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CAMBRIAN STRATIGRAPHY AND TRILOBITE FAUNAS OF SOUTHEASTERN NEWFOUNDLAND

R. D. Hutchinson

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By

R. D. Hutchinson

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PREFACE

Cambrian rocks of Newfoundland occur as widely scattered, poorly exposed outcrops. They have, in the past, presented many problems to the field geologist, and have proved difficult to correlate from one locality to another. Although the rocks are sparsely fossiliferous, at each major outcrop the author was able to collect representative suites of fossils, which he related to the standard zones of the Cambrian period. From there, it was but a short step to establishing a workable system of formations for the whole region.

The sequence of Cambrian faunas follows that of western Europe rather than that of continental North America, thus affording further convincing evidence that the Cambrian world was divided into several distinct faunal and stratigraphic provinces.

J. M. HARRISON,
Director, Geological Survey of Canada

OTTAWA, October 4, 1961

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CAMBRIAN STRATIGRAPHY AND TRILOBITE FAUNAS OF SOUTHEASTERN NEWFOUNDLAND

Abstract

Cambrian rocks of southeastern Newfoundland occur in scattered outcrops, mainly on Avalon and Burin Peninsulas, and comprise a miogeosynclinal sequence of dominantly shaly rocks, with minor limestone, siltstone, and sandstone. The rocks are commonly metamorphosed, poorly exposed and sparsely fossiliferous, and correlation of the various local sequences has hitherto proved difficult owing to lack of faunal control.

This report provides detailed stratigraphic sections and systematic descriptions of many genera and species, including seventeen new trilobite species. The faunal sequence is similar to that of western Europe. Three Lower Cambrian zones are recognized with varying degrees of certainty; in ascending order they are named: *Coleoloides, Callavia,* and *Protolenus.* Four Middle Cambrian zones are characterized by species of *Paradoxides.* Upper Cambrian zones of *Agnostus pisiformis, Olenus,* and *Parabolina* occur, and unfossiliferous beds overlying the *Parabolina* zone may correlate with the *Leptoplastus* zone of Europe. The youngest Cambrian beds contain *Peltura scarabaeoides* and are assigned to the *Peltura* zone. The Cambrian is overlain by Lower Ordovician shales with *Shumardia* and *Dictyonema flabelliforme.*

Résumé

Les roches cambriennes du Sud-Est de Terre-Neuve se présentent sous forme d'affleurements disséminés, surtout dans les presqu'îles Avalon et Burin; elles comprennent une succession miogéosynclinale composée principalement de roches argileuses, de même qu'un peu de calcaire, de siltstone et de grès. Ces roches sont en bien des endroits métamorphisées. Leurs affleurements sont généralement mauvais et fossilifères qu'en des endroits épars. Jusqu'ici, il a été difficile d'établir une corrélation entre les diverses successions locales vu le manque d'une faune caractéristique.

Le présent rapport renferme des coupes stratigraphiques détaillées et des descriptions systématiques de plusieurs genres et espèces, y compris dix-sept nouvelles espèces de trilobites. La succession de la faune s'apparente à celle de l'Europe occidentale. On a reconnu, avec plus ou moins de certitude, trois zones appartenant au Cambrien inférieur. Elles se nomment, par ordre ascendant: zone à *Coleoloïdes,* zone à *Callavia* et zone à *Protolenus.* Le Cambrien moyen est représenté par quatre zones caractérisées par les espèces des *Paradoxides.* Le Cambrien supérieur est représenté par les zones à *Agnostus pisiformis,* à *Olenus* et à *Parabolina;* et les couches non fossilifères, qui recouvrent la zone à *Parabolina,* pourraient bien être l'équivalent de la zone à *Leptoplastus* de l'Europe. Les couches cambriennes les plus récentes contiennent des *Peltura scarabaeoides,* et l'auteur les attache à la zone à *Peltura.* Les roches cambriennes sont recouvertes par des schistes de l'Ordovicien inférieur à *Shumardia* et à *Dictyonema flabelliforme.*

Chapter I

INTRODUCTION

The Cambrian rocks of southeastern Newfoundland occur in widely scattered outcrops, mainly on Avalon and Burin Peninsulas, with minor extensions onto the main part of the island of Newfoundland to the west of Trinity Bay and north of Fortune Bay. These rocks are commonly poorly exposed, are somewhat metamorphosed, and are only sparingly fossiliferous at most localities. For these reasons, previous workers engaged in geological mapping in this region encountered difficulty in correlating the Cambrian rocks from map-area to map-area, so that differing rock sequences were referred to the Cambrian in different parts of eastern Newfoundland. To rectify the resultant stratigraphic confusion the writer was assigned by the Geological Survey of Canada to study the Cambrian rocks of the region, and a part of the field season of 1951 and the entire seasons of 1952 and 1955 were spent investigating these rocks.

