Formation is on Cornwallis Island (Thorsteinsson, 1958) where it includes 8,500 feet of limestone, argillaceous limestone, minor amounts of dolostone, calcarous shale, sandstone, siltstone and shale. It has been divided into four lithological units, members A, B, C and D in upward succession (table 1). Thorsteinsson (1958:75) drew the contact with the conformably overlying Snowblind Bay Formation at the first persistent stratum of limestone conglomerate.

On Prince of Wales Island the Read Bay Formation outcrops as a narrow strip near the east coast and also occurs on adjacent small islands including Prescott and Pandora Islands (fig.1). The formation has not been completely investigated and little information is available apart from

<table>
<tr><th colspan="3"></th><th>graptolitic facies</th><th colspan="2">shelly facies</th></tr>
<tr><td rowspan="7">SILURIAN</td><td rowspan="3">LUDLOVIAN</td><td>UPPER</td><td></td><td colspan="2">SNOWBLIND BAY FORMATION (part)</td></tr>
<tr><td>MIDDLE</td><td rowspan="7">CAPE PHILLIPS FORMATION</td><td rowspan="3">READ BAY FORMATION</td><td>MEMBER D
MEMBER C
MEMBER B</td></tr>
<tr><td>LOWER</td><td rowspan="2">MEMBER A</td></tr>
<tr><td colspan="2">WENLOCKIAN</td></tr>
<tr><td rowspan="3">LLANDOVERIAN</td><td>UPPER</td><td colspan="2" rowspan="4">ALLEN BAY FORMATION</td></tr>
<tr><td>MIDDLE</td></tr>
<tr><td>LOWER</td></tr>
<tr><td rowspan="2">ORDOV-ICIAN</td><td colspan="2">ASHGI-LLIAN</td></tr>
<tr><td colspan="2">CARADOC-CIAN</td><td>CORNWALLIS</td><td colspan="2">FORMATION</td></tr>
</table>

Table 1. Formations present on Cornwallis Island (after Thorsteinsson,1958,table 6).

isolated localities examined by the Geological Survey of Canada during 'Operation Franklin' (Fortier _et al._, 1963) and 'Operation Prince of Wales' (Blackadar and Christie, 1963; Christie, 1967).

Christie's section at Young Bay (fig. 1) reveals 840 feet of Read Bay sandstone and fossiliferous limestone which grade conformably downwards into fossiliferous Allen Bay dolostone and conformably upwards into the Peel Sound Formation. It is not known whether the individual members of the Read Bay Formation may be recognized but it is apparent that the formation is considerably reduced compared with its development on Cornwallis Island.

In Wilson's Gorge (fig. 1) and the unnamed valley further north the formation consists of several hundred feet of fossiliferous limestone (some dolomitic) grading into the overlying Peel Sound sandstones (see fig. 3 and description of section).

A conformable contact with the Peel Sound Formation was also observed southeast of Mount Matthias and in central Pandora Island (fig. 1). However, the contact is an angular unconformity eight miles south of Bellot Cliff (Kerr and Christie, 1965, and personal observation).

Fauna and correlation (table 1). Vertebrates have not been recorded from the Read Bay Formation on Prince of Wales Island although they are known on Somerset and Cornwallis Islands. Little work has been done on the abundant invertebrate fauna but one age determination is available for a horizon 565 feet below the top of the Read Bay Formation at Young Bay (fig. 1; G.S.C. loc. 50762; Christie, 1967) from which Bolton (1965:8) described *Encrinurus (Frammia) arcticus* (Haughton). The association of this species with the Arctic *Atrypella scheii* (Holtedahl) fauna which is particularly abundant in Member A of the Read Bay Formation suggests a Lower Ludlovian age.

On adjacent Somerset and Cornwallis Islands vertebrates are known from several horizons (Thorsteinsson, 1958; Dineley, 1966a) and correlations have been attempted. In northern Cornwallis Island the Read Bay Formation and the underlying Allen Bay Formation grade laterally northward and basinward into the calcareous shale of the Cape Phillips Formation (table 1). The latter formation was assigned by Thorsteinsson (1958, table 5, 6) to the Ashgillian and Middle Ludlovian, but Kerr (1967:682) considers it to be Early Devonian as well. Its partial correlation with the Read Bay Formation was based on graptolite and ostracoderm faunas common to both formations. At one locality Thorsteinsson found a new cyathaspidid associated with a Wenlockian graptolite fauna and suggested that the Allen Bay/Read Bay contact lies within the Wenlockian. The presence of *Monograptus bohemicus* in the upper part of Member A suggested that no part of this member is younger than lower Ludlovian. He assigned a middle Ludlovian or younger age to Members C and D because of the zone of *M. ultimus* overlying Member B at one locality. However, it is important to note that he considered the upper age limit of the Read Bay Formation to be somewhat doubtful because of inadequate collecting from the upper parts of Member D (Thorsteinsson, 1958:73). Other authors including Douglas *et al.* (1963, table 2) and Kerr (1967:680, 682, table 1) regarded the top of the Read Bay Formation as Early Devonian. It is evident that the upper age limit of the Read Bay Formation remains uncertain, although a Late Ludlovian age seems most likely.

Peel Sound Formation

Description. The type section of the Peel Sound Formation is on the east flank of the Cape Anne syncline, northwest Somerset Island (Thorsteinsson and Tozer, 1963:122). A thicker section on the west flank of the syncline is more complete and contains the following members (Dineley, 1966a: 273):

	feet
4. Polymict conglomerate	300
3. Sandstone	850
2. Oligomict conglomerate	1850
1. Sandstone, siltstone, limestone and dolostone	500
total thickness	3,500

The contact with the underlying Read Bay Formation is conformable and Dineley arbitrarily drew the lower boundary of the Peel Sound Formation at the lowest red siltstone, following Thorsteinsson and Tozer (1963:122). The lowest member comprises grey-green or light red calcilutite or dolostone, calcareous shale and calcareous siltstone. Ripple marks, desiccation cracks and planar- and cross-lamination are present. The oligomict conglomerate member consists of rounded calcilutite clasts in a calcarenite matrix with minor chert and quartzite pebbles. This unit is apparently absent from the eastern limb of the syncline suggesting a local but rapid facies change, a characteristic feature of this formation. The sandstone member comprises mainly red quartzose sandstone with many pebble horizons. The polymict conglomerate member consists of well-rounded clasts with a maximum clast diameter of one foot, set in an immature sandstone.

Other workers on the Peel Sound Formation include Blackadar and Christie (1963), Kerr and Christie (1965) and Kerr (1967), but the most detailed investigations are those carried out in 1966 and 1967 on Prince of Wales and adjacent small islands by A.D. Miall, University of Ottawa, to whom the writer is indebted for much of the following information (see Broad, Dineley and Miall, 1968; Miall, ~~1969~~).

On Prince of Wales Island rocks of the Peel Sound Formation decrease in grain size westward away from the Boothia Arch and may be subdivided into three facies belts - conglomerate, sandstone and carbonate - trending north-south (fig. 1). The clastic beds are at least partly lateral facies equivalents. The carbonate beds, although referred to as facies and considered in part laterally equivalent to the conglomerate and sandstone facies, may be in part correlative with the underlying Read Bay Formation (Blackadar and Christie, 1963, map 37-1963) and possibly younger formations.

The conglomerate facies belt varies in width from one to eleven miles and rocks other than coarse-grained pebbly sandstone and pebble and boulder conglomerate are rare. Clasts reach a diameter of four feet and are lithologically similar to Palaeozoic and basement rocks on Somerset and eastern Prince of Wales Islands. The conglomerate lies, usually conformably, above massive limestones of the Read Bay Formation but locally transitional beds of red sandstone, siltstone and minor conglomerate lie between the Read Bay limestone and the massive Peel Sound conglomerate. These transitional beds are known in parts of Somerset Island (Dineley, 1966a). On Prince of Wales Island they are present in Wilson's Gorge but are absent in the unnamed valley a mile and a half farther north.

On Prince of Wales Island palaeocurrent directions apparently indicate an easterly source for Peel Sound sediments. The presence of reworked Peel Sound sediments at separate horizons within the conglomerate succession confirms the suggestion of Kerr and Christie (1965) that the uplift of the Boothia Arch was intermittent rather than a single episode.

The sandstone facies consists of a six to eleven mile wide belt of monotonous red sandstone containing rare vertebrates,rare washout channels and small-scale current features. Where it interfingers with the conglomerate to the east a transitional sandstone/conglomerate facies less than two miles wide may be delimited. Similarly a carbonate/ sandstone facies eight miles wide occurs along the western margin.

The carbonate facies comprises horizontal or gently dipping carbonate strata occupying all of western Prince of Wales Island. There has been little study of these rocks but they are thought to be predominantly calcilutites, locally partly or wholly dolomitized.

<u>Fauna and correlation</u> (fig. 2). Previous opinions on the age of the Peel Sound Formation are based on stratigraphic and faunal evidence from scattered localities. These conclusions are summarized below and the most relevant are represented diagrammatically in figure 2.

(1) From a locality two miles inland from Reliance Bay, northwest Prince of Wales Island, Thorsteinsson and Tozer (1963:126) obtained gastropods, brachiopods and a trilobite, apparently of a late Silurian or early Devonian age. They also deduced a Lower Devonian age from its stratigraphic position above the Read Bay Formation and from cyathaspidids collected on Somerset Island (op. cit.: 125).

(2) Blackadar and Christie (1963, map 37-1963) subdivided the Peel Sound Formation on Prince of Wales Island

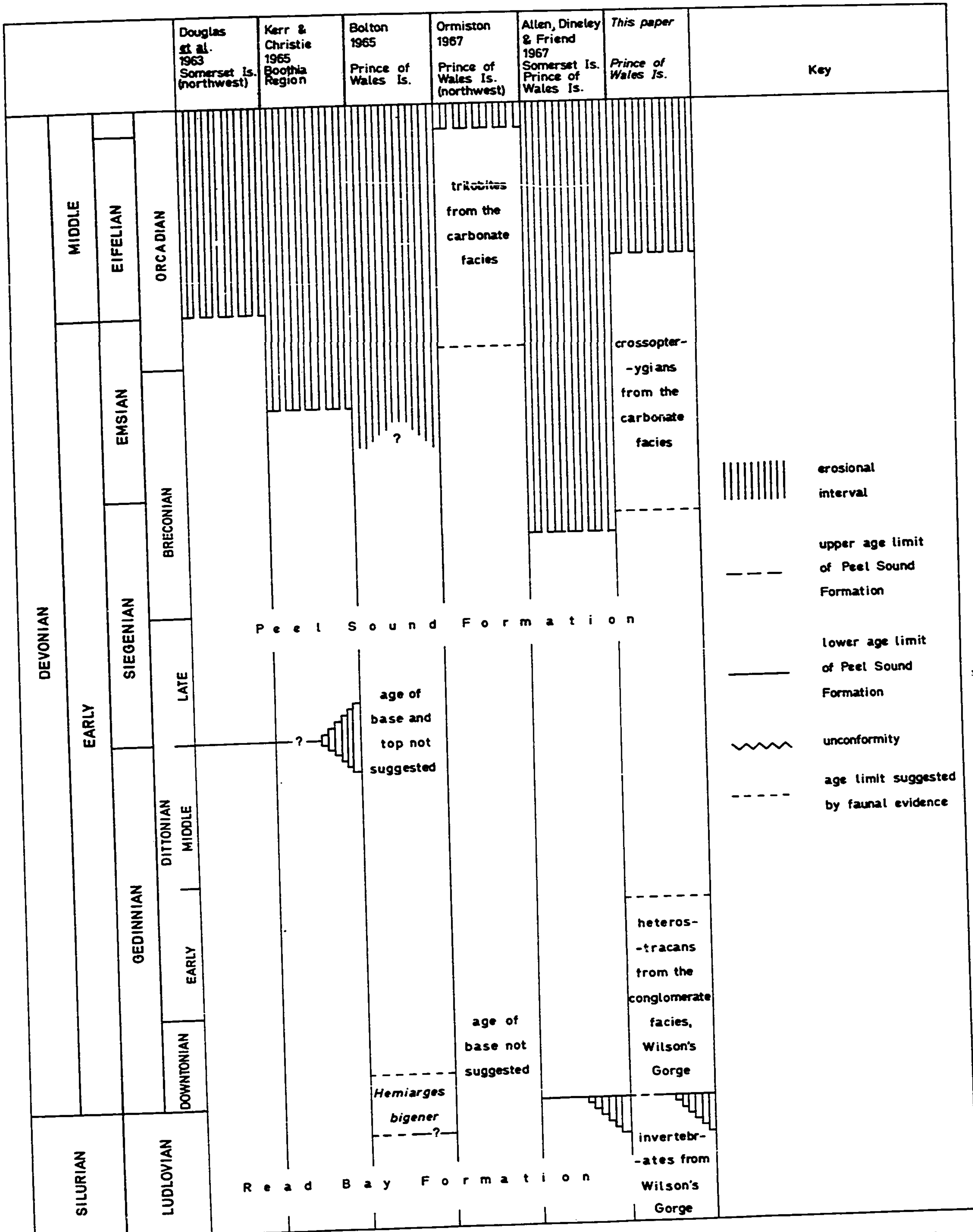

Fig. 2. Proposed age of the Peel Sound Formation on Prince of Wales Island compared with that of previous workers. Faunal evidence included where available.

into conglomerate, sandstone and carbonate facies, as discussed earlier. They noted that the carbonate beds to the west mainly constitute a carbonate facies of the Peel Sound Formation but probably also include some beds equivalent to the Read Bay Formation or beds younger than the Peel Sound Formation.

(3) On Somerset Island Douglas et al. (1963, table 2) considered the Peel Sound Formation to be Siegenian and Emsian (fig. 2) for reasons not given.

(4) Kerr and Christie (1965, table 1) indicated a Siegenian and partly Emsian age for the Peel Sound Formation in the Boothia Region. This conclusion was mostly based on stratigraphic evidence and the presence of cyathaspidids on Somerset Island.

(5) Bolton (1965:8) described the trilobite *Hemiarges bigener* Bolton found in a thin argillaceous limestone amidst massive conglomerate near the base of the Peel Sound Formation south of Bellot Cliff and indicated a very late Silurian or Early Devonian age.

(6) The most important contribution to the age of the base of the Peel Sound Formation is the work of Dineley (1965:55) on Somerset Island. He suggested that on evidence from vertebrate faunas, the base of the Peel Sound Formation corresponds to a horizon low in the Downtonian and approximates to the Siluro-Devonian boundary. This position was extended to both Somerset and Prince of Wales Islands by Allen, Dineley and Friend (1967, table 3) who also indicated the Snowblind

Bay Formation on Cornwallis Island to be, in part, contemporaneous with the Peel Sound Formation.

(7) The first precise determination of the age of the carbonate facies on Prince of Wales Island was made by Ormiston (1967). Ormiston collected trilobites, brachiopods, unidentified placoderms and other fossils from the head of Drake Bay (fig. 1) and from a locality twenty miles to the northeast. The presence of *Dechenella (Basidechenella) laticaudata* Ormiston suggested an Early or Middle Devonian age to him while the presence of *Schizoproetoides ellesmerensis* Ormiston suggested correlation with the Blue Fiord Formation of Ellesmere Island. He regarded the Blue Fiord Formation as Eifelian but recent work on its conodont and brachiopod faunas indicates an earlier Devonian (Emsian) age (Johnson, 1965:378; Johnson and Talent, 1967:153; J.W. Kerr, 1968, personal communication).

(8) On lithological and stratigraphical evidence Kerr (1967:688) suggested that the conglomerates at Bellot Cliff probably correlate with the upper part of the Snowblind Bay Formation (Early Devonian) of Cornwallis Island and the Stuart Bay Formation (late Early Devonian) of Bathurst Island.

(9) On evidence from its lithology and vertebrate fauna Trettin (1967:695) suggested a further correlation of the Peel Sound and Snowblind Bay Formations with the Stallworthy Formation (Early Devonian) of Axel Heiberg Island.

With the exception of the work of Dineley and Ormiston, it is clear that previous age determinations are somewhat vague and have been seriously limited by lack of faunal evidence near the base of the Peel Sound Formation. Age determinations drawn from the present study of a heterostracan fauna from the base of the Peel Sound Formation are discussed later.

Vertebrates have previously been recorded from three localities on Prince of Wales Island, one within the conglomerate facies west of Browne Bay (GSC loc. 50735), and the others from the carbonate facies in the Drake Bay region (Ormiston, 1967). Previous to these reports the only vertebrates known from the Peel Sound Formation were from several localities on Somerset Island, briefly described below.

The first collection of vertebrates from Somerset Island made by Thorsteinsson and Tozer during Operation Franklin in 1955 included a cyathaspidid closely related to *Anglaspis*, a genus close to *Corvaspis*, and a poraspid (in Fortier et al., 1963:122). On the basis of the first two forms Thorsteinsson and Tozer suggested a Lower Devonian age for the Peel Sound Formation (op. cit.:125). This was confirmed by the stratigraphic position of the Peel Sound beds overlying the Read Bay Formation which had previously been established as middle and probably upper Ludlovian on Cornwallis Island (Thorsteinsson, 1958:73; Fortier et al., 1963:125).

Parties from the University of Ottawa in northwestern

Somerset Island subsequently collected large numbers of ostracoderms and other vertebrates from both the Peel Sound and Read Bay Formations (Dineley, 1965, 1965a, 1966, 1966a). The fauna includes *Torpedaspis* gen. nov., *Pionaspis, Traquairaspis, ?Kallostrakon, Corvaspis,* a form close to *Anglaspis expatriata* Denison, cephalaspids including *Hemicyclaspis, Pseudotraquairaspis* gen. nov. and several problematic forms (possibly new genera), acanthodians, eurypterids, ostracods and a gastropod. Localities near Creswell Bay yielded ostracoderms and other vertebrates within the basal 300 feet of the Peel Sound Formation and include *Anglaspis, Listraspis, Pionaspis, ?Cyathaspis, Pseudotraquairaspis* gen.nov., *Traquairaspis, Hemicyclaspis,* cephalaspids and forms akin to *Torpedaspis* gen. nov.

III STRATIGRAPHY

New localities of vertebrates and associated faunas on Prince of Wales Island

In view of the large collections of vertebrates from Prince of Wales Island this study is restricted to the faunas from the richest locality, Wilson's Gorge. The remaining collections await detailed study but a list of the localities and their vertebrate and invertebrate faunas is given below (see fig. 1).

(1) Near Baring Channel are several localities within the sandstone, the sandstone/carbonate and the carbonate facies. The faunas include *Ctenaspis*, pteraspids, cephalaspidids, arthrodires, acanthodians, placoderms, eurypterids and crossopterygians. Some faunas are associated with ostracods and plants. The vertebrates suggest Downtonian, Dittonian and slightly younger ages. The youngest vertebrates are from the most westerly locality on Prince of Wales Island and include crossopterygians-osteolepids or porolepids indicative of an Early/Middle Devonian age.

An invertebrate fauna associated with ostracoderms was collected by A.D. Miall within the carbonate facies on the north coast of Baring Channel (GSC loc. 82456:*Favosites* sp., auloporid-like and disphyllid-like corals, chonetid and atrypid brachiopods, *Lingula* sp., *Nucula (Nuculoides)* sp., *?Euomphalus* sp., orthoconic cephalopod indet., *Dechenella (Basidechenella)* sp., *Schizoproetus or Schizoproetoides* sp., and a kloedenid ostracod indet.) and was identified as possibly Middle Devonian by T.E. Bolton.

The easternmost vertebrate locality in the Baring Channel area is in the sandstone facies sixteen miles southwest of Bellot Cliff. Bone fragments and *Pteraspis* occur a few feet below a fauna (GSC loc. 82479, 82480) with *Modiomorpha* sp. or *Modiolopsis* sp., *Megambonia* sp. cf. *M. aviculoidea* Hall, an atrypid brachiopod, and a large leperditiid ostracod indet.

(2) Two miles southeast of Mount Matthias large fragmentary ostracoderms were obtained from a sandstone lens in the basal Peel Sound conglomerate.

(3) On the northwest coast of Browne Bay, twelve miles east of GSC locality 50735, A.D. Miall collected ostracoderms from the sandstone facies.

(4) On the northwest coast of Prescott Island well preserved cyathaspidids were obtained from a sandstone lens amidst massive conglomerates.

(5) Eight miles west of Pandora Island well preserved ostracoderms including cyathaspidids and traquairaspidids were obtained from the sandstone and carbonate/sandstone facies.

(6) In central Pandora Island fragmentary ostracoderms were obtained from a pebbly conglomerate at the base of the Peel Sound Formation.

(7) Twelve miles southeast of Young Bay, Miall ob-

tained large ostracoderms from the basal Peel Sound sandstone in the conglomerate facies.