St. John's, the main centre in the area, is readily accessible by rail or air. From St. John's, a good network of main roads provides access to the larger centres of population. There are few secondary roads and many Cambrian outcrops remote from the main towns are most conveniently reached by sea. A few areas, inaccessible by both road and water, must be reached on foot.

Previous Geological Work

Geological work done on the Cambrian rocks of the region prior to 1925 has been summarized by Howell (1925, pp. 11-19)[1], who made a detailed, bed-by-bed study of the Middle Cambrian rocks exposed along Manuels River, on the east shore of Conception Bay. In his report he listed fossils collected from each bed and described several new species of trilobites. Later, Resser (1937) described several more species of trilobites from the area, although he did no new field work. Bogert (MS., 1938), of the Newfoundland Geological Survey, studied the Smith Point limestone in the Trinity Bay region as a possible source of limestone for portland cement, and in his report outlined briefly the distribution of the Cambrian rocks along the east shore of Trinity Bay.

No other studies dealing specifically with the Cambrian rocks have been published. However, in the course of geological mapping within the region, both by the Newfoundland Geological Survey and the Geological Survey of Canada, several workers have mapped the distribution of Cambrian rocks, described their stratigraphy, and in some instances provided lists of the fossils collected within individual map-areas.

[1] *Names and dates in parentheses are those of references cited in the Bibliography.*

Scope and Method of Work

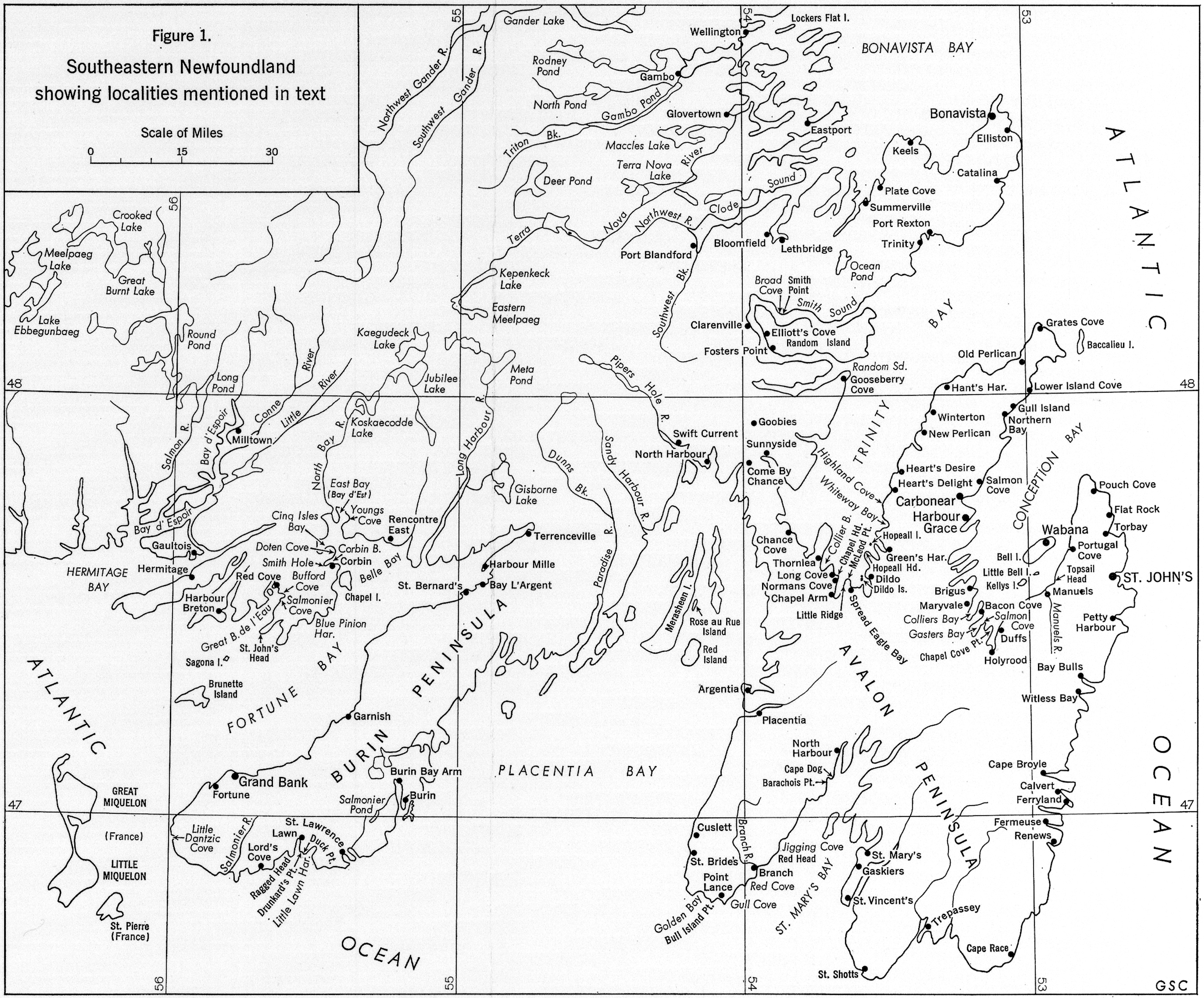
The chief purposes of the present study were to work out the stratigraphy, correlation, and sequence of faunas of the Cambrian rocks. No effort was made to map their exact distribution, as this had been adequately known for most of the region from previous geological mapping by officers of the provincial and federal Geological Surveys.