(8) Eight miles inland of Transition Bay several localities in the carbonate/sandstone facies yield ostracoderms including cyathaspidids, traquairaspidids and *Corvaspis*, indicative of a Downtonian/Dittonian age. About thirty feet stratigraphically lower occur (GSC locs. 82457-61, 82478): *Prismatophyllum* sp., *Thecostegites* sp. cf. *T. compactus* Dubulatov, a colonial coral like '*Cyathophyllum*', tiny gastropods indet., and *Leperditia gibbera* Jones. The ostracod was identified by M.J. Copeland. T.E. Bolton identified the remainder of the fauna and remarked that the corals *Prismatophyllum* and *Thecostegites* suggested a Devonian rather than a Silurian age.

(9) The fauna from the richest locality, Wilson's Gorge, is described in detail below (p.51).

Read Bay Formation in Wilson's Gorge

The Read Bay Formation consists of more than two hundred feet of fossiliferous limestone, vertical or overturned to the west. The contact with the underlying Allen Bay Formation dolostones was not seen in this section but the lowest exposed beds of the Read Bay Formation are dolomitic.

The top 88 feet are predominantly limestone with minor sandstone and siltstone (see fig. 3 and measured section). The limestone units are grey, silty or sandy, and are

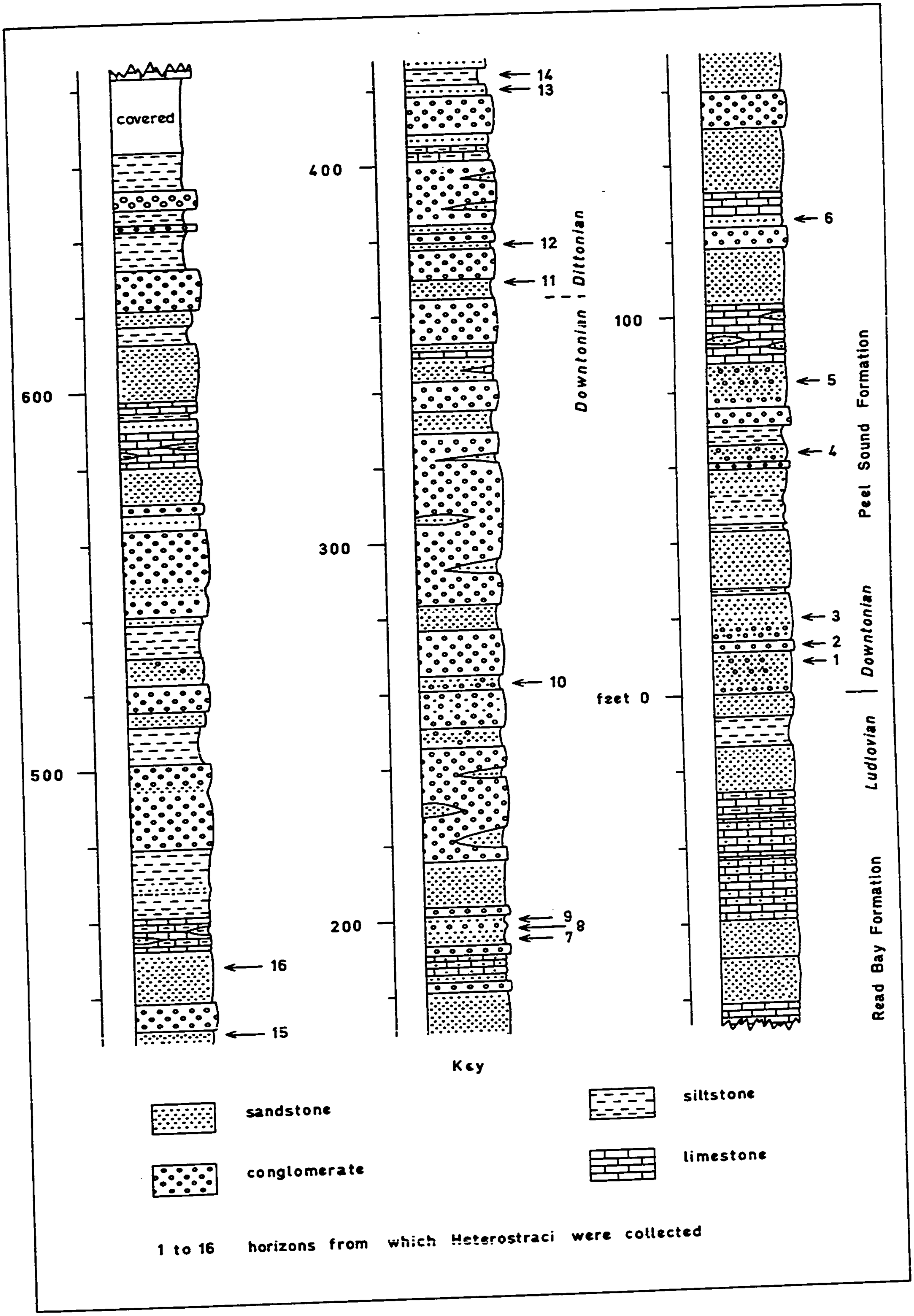

Fig. 3. Columnar section in Wilson's Gorge.

well bedded or laminated. They are abundantly fossiliferous and contain trace fossils, bryozoa, stromatolites, colonial corals, brachiopods, gastropods, cephalopods and ostracods, in addition to fossil debris. The sandstone units are white or grey-green, laminated or massive, and some contain silty intraclasts or show ripple marks. The siltstone unit is grey, calcareous, has rare lenses of fossil debris and contains brachiopods and ostracods.

The following fauna (GSC loc. 82470) was identified by T.E. Bolton and M.J. Copeland: *?Pentamerifera* sp. or *?Harpidium* sp., *Atrypella* sp. or *Clorinda* sp., *Leperditia gibbera* Jones, and a cephalopod like *Amphicyrtoceras*. Bolton assigned this fauna to the Silurian.

Peel Sound Formation in Wilson's Gorge

General Remarks. The Peel Sound Formation contains more than 685 feet of conglomerate, sandstone, siltstone and minor limestone (see fig. 3 and measured section), standing vertically or with a steep westward dip. The contact with the underlying Read Bay Formation is conformable and is drawn at the base of the group of beds containing the first conglomerate. The first conglomerate constitutes unit 3 and the base of the formation is drawn at the base of unit 1. Units 1, 2 and 3 constitute a single mappable group which is lithologically (and faunally) distinct from the underlying beds.

The gradational passage from the Read Bay into the

Peel Sound Formation is marked by an upward increase in, and coarsening of, clastics, and a decrease in the proportion of limestone. A striking feature of this gradation is the apparent absence of vertebrates in the Read Bay Formation and the abrupt appearance of diverse ostracoderms in the lowest beds of the Peel Sound Formation. The significance of this faunal change is discussed later.

The upper part of the formation is incomplete. There is no continuous exposure between unit 114 which dips westwards at about 70 degrees and the 200 feet or so of horizontal or gently westward-dipping conglomerate of unit 116 half a mile upstream.

Sandstone. In the measured section sandstone and conglomerate are the predominant lithologies (fig. 3). The aggregate thickness of the 58 sandstone units totals 265.25 feet. Sandstone occurs interbedded with, or as lenses within, the conglomerate. Sandstone units are predominantly red but some are grey, green, white, yellow, purple or mottled. They are coarse to fine grained and many are poorly sorted containing rounded clasts up to one inch in diameter. The largest clasts have the lowest sphericity and occur near the base of the formation, for example, chert clasts seven inches long and two inches thick in unit 15. Sedimentary structures are rare. Beds are massive, well bedded or finely laminated. Crossbedding is present in units 9 and 55 and one example of graded bedding was observed. Unit 9 also contains ripple marks, prod casts and lenses of fossil debris up to one foot long by two inches thick.

Throughout the section sandstone weathers more rapidly than the conglomerate. Also, the basal 214 feet of the formation which is predominantly sandstone has low relief and the outcrop is mostly scree-covered.

Invertebrate remains are rare. Ostracods occur in units 9, 43, 60 and 64, small gastropods in units 27, 60 and 64, pelecypods in unit 60, *Lingula* sp. in units 35 and 38. Unit 29 (GSC loc. 82490, identified by T.E. Bolton) yielded *Mesotrypa* sp., *Favosites* sp., one arachnophyllid coral, ostracods and gastropods in a fine calcareous sandstone matrix containing fossil debris and limestone clasts up to 0.25 inch in diameter.

Ostracoderm remains are present in twenty sandstone units being common to abundant in units 2, 4, 16, 19, 23, 34, 35, 38, 49, 60, 71 and 74, of which unit 4 may be considered a 'bone bed'. A preliminary faunal list for each fish horizon is included in the measured section.

Conglomerate. The aggregate thickness of the 32 conglomerate units is 264.75 feet. Conglomerate units are red or grey and commonly contain, or are interbedded with, sandstone lenses or beds (fig. 3). Clasts include limestone, dolostone, conglomerate, sandstone, siltstone and gneiss. The largest clasts are seven inches in diameter. Roundness of clasts is moderate; sphericity is moderate to low.

Conglomerate matrices are red, grey or yellow, and coarse to medium grained sandstone. Graded bedding is present in unit 46, crossbedding in unit 66. The conglomerate is more resistant to weathering than other lithologies in the section. Its major development begins 214 feet above the base of the formation and is emphasized by massive vertical conglomerate buttresses.

Bone fragments occur in the matrices of six conglomerate units. Associated clasts range from one to five inches in diameter and demonstrate that large clasts do not necessarily preclude the occurrence of vertebrate remains.

<u>Siltstone</u>. Siltstone is more common in the top 258 feet of the section and 15 units total 81 feet (fig. 3). Siltstone units are mostly red but some are grey, green, yellow or purple. Some are finely laminated and one unit shows upward fining from an underlying sandstone. Other sedimentary structures were not observed.

Invertebrate fossils, fragmentary and unidentified, occur in unit 89, and bone fragments occur in unit 72.

<u>Limestone</u>. Limestone constitutes 8 units and accounts for 54 feet of the section (fig. 3). Limestone units are grey or grey-blue and some contain crenulate shaley partings or arenaceous layers or lenses. They may be massive, well bedded or nodular.

Invertebrate fossils are present in each limestone unit. Gastropods occur in units 24 and 96, brachiopods in units 32 and 96, pelecypods and a cephalopod in unit 96. Unit 20 (GSC loc. 82759, identified by M.J. Copeland) contains *Herrmannina* sp. and *?Primitia* sp. Unit 67 (GSC locs. 82762-66) contains the following ostracod fauna: *Leperditia gibbera* Jones, *"Beyrichia" plagosa* Jones, cf. *Welleriopsis* sp., *Bairdiocypris* sp., *"Bythocypris"* sp. and *?Primitia* sp. M.J. Copeland identified the fauna commenting that it could be of Lower Devonian age although it is similar to faunas in the Read Bay Formation on Beechey Island (southwest of Devon Island). Unit 96 (GSC loc. 82473) contains *?Clorinda* sp., *Conocardium* sp., ostracods and an amphicyrtocerid cephalopod. T.E. Bolton identified the fauna as Silurian. This apparently anomalous Silurian age 589 feet above the base of the Peel Sound Formation is discussed later.

Measured section in Wilson's Gorge

Wilson's Gorge is an informal name assigned to a steep-sided stream valley nine miles north of Transition Bay, southeastern Prince of Wales Island (fig. 1; grid reference 14XNR8413, map 68A, Fisher Lake, District of Franklin, Northwest Territories; aerial photograph no. A16320-134). The Read Bay and Peel Sound Formations are exposed.

* indicates fish bearing horizon

** indicates fish collecting horizon

Unit	Thickness in feet Unit	From base
Peel Sound Formation (Downtonian and Dittonian) (approximately 935 feet)		
Top of section		
(a) Section measured on northeast and south side of gorge		
116 Conglomerate.	?200	?935
115 Covered.	?50	?735
114 Limestone, nodular, grey, finely comminuted unrecognizable fossil debris.	2	685
113 Covered.	20	683
112 Siltstone, grey-green, laminated	10	663
111 Conglomerate, clasts up to 1 inch maximum diameter.	5	653
110 Siltstone, reddish.	4	648
109 Conglomerate, clasts up to 1 inch maximum diameter.	2	644
108 Siltstone, reddish, laminated.	10	642
107 Conglomerate, clasts up to 1 inch maximum diameter; passing into	11	632
106 Sandstone, white, coarse-grained, rare small clasts; yellow weathering veins.	4	621
105 Siltstone, red; laminated; weathers purple	4	617

Unit	Thickness in feet Unit	From base
104 Siltstone, red.	1	613
103 Sandstone, whitish, coarse-grained; clasts up to 0.5 inch maximum diameter; crossbedded.	2	612
102 Sandstone, red, fine-grained; laminated, passing into	$1\frac{1}{2}$	610
101 Sandstone, red, coarse-grained.	$2\frac{1}{2}$	$608\frac{1}{2}$
100 Sandstone, red and purple; laminated.	9	606
99 Limestone, grey-blue; massive but slightly nodular; small gastropods.	3	597
98 Siltstone, yellow-grey; calcareous.	2	594
97 Sandstone, grey, coarse-grained; laminated.	3	592
96 Limestone, grey; nodular; thin shaly partings; weathers rubbly; small cephalopod indet. - Amphicyrtocerid, tiny smooth brachiopods - *?Clorinda* sp., pelecypods - *Conocardium* sp., ostracods. GSC loc. 82473.	9	589
95 Sandstone, red, fissile.	10	580
94 Conglomerate, clasts up to 1.5 inches maximum diameter.	3	570
93 Sandstone, white with red mottling,		

Unit	Thickness in feet Unit	From base
coarse-grained.	3	567
92 Conglomerate, red, clasts up to 2 inches maximum diameter, mostly limestone and siltstone, rarely gneiss (gneiss clasts do not occur in any conglomerate below this horizon); matrix of red sandstone; cross-bedded red sandstone near base.	15	564
91 Conglomerate, clasts up to 2 inches maximum diameter, clasts are mostly dolostone, rarely quartz; matrix is yellow sandstone with calcareous cement; upper 1.5 feet is white, coarse-grained sandstone streaked with yellow.	8	549
90 Sandstone, grey-yellow, fine grained; laminated.	2	541
89 Siltstone, green-grey; traces of ?fossil debris.	9	539
88 Sandstone, red and grey, coarse-grained; occasional pebbles.	7	530
87 Conglomerate, clasts up to 3 inches maximum diameter.	7	523

Unit	Thickness in feet Unit	From base
86 Sandstone, red; laminated.	4	516
85 Siltstone, green.	6	512
84 Siltstone, red; laminated.	4	506
83 Conglomerate, clasts up to 1 inch maximum diameter.	6	502
82 Sandstone, red, fine-grained; occasional pebbles.	1½	496
81 Conglomerate, clasts up to 7 inches maximum diameter.	15	494½
80 Siltstone, grey, green, purple.	10	479½
79 Siltstone, grey-green, finely laminated at the top, grading upwards into thin, fine-grained, white sandstone.	8	469½
78 Limestone, silty; sandy lenses; crenulate partings; gastropods - *Hormotoma* sp., ostracods - *Primitia* sp. GSC loc. 82474.	9	461½
*77 Sandstone, red, medium-grained; rounded quartz grains set in finer matrix; calcareous matrix; ostracoderm fragments up to 1.3 inches long, some minute, all bluish in colour-Heterostraci indet. Fish horizon 16.	8	452½

Unit	Thickness in feet: Unit	Thickness in feet: From base
76 Sandstone, red and grey, medium-grained; laminated.	5	$444\frac{1}{2}$
75 Conglomerate, clasts up to 2 inches maximum diameter.	7	$439\frac{1}{2}$
**74 Sandstone, red, fine-grained; laminated; fissile; rounded quartz grains set in finer matrix; calcareous matrix; ostracoderms fragmentary, bluish, up to 0.5 inches long, scales common, Heterostraci indet. Fish horizon 15.	2	$432\frac{1}{2}$
*73 Sandstone, grey, coarse-grained; disseminated clasts up to 0.5 inch maximum diameter; rare ostracoderm fragments; passing into	4	$430\frac{1}{2}$
**72 Siltstone, grey; laminated; micaceous; matrix calcareous and dolomitic; *Traquairaspis* fragments up to 1.5 inches long, white in colour, fragments of small cyathaspidids, blue in colour; *Anglaspis* cf. *A. expatriata, Traquairaspis rambaldi* sp. nov., Heterostraci indet. Fish horizon 14, passing into	5	$426\frac{1}{2}$

Unit	Thickness in feet Unit	From base
**71 Sandstone, red, fine-grained; fine laminae, calcareous matrix; ostracoderm fragments up to 1.1 inches long, white in colour. *Traquairaspis denisoni*, *T. rambaldi* sp. nov., *Pseudotraquairaspis* sp. *A* gen. et sp. nov. Fish horizon 13.	3	421½
*70 Conglomerate, rare ostracoderm fragments.	9	418½
69 Sandstone, red, medium- to fine-grained; passing into	2	409½
68 Sandstone, grey, coarse-grained.	1¼	407½
67 Limestone, silty; conspicuous bedding; abundant ostracods - *Leperditia gibbera* Jones, "*Beyrichia*" *plagosa* Jones, cf. *Welleriopsis* sp., *Bairdiocypris* sp., "*Bythocypris*" sp., *?Primitia* sp. GSC locs. 82762-66.	5	406¼
*66 Conglomerate, clasts up to 4 inches maximum diameter; arenaceous beds are crossbedded and weather to very poorly consolidated sandstone.	15	401¼

Unit	Thickness in feet Unit	From base
65 Conglomerate.	2	386¼
*64 Sandstone, red and grey; rounded gastropods and ostracods; rare ostracoderm fragments.	2	384¼
63 Conglomerate, clasts up to 1 inch maximum diameter.	3	382¼
**62 Sandstone, red, fine-grained; laminated; calcareous matrix; ostracoderm fragments up to 2.5 inches long, common small white fragments aligned parallel to laminae. *Traquairaspis denisoni*. Fish horizon 12.	1½	379¼
61 Conglomerate, clasts up to 4 inches maximum diameter.	8	377¾
**60 Sandstone, red, coarse-grained; laminated at top; rare clasts up to 0.25 inch maximum diameter; calcareous matrix; ostracods, gastropods and pelecypods; ostracoderm fragments up to 3.5 inches long, all white in colour, many are crushed. *?Pionaspis* sp. (not described), *Torpedaspis elongatus* gen. et sp. nov., *Corvaspis* cf. *C. kingi*, *Pteraspis (Simopteraspis)*		

Unit	Thickness in feet Unit	From base
arctica sp. nov. Fish horizon 11.	2	369¾
59 Sandstone, grey, coarse-grained; clasts up to 0.25 inch maximum diameter.	1	367¾
*58 Sandstone, red, fine-grained; ostracoderms, fragmented and entire, all with peculiar bluish lustre. Heterostraci indet.	2	366¾
57 Sandstone, mottled, red and green, coarse-grained.	3	364¾
*56 Conglomerate, clasts up to 5 inches maximum diameter; rare comminuted ostracoderm fragments in the matrix at the top.	12	361¾
55 Sandstone, red, fine-grained; laminated; calcareous matrix; discontinuous lenses of white limestone, becoming interbedded red and white rock towards top; small-scale crossbedding.	10	349¾
54 Conglomerate, clasts up to 4 inches maximum diameter.	7	339¾
53 Sandstone, red, fine-grained.	5	332¾
52 Conglomerate, clasts up to 4 inches maximum diameter; passing into	45	327¾

Unit	Thickness in feet Unit	From base
*51 Sandstone, mottled red and green; laminated; Cyathaspididae indet.	6	282¾
50 Conglomerate, clasts up to 5 inches maximum diameter.	12	276¾
**49 Sandstone, red, medium-grained; finely laminated; clasts of dolostone and limestone up to 0.2 inch maximum diameter; rare red shale intercalations; conglomerate at top of unit with clasts up to 0.5 inch diameter; matrix dolomitic and calcareous; ostracoderm shields up to 2.3 inches long, some flat fragments aligned parallel to bedding. *Listraspis* sp., *Corvaspis* cf. *C. kingi*, *Pseudotraquairaspis* sp. *B* gen. et sp. nov. Fish horizon 10.	4	264¾
*48 Conglomerate, clasts up to 1 inch maximum diameter; ostracoderm fragments.	1¼	260¾
47 Sandstone, red, medium-grained.	1	259½
46 Conglomerate, clasts up to 1 inch maximum diameter; graded bedding.	2	258½
45 Sandstone, red, medium-grained.	1	256½

Unit	Thickness in feet Unit	From base
44 Conglomerate, clasts up to 1 inch maximum diameter; matrix of coarse-grained, grey, sandstone.	5	255½
43 Sandstone, mottled red and green, medium grained; rare clasts up to 0.25 inch maximum diameter; rare ostracods.	4	250½
42 Sandstone, grey, rare clasts up to 0.25 inch maximum diameter.	3	246½
41 Conglomerate, clasts all dolostone or limestone, up to 3 inches maximum diameter; upper suface planar and smooth (but not striated) and clasts are truncated.	30	243½
(b) Section measured on north side of gorge.		
40 Sandstone, grey, medium-grained; weathers yellow.	12	213½
**39 Conglomerate, clasts up to 1 inch maximum diameter; rare ostracoderm fragments.	1¾	201½
**38 Sandstone, grey, medium-grained; laminated; matrix dolomitic but slightly calcareous; abundant		

Unit		Thickness in feet Unit	From base
	ostracoderms, entire and fragmentary, mostly black or dark blue in colour, up to 5 inches long. *Lingula* sp. (not in position of growth), *Poraspis* cf. *P. polaris*, *P.* cf. *P. intermedia*, *Torpedaspis elongatus* gen. et sp. nov., *Corvaspis* cf. *C. kingi*, *Traquairaspis* cf. *T. pococki*, *Pseudotraquairaspis* sp. *A.* gen. et sp. nov., Heterostraci indet. Fish horizon 9.	1	199$\frac{3}{4}$
*37	Conglomerate, clasts up to 1 inch maximum diameter; rare ostracoderm fragments.	$\frac{3}{4}$	198$\frac{3}{4}$
*36	Sandstone, pebbly; rare ostracoderm fragments.	$\frac{1}{2}$	198
**35	Sandstone, grey-green, fine-grained; rare disturbed greenish laminae; matrix dolomitic; grades upwards into greenish, finely laminated, siltstone; abundant ostracoderms, entire and fragmentary, up to 2.7 inches long, all black in colour, scales common. *Lingula* sp. (not in		

Unit		Thickness in feet Unit	From base
	position of growth), *Poraspis* cf. *P. polaris*, *Corvaspis* cf. *C. kingi*, *Traquairaspis denisoni*, Heterostraci indet. Fish horizon 8.	2	197½
**34	Sandstone (a) northside of gorge: greenish; basal conglomerate with clasts up to 1 inch maximum diameter; ostracoderm plates and scales; *Torpedaspis elongatus* gen. et sp. nov., Heterostraci indet., (b) south side of gorge: grey, fine-grained; clasts are rare, well rounded but have poor sphericity; fine greenish laminae; matrix dolomitic but slightly calcareous; limestone conglomerate 1.5 feet thick at base of unit with clasts up to 1 inch maximum diameter, some clasts tabular; abundant ostracoderms up to 6 inches long but marked absence of small fragments and scales; some ostracoderms show preferred orientation and some show imbricate accumulation of up to 15 concave shields. *Torpedaspis*		

Unit	Thickness in feet Unit	From base
elongatus gen. et sp. nov., *Corvaspis* cf. *C. kingi*, *Traquairaspis* cf. *T. pococki*, *Pseudotraquairaspis* sp. *A* gen. et sp. nov., *P.* sp. *B* gen. et sp. nov., Heterostraci indet. Fish horizon 7.	2	195½
33 Conglomerate, green; extremely angular clasts of dolostone and limestone; laminated; arenaceous horizons; some horizons weather red.	3	193½
32 Limestone, crenulate partings; sandy lenses; fossil fragments; small brachiopods.	5	190½
31 Sandstone, grey, fine-grained; weathers yellow.	2	185½
30 Conglomerate, clasts up to 2 inches maximum diameter.	3	183½
29 Sandstone, grey, fine-grained; weathers yellow; arachnophyllid coral, *Favosites* sp., bryozoan colony - *?Mesotrypa* sp., ostracods, gastropods. GSC loc. 82490.	12	180½
28 Sandstone, mottled red and yellow,		

Unit	Thickness in feet Unit	From base
medium-grained; rare clasts up to 1 inch maximum diameter; passing into	9	168½
27 Conglomerate, grey; all clasts dolostone up to 4 inches maximum diameter.	10	159½
26 Sandstone, grey, mottled red and grey in places, medium-grained; rare pebbles.	3	149½
25 Sandstone, grey, fine-grained, weathers yellow.	14	146½
24 Limestone, grey, crenulate shaley partings; fossil debris, gastropods.	6	132½
**23 Sandstone, grey, reddish and mottled, medium-grained; laminated; calcareous matrix; ostracoderm fragments. *Corvaspis* cf. *C. kingi*. Fish horizon 6.	3	126½
22 Conglomerate, grey, clasts mostly dolostone up to 3 inches maximum diameter.	6	123½
21 Sandstone, grey, fine-grained.	15	117½
20 Limestone, grey; arenaceous lenses up to 0.5 inch thick; fossil debris, ostracods - *Herrmannina* sp.,		

Unit	Thickness in feet Unit	From base
?Primitia sp. GSC loc. 82759.	15	102½
**19 Sandstone, grey, medium-grained; rare clasts of chert and dolostone up to 1 inch maximum diameter; massive; dolomitic matrix; ostracoderms occur throughout unit, fragmentary and entire. *?Pionaspis* (not described), *Pseudotraquairaspis* sp. *B* gen. et sp. nov. Fish horizon 5.	12	87½
18 Conglomerate, grey; dolostone and limestone clasts up to 3 inches maximum diameter, poorly sorted, roundness variable.	5	75½
17 Siltstone, green.	5	70½
**16 Sandstone, grey, medium- to coarse-grained; clasts up to 1 inch maximum diameter; dolomitic matrix; common ostracoderm fragments, including cyathaspidid scales. Heterostraci indet. Fish horizon 4, passing into	1½	65½
15 Sandstone, coarse-grained; rounded chert clasts up to 7 inches long		

Unit	Thickness in feet: Unit	Thickness in feet: From base
by 2 inches thick; well rounded clasts of laminated chert up to 1 inch maximum diameter; abundant fossil debris.	3	64
14 Conglomerate, clasts up to 1 inch maximum diameter.	1½	61
13 Sandstone, grey, medium-grained.	7	59½
12 Sandstone, green, fine-grained; siltstone at top and base.	8	52½
11 Siltstone, green, massive.	2	44½
10 Sandstone, grey, medium-grained.	4	42½
9 Sandstone, grey, fine-grained; crossbedded; calcareous matrix; fissile; ripple marks; casts of prod structures; lenses of fossil debris up to 1 foot long by 2 inches thick; small ostracods.	9	38½
8 Sandstone, grey, medium-grained; passing into	2	29½
7 Siltstone, green.	1	27½
6 Sandstone, coarse-grained; rounded clasts of ostracod limestone; fissile.	6	26½
5 Sandstone, green.	3	20½

Unit	Thickness in feet Unit	From base
**4 Sandstone, grey-yellow, coarse-grained; clasts of limestone and quartz, well rounded, poor sphericity, up to 1 inch maximum diameter; fissile; a bone bed - abundant ostracoderms entire and fragmented, up to 7 inches long, mostly flat and aligned parallel to the bedding. *Poraspis* cf. *P. polaris*, *?Ariaspis*, *Corvaspis* cf. *C. kingi*, *Traquairaspis denisoni*, *Pseudotraquairaspis* sp. *B* gen. et sp. nov., Heterostraci indet. Fish horizon 3.	3	17½
**3 Conglomerate, grey; clasts mostly dolostone, some limestone, up to 3 inches maximum diameter, all well rounded but with poor sphericity; some clasts show preferred orientation; matrix of coarse-grained calcareous sandstone with rounded quartz grains; abundant ostracoderms. entire and fragmented, all blue or white in colour, up to 4 inches long, some fragments show preferred orientation, some are crushed.		

Unit	Thickness in feet Unit	From base
Torpedaspis elongatus gen. et sp. nov. Fish horizon 2.	3½	14½
**2 Sandstone, grey, medium- to coarse-grained; rounded quartz grains set in finer matrix with calcareous cement; abundant white ostracoderms, fragmented and entire, up to 3 inches long and aligned parallel to the bedding. *Torpedaspis elongatus* gen. et sp. nov., *Corvaspis* cf. *C. kingi*. Fish horizon 1.	4	11
*1 Sandstone, grey, fine-grained; clasts up to 0.25 inch maximum diameter; ostracoderm fragments.	7	7

Base of Peel Sound Formation. Total thickness (measured and estimated) approx. 935 feet.

Conformable passage into

<u>Read Bay Formation (Ludlovian)</u>

(uppermost 88 feet measured)

10 Sandstone, white, medium-grained; laminated.	6	88
9 Siltstone, grey; crossbedded, cal-		

Unit	Thickness in feet Unit	From base
careous; rare layers of fossil debris; brachiopod - *?Pentamifera* sp. or *?Harpidium* sp., ostracod indet. GSC loc. 82471.	8	82
8 Sandstone, grey-green, fine-grained; massive; rare green silty intraclasts.	12	74
7 Limestone, silty; horizons of brachiopods; *?Harpidium* sp., small gastropod indet. GSC loc. 82472.	7	62
6 Limestone, grey; arenaceous; small cephalopod - *?Amphicyrtoceras* sp., smooth brachiopod - *?Atrypella* or *?Clorinda*, gastropod indet., ostracods - *Leperditia gibbera* Jones. GSC loc. 82470.	10	55
5 Limestone, grey; finely laminated; partings of medium-grained sandstone throughout; fossil debris; trace fossil, brachiopods, gastropods.	5	45
4 Limestone, grey, partings of medium-grained sandstone; abundant fossil debris; stromatolitic lenses, colonial corals.	12	40
3 Sandstone, white, fine-grained;		

Unit	Thickness in feet Unit	From base
laminated; ripple marks.	10	28
2 Sandstone, grey, fine-grained; ?stromatolites.	12	18
1 Limestone, arenaceous partings; bryozoa, gastropods.	6	6

Below this are several hundred feet of fossiliferous lime-stone.

IV SYSTEMATIC PALAEONTOLOGY

Order HETEROSTRACI Lankester, 1868

Family CYATHASPIDIDAE Denison, 1964

Subfamily CYATHASPIDINAE Denison, 1964

Genus *Listraspis* Denison, 1964

Listraspis sp. indet.

Pl. 1, figs. 1, 2

Diagnosis. Dorsal shield divided into rostral, orbital, lateral and central epitega. Orbits completely enclosed. Lateral epitegal elements bear postero-lateral points. Small dorsal keel.

Material. 1 internally preserved dorsal shield (AK 212).

Horizon. 10 (see fig. 5).

Description

Dorsal shield (pl. 1, figs. 1, 2).

Dimensions: (cm)

median length:	3.3	width ratio :	0.69
maximum width:	2.3	orbital width ratio :	0.42
orbital width:	1.4	orbital length ratio:	0.12
orbital length:	0.4	pineal ratio :	0.20
pineal length:	0.5		

The margin is broadly rounded anteriorly and passes gently into the outer margins of the lateral epitega. The latter are horizontal extensions of the dorsal shield lying posterior to the orbits and reaching a maximum width of 0.2 cm at their postero-lateral points. Posteriorly the margin is incomplete but a distinct median lobe is present and is graced by a small, thin, triangular median dorsal keel (pl. 1, fig. 2). This is not a spine but merely an extension of the dorsal shield into the vertical plane. The keel originates 0.8 cm in front of the posterior margin, rises 0.3 cm above the remainder of the shield, and is inclined posteriorly at an angle of 30 degrees. Since the posterior part of the shield itself is inclined posteriorly, the leading edge of the keel is almost horizontal.

The shield is almost flat anteriorly, deeply arched centrally and moderately arched posteriorly. The orbits are small and are completely enclosed. There is no trace of the branchial openings nor impressions of the pineal macula or semi-circular canals.

<u>Ornamentation</u> (Pl. 1, figs. 1, 2).

The ornament consists of thin continuous ridges of dentine separated by narrow grooves, with a density of 12 per mm. Each ridge has an acute crest and bears numerous fine serrations along its base which interdigitate with those of adjacent ribs. The ornament pattern clearly demarcates rostral, orbital, lateral and central epitega, and is generally parallel to the edge of the shield except on the posterior and postero-lateral margins. The pattern is transverse on the rostral epitegum, sworled in the pineal region, but elliptical elsewhere on the central epitegum. Along the postero-lateral margins of the lateral points the dentine ridges turn slightly outwards and lend an overlapping, irregular appearance to the margin, at least in ventral view. Along both the dorsal spine and the lateral elements the ornament is continuous with that of adjacent areas indicating that these features are not separate elements, but merely epitega.

Discussion

This specimen has been compared with type material of the only species, *Listraspis canadensis* Denison in the National Museum of Canada (nos. 10031 and PF 3682 (cast)). Clearly there is close correspondence between the length, orbital ratio, pineal ratio, type and density of dentine ridges, general pattern of ornamentation, presence of epitega, distinct lateral elements and the completely enclosed orbits. This specimen shows however, some special features. It is narrower and has a smaller width ratio, the shield is more strongly arched, branchial plates are missing or absent, lateral brims are absent, a distinct posterior median keel is present, and the posterior lateral margins of the lateral elements have an unusual ridge pattern, at least in ventral view.

In spite of the presence of the posterior median keel this specimen clearly belongs to the genus *Listraspis*. It is probably a new species.

The presence of a marked median keel, triangular in profile, rather than a separate spine is important, for cyathaspidids do not normally possess a strongly developed median dorsal process. A posterior median crest has been described for *Cyathaspis*, *Ctenaspis* and *Listraspis* but only in *Ariaspis* is there a separate median dorsal element (a ridge scale incorporated into the dorsal shield). Denison (1964:392) noted the superficial resemblance of *Listraspis* to the pteraspids, mainly in view of the completely enclosed orbits, the postero-median process and the fine, serrated dentine ridges which are unlike any other cyathaspidid ornament. This probable new species of *Listraspis* thus emphasizes the superficial resemblance to the pteraspids.

Stratigraphic significance

Listraspis has only previously been recorded from one locality, 30 miles northwest of Muncho Lake, northern British Columbia, from sediments of Early Devonian age.

Subfamily PORASPIDINAE Denison, 1964

Genus *Poraspis* Kiaer, 1930

Poraspis cf. *P. polaris* Kiaer, 1930

Pl. 1, figs. 3, 4, pl. 2, fig. 1

Synonymy. *Poraspis polaris* Kiaer, 1930, fig. 3a-b.

_____, 1932, figs. 1-2, pl. 1

_____, and Heintz, 1935, p. 59-76, figs. 2, 3, 7-19, pls. 1-8, pl. 9, fig. 1, 2, pl. 10, fig. 1, pls. 11-13, pl. 26, fig. 1, pl. 31, fig. 1, pl. 32, fig. 2, pl. 34, figs. 1-5, pl. 35, figs. 1-3, pls. 36-37, pl. 38, fig. 1.

Säve-Söderbergh, 1941, fig. 5.

Holmgren, 1942, p. 10, fig. 7.

Diagnosis. Shields slender and elongate, not exceeding 2.1 cm in length and 1.2 cm in width. Rostrum small, rostral margin rounded but extenuated and slightly constricted. Posterior median lobe distinct. Ornament fine, 5-12 ridges per mm. Epitega absent.

Material. 15 dorsal shields (AI: 219, 221-223, 237, 248, 259, 261, 279, 280, 282, 284, 287, 288; AC 254).

3 ventral shields (AI:251, 257, 260).

4 fragmented shields.

Horizons. 19 specimens from 3, 2 from 8, 1 from 9 (see fig. 5).

Description

Dorsal shield (pl. 1, figs. 3, 4, pl. 2, fig. 1).

Dimensions: (cm)

	small form (9 specimens)	large form (5 specimens)
median length :	1.2 - 1.5	1.9 - 2.1
maximum width :	0.6 - 0.9	0.85 - 1.2
orbital width :	0.4 - 0.8	0.6 - 0.8
orbital length:	0.175- 0.25	0.2 - 0.35
pineal length :	0.2 - 0.3	0.35 - 0.5
width ratio :	0.50 - 0.69	0.44 - 0.57
orbital width ratio:	0.33 - 0.53	0.30 - 0.40
orbital length ratio:	0.13 - 0.19	0.10 - 0.16
pineal ratio :	0.15 - 0.23	0.175 - 0.23

The dorsal shields may be separated into two groups on the basis of size; a smaller form, length 1.2 to 1.5 cm, width 0.6 to 0.9 cm and a larger form, length 1.9 to 2.1 cm, width 0.85 to 1.2 cm. Since there is otherwise no difference between them, both groups are described together and their significance is discussed later.

The rostral margin of all dorsal shields narrows rapidly and has a slight pre-orbital constriction. A small rostral brim is present. Orbital notches are deep, and strongly developed pre-orbital lobes curve under the shield and become ventral. Laterally the margins of the shield are uniformly curved and are interrupted by the moderately developed branchial notches lying in the posterior third of the shield. Posteriorly the shield terminates in a rounded median lobe.

The pineal macula and semi-circular canals are well developed (AC 254, pl. 2, fig. 1). The former lies unusually far forward of the orbits. Pores of the lateral line system are large and each is enclosed by a circular dentine ridge. All specimens show part of the lateral line system, but this is not described.

Ventral shield.

Dimensions: (cms)

maximum length : 1.1 - 2.1   width ratio : 0.62 - 0.68

median width : 0.75 -1.2

All specimens are poorly preserved, and a complete description is not possible. A posterior median lobe is present and has similar proportions to the corresponding lobe in the dorsal shield. Both shallow orbital and branchial 'notches' occur.

Ornamentation (pl. 1, figs. 3, 4, pl. 2, fig. 1).

The ornament consists of fine dentine ridges, 5-12 per mm, with flat crests and separated by narrow grooves. Generally the smaller forms have coarser ornament (5-8 ridges per mm) than the large forms.

Although the pattern is variable, the dentine ridges generally follow the lateral margins of the shield. On the rostral margin several rows of ridges are arranged transversely; in the pineal region the pattern is most diverse and may be symmetrically fanned (AI 221, pl. 1, fig. 4), asymmetrically fanned (AI 222, pl. 1, fig. 3), or divergent from the rostral margin. In the ventral shield the pattern is incompletely known but is mostly longitudinal. Density of the ridges is 5 - 9 per mm.

Discussion

This material resembles *Poraspis polaris* Kiaer in that there is a similar wide range in the width ratios, the orbital length ratio is generally close to 0.14 - 0.15, and the rostrum is extenuated and faintly constricted anterior to the orbits. The most distinctive feature, their small size, is unusual. *Poraspis polaris* was established by Kiaer on shields from Spitsbergen 3.0 - 4.0 cm in length. Later, Kiaer and Heintz (1935:79) noted that a smaller species from the same horizons, *P. brevis* with a length of 2.5 - 2.8 cm, was so similar to the latter that it could be considered a juvenile form. An analogous situation occurs with the small and large forms of *P.* cf.P *polaris* described above. It is likely, but remains unproven, that adults and juveniles are represented by the large and small forms respectively.

The stratigraphic significance of *P. polaris* is discussed later, following the description of *P.* cf. *P. intermedia*.

Poraspis cf. *P. intermedia* Kiaer and Heintz, 1935

Pl. 2, figs. 2-4

Synonymy. *Poraspis intermedia* Kiaer, 1932:14 (nomen nudum).
Kiaer and Heintz, 1935:79,
pls. 16-17.

Diagnosis. Dorsal shield very small, with wide, broadly rounded rostrum, posterior median lobe, anterior orbits and prominent pre-orbital lobes. Ornament of fine smooth ridges, 10-13 per mm. Epitega absent.

Material. 3 dorsal shields (AB:239, 240, 270).

Horizon. 9 (see fig. 5).

Description

Dorsal shield (pl. 2, figs. 2-4).

Dimensions: (cm)

median length	: 1.0	width ratio	: 0.65-0.70
maximum width	: 0.6-0.7	orbital width ratio	: 0.50
orbital width	: 0.5	orbital length ratio	: 0.10-0.15
orbital length	: 0.1-0.15	pineal ratio	: 0.20
pineal length	: 0.2		

The rostral margin is broadly and uniformly rounded and lacks a rostral brim. Posterior to the orbits the lateral margin diverges slightly and is almost straight except for a distinct branchial notch and a small, acute post-branchial lobe. A gently rounded posterior median lobe is present. In profile the shield is gently arched and a maximum height of about 0.2 cm is attained in the post-pineal pre-branchial region. The orbital notches are distinctly anterior and are strongly developed, being about as large as their pre-orbital lobes. The pineal macula and semi-circular canals are strongly developed (AB 239; pl. 2, fig. 4); the former lies scarcely posterior to the orbits. The lateral line pores are large.

Ornamentation (pl. 2, figs. 2-4).

The ornament consists of fine, almost continuous ridges with a density of 10 - 13 ridges per mm but is coarser on the rostral margin. Each ridge is flat-crested and has smooth margins. The pattern of ornamentation varies considerably between specimens. It is longitudinal laterally and posteriorly, but becomes transverse on the rostral margin. In the pineal region it may be fanned (AB 239, pl. 2, fig. 4); AB 270a, pl. 2, fig. 2), or asymmetrical (AB 240, pl. 2, fig. 3).

Discussion

This material resembles the *lata* form of *Poraspis intermedia* in the following features: (1) the width ratio is similar although slightly greater, (2) the orbits are anterior in position and the orbital length ratio is similar, (3) the rostrum is uniformly and broadly rounded and is not constricted anterior to the orbits, (4) the post-branchial region is short and the post-branchial lobes are small but distinct.

The new material differs only in its smaller size (the *lata* forms of *Poraspis intermedia* figured by Kiaer and Heintz (1935) are 2.6-2.8 cm in length), and in the more anterior position of the pineal macula relative to the orbits. It is clear that it resembles only the *lata* form and has little in common with the *angusta* form.

The specimens described above are particularly interesting in that they are believed to be the smallest described cyathaspids. The smallest previously described poraspid, *P. brevis* Kiaer and Heintz (1935) is 2.5 cm in length, while the smallest previously described cyathaspids are *Homalaspidella nitida* Kiaer, and *Anglaspis insignis* Wills, both 2.0 cm in length.

Stratigraphic significance of the genus *Poraspis*

Species of the genus *Poraspis* have been described from Spitsbergen, Podolia, Britain and France, from sediments varying in age from Middle Downtonian to Late Dittonian. (1) In Spitsbergen, the type area, eight species were described from the Fraenkelryggen and Ben Nevis divisions of the Red Bay Series (Middle Downtonian to mid-Late Dittonian). *P. polaris* occurs abundantly in the Primaeva, Polaris and Anglaspis horizons considered to be earliest Dittonian, while *P. intermedia* is confined to the Anglaspis horizon. (Kiaer, 1930, 1932; Kiaer and Heintz, 1935). (2) Four species of *Poraspis* have been found in the Czortkow stage (early-Middle Dittonian) and the Old Red stage 1 (Middle Dittonian) of Podolia (in Denison, 1964; Obruchev and Karatajute-Talimaa, 1967). (3) In Britain *Poraspis* has been recorded from the Middle Dittonian of Monmouthshire and Herefordshire and the Late Downtonian and Middle Dittonian of Shropshire (White, 1950a, 1961; Ball and Dineley, 1961). (4) In France one species of *Poraspis* occurs in the Psammites de Liévin (Early Geddinian), Pas de Calais (in Denison, 1964).

Thus, previously recorded occurrences of *Poraspis polaris* and *P. intermedia* are restricted to sediments of Early Dittonian age, while the range of the genus *Poraspis* appears to be from Late Downtonian to Middle Dittonian. A Late Downtonian - Middle Dittonian faunal age is therefore suggested for horizons 3, 8 and 9.

Genus *Ariaspis* Denison, 1963

?Ariaspis sp.

Pl. 3, figs. 1, 2

Diagnosis. Small cyathaspidid with shallow orbital notches, pre-orbital lobes, lateral elements and a dorsal spine. Epitega not observed.

Material. 2 dorsal shields (AI:256, 215).

Horizon. 3 (see fig. 5).

Description

Dorsal shield (pl. 3, figs. 1, 2).

Dimensions: (cm)

median length	: 1.7,2.0	width ratio	: 0.52,0.60
maximum width	: 0.9,1.2	orbital width ratio	: 0.41,0.40
orbital width	: 0.7,0.8	orbital length ratio	: 0.17,0.15
orbital length	: 0.3	pineal ratio	: 0.26,0.25
pineal length	: 0.45,0.50		

The anterior margin is broadly rounded and bears prominent antero-lateral pre-orbital processes. The orbits are shallow notches which lie immediately behind the pre-orbital processes. The lateral margins are gently curved throughout and begin to converge just behind the semi-circular canals, where the shield is of maximum width. Small postero-lateral elements are present and have a maximum width of 0.1 cm at their postero-lateral points. These points are in line with a change in slope bordering the lateral elements posterior to the orbital notches. Ventral to the change in slope the lateral margin of the shield is almost vertical. The posterior margin narrows towards the median line and bears a distinct dorsal spine, preserved only in AI 256 (pl. 3, fig. 1). This originates 0.2 cm anterior to the posterior margin and before breakage rose to a height of 0.2 cm at an angle of 20 degrees. It is not a separate element but an extension of the dorsal shield into the vertical plane.

The pineal macula and semi-circular canals are conspicuous but the branchial opening cannot be seen.

Ornamentation (pl. 3, figs. 1, 2).

The ornament is distinctive, consisting of discontinuous dentine ridges with rounded crests separated by narrow grooves. Their density varies from 5 per mm on the rostral margin, where the ridges are also shorter, to 7-8 per mm elsewhere. Orientation of the ornament is transverse on the rostrum, sworled or transverse in the pineal region, but longitudinal elsewhere. Epitega are not apparent.

Discussion

These two specimens resemble *Ariaspis* Denison, in the absence of a median process on the rostral margin, in the presence of lateral laminae separated by a marked change in slope and terminating in sharp points, and in the absence of epitega. They differ, however, by having a narrower and more vaulted shield, a dorsal spine instead of a postero-median scale, and a posterior margin which narrows medially and is not transverse. Thus, although possibly a new genus, these specimens are clearly closely related to *Ariaspis* and will be referred to as such for the time being.

The presence of the dorsal spine is particularly important because this feature is unknown in other cyathaspidids, but is characteristic of the pteraspids. *?Ariaspis* is doubtless a cyathaspid and the presence of the dorsal spine is probably a feature of convergence rather than a pteraspid affinity.

Stratigraphic significance

Ariaspis is represented by one species from Beaver River, southeast Yukon, from limestones and graptolitic shales originally assigned to the Middle Ludlovian (Denison, 1963:140) but later revised to an Early Downtonian age (Denison, 1964:450). Since Denison's cyathaspidid horizon is overlain by beds containing *Monograptus dubius*, his original Middle Ludlovian age seems more likely. The above material suggests a form more specialized than *Ariaspis*, hence an age younger than Middle Ludlovian (i.e. Late Ludlovian or Downtonian) is suggested for fish horizon 3.

Genus *Anglaspis* Jaekel, 1927

Anglaspis cf. *A. expatriata* Denison, 1964

Pl. 3, fig. 3

Synonymy. *Anglaspis expatriata* Denison 1964:431, fig. 151.

Diagnosis. Lateral epitegal brim developed with pointed postbranchial lobe, median lobe on posterior margin, median dorsal ridge present, pineal macula and semi-circular canals distinct.

Material. One incomplete dorsal shield (AP 204).

Horizon. 14 (see fig. 5).

Description

Dorsal shield (pl. 3, fig. 3).

Dimensions: (cm)

median length : 2.8	width ratio
maximum width : 1.8	orbital widt
orbital width :?1.0	orbital leng
orbital length:?0.5	pineal ratio
pineal length : 0.6	

The shield is constricted at the b in front of which the lateral epitegum for perfectly preserved. This is constricted rio-lateral brim has a width of 0.1 cm, th brim a width of 0.2 cm. Behind the ?branc branchial lobe expands posteriorly to a w it terminates in a sharp point which lies as the posterior lobe on the posterior ma branchial lobe bears ornament on its vent not a cornual element but a lateral exten shield. The posterior margin bears a dis lobe. Orbits are present as small, imper shallow notches situated antero-laterally ridge is present and occupies the posteri dorsal shield. Its anterior 0.5 cm is mc the remainder which occurs in internal v groove extending almost to the posterior preserved are the pineal macula and semi The branchial opening is believed to lie postero-lateral points.

Ornamentation (pl. 3, fig. 3).

The ornament consists of fine, continuous dentine ridges of equal width on the anterior part of the shield, but narrower on the ventral part of the post-branchial lobe. Density of the ridges is 8-10 per mm laterally, but cannot be measured centrally. Rostral, orbital, lateral and central epitega are distinct. The ornament pattern however, is not well known but is longitudinal laterally and is probably fanned in the rostral region.

Discussion

This single incomplete specimen is closest to *Anglaspis expatriata* Denison, described only from Mt. Sekwi, near Keele River, N.W.T. Comparison of AP 204 with the type specimen of *Anglaspis expatriata* (no. 10038) in the National Museum of Canada indicates a close resemblance, at least in internal view. Although slightly larger, the width and pineal ratios are similar, there is a posterior median lobe and lateral elements, the shield is constricted at the branchial openings, a median dorsal groove is present in internal view, and the ornament in the anterior region has 8 ridges per mm.

It resembles *A. macculloughi* (Woodward) in the presence of postero-lateral points, but differs in having much finer ornament, and more anterior orbits and pineal macula. Thus, in spite of certain special features, such as the postero-lateral points, and the anterior constriction of the lateral element, a form more closely related to *A. expatriata* than to *A. macculloughi* is suggested.

Stratigraphic signficance

The age of the horizon containing *A. expatriata* at Mt. Sekwi was considered by Denison (1964:451) to be Late Downtonian on the basis of the resemblance of this species to *A. macculloughi* from Britain. In the Anglo-Welsh area *A. macculloughi* ranges from the Late Downtonian zone of *Traquairaspis symondsi* to the Middle Dittonian zone of *Pteraspis crouchi* (Ball and Dineley, 1961). A similar age is suggested for horizon 14 in Wilson's Gorge.

Genus *Torpedaspis* nov.

Pls. 4-9; fig. 4

Diagnosis. A large cyathaspidid with cigar-shaped shields up to 16.4 cm long. Ornamentation of fine discontinuous ridges. Tail asymmetrically diphycercal with a length of about 9 cm.

Type species. *Torpedaspis elongatus* sp. nov.

Etymology. *Torpedaspis* - refers to the torpedo-like appearance of the headshield.

Torpedaspis elongatus sp. nov.

Pls. 4-9; fig. 4

Diagnosis. As for genus.

Holotype. AG 14 (pls. 7-9) is complete with the posterior part of the body and tail although dorsal and ventral shields are crushed.

Paratypes. All referred material.

Etymology. *elongatus* refers to the elongate shape of the headshield.

Material. 1 complete individual with crushed headshield but articulated posterior body and tail (AG 14, holotype).

27 dorsal shields (AR 217; AJ:297-298; AI:295-296; AB: 35, 39; AG: 1-2, 7, 9-13, 15-17, 19, 20, 22-25, 27, 29, 32; AM: 299, 300).

14 ventral shields (AB 38; AG: 4, 6, 11, 12, 18, 21, 28, 36, 40, 291-293; AM 37).

3 branchial plates (AG: 41-43).

2 median dorsal scales (AG: 53, 57).

6 lateral scales (AG: 45-50, 58).

6 median ventral scales (AG: 44, 51-54, 56).

Horizons. 1, 2, 3, 7 (abundant), 9, 11 (see fig. 5).

Description

Dorsal shield (pl. 4, figs. 1, 2, pl. 6, fig. 1, 2).

Dimensions: (cm)

median length	:	13.9-16.4
maximum width	:	3.5-4.9
orbital width	:	2.3-3.5
orbital length	:	1.7-2.1
pineal length	:	2.4-2.9
postbranchial length	:	6.7-10.4
width ratio	:	0.24-0.33
orbital width ratio	:	0.17-0.24
orbital length ratio	:	0.10-0.15
pineal ratio	:	0.15-0.20
postbranchial ratio	:	0.48-0.63

The dorsal shield is strongly arched, is depressed anteriorly and presents a streamlined appearance in both profile and plan views. It narrows both anteriorly and posteriorly attaining maximum width between the branchial notches. Anteriorly the rostrum is uniformly rounded but is flattened dorso-ventrally. On the ventral surface of the rostrum a large pre-oral brim (AG 2, pl. 6, fig. 2), triangular in shape is laterally continuous with the ventral extremities of the pre-orbital lobes (AG 1, pl. 4, fig. 2). The orbital notches are small, not exceeding 0.2 cm in depth and their post-orbital lobes have a marked ventro-lateral aspect. The branchial notches are well developed and their post-branchial lobes are also slightly ventral but less so than the post-

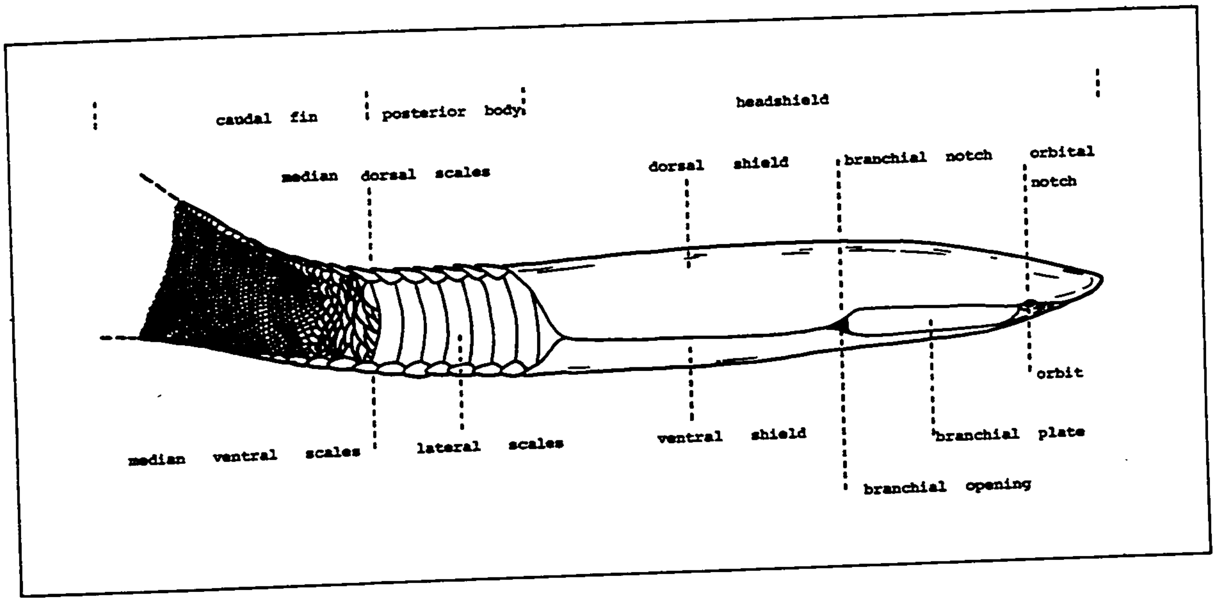

FIG. 4. Torpedaspis elongatus gen. et sp. nov.;restoration in lateral view (about one half natural size).

orbital lobes.

Unfortunately, the posterior margin of the dorsal shield is fragmentary in all specimens. It is, however, best preserved in AG 23 (pl. 6, fig. 1) where it narrows to a blunt median lobe projecting about 1.5 cm behind the lateral margins of the shield.

The pineal macula is a small but distinct elevation not open to the exterior. There is no trace of any canals of the lateral line system, in either dorsal or ventral shields, nor any evidence of semi-circular canals or gill pouches in the dorsal shield.

Ventral shield (pl. 5, figs 1, 2).

Dimensions: (cm)

median length	:	13.3	-	15.5
maximum width	:	3.6	-	4.0
post-branchial length	:	8.4	-	8.9
width ratio	:	0.26	-	0.30
post-branchial ratio	:	0.61	-	0.63

The ventral shield is shorter and less strongly arched than the dorsal shield. Anteriorly the margin is gently rounded and like the dorsal shield is depressed dorso-ventral-ly. Posteriorly the lateral margins diverge and form sub-dued "branchial" notches in the region of maximum width. Be-hind the post-branchial lobe the lateral margin is almost straight. The posterior margin is fragmentary in all specimens; it is probably similar to that of the dorsal shield but less strongly arched and with a subdued median lobe.

Branchial plate (pl. 6, fig. 3).

The branchial plate is flat, narrow and elongate, and may be 3.4 - 4.2 cm long by 0.6 - 0.8 cm wide. In AG 41 (pl. 6, fig. 3) the dorsal margin is almost straight compared with the slightly curved ventral margin. Anteriorly the margin is rounded: posteriorly it is transverse. Characteristically the ornament is parallel to the ventral, but oblique to the dorsal margin.

Ornamentation (pl. 6, fig. 3).

Ornament consists of fine, discontinuous dentine ridges mostly about 5 - 7 per mm, but with an overall density of 4 - 10 per mm. Ridges are coarser on the rostrum and pre-oral brim. They are generally parallel to the margins of the plates but on some dorsal shields a sworled pattern is developed laterally between the orbits and branchial notch and around the pineal macula. Epitega are not distinguishable.

Posterior part of body and caudal fin (pls. 7-9; fig. 4).

In the present description the posterior part of the body is the scale-clad portion lying behind the headshield. The caudal fin or tail is that part clad in small scales and lying posterior to the large scale rows.

The posterior part of the body and caudal fin are laterally compressed and have a combined length of 9 cm. Anteriorly the scales are relatively large and are arranged in four longitudinal series; median dorsal, paired lateral, and median ventral. Ventro-lateral scales are not present.

There are twelve median dorsal scales in the holotype. They measure 0.9 cm long by 0.5 cm wide and decrease in size posteriorly. They are strongly vaulted and somewhat rhomboidal in shape.

There are seven paired lateral scales 2.1 - 3.7 cm long and 0.5 - 0.9 cm wide. Articulated scales in the holotype indicate an overlap of as much as 50% between successive scales. They are gently arched dorso-ventrally and have concurved anterior and posterior margins. Their ornament consists of fine dentine ridges, generally parallel to the length of the scale. A thickened dentine ridge parallels the anterior margin, behind which lie three of four finer ridges, which in the posterior part of the scale, are longer and arranged obliquely.

There are twelve median ventral scales. They are poorly preserved but are similar in size and shape to the median dorsal scales, but less strongly vaulted.

On the caudal fin scales are small and lose the arrangement in longitudinal rows except for the dorsal and ventral median scales. Posterior to the lateral scales there are about six rows of small overlapping scales of uncertain shape while the remainder of the caudal fin is covered by numerous irregular overlapping scales decreasing in size posteriorly. The largest measure 0.3 cm long by 0.2 cm wide.

Discussion

Although not the largest ostracoderm from Wilson's Gorge, *Torpedaspis* has a total length in the holotype of 23.5 cm and thus becomes the largest described cyathaspidid. Previously the largest described cyathaspidid was *Allocryptaspis utahensis* Denison which has a dorsal shield 11 cm in length. The ostracoderm larger than *Torpedaspis* is not described in this account.

Another striking feature of *Torpedaspis* is the dorso-ventrally flattened carapace and the laterally compressed posterior body and tail. This mode of preservation is known in other ostracoderms and most likely represents an original feature.

The completeness of the holotype is of importance since well preserved entire cyathaspidids are rare, and reconstructions based on fragmentary material are suspect. The restoration of *Torpedaspis elongatus* (fig. 4) compares well in general features with the best known entire cyathaspidid, *Anglaspis heintzi* from the Spitsbergen Dittonian (Kiaer, 1932). There are, however, distinctive characters. Most important, the asymmetrically diphycercal caudal fin is an unexpected feature and previously unknown in the cyathaspidids. (*A. heintzi* has a reversed heterocercal tail). It is likely that this kind of tail is related to the streamlined nature of the headshield and the elongate build of the animal as a whole.

The large surface area of the caudal fin suggests that the animal was capable of powerful thrusts while the elongate, inflexible headshield suggests an inability to control movement in more than one direction. An animal capable of moving rapidly in short, powerful bursts in envisaged.

The distribution of the body scales is like that in *A. heintzi* but their shape is closer to *Allocryptaspis laticostata* (Denison, 1964, fig. 96). Of unknown significance is the absence of ventro-lateral scales.

Affinity with *A. utahensis* is suggested by the general antero-ventral features of the dorsal shield and, in particular, the pre- and post-orbital lobes and small orbits (Denison, 1964, fig. 153). *Torpedaspis* however, is distinctive in possessing a large, lobed pre-oral brim.

On the basis of the above characters suggesting affinities with *Anglaspis* and *Allocryptaspis*, this new genus is assigned to the subfamily Poraspidinae.

Stratigraphic significance

Undescribed specimens of *Torpedaspis* have been found in the lower part of the Peel Sound Formation of Somerset Island. At present this genus is confined to the lower part of the Peel Sound Formation of Somerset and Prince of Wales Islands. In Wilson's Gorge it occurs between 7 and 370 feet above the base of the formation (see fig. 5). It is abundant at fish horizon 7, 195 feet above the base of the formation.

Although on Somerset Island *Torpedaspis* is associated with cyathaspidids and other heterostracans generally regarded as Downtonian in age, no occurrence of *Torpedaspis* is known in the Canadian Downtonian elsewhere (D.L. Dineley, 1968, personal communication).

Family CORVASPIDIDAE Dineley, 1953

Genus *Corvaspis* Woodward, 1934

Corvaspis cf. *C. kingi* Woodward, 1934

Pls. 10-12, pl. 13, fig. 1

<u>Synonymy</u>. *Corvaspis kingi* Woodward, 1934: 566-567, pl. 19, figs. 1-3.

Dineley, 1953: 166-181, pls. 1-2, figs, 1-16.

Stensiö, 1958: 321-326, figs. 181-182.

Tarlo, 1960: 217-266, pls. 37-38, figs. 1-3, 5.

Gross, 1961: 96-100, figs. 8-9.

Karatajute-Talimaa, 1962: 49-52, text-figs. 1_1-1_5, pl. 1, figs. 1-14.

Dineley, 1964b: 93-97, pls. 1-2, figs. 4-5.

Obruchev, 1964: 49, 59, text-figs. 9, 20, 21.

Stensiö, 1964: 257-262, figs. 83-84.

Tarlo, 1964: 19, 42, 73-75, pl. 9, fig. 2, text-figs. 15B-F.

Tarlo, 1965: 16-17, pl. 3.

Tarlo, 1967: 48-49, figs. 3b-f.

Diagnosis. Plates of irregular outline characterized by ornament of discontinuous longitudinally aligned dentine ridges or tubercles, sometimes arranged in superficial tesserae, generally separated from one another by a narrow groove. Large median discs, and smaller plates. Scales with simple ribbed dentine surface.

Material. 12 fragments of median plates (AR 217; AI 264, 268, 273-276, 278; AD: 265, 266; AB 271; AG: 294; AK: 267; AM 272).

2 branchial plates (AC 269; AB 279).

2 orbital plates (AI 263: AK 262).

Horizons. 1, 3, 6, 7, 8, 9, 10, 11 (see fig. 5).

Description

Median plate (pl. 10, figs. 1, 4, pls. 11, 12).

The largest specimen is from horizon 7 and measures 6.5 cm by 4.7 cm (pl. 11). It is gently arched longitudinally and has a maximum height of 0.6 cm. An unusual feature is the presence of a small pineal macula which thus designates the anterior end of the plate. The pattern of ornamentation is parallel to the margin of the plate. The plate narrows anteriorly but all margins are incomplete. The ridges have a density of 2 per mm and their length varies from 0.1 cm in the pineal region to 1.3 cm posteriorly. They are wide, smooth, flat-crested and are separated by poorly defined narrow grooves. Ornament pattern is synchronomorial except for its irregularity in the anterior region.

Other large specimens are from horizon 3. One plate measures 6.5 cm by 3.0 cm (pl. 12). The other measures 5.6 cm by 2.8 cm (pl. 10, fig. 1).

All specimens of *Corvaspis* are incomplete; definite or regular margins are not preserved and thus the original shape of the plates is uncertain. All plates are remarkably flat with the exception of AM 272a which has a slight longitudinal curvature.

Ornamentation of median plates

The ornament is typically of long or short dentine ridges with or without associated irregular tubercles, generally arranged parallel to the long axis of the plate but converging towards the midline in the anterior region. Superficial separation of the ornament into scale-like areas (tesserae) occurs on some specimens, but this feature is not prevalent. Density of the ridges varies from 2-6 per mm but it is 2-3 per mm on most specimens. The thickness of most plates is about 0.75 mm but varies from ?0.30 to 1.0 mm.

Eight fragments of median plates from horizon 3 bear ornament of a basic synchronomorial arrangement of dentine ridges (2-3 per mm) with unevenly distributed irregular cyclomorial units never more than 4 ridges in width. In one specimen (pl. 12, fig. 1) cyclomorial units are best developed near the anterior end of the plate where each adjacent unit is separated into poorly defined tesserae by superficial grooves and occasional tubercles. Cyclomorial units are best developed in AI 275 (pl. 10, fig. 4) where the ridges are also shorter and more tubercular, and in AI 276 (pl. 10, fig. 3).

Specimen AM 272a (pl. 10, fig. 1) exhibits ornament which is entirely synchronomorial except for the irregularities at the anterior end. Ridges are shortest anteriorly, where tubercles are also present, but they may attain a length of 0.9 cm in the posterior median region. Each ridge has a rounded crest and some possess irregular marginal crenulations. Throughout the plate the ?anterior end of each ridge appears to be flatter lying than the posterior end which is slightly raised and overlaps succeeding ridges.

Branchial plate (pl. 10, fig. 2).

The most complete branchial plate is elongate in shape, narrows anteriorly, and has an irregular outline. It is 1.5 cm long, 0.45 cm wide at its posterior end, 0.3 cm wide at the anterior end, and is arched at an angle 120 degrees along the median line. Ornament consists of irregular ridges (density 3-4 per mm) and short irregular tubercles arranged roughly concentrically around the median line. The crest of the plate itself is occupied by several depressed tubercles. Irregular tubercles occur at the anterior end of the plate and around its lateral margins. All ridges and tubercles bear rounded crests, possess marginal crenulations and are separated by narrow grooves. Orientation of this plate is uncertain; the narrow end with irregular ornament is probably anterior.

Interest lies in the extenuated row of eight mucus pores obliquely arranged across the left postero-lateral corner of the plate. The sensory canal system is not however, discussed in this account.

Orbital plate (pl. 13, figs. 1, 2).

The two incomplete orbital plates are rougly circular in outline and have a maximum diameter of 0.6 cm. Both plates are gently arched and attain a height of 0.1 cm. The orbit itself is probably centrally situated and is circular with a diameter of 0.25 cm. Ornament consists of dentine ridges and tubercles arranged concentrically. The innermost ridge is incomplete but is probably circular and completely surrounds the orbit. Succeeding ridges become progressively less continuous and become short and irregular, apparently constituting a marginal zone. In profile, each ridge has a flat or rounded crest and is separated from adjacent ridges by a narrow groove. Density of the ridges is 2-3 per mm. The innermost ridge is smooth-sided but elsewhere ridges and tubercles alike develop fine irregular marginal crenulations which sometimes interdigitate with those of adjacent ridges. Thickness of the plate is about 0.75 mm.

Discussion

This material is similar to *Corvaspis kingi* Woodward, but differs in the thinness of the plates, and the variation in the density of the dentine ridges. Specimens described from Britain usually have a thickness of 1.75 to 2.0 mm and a ridge density of 3 per mm (Dineley, 1964b). The variation of ornament within the genus has received comment from most authors, and the wide variation in the present material is not exceptional. However, only two plates (an orbital, AK 262 and a branchial, AB 279) show marginal tuberculation typical of most pieces of *Corvaspis kingi*. This is probably because none of the specimens possesses definite margins.

Some plates show tesserae similar to those described for *Corvaspis kingi* (Woodward, 1934; Dineley, 1953; Tarlo, 1960), but they are not well developed nor prevalent. In one specimen (pl. 12) it is possible to trace a gradation from normal longitudinal ornament to irregular tesserae, a feature also observed by Dineley (1953:170) and Tarlo (1960:219; 1965:17, pl. 3, figs. 3, 6; 1967: 48).

There is striking similarity between the single complete branchial plate (pl. 10, fig. 2) and the ridge plate figured by Dineley (1953, pl. 2, fig. 2). In spite of its strongly arched nature Tarlo (1960: 220; 1965: 17) considered the latter to be a branchial plate in view of the presence of sensory canals. The new material is also thought to be a branchial rather than a ridge plate for the same reason.

The thinness of this material is a feature common to *Corvaspis* aff. *kingi* described from the Yukon by Dineley (1964b). The absence of tesserae in the latter material could be attributed to inadequate material for some plates are similar to non-tesserate plates from Prince of Wales Is- land (in particular plate AM 272a, pl. 10, fig. 1). There is also close correspondence in size and ornamentation be- tween orbital plates AI 263 and AK 262 (pl. 13, figs. 1, 2) and the orbital plates figured by Dineley (1964b, figs. 4, 5); also the ornament of one orbital plate (AK 262, pl. 13, fig. 2) and another undescribed plate suggest in their finely crenulate tubercles, an affinity with Heterostraci indet., Type A described by Denison (1963:136, figs. 80B, 81A). Dine- ley (1964b: 96, fig. 4) noted an affinity between his orbital plate and Denison's material cited above.

Corvaspis was originally described as a cyathaspidid by Woodward (1934) but Dineley (1953) established the family Corvaspididae which Stensiö (1958) subsequently raised to ordinal status. Tarlo (1960) suggested inclusion of *Corvaspis* in the psammosteids but later (1962, 1965) retained it within the family Corvaspididae. Here the family is merely included within the Heterostraci.

Stratigraphic significance of *Corvaspis*

The occurrence of *Corvaspis* on Prince of Wales Island is an expected extension of the geographical distribution of the genus.

Corvaspis was first described from the Welsh Borderland (Woodward, 1934; White, 1950a, 1961; Dineley, 1953; Ball and Dineley, 1961, table 1) where it ranges from the top of the *Traquairaspis symondsi* zone to the lower part of the *Pteraspis (Belgicaspis) crouchi* zone. *Corvaspis* has also been recorded from (1) the Fraenkelryggen Division of the Red Bay Series (Late Downtonian to Early Dittonian) of Spitsbergen by Føyn and Heintz (1943) and Dineley (1953), (2) the Upper Silurian of West Germany (Gross, 1961), (3) the Czortkow Series (Early Dittonian) of Podolia (Stensiö, 1944; Dineley, 1953; Obruchev and Karatajute-Talimaa, 1967), (4) the Upper Downtonian of Lithuania (Karatajute-Talimaa, 1962; Obruchev and Karatajute-Talimaa, 1967), and (5) three localities in northern Canada.

Thorsteinsson and Tozer (1963:122) recorded a genus comparing favourably with *Corvaspis* from the Peel Sound Formation of Somerset Island. Further corvaspidid material from Somerset Island includes a specimen showing unusual cyclomorial ornamentation (Dineley, 1965b, fig. D) which, as noted by Tarlo (1965:19, 1967: 49) probably belongs to a new genus.

The only full description of *Corvaspis* from Canada is from the Late Silurian of northern Yukon (Dineley, 1964b). This material closely resembles the new material described above.

A form of *Corvaspis* is also present in the ostracoderm faunas from the Silurc-Devonian Delorme Formation of the Natla River area of the Mackenzie Mountains, Northwest Territories (Dineley, 1968: 101).

In most of these localities *Corvaspis* occurs with *Traquairaspis*. The close association of these two genera on Prince of Wales Island conforms to that in Europe and the Yukon.

Family TRAQUAIRASPIDIDAE Kiaer, 1932

Traquairaspis denisoni Dineley, 1964a
Pl. 13, fig. 3, pl. 14

Synonymy. *Traquairaspis denisoni* Dineley, 1964a: 210-215, pl. 38, text-figs. 1-4.

Diagnosis. Dineley (ibid.: 211) gives the following diagnosis for this species.

"A *Traquairaspis* of large size with dorsal disc reaching a length of about 10 cm, of generally oval outline and lacking a dorsal spine. External ornamentation similar to that of other species but with tubercles drawn into long, fine ridges, continuous and running apparently parallel to the edge of the plate." To this may now be added: dorsal shield bears branchio-cornual plates.

Material. 9 almost complete dorsal discs (AI: 73, 76, 80, 83, 174, 175, 199, 200, 289).

5 almost complete ventral discs (AI: 177, 190, 192; AL 74 and many fragments).

4 orbital plates (AI: 131, 194, 198; AC 68; AN 301).

1 branchio-cornual plate (AI 175).

All specimens are preserved in internal view or as natural casts.

Horizons. 3, 8, 12 and 13 (see fig. 5). This species is most common at horizon 3 where one bedding plane yielded innumerable closely packed dorsal and ventral shields.

Description

Dorsal disc (pl. 13, fig. 3, pl. 14, fig. 1).

Dimensions: (cm)

maximum length : 6.5-7.6 width ratio: 0.52-0.80

maximum width : 3.5-5.8

maximum height : 1.2-1.7

The dorsal disc is roughly oval in outline with a small median sulcus on the anterior margin between two rounded lobes. Lateral to these the margin diverges before being constricted about half way along its length. Thereafter it continues smoothly to the posterior margin. The latter is poorly preserved but in specimen AI 175 (pl. 13, fig. 3) it is seen to rise dorsally and terminate in a small median lobe. In internal view a smooth area 0.3 cm wide and bounded anteriorly by a small groove runs parallel to this posterior margin. There is no dorsal spine but a prominent median ridge occupies the posterior half of the plate and attains its maximum development slightly anterior to the posterior margin. The median ridge is a variable feature since it is pronounced in some specimens but barely discernable in others. Lateral carinae are present in the posterior two thirds of the disc and extend roughly parallel to the lateral margins. They are well developed in specimen AI 175 (pl. 13, fig. 3) and represent a change in the degree of vaulting of the plate. In each specimen a zone of growth ridges occupies the marginal 1 cm of the plate in internal view. The disc is widest and most depressed anteriorly while maximum height (0.9 cm in AI 174, pl. 14, fig. 1) is attained in the posterior region.

Ventral disc (pl. 14, fig. 2).

Dimensions: (cm)

maximum length: 6.3-6.7 width ratio: 0.59-0.69

maximum width : 4.0-4.6

maximum height: 0.4

The general outline is oval and the maximum width is attained anteriorly. All specimens show a smooth, flat, unornamented central area surrounded by an ornamented brim, features characteristic of *Traquairaspis*. Although the anterior margin is incomplete specimen AI 192 (pl. 14, fig. 2) bears two slight anterior lobes separated by a small median sulcus, neither as pronounced as in the dorsal disc. The median sulcus traverses the ornamented brim and terminates as a small indentation on the central area. Posteriorly the margin is gently rounded. Internally the ventral disc bears a series of growth ridges similar to those of the dorsal disc.

Branchio-cornual plate (pl. 14, fig. 3).

This plate is known only in specimen AI 175 in which it is attached to the postero-lateral region of the dorsal disc. The fragment is curved antero-laterally, and is 3 cm long by 1 cm wide. The cornuum itself lies in a horizontal plane and extends 0.5 cm from the lateral margin of the dorsal disc.

Orbital plate (pl. 14, fig. 4).

The orientation and exact size and shape cannot be determined from the 5 specimens available but it is slightly vaulted longitudinally and does not exceed a length and width of 3.0 cm and 1.5 cm respectively. The enclosed orbit projects obliquely from the exterior of the plate and is circular in shape with a diameter of 0.25-0.30 cm.

<u>Ornamentation</u> (pl. 14, figs. 2, 3).

Ornament consists of more or less continuous, fine crimped ridges or long, thin tubercles, parallel to the margins. Density of the ridges is 2-5 per mm. All specimens from horizons 3 and 8 have an ornament density of 2-2.5 ridges per mm but the single specimen from horizon 12 has finer ornament (3-5 ridges per mm). In two specimens (pl. 14, figs. 2, 3) the crimping of the ridges is seen to be due to minute lateral projections which do not join with those of adjacent ridges. Between each projection the ridge margin varies from arcuate to rectilinear.

<u>Discussion</u>

The described material differs from *Traquairaspis symondsi* (Lankester) and from *T. pococki* (White) in the reduced tubercular element of the ornament and the absence of a dorsal spine. It does not resemble *Yukonaspis angusta* (Denison) which has a much narrower shield. This material has been compared with the holotype of *Traquairaspis denisoni* and a very close resemblance is apparent. It is, however, a few centimetres smaller, but the width ratio (0.72) of the holotype falls within the range established for the above material (0.52-0.80).

<u>Stratigraphic significance</u>

T. denisoni has been recorded previously only from Muncho Lake, British Columbia from a horizon yielding many ostracoderms and probably of Late Downtonian or Early Dittonian age (Dineley, 1964a). The significance of the genus is discussed later.

Traquairaspis rambaldi sp. nov.

Pl. 15, pl. 16, fig. 3

Diagnosis. A *Traquairaspis* with biconcave posterior dorsal margin, sharp postero-median dorsal lobe and large ornamented dorsal spine. Ornament of smooth, beaded or strongly crimped dentine ridges.

Syntypes. All figured material.

Etymology. *rambaldi* - after E. Rambaldi, Department of Geology, University of Ottawa, whose encouragement during this project was much appreciated.

Material. 3 dorsal discs (AP: 59, 81, 62).
2 ventral discs (AP: 60, 79).
1 orbital plate (AP 61)
1 branchio-cornual plate (AN 78)

All material is fragmentary and preserved in internal view.

Horizons. 13 and 14 (see fig. 5).

Description

Dorsal disc (pl. 15, figs. 1, 4).

The largest fragment (3.1 cm by 3.0 cm) is deeply arched and represents a plate originally about 6.0 cm in length and maximum width. Postero-laterally the plate is wide and terminates in irregularly curved, rounded, postero-lateral lobes. The posterior margin is moderately arched and bears a prominent pointed median lobe.

An important feature is the presence of a large dorsal spine evident only in section where it attains a height of at least 0.8 cm (pl. 15, fig. 4).

A distinctive feature of this species is the change in profile of the posterior part of the dorsal disc. The marginal 1.3 cm of the dorsal plate is almost flat, but towards the median line two changes in slope are marked by 2 pairs of longitudinal carinae. The innermost pair is aligned parallel to the base of the dorsal spine but is more elevated and is separated from it by a shallow depression (pl. 15, fig. 4). The height of the dorsal disc is at least 1.3 cm.

In internal view growth lines occupy the marginal 1 cm of the posterior part of the dorsal disc.

Ventral disc (pl. 15, fig. 2).

The fragments are small and show no unusual features. An ornamented marginal brim 2 cm wide surrounds a smooth, unornamented central area. Marginal growth ridges are visible in internal view. The plates are not arched and centrally have a uniform height of 0.7 cm.

Orbital plate (pl. 15, fig. 3).

Although incomplete, the orbital plate (1.8 cm by 1.1 cm) is elongate in shape and is arched longitudinally. The enclosed orbit is circular with a diameter of 0.3 cm. A marginal zone of growth lines is seen in internal view. Its orientation is uncertain.

Branchio-cornual plate (pl. 16, fig. 3).

This plate is almost complete and measures 5.3 cm long by 1.3 cm wide. In outline it has a gently curved ventral margin, a short oblique anterior margin and an irregular, incomplete dorsal margin. The branchial portion is gently arched longitudinally. The branchial opening is oval in shape, about 0.5 cm in length and is situated about midway along the length of the plate.

Unfortunately, the cornuum is present in section only because it occupies a plane contrary to that of the branchial portion. The cornuum is 0.3 cm thick and is ornamented on both dorsal and ventral surfaces.

Ornamentation (pl. 15, fig. 4, pl. 16, fig. 3).

Ornament consists of fine, discontinuous dentine ridges, sharp-crested and separated by shallow grooves about 4 times the width of each ridge. Density of the ridges varies from 2.5 to 4 per mm, and is constant on all plates except one. A ventral plate (AP 60) shows differentiation of the ornamented brim into an outer zone of coarser ornament

(2.5-3 ridges per mm) and an inner zone of finer ornament (4 ridges per mm). Ridges are of two varieties depending on their degree of marginal crenulation. Most commonly they are almost smooth or gently beaded; subordinately they may bear exaggerated crenulations and become sinuous. Although some ridges are as short as 0.1 cm, they are all narrow and cannot be described as tubercles. The pattern of ornamentation is apparently parallel to the margins of all plates except the branchio-cornual (AN 78, pl. 16, fig. 3) where the ridges are deflected into a series of curves along the dorsal margin.

Ornamentation continues to the crest of the dorsal spine and is present on both dorsal and ventral surfaces of the cornuum.

Discussion

In view of the presence of the dorsal spine this material cannot be assigned to *Pseudotraquairaspis* gen. nov. (described later) or to *Traquairaspis denisoni* Dineley. Ornament is similar to but less crenulate than that of *T. denisoni*. It is clear that the absence of stellate tubercles precludes association with both *T. pococki* and *T. symondsi*.

It is proposed to refer to this material as *Traquairaspis rambaldi* sp. nov.

The stratigraphic significance of *Traquairaspis* is discussed later.

Traquairaspis cf. *T. pococki* (White, 1946)

Pl. 16

Synonymy. *Cyathaspis cambelli* Traquair, 1913: 923-960.

Traquairaspis cambelli Kiaer, 1932: 25, pl. 11.

Tarlo, 1962: 262, fig. 7.

Phialaspis pococki White, 1946: 238, pl. 12, figs. 1-44, 55, 56.

Diagnosis. A *Traquairaspis* of small size, ventral disc attaining a length of 5.0 cm. Ornamentation of stellate ridges but rare tubercles, density 2-3 ridges per mm.

Material. 1 incomplete dorsal disc (AB: 159).
3 incomplete ventral discs (AG 82; AB: 65, 165).
2 complete ventral discs (AG 84; AB 64).

Horizons. 7 and 9 (see fig. 5).

Description

Dorsal disc

Before sectioning, the dorsal disc showed that the originally surrounding plates (rostral, pineal, orbital and branchio-cornual) had been disarticulated leaving its present margins smooth and unbroken. The most interesting feature is the presence of a well developed median-dorsal spine (pl. 16, fig. 4) originating about 2.5 cm behind the anterior margin of the disc and reaching a maximum height of 0.6 cm. Serial sections show the posterior portion of the dorsal spine to be club-shaped, the highest portion being about five times as thick as the thin neck connecting it to the dorsal disc.

The presence of such a well developed dorsal spine distinguishes this species from both *T. denisoni* for which no spine has been recorded and *Pseudotraquairaspis* gen. nov. (described later), and makes it closely comparable to *T. pococki*.

Ventral disc (pl. 16, figs, 1, 2, 5).

Dimensions: (cm)

median length	: 4.0-5.0	width ratio: 0.74-0.79
maximum width	: 3.5-4.0	
height	: 0.3-0.7	

The ventral disc exhibits an unornamented central area surrounded by an ornamented brim. These features are characteristic of the genus *Traquairaspis*.

The flat central area is gently rounded at both ends, is widest anteriorly and narrows posteriorly. Externally the surface slightly overhangs the marginal brim. In outline the anterior margin is variable in shape. It may be straight (AB 64, pl. 16, fig. 5), 2-lobed (AB 65), 4-lobed (AG 84, pl. 16, fig. 1) or crenulate (AB 87, pl. 16, fig. 2). Posteriorly the margins, where preserved, are gently curved. The width of the brim is fairly constant, being about 0.8 cm in AG 84 (pl. 16, fig. 1). Maximum height is attained posteriorly where the slope of the brim is greatest, while anteriorly the disc is almost flat. Two specimens (pl. 16, figs. 1, 5) possess conspicuous dorso-ventral depressions and an associated small lateral lobes near the posterior 'corners' of the ventral disc.

In internal view growth ridges occupy the outer half of the ornamented brim and are parallel to the margin of the disc.

Similar growth ridges have been observed in all species of *Traquairaspis* by previous authors.

Sensory canal system

This is not described in detail. Sensory canals may be observed on all but one of the ventral discs. The system is best shown in specimen AG 84, where a lateral canal with numerous side canals branching alternately to the left and right extends almost the entire length of the disc. Close to the anterior margin a V-shaped median canal extends almost entirely across the anterior margin. Such a sensory canal system is similar to that of *T. pococki* which White (1964:223) described as being very variable and irregular. *T. symondsi* does not possess a V-shaped anterior canal on the ventral disc (White, 1946: 233).

Ornamentation (pl. 16, figs. 2, 4).

Ornamentation on all plates consists of coarse crenulate ridges and rare, widely spaced tubercles. Density of ridges varies from 1.5 to 4 per mm. On the ventral disc the ridges are all roughly parallel to the outer margin. They are more continuous adjacent to the central flat area but are shorter and discontinuous closer to its margin. In the anterior region of the brim all ridges are short and arranged irregularly. Laterally along the ventral brims the ridges are deflected into a series of short, concentric curves similar to the ornament pattern described for *T. denisoni*, *T. pococki* and *T. symondsi*.

In the dorsal disc the ornament is parallel to the margins of the disc. Ridges continue along the sides of the dorsal spine where they have a density of 2.5 per mm.

Discussion

The presence of a pronounced dorsal spine precludes association of this species with *T. denisoni* and *Pseudotraquairaspis* gen. nov. (described later). The presence of the anterior V-shaped canal on the ventral disc precludes association with *T. symondsi*. It should be noted, however, that the ornament is very similar to *T. denisoni*. This material closely resembles *T. pococki* from the Downtonian of the Anglo-Welsh area of Britain. There are, however, certain notable differences viz.: a slightly smaller size, the presence of postero-lateral flanges on the ventral disc not previously described for *Traquairaspis*, a variably lobed anterior margin of the ventral disc and less tubercular ornament.

Stratigraphic significance of the genus *Traquairaspis*

Traquairaspis is an ubiquitous component of Early Devonian ostracoderm faunas recorded from Britain, Spitsbergen, western Europe, eastern Europe and Russia,and Canada.

(1) In the Anglo-Welsh area of Britain White was the first to demonstrate the stratigraphic importance of *Traquairaspis* in the Late Downtonian (White, 1946, 1950a). From this followed his scheme of 'fish zones' for the Lower Devonian (White, 1956) shown in a modified form after Dineley and Gossage (1959) in table 2.

BRECONIAN	*Pteraspis (Rhinopteraspis) dunensis* White	MIDDLE SIEGENIAN
DITTONIAN	*P. (R.) leachi* White	EARLY SIEGENIAN
	P. (Belgicaspis) crouchi Lankester *P. rostrata* (Agassiz)	LATE GEDINNIAN
	P. (Simopteraspis) leathensis White	EARLY GEDINNIAN (in part)
DOWNTONIAN (in part)	*Traquairaspis symondsi* (Lankester) *T. pococki* (White)	

Table 2. Lower Devonian vertebrate zones in the Anglo-Welsh area of Britain (after White, 1956; Dineley and Gossage, 1959).

Subsequent work in the Anglo-Welsh (Dineley and Gossage, 1959; Ball and Dineley, 1952, 1961, table 1) confirmed the validity of the *Traquairaspis* zonal sequence despite a certain amount of overlap between the ranges of its two species and between the range of *Traquairaspis* and *Pteraspis*.

(2) In Spitsbergen Føyn and Heintz (1943) reported the occurrence of *Traquairaspis* associated with *Corvaspis*, *Pteraspis*, and poraspids, in the basal beds of the Late Downtonian Fraenkelryggen Division of the Red Bay Series. Unfortunately, the pteraspids from the overlying succession have never received detailed study but it is clear that there is a *Traquairaspis* - *Pteraspis* faunal sequence analogous to that in Britain (Kiaer, 1928; Dineley, 1967: 16, table 2).

(3) In France, Belgium and the Rhineland a sequence of *Traquairaspis* and *Pteraspis* species occurs similar to that in the Anglo-Welsh area of Britain (White, 1956; Schmidt, 1959; Dineley, 1967).

(4) In eastern Europe *Traquairaspis* occurs in the Early Dittonian Czortkow Group in Podolia where it is closely associated with abundant pteraspids including *Pteraspis (Belgicaspis) crouchi* (Ørvig, 1961; Denison, 1956; Karatajute-Talimaa, 1967; Nikiforova et al., 1967) and is known from the Early Dittonian Eptarma beds from the Timan Range (Karatajute-Talimaa, 1967). *Traquairaspis* is also present in the Early

Dittonian Tilze beds of Lithuania where it associated with other ostracoderms including *Corvaspis*, *Anglaspis*, poraspids and *Pteraspis (Belgicaspis) crouchi* (Karatajute-Talimaa, 1962, 1967) and in the late Downtonian Tiljuk suite of Latvia (Obruchev, 1964).

In Russia Rzhonsnitskaya (1967) noted the presence of *Pteraspis (Belgicaspis) crouchi* and *Traquairaspis* within the Tiverian stage (Late Downtonian to Early Dittonian; (op. cit.: 334).

(5) In Canada *Traquairaspis* is known from widely separated localities, most of them of such recent discovery that details are not available. However, the presence of *Traquairaspis symondsi* in the Knoydart Formation of Nova Scotia is now well documented (Ami, 1901; Dineley, 1964a). In that area the presence of *T. symondsi* low in the sequence and *Pteraspis (Simopteraspis) whitei* and *P. (Belgicaspis) crouchi* respectively higher in the succession compares closely with the sequence of forms established in Britain. Dineley (1967) was able to establish that in the Knoydart Formation the approximate horizon of the Downtonian/Dittonian boundary lies between the *Traquairaspis* beds and the *P. (S) whitei* beds.

From northwest of Muncho Lake in British Columbia Denison (1964:451) reported a *Traquairaspis* of about the same size as *T. symondsi* and suggestive of a Late Downtonian age. It is associated with *Listraspis* and *Pionaspis*.

From the Yukon Territory Denison (1963) described an ostracoderm *?Traquairaspis angusta* subsequently referred to a new genus *Yukonaspis* Obruchev (1964). It came from a dolomite lens yielding abundant ostracoderms including *Ariaspis*. The age of the horizon was originally thought to be Middle Ludlovian (Denison, 1963: 140) due to the occurrence of *Monograptus dubius* above the ostracoderms but the fauna was later referred to the Early Downtonian (Denison, 1964:450) as suggested by the presence of *Yukonaspis angusta*.

Recent reconnaissance in the Mackenzie Mountains, Northwest Territories has revealed abundant ostracoderms in the Siluro-Devonian Delorme Formation (Dineley, 1968:101). Of particular interest is the presence of *Traquairaspis*, *Pteraspis* and forms akin to *Corvaspis*, in respectively younger horizons thus apparently reproducing the British faunal sequence.

Traquairaspis is also known from arctic regions other than Prince of Wales Island. On Somerset Island *Traquairaspis* occurs abundantly within the Read Bay and/or Peel Sound Formations (Dineley, 1966a). Two occurrences of *Traquairaspis* are known from Ellesmere Island. The genus occurs at the top of the Early Devonian Stallworthy Formation (Trettin, 1967: 695). A specimen of *Traquairaspis* has recently been recorded from the Devon Island Formation on southern Ellesmere Island. The age of that formation may be as young as Early Devonian (R. Thorsteinsson, 1968, personal communication).

In Wilson's Gorge, the presence of three species of *Traquairaspis* suggests that this genus was an important faunal element in the Early Devonian of this area. This may be considered analogous to, and probably contemporaneous with, the development of *Traquairaspis* in the Late Downtonian of the Anglo-Welsh area and probably other regions. Accordingly, on the evidence of *Traquairaspis* alone, fish horizons 3, 7, 8, 9, 12, 13 and 14 which contain this genus are considered Downtonian (fig. 5). This includes beds up to 422 feet above the base of the formation. The significance of the presence of *Pteraspis* overlying most of the *Traquairaspis* occurrences is discussed later (p. 115).

Genus *Pseudotraquairaspis* nov.

Pls. 17, 18, pl. 19, fig.1

Diagnosis. Dorsal shield wide, deeply convex with fused, pineal, median, orbital, rostral and branchio-cornual plates. Ornament of long, narrow crenulate tubercles interspaced with finer dentine ridges, more or less parallel to margin of plates. Lateral branchial channels in dorsal disc diverge posteriorly. Median dorsal ridge. Ventral disc oval, depressed, and without ornament. Pre-pineal macula present.

Type species. *Pseudotraquairaspis* sp. *A* nov.

Other species. *Pseudotraquairaspis* sp. *B* nov.

Etymology. *Pseudo* (Greek): false, referring to the most closely related genus, *Traquairaspis* Kiaer, 1932.

Pseudotraquairaspis sp. *A* nov.

Pl. 17, pl. 18, figs. 1-3

Diagnosis. As for genus. Dorsal shield 5.3 to 7.4 cm long, large width ratio, narrow-crested median dorsal ridge. Ventral shield with or without anterior median notch.

Syntypes. All figured material.

Material. 28 complete and 4 fragmented dorsal shields (AG: 138, 140, 151, 156, 157, 160, 161, 164, 197, 209; AB: 89, 92, 100-102, 104, 107, 110, 114, 115, 118, 120, 125, 129, 142, 149, 158, 166, 169, 172; AN: 116, 130).

22 complete and 5 fragmented ventral shields (AG: 114, 133, 135-137, 139, 143, 152, 154, 161-163, 211; AB: 88, 90, 93-97, 113, 119, 124, 126, 167, 171, 173).

Horizons. 7 (abundant), 9 (abundant) and 13 (see fig. 5).

Description

Dorsal shield (pl. 17, figs, 1, 3, pl. 18, figs. 1, 3).

Dimensions (of 17 shields): (cm)

median length	:	5.3 -7.4
maximum width	:	3.7 -5.5
interorbital width	:	0.9 -1.3
orbital length	:	0.2 -0.6
pineal length	:	0.5 -0.8
postbranchial length	:	3.2 -3.9
width ratio	:	0.64-0.88
interorbital ratio	:	0.13-0.22
orbital ratio	:	0.3 -0.9
pineal ratio		0.7 -0.13
postbranchial ratio	:	0.47-0.69

The dorsal shield is composed of 7 plates - median, rostral, pineal,and paired orbitals and branchio-cornuals - fused to form a rigid structure. The margins of the plates are not visible in internal view but are revealed through the pattern of ornamentation in each plate. Single, isolated plates are not known.

The most complete specimens (pl. 17, figs. 1, 3) show the dorsal shield to be oval in outline and deeply convex. A narrow median ridge, not exceeding 0.5 cm in height, lies 3.5 to 4.3 cm behind the anterior margin. In profile the shield is smoothly arched posteriorly but is strongly depressed anteriorly. A broad horizontal marginal brim, 0.4 cm wide, extends from the orbital region to the posterior margin where it terminates as a reduced cornual element. About half the length of the shield behind the anterior margin the dorsal surface of the brim bears two horizontal shallow branchial grooves about 1 cm long and inclined posteriorly at an angle of about 45 degrees to the median line. The branchial channel is oval in section, about 0.4 cm wide and narrows posteriorly. The branchial opening itself lies between the dorsal and ventral shields and between very small pre-branchial and post-branchial lobes. These lobes are themselves lateral extensions of the brim. Maximum width in most specimens occurs post-branchially.

Anteriorly the margin is gently rounded with a small but nevertheless distinct median rostrum.

The orbits are small and lie close to the antero-lateral margin with the pineal macula lying unusually close (0.1 to 0.2 cm) behind them.. The semi-circular canals are prominent while anterior to the pineal macula another macula of unknown affinity occurs on the rostral process of some specimens.

The posterior margin narrows to a small median lobe.

<u>Ventral shield</u> (pl. 17, fig. 2, pl. 18, fig. 2).

Two distinct kinds of ventral shield are known - one with an anterior median notch and another with a smooth anterior margin.

Dimensions: (cm)

	maximum length	maximum width	width ratio
11 notched shields:	6.3-7.8	3.0-4.2	0.44-0.60
12 smooth shields :	6.1-7.5	3.2-4.3	0.46-0.61

Apart from the fact that the notched shields are slightly longer and narrower, the dimensions of the two varieties are similar.

All ventral shields are roughly oval in outline and almost flat in profile. The anterior margin of the notched variety (pl. 17, fig. 2) possesses a distinct median notch up to 0.2 cm deep and 0.7 cm wide, which is entirely absent in the smooth variety (pl. 18, fig. 2). The posterior margin is more or less transverse but may be slightly crenulate or bear a small median lobe. A marginal zone 0.3 cm wide along the lateral margins is marked by a change in slope and forms a distinct lateral brim. This commonly shows one or more coarse growth lines parallel to the margins. Maximum height occurs anteriorly. Posteriorly the shields are almost flat. Both varieties of ventral shield lack ornamentation.

There appears to be marked stratigraphic separation of the notched and smooth shields. Of the 13 ventral shields from horizon 7 only one is of the notched variety, while horizon 9 yielded 14 ventral shields, all of the notched variety. The significance of this is discussed later.

Ornamentation (pl. 18, figs. 1, 3).

On the dorsal shield ornamentation consists of longitudinal rows of elongate lacrimiform tubercles separated by fine, discontinuous ridges, comparable to the ornament of *Traquairaspis pococki*. The tubercles narrow anteriorly, bear rounded crests and have moderate relief. The ridges have a density of about 4-6 per mm and are crenulate with short, lateral proeesses. The ornament is generally parallel to margins of each plate.

Discussion

This new material is closely related to *Traquairaspis* in view of the plates composing the dorsal shield, enclosed orbits, unusual ventral shield and similar ornamentation. Unlike *Traquairaspis* however, plates have not been found disarticulated and are fused to form a single dorsal unit. A narrow ridge surmounting a short median crest takes the place of a dorsal spine. Also, the *Traquairaspis* type of ventral shield with an ornamented brim is entirely lacking. The almost flat ventral shield is entirely smooth and may or may not bear an anterior notch.

Several other features are characteristic of *Pseudotraquairaspis*.

(1) In ventral view, the horizontal brims of the branchio-cornual plates show the backwardly-directed branchial channels. Thus, the branchial opening is bounded by the margin of the branchio-cornual plate and lies between the dorsal and ventral shields.

(2) A tendency to strengthen the headshield is indicated by fusion of the individual plates of the dorsal shield.

The absence of isolated plates amongst such abundance of shields suggests extreme cohesion. Since the individual plates may be inferred from the pattern of ornamentation, these areas could be regarded as epitega.

(3) The significance of the two varieties of ventral shield is not apparent. Both occur closely associated with the single kind of dorsal shield. It is possible that two species or sexually dimorphic forms differing only in the ventral shield are represented.

Thus, despite certain similarities and a definite relationship to, it is clear that this new material represents a genus separate from, *Traquairaspis*. Accordingly, the genus *Pseudotraquairaspis* nov. is proposed.

Pseudotraquairaspis sp. *B* nov.

Pl. 18, fig. 4, pl. 19, fig. 1

Diagnosis. As for genus. Dorsal shield 4.2-6.0 cm long, small width ratio, long median dorsal ridge. Ventral shield has smooth anterior margin.

Syntypes. All referred material.

Material. 9 almost complete dorsal shields (AI: 75, 134, 203; AG: 202, 208; AK 117, 127, 128, 294).
4 almost complete ventral shields (AI: 132, 206, 210; AE 150).

Horizons. 3, 5, 7 and 10 (see fig. 5).

Description

Dorsal shield (pl. 18, fig. 4).

Dimensions: (cm)

median length	: 4.2-6.0	width ratio	: 0.53-0.64
maximum width	: 2.6-3.6	interorbital ratio	: 0.11-0.19
interorbital width	: 0.6-1.0	orbital ratio	: 0.3 -0.7
orbital length	: 0.2-0.5	pineal ratio	: 0.7 -0.14
pineal length	: 0.4-0.9	postbranchial ratio	: 0.43-0.62
postbranchial length	: 2.6-4.1		

Although the dorsal shield is essentially similar to that of *P.* sp. *A* nov. (see prior description) in general shape, presence of branchial openings and channels, position of pineal macula, pre-pineal macula and distinct semi-circular canals, certain characters are distinctive, viz. (a) the size and width ratio are smaller, (b) the median ridge is longer and extends from behind the semi-circular canals almost to the posterior margins, (c) the posterior margin bears two small elevations on either side of the median line, and in one specimen a distinct lobe occurs on the postero-lateral corner, and (d) the ornamentation is similar, but finer, there being about 6 ridges per mm.

Ventral shield (pl. 19, fig. 1).

Dimensions: (cm)

median length: 4.0-5.5 width ratio: 0.53-0.58

maximum width: 2.3-3.2

In outline the ventral shield is oval with a smooth, convex anterior margin and a more or less transverse but crenulate posterior margin. In profile it is similar to the smooth ventral shield of *P.* sp. *A*. It is fairly flat but has a lateral and a posterior rim marked by a change in slope about 0.3 cm from the margins. Ornamentation is absent from the ventral shield.

Discussion

This material is sufficiently different from *P.* sp.*A* to warrant assignation to a separate species. This species is smaller and is more common stratigraphically lower than *P.* sp.*A*. It could be an ancestral form of the latter.

Thorsteinsson recently obtained a dorsal shield of about the same size and closely resembling this species, from the Cape Phillips Formation on the Abbott River, Cornwallis Island. The specimen came from beds above the zone of *Monograptus testis* and below the zone of *M. nilssoni* and is associated with graptolites which suggest the zone of *M. vulgaris*. A latest Wenlockian age is suggested (R. Thorsteinsson, 1968, personal communication). If further work proves this specimen to be congeneric with *Pseudotraquairaspis*, a considerable stratigraphic range from the Wenlockian to the Dittonian will be apparent for this genus. The generic characters of *Pseudotraquairaspis* might thus be truly "primitive", acquired at an early date, and retained with little modification after the arrival of the more widely known *Traquairaspis*.

Family PTERASPIDIDAE White, 1935

Genus *Pteraspis* Kner, 1847

Subgenus *Simopteraspis* White, 1950b

Pteraspis (Simopteraspis) arctica sp. nov.

Pl. 19, figs. 2-4.

Diagnosis. A *Pterasis* of small size, with blunt, broadly rounded rostrum, triangular pineal plate separated from the orbital plates, long slender dorsal spine the base of which is inserted well forward of the posterior margin of the shield, and very fine ornamentation.

Holotype. 1 dorsal shield (AM 227).

Etymology. *arctica* - refers to the arctic latitude of the type locality.

Material. 1 complete right half of a dorsal shield preserved in internal view.

Horizon. 11 (see fig, 5).

Description

Dorsal shield (pl. 19, figs. 2-4).

<u>Dimensions</u>: (cm)

maximum length (excluding dorsal spine): 2.4

maximum width	: 1.35	width ratio	: 0.56
orbital width	: 1.1	orbital width ratio	: 0.45
orbital length	: 0.55	orbital length ratio	: 0.22
pineal length	: 0.4	pineal ratio	: 0.16
postbranchial length	: 0.5	postbranchial ratio	: 0.20

The shield is small with gently rounded outlines. The rostral margin is broadly rounded and curves ventrally before terminating in a gentle pre-oral lobe. Laterally the margin is interrupted to accommodate the orbits behind which it diverges slightly towards the branchial opening before converging again. Posteriorly the margin terminates in a rounded median lobe 0.3 cm behind the base of the dorsal spine. This spine is a well developed probably separate arcuate element, arising 2.15 cm from the anterior margin of the shield (pl. 19, fig. 3). It is 1.1 cm in length (the tip is broken), originates an angle of 30 degrees and gently tapers in thickness from a diameter of 0.1 cm at its base.

In profile the shield is depressed rostrally but posteriorly reaches a maximum height of 0.5 cm.

The margins of the individual plates comprising the dorsal shield can only be inferred from the limited areas where the ornament pattern is visible. The branchial plate is long and slender and partly ventral in position. A postero- ventrally inclined elongate oval slit 0.4 cm long and

0.1 cm wide just anterior to the dorsal spine constitutes the branchial opening. The orbital plate encloses a circular orbit with an internal diameter of 1.3 cm and bears a conspicuous bony thickening along its inner ventral segment. The pineal plate is triangular in shape and its lateral extremities are separated from the orbital plates. It bears a prominent pineal macula. Cornual plates, if present, cannot be observed. Impressions of one semi-circular canal and six gill pouches are conspicuous features and occur on the inner surface of the median plate. The first two gill pouches are situated lateral to the semi-circular canal, but the remainder are posterior.

<u>Ornamentation</u> (pl. 19, figs. 3, 4).

Ornament consists of fine dentine ridges about 13 per mm, separated by grooves and bearing crenulate margins. The pattern of ornamentation is the only indication of the shape of the underlying plates. In the rostral region the ridge pattern is concentric but rapidly merges with that of adjacent plates. As far as can be determined the ridges of the median plate are parallel to its margins and generally confluent around the median line. Ornament continues the length of the dorsal spine.

<u>Discussion</u>

This new species has strongest affinites with *Pteraspis (Simopteraspis) vogti* Kiaer (1928) and *P. (S.) leathensis* White (1950b) on account of the short, broadly rounded rostrum and the small triangular pineal plate separated from the orbitals. It resembles *P. (S.) primaeva* Kiaer (1928) with respect to its small size and impressions of internal organs.

The shape and position of the slender dorsal spine are unusual features characteristic of the new material. The dorsal spine is similar in shape to that of *Rhinopteraspis*, while the rather anterior position of the base of the dorsal spine is similar to that in *Pteraspis (P.) stensiöi* White (1935). However, it is clear that the blunt rostrum and finer ornamentation preclude affinity with either form.

In size this material is comparable to some specimens of *P. (Belgicaspis) crouchi* less than 2 cm in length (White, 1950b:88; 1961:256), but the rostrum is again a distinctive feature. Assignation to *Protaspis* Bryant (1933) is precluded since the branchial openings lie well forward of the posterior margin of the dorsal shield. In short, the unique characters shown by this single specimen are sufficient to justify its allocation to a new species. Accordingly it is referred to *Pteraspis (Simopteraspis) arctica* sp. nov.

It is apparent that excepting the unusual size and shape of the dorsal spine, this specimen shows the early features characteristic of the *Pteraspis (Simopteraspis)* group of species. The dorsal spine is undoubtedly a specialized character as suggested by its size and shape which are out of keeping with the general proportions of the animal.

Stratigraphic significance of the genus *Pteraspis*

In North America previously described pteraspids are confined to four areas: (1) the Knoydart Formation of Late Downtonian - Early Dittonian age in Nova Scotia (Denison, 1955; Dineley, 1964a), (2) the Water Canyon Formation, and (3) the Beartoothe Butte Formation, in Colorado and Wyoming both regarded as Late Dittonian or Breconian (Bryant, 1933; Denison, 1953), and (4) the Holland Quarry shale of Late Dittonian age in Ohio (Denison, 1960). Many undescribed pteraspids have also been collected from the Baring Channel area, northern Prince of Wales Island (see fig. 1). Pteraspids have also been reported from the Mackenzie Mountains, Northwest Territories by Dineley (1968) where they are associated with other undescribed ostracoderms in the Siluro-Devonian Delorme Formation.

In Britain the stratigraphic significance of *Pteraspis* in the Early Devonian has been well established (see discussion of the significance of *Traquairaspis* and table 2). In the Anglo-Welsh area the general replacement of *Traquairaspis* faunas by *Pteraspis* faunas has been taken to mark the base of the Dittonian stage (White, 1950a:56, 1950b:69-70, 1956; Ball and Dineley, 1961:202, table 1).

The presence of the genus *Pteraspis* in the Wilson's Gorge fauna is interesting on two accounts. First, this is the first description of a new *Pteraspis* species from the Canadian Arctic. Second, the presence of *Pteraspis* 368 feet above the base of the Peel Sound Formation is considered indicative of an Early Dittonian age. The significance of *Traquairaspis* in the section has already been discussed. Its presence suggests that beds between 14.5 and 422 feet above the base of the formation are Downtonian. Since *Pteraspis* is by definition restricted to the Dittonian the base of the Dittonian must lie not higher than 368 feet above the base of the formation. This horizon is indicated on the range chart (fig. 5) and is taken to be the approximate position of the Downtonian/Dittonian boundary. The resulting overlap of the ranges of *Traquairaspis* and *Pteraspis* is not unusual and is known in the Anglo-Welsh area (Ball and Dineley, 1961, table 1).

The geographical distribution of North American pteraspids indicates morphological and geographical separation of *Protaspis* dominated western faunas from *Pteraspis* dominated eastern faunas. The "arctic province" is probably either a centre for dispersal or a migration "corridor" (D.L. Dineley, 1968, personal communication). The presence of a *Pteraspis (Simopteraspis)* species in the Canadian arctic at a low stratigraphic level supports the "corridor" view.

V SIGNIFICANCE OF HETEROSTRACAN FAUNA OF WILSON'S GORGE

Distinctive features

Although the Wilson's Gorge fauna has not been completely described, several important points merit consideration.

(1) The fauna is unusual in its exclusive heterostracan composition and the absence of cephalaspids, arthrodires and acanthodians, often present in Lower Devonian vertebrate assemblages. This feature is remarkable in view of the presence of all these groups at equivalent stratigraphic horizons on Somerset Island. Possibly peculiar local ecological factors such as barriers restricting migration were responsible for differences between faunas on opposite sides of the Boothia Arch.

(2) The presence of *Traquairaspis*, *Corvaspis* and *Pteraspis* is significant (fig. 5) because these genera often occur together in Lower Devonian vertebrate assemblages in Britain, Spitsbergen and Podolia. Further affinity with the European faunal sequence lies in the *Traquairaspis/Pteraspis* faunal change already discussed, and the presence of a species similar to *Traquairaspis pococki*. Tarlo (1964:92) commented on the widespread distribution of *Corvaspis* and other heterostracans found in Britain, Spitsbergen and Podolia. Since these areas could only have been connected by the sea he postulated that at some time in their life cycle, possibly at a larval stage, heterostracans were tolerant of sea water. The general resemblance between the Wilson's Gorge fauna and

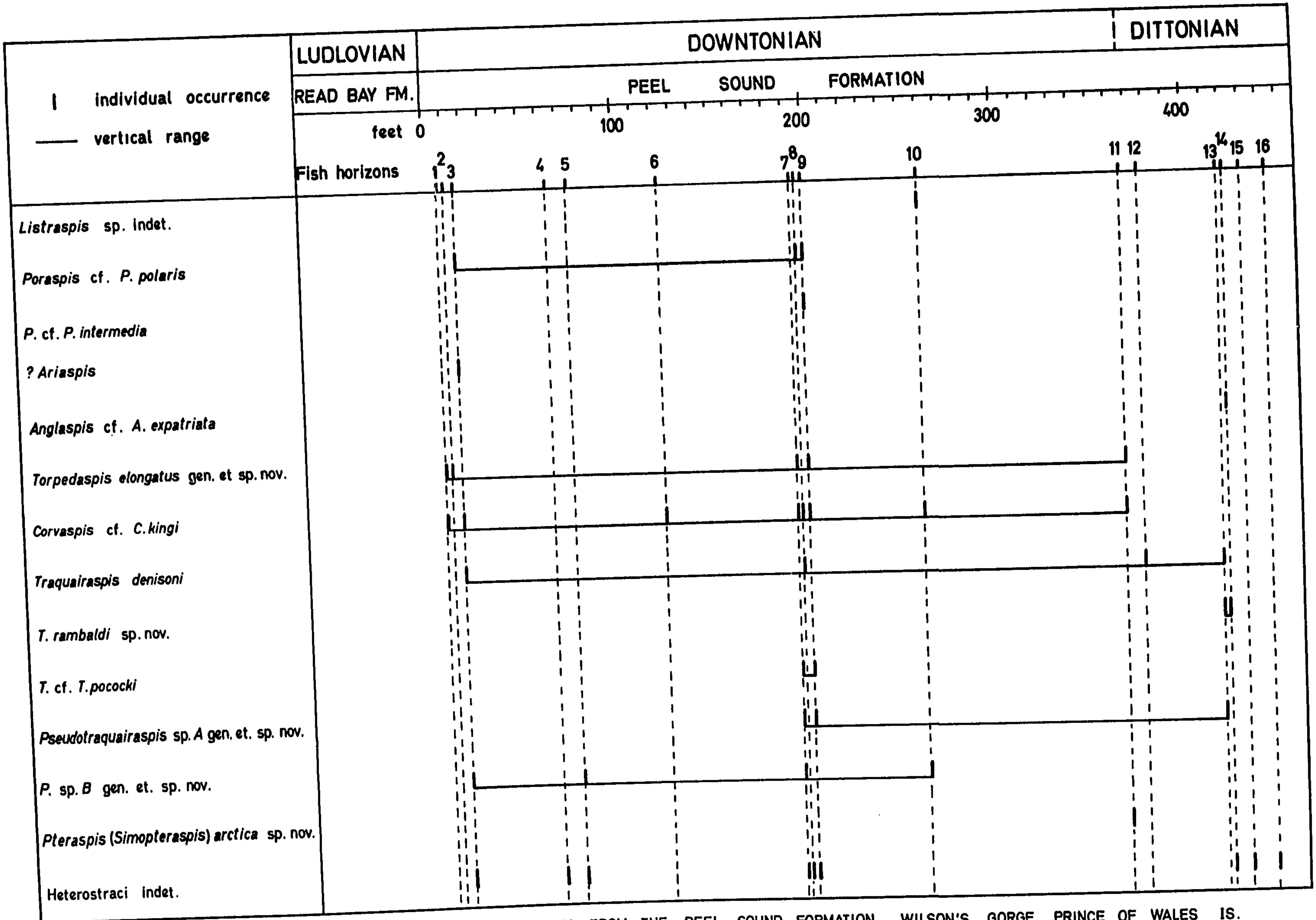

FIG. 5. VERTICAL RANGE OF HETEROSTRACI FROM THE PEEL SOUND FORMATION, WILSON'S GORGE, PRINCE OF WALES IS.

parts of faunas in Europe, Spitsbergen and Britain tends to support this hypothesis.

(3) Several unusual heterostracans are present in the fauna. Included are the largest and smallest known cyathaspidids, *Torpedaspis elongatus* sp. nov. and *Poraspis* cf. *P. intermedia* respectively, specialized cyathaspidids *Listraspis* and *?Ariaspis* with distinct median dorsal elements, and a primitive *Pteraspis (Simopteraspis)* with an unusually large spine. Of the several undescribed forms the most important is a new genus of a large, remarkably flat heterostracan and genera similar to *Pionaspis* and *Weigeltaspis*.

(4) The fauna is further characterized by the unique composition of each faunule, the predominance of one or two species within a faunule, and the short vertical range of some species (fig. 5). In particular fish horizon 3, the 'bone bed', is unique in its diverse fauna, the large quantity of material, and the relative abundance of *Traquairaspis denisoni* and the large, flat, undescribed heterostracan which is restricted to this horizon. Horizon 7 is characterized by the predominance of *Torpedaspis elongatus* sp. nov., horizon 9 by *Pseudotraquairaspis* sp. *A*, and horizon 11 by undescribed forms similar to *Pionaspis*.

The significance of the preceding points is explained in the following manner. The unique composition of most faunules, the abundance of fossils and the short vertical range of many species indicates a sequence of favourable environments occupied by different heterostracan faunas.

Horizon 3, the earliest and most fossiliferous horizon represents a flourishing heterostracan fauna which had successfully colonized a favourable brackish coastal environment newly emergent due to the uplift of the Boothia Arch at the beginning of Peel Sound time. The heterostracan habitat and sequence of environments represented in Wilson's Gorge is described in a later section.

The large size of the faunas, the presence of new and unusual heterostracans at several horizons in Wilson's Gorge, if considered together with the remarkable quantity of heterostracans (and other ostracoderms) on Somerset and Prince of Wales Islands and Boothia Peninsula suggest a large regional Lower Devonian heterostracan population in this area. This supports Tarlo's suggestion that the arctic was a centre of heterostracan evolution during the early Devonian (Tarlo, 1962a: 153; 1964:76).

<u>Age of the fauna</u>

A Downtonian or Dittonian age is suggested by all identified vertebrates in Wilson's Gorge. The oldest age, Ludlovian or Downtonian, is indicated by *?Ariaspis*. This is an unusual and specialized cyathaspidid from the bone bed (fish horizon 3) near the base of the Peel Sound Formation. The youngest age, Dittonian, is indicated by *Pteraspis (Simopteraspis) arctica* sp. nov. from one of the highest fish horizons.

The most important index fossils are the genera *Traquairaspis* and *Pteraspis*. Their stratigraphic ranges are well established in Britain, where the base of the Dittonian is marked by a distinctive faunal change, the replacement of *Traquairaspis* by *Pteraspis*. This faunal change occurs in Wilson's Gorge and the incoming of *Pteraspis* 370 feet above the base of the formation is therefore considered indicative of the beginning of Dittonian time. The presence of *Traquairaspis* alongside *Pteraspis* is not unusual since *Traquairaspis* ranges just into the early Dittonian in the Anglo-Welsh area (Ball and Dineley, 1961, table 1).

Corroborative evidence for the Downtonian and Dittonian age of the Peel Sound Formation in Wilson's Gorge is the Silurian age of the conformably underlying Read Bay Formation. On Cornwallis Island the uppermost members of the Read Bay Formation were considered middle or upper Ludlovian (Thorsteinsson, 1958:73), and Silurian invertebrate fossils were collected from the top of the formation in Wilson's Gorge (GSC locs. 82470-72). An anomalous Silurian age inferred from an invertebrate fauna 589 feet above the base of the Peel Sound Formation (GSC loc. 82473) cannot be considered reliable in view of the small collection and poor preservation. Invertebrate fossils are rare at this horizon and more intensive collecting is required.

The section in Wilson's Gorge thus includes rocks of Late Ludlovian, Downtonian and Dittonian age. The top of the Read Bay Formation is considered to be Late Ludlovian, the basal 370 feet of the Peel Sound Formation up to the incoming of *Pteraspis* is Downtonian, and the overlying beds up to the top of the section are Dittonian. In this section the Siluro-Devonian boundary therefore approximates to the gradational junction between the Read Bay and Peel Sound Formation, thus confirming the age suggested for this contact on Somerset Island (Dineley, 1965a; Allen, Dineley and Friend, 1967).

Heterostracan habitat and environment

In Wilson's Gorge sedimentological and faunal evidence suggests a sequence of depositional environments from shallow marine through transitional to continental conditions. The transitional environment was possibly lagoonal but evidence is lacking. This sequence is similar to that suggested for Read Bay and Peel Sound rocks on Somerset Island (Dineley, 1966a).

(1) The top 88 feet of the Read Bay Formation consists of fossiliferous bioclastic marine limestone with thin arenaceous partings and lenses, sandstone with ripple marks and siltstone intraclasts and crossbedded siltstone (fig. 3 and description of section). These suggest a shallow near shore marine environment which was receiving clastics from the rising west flank of the Boothia Arch. This was apparently an unfavourable environment for vertebrates since none was discovered despite intensive search.

(2) The basal 17 feet of the Peel Sound Formation consists of pebbly sandstone and conglomerate (fig. 3 and description of section). Bone fragments occur throughout, culminating in a bone bed (fish horizon 3) with a diverse heterostracan fauna. The large size and lack of abrasion of these remains indicate minimal transportation.

Continued uplift of the Boothia Arch and flanking shelf environment probably created local brackish environments which were a favourable heterostracan habitat. Uplift of the Boothia Arch is testified by the influx of coarse terrigenous clastics which temporarily ended a period of minimal sedimentation during which heterostracan remains accumulated.

(3) Between 17 and 213 feet above its base the formation comprises grey or red sandstone (often pebbly and with rare ripple marks and prod casts), conglomerate, limestone and siltstone, in decreasing order of abundance (fig. 3 and description of section). One limestone and one sandstone contain a marine fauna. *Lingula* occurs in two heterostracan rich sandstones. Heterostracan remains are common and where they occur they are present in abundance. In fish horizons 4 to 9 their large size and minimal fragmentation and abrasion indicate little transportation. However, there is some evidence of bottom currents in preferred orientation of some elongate shields and the local imbricate accumulation of as many as fifteen concave shields.

A continuing restricted brackish environment supporting successive heterostracan faunas is envisaged. Periodic subsidence of the depositional area is indicated by two marine faunas representing temporary marine incursions. The apparent absence of vertebrate remains from any marine units in the section suggests that the marine environment was unsuitable. Possibly the vertebrates migrated upstream to a more favourable habitat during each marine episode.

(4) Between 213 and 452 feet above its base the formation consists of conglomerate, sandstone, siltstone and an ostracod limestone, in decreasing order of abundance. Ostracods, gastropods and pelecypods occur in fish horizon 11. Fish horizons are less common and less fossiliferous than those lower in the section.

A restricted brackish environment supporting successive short-lived heterostracan faunas is envisaged. This habitat was repeatedly invaded by successive alluvial fans now represented by boulder conglomerate, the result of flash floods and more rapid uplift of the Boothia Arch (A.D Miall, personal communication). A single marine transgression represented by a limestone containing ostracods of a Read Bay type, suggests continued proximity of the sea.

(5) From 452 feet to the top of the section the formation consists of conglomerate, laminated siltstone, laminated sandstone and limestone, in decreasing order of abundance. Vertebrates were not found despite intensive search.

Restricted brackish conditions persisted but were periodically interrupted by the influx of coarse alluvial fan clastics. Siltstone is more common than elsewhere in the section and represents fine sediment suggesting quiet, possibly lagoonal conditions. Possibly the increase in fine sediment created a muddy environment unsuitable for heterostracans or other vertebrates. Continued encroachment of alluvial fans eventually destroyed this environment and gave rise to a piedmont fluviatile regime.

VI SUMMARY AND CONCLUSIONS

Heterostracan faunas, in particular the zone fossils *Traquairaspis* and *Pteraspis*, indicate a Downtonian and Dittonian age for the Peel Sound Formation in Wilson's Gorge and suggest a faunal sequence similar to that in Britain. In this section the conformable junction between the Read Bay and Peel Sound Formations therefore approximates to the Siluro-Devonian boundary.

This evidence is the most precise yet available for the age of the lower part of the Peel Sound Formation. The sandstone and carbonate facies elsewhere on the island are tentatively considered partly contemporaneous with, and also slightly younger than, the conglomerate facies in Wilson's Gorge on evidence from preliminary study of their vertebrate faunas.

Read Bay and Peel Sound rocks in Wilson's Gorge represent a sequence of depositional environments from shallow marine through transitional to continental conditions. Uplift of the Boothia Arch during early Peel Sound time created successive brackish coastal environments having limited access to the sea and supporting flourishing heterostracan populations. Continuous uplift and influx of predominantly coarse sediment periodically destroyed these environments and their heterostracan faunules. Thus, many of the sixteen stratigraphically separated faunules are characterized by faunas with little resemblance to those of other faunules. The environment was eventually permanently destroyed by widespread alluvial fans and the onset of continental fluviatile conditions.

Further work must include detailed study of the remainder of the vertebrate collections from Prince of Wales Island. This would enhance further study of the relationships of the conglomerate, sandstone and carbonate facies and would permit correlation of the Peel Sound Formation with formations elsewhere in the arctic. Intensive collecting of invertebrate faunas associated with the vertebrate fossils, particularly in Wilson's Gorge, and comparison with faunas elsewhere would also be profitable.

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PLATE 1

Listraspis sp. indet.

Figure 1 Dorsal shield: internal view showing lateral elements, posterior median lobe (AK 212; X 2.9).

Figure 2 Dorsal keel: right lateral view (AK 212; X 10).

Poraspis cf. *P. polaris* Kiaer

Figure 3 Dorsal shield: asymmetric anterior ornament (AI 222; X 6.5).

Figure 4 Dorsal shield: rostrum, orbital notch, branchial notch, posterior median lobe, symmetrically fanned anterior ornament (AI 221; X 5.7).

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PLATE 1

PLATE 2

Poraspis cf. *P. polaris* Kiaer

Figure 1 Dorsal shield: pineal macula, ornament (AC 254; X 5.7).

Poraspis cf. *P. intermedia* Kiaer and Heintz

Figure 2 Dorsal shield: orbit, posterior median lobe, semi-circular canals, fanned anterior ornament (AB 270a; X 7).

Figure 3 Dorsal shield: posterior median lobe, branchial notch, asymmetric anterior ornament (AB 240; X 7.5).

Figure 4 Dorsal shield: fanned anterior ornament, pineal macula, semi-circular canals (AB 239; 7.5).

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PLATE 2

PLATE 3

? *Ariaspis* sp.

Figure 1 Dorsal shield: postero-lateral points, dorsal spine, semi-circular canals, ornament (AI 256; X 4.3).

Figure 2 Dorsal shield: pre-orbital processes, postero-lateral point, ornament (AI 215; X 4.3).

Anglaspis cf. *A. expatriata* Denison

Figure 3 Dorsal shield: internal view showing lateral brim, postero-lateral point, posterior median lobe, median dorsal ridge, pineal macula, semi-circular canals (AP 204; X 3).

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PLATE 3

PLATE 4

Torpedaspis elongatus gen. et sp. nov.

Paratype (AG 1; X 1.4)

Figure 1 Dorsal shield.

Figure 2 Dorsal shield: right lateral view, showing orbital notch, branchial notch.

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PLATE 5

Torpedaspis elongatus gen. et sp. nov.

Paratype (AG 5; X 1.6)

Figure 1 Ventral shield: branchial notch, posterior median lobe.

Figure 2 Ventral shield: lateral view showing branchial notch, posterior median lobe.

PLATE 6

Torpedaspis elongatus gen. et sp. nov.

Paratypes

Figure 1 Dorsal shield: pineal organ (AG 23; X 1.3).

Figure 2 Dorsal shield: ventral view showing pre-oral rostral brim (AG 2; X 1.7).

Figure 3 Branchial plate: lateral view of right plate (AG 41; X 2.8).

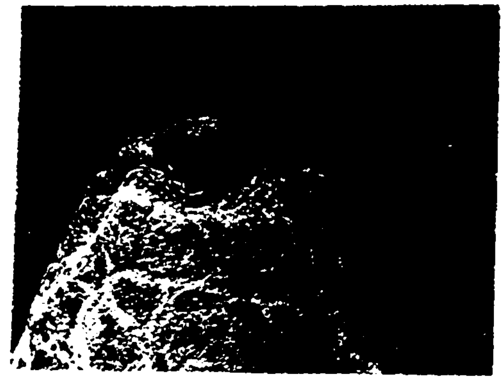

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PLATE 6

PLATE 7

Torpedaspis elongatus gen. et sp. nov.

Holotype (AG 14a)

Figure 1 Entire specimen: left lateral view showing headshield, posterior body, and caudal fin (actual size).

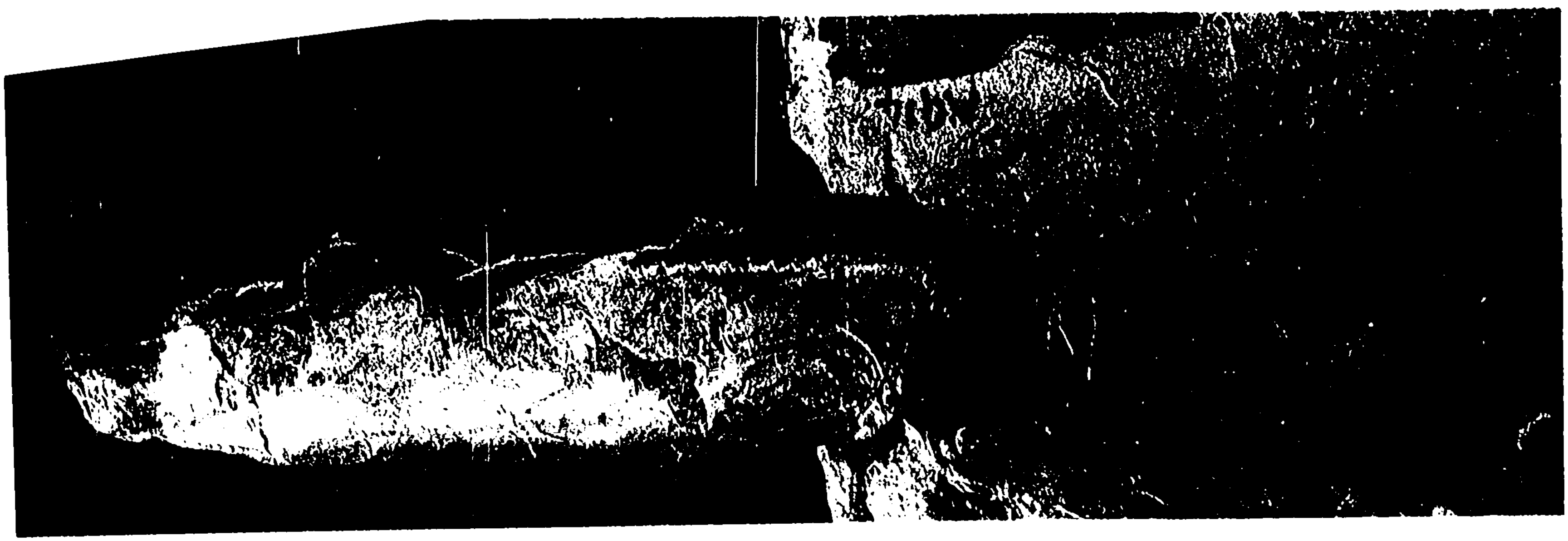

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PLATE 7

PLATE 8

Torpedaspis elongatus gen. et sp. nov.

Holotype (AG 14b; X 1.1)

Figure 1 Entire specimen: natural cast of headshield, posterior body, and caudal fin.

PLATE 8

PLATE 9

Torpedaspis elongatus gen. et sp. nov.
Holotype (AG 14a; X 2.2)

Figure 1 Posterior body and caudal fin: left lateral view showing lateral scales, median dorsal scales, and median ventral scales.

PLATE 10

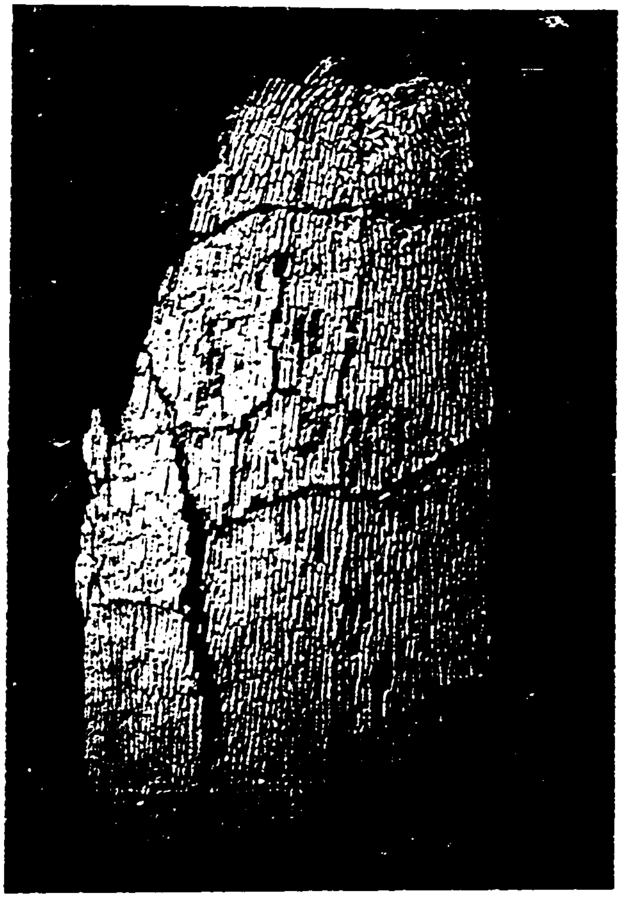
Corvaspis cf. *C. kingi* Woodward

Figure 1 Median plate: ornament generally synchronomorial but irregular anteriorly (AM 272a; X 2).

Figure 2 Branchial plate: ornament synchronomorial medially becoming irregular marginally (AB 279; X 7).

Figure 3 Fragment of plate: ornament cyclomorial (rubber mould of AI 276; X 3).

Figure 4 Median plate: ornament cyclomorial (rubber mould of AI 275; X 1.9).



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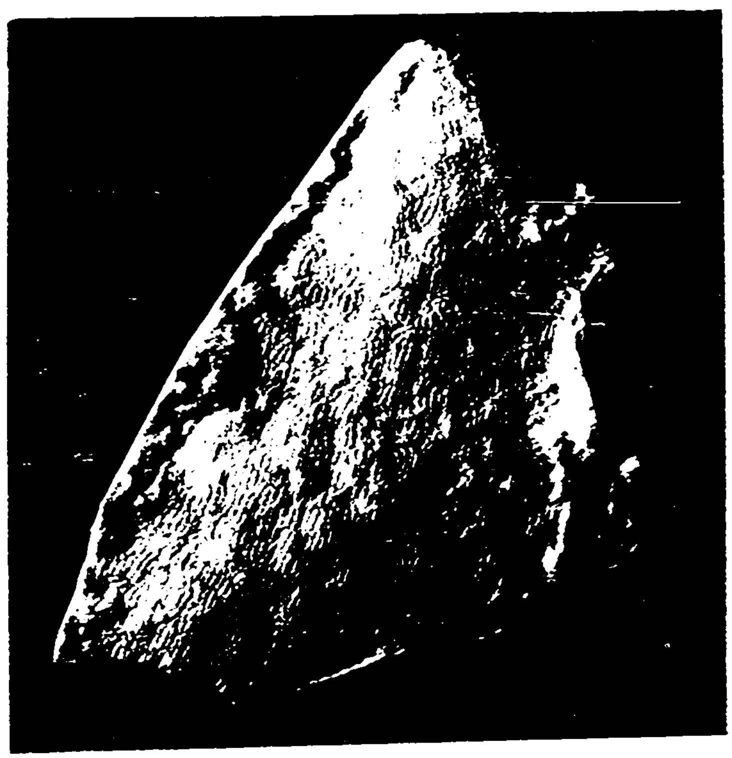

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PLATE 10

PLATE 11

Corvaspis cf. *C. kingi* Woodward

Figure 1 Median plate: ornament generally synchronomorial but irregular anteriorly; note pineal macula (AG 294; X 1.8).

PLATE 12

Corvaspis cf. *C. kingi* Woodward

Figure 1 Median plate: ornament cyclomorial with poorly developed tesserae at anterior end (rubber mould of AI 268; X 2.2).

PLATE 13

Corvaspis cf. *C. kingi* Woodward

Figure 1 Orbital plate: note marginal zone of irregular tubercles (AI 263; X 7).

Figure 2 Orbital plate (AK 262; X 8).

Traquairaspis denisoni Dineley

Figure 3 Dorsal disc: natural cast showing posterior median lobe and growth ridges; note left branchio-cornual plate (AI 175; X 1.3).

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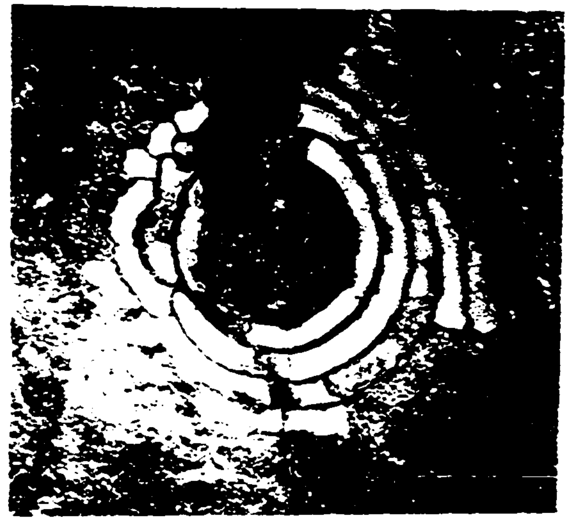

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PLATE 13

PLATE 14

Traquairaspis denisoni Dineley

Figure 1 Dorsal disc: internal view showing growth lines (AI 174; X 1.4).

Figure 2 Ventral disc: smooth central area and fragment of ornamented marginal brim (AI 192; X 1.5).

Figure 3 Branchio-cornual plate: note ornament (AI 175; X 2.3).

Figure 4 Orbital plate: note growth lines; orientation uncertain (AI 198; X 3).

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PLATE 14

PLATE 15

Traquairaspis rambaldi sp. nov.

Syntypes

Figure 1 Dorsal disc: postero-lateral view of natural cast showing posterior median lobe (AP 59b; X 1.8).

Figure 2 Ventral disc: internal view showing small part of smooth central area surrounded by wide ornamented brim, growth lines (AP 60; X 1.8).

Figure 3 Orbital plate: internal view showing growth lines, orientation uncertain (AP 61; X 4).

Figure 4 Dorsal spine: vertical transverse section through posterior part of dorsal disc. Specimen laterally compressed; note ornament and inner pair of lateral carinae (AP 59a; X 5).

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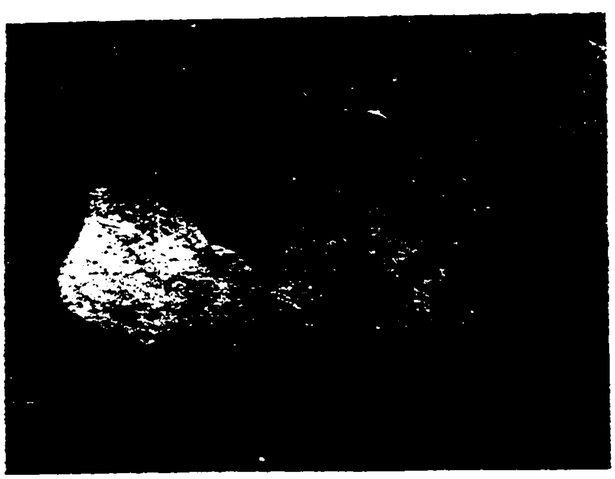

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PLATE 15

PLATE 16

Traquairaspis cf. *T. pococki* (White)

Figure 1 Ventral disc: internal view showing flat central area and marginal brim; note four-lobed anterior margin (AG 84; X 1.6).

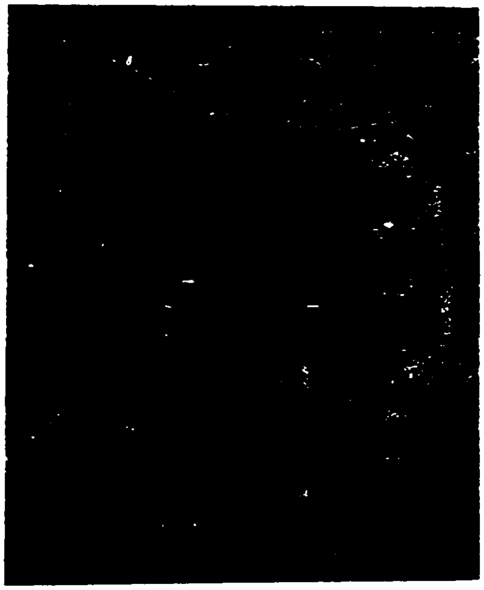
Figure 2 Ventral disc: internal view showing smooth central area and ornamented marginal brim (AB 87; X 1.3).

Figure 4 Dorsal spine: vertical section (AB 159; X 11).

Figure 5 Ventral disc: internal view showing flat central area and marginal brim; note transverse anterior margin (AB 64; X 1.6).

Traquairaspis rambaldi sp. nov.

Figure 3 Branchio-cornual plate: internal view of right plate. Note branchial opening, and cornual portion occupying plane contrary to remainder of plate (AN 78; X 2.1).



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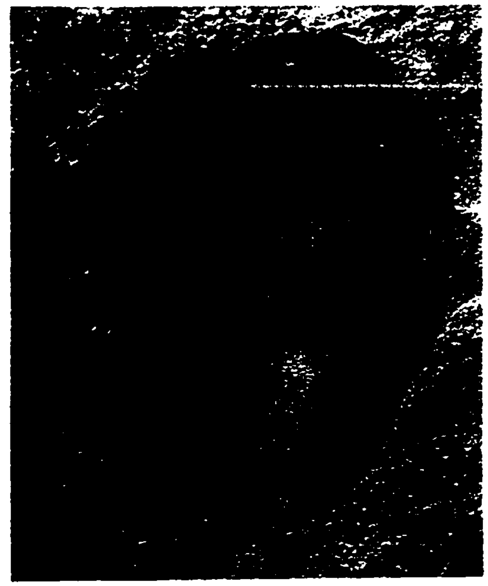

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PLATE 16

PLATE 17

Pseudotraquairaspis sp. *A* gen. et sp. nov.

Syntypes

Figure 1 Dorsal shield: internal view showing marginal brim, branchial channels, orbit, pineal macula and semi-circular canals (AB 107; X 1.6).

Figure 2 Ventral shield: note anterior median notch (AB 173; X 1.4).

Figure 3 Dorsal shield: internal view showing marginal brim, branchial channels, posterior median lobe, median ridge, orbits, pineal macula, semi-circular canals (AB 125a; X 1.4).

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PLATE 17

PLATE 18

Pseudotraquairaspis sp. *A* gen. et sp. nov.

Syntypes

Figure 1 Dorsal shield: internal view of partly etched specimen; note ornament of tubercles and fine ridges (AB 169; X 1.4).

Figure 2 Ventral shield: note smooth anterior margin (AG 143; X 1.3).

Figure 3 Dorsal shield: natural cast of exterior showing ornamentation of lacrimiform tubercles separated by fine ridges (AM 130; X 1.4).

Pseudotraquairaspis sp. *B* gen. et sp. nov.

Syntype

Figure 4 Dorsal shield: note branchial channel, posterior median lobe, and long median ridge (AK 117; X 1.3).

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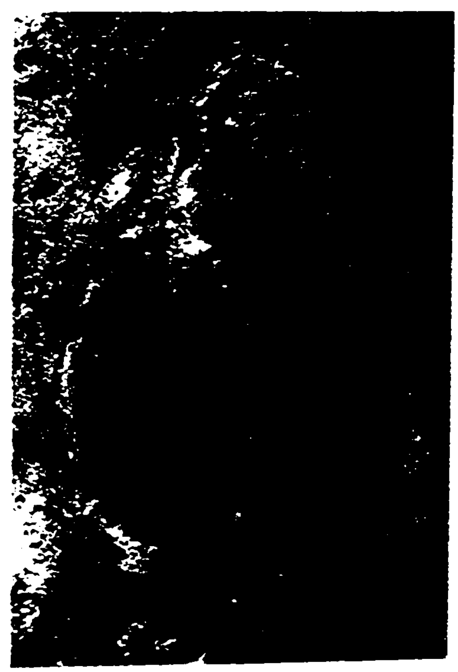

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PLATE 18

PLATE 19

Pseudotraquairaspis sp. *B* gen. et sp. nov.

Syntype

Figure 1 Ventral shield (AI 210; X 1.5).

Pteraspis (Simopteraspis) arctica sp. nov.

Holotype (AM 227)

Figure 2 Dorsal shield: internal view of right half; note blunt, rounded rostrum, dorsal spine, orbit, elongate branchial opening, impressions of one semi-circular canal and six gill pouches (X 3).

Figure 3 Dorsal spine: tip is incomplete (X 8).

Figure 4 Dorsal shield:detail of anterior region in internal view; note orbit and pineal macula; ornament follows junction of median, rostral, orbital and pineal plates (X 11).

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PLATE 19