The field work consisted of a search for, and study, measurement, and collection of faunas from the best-exposed sections of the Cambrian rocks. These rocks, because they are softer than most other rocks of the region, are commonly well exposed only along the sea-coasts, or along the valleys of the larger rivers. Accordingly, shoreline reconnaissance surveys were made by canoe or chartered boat of all areas where Cambrian rocks were known, or were thought likely to be exposed. When a satisfactory section was located, as much time as necessary was devoted to its study. In areas of Cambrian rocks where no well-exposed sections could be found, an effort was made to piece together composite sections from study of isolated exposures. Commonly, however, this proved unsatisfactory, because of the metamorphism and scarcity of fossils at most localities. In all, twenty-two fairly satisfactory sections were found and studied in detail. These sections are presented as Appendix I of this report. In several other areas where lack of continuous exposure prevented detailed measurements, Cambrian rocks were studied and fossil collections were made.

This study, though of a reconnaissance nature, probably located most of the better-exposed Cambrian sections within the region, although future more detailed mapping may reveal some that were missed.

Acknowledgments

Assistance and advice of many former colleagues on the staff of the Geological Survey of Canada are acknowledged, in particular L. J. Weeks, Hans Frebold, W. D. McCartney, S. E. Jenness, E. R. Rose, A. M. Christie, and D. Bradley. The writer was assisted in the field by J. MacKillop, K. Stewart, D. Magnusson, J. Scott, K. Ewing, in 1951; D. Magnusson and S. Nording, in 1952; and Rev. Father R. Sanschagrin, OMI, and H. Harvey, in 1955. Thanks are also due to various present and former members of the staff of the Newfoundland Department of Mines, in particular to C. Howse and D. M. Baird, for assistance in carrying out the field work, and for discussions of the results. The residents of the area were uniformly helpful during the execution of the field work. Dr. G. A. Cooper of the U.S. National Museum and Dr. M. A. Fritz of the Royal Ontario Museum kindly loaned fossil specimens for study.



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Chapter II

OUTLINE OF CAMBRIAN SYSTEM IN SOUTHEASTERN NEWFOUNDLAND

Outcrops are found in numerous, widely scattered basins southeast of a line joining the head of Bay d'Espoir and the head of Clode Sound, Bonavista Bay (*see* Fig. 1). They commonly occur as synclinal or downfaulted remnants surrounded by large areas of Precambrian rocks, but north of Fortune Bay, metamorphosed Cambrian rocks are known as roof pendants in batholithic intrusions of probable Devonian age. The Cambrian rocks, in general, are less resistant to erosion than the other rocks of the region, and therefore commonly underlie lowland areas. However, near the head of Trinity Bay, and on the west shore of St. Marys Bay, massive lava flows, breccias, and intrusive dioritic sills and dykes are interbedded with and intrusive into the Cambrian sedimentary rocks. These igneous rocks are more resistant and form prominent ridges breaking the general lowland surface of the Cambrian basins.

The Cambrian rocks of southeastern Newfoundland comprise a miogeosynclinal sequence of dominantly shaly rocks, with minor limestone, siltstone, sandstone, and, locally, a basal conglomerate. The Lower Cambrian rocks are mainly red, purple, or green shale or slate, commonly with limestone nodules; however, a thin formation of red limestone occurs over most of the area. The Middle Cambrian rocks consist of dark green, grey, or black shale or slate with nodules and thin beds of limestone with thin volcanic lavas in one area. Locally, the Middle Cambrian is represented by green to grey siltstone, sandstone, and silty shale. The Upper Cambrian rocks comprise grey to black, micaceous, silty shale, with some massive, quartzitic siltstone, and nodules of black limestone. Early Ordovician rocks are present in two basins, and are lithologically like the underlying Upper Cambrian beds. The thickness of the Cambrian system within the area varies from less than 1,000 feet to an estimated maximum of 4,000 feet.

The degree of folding and metamorphism varies from basin to basin. In some areas, these rocks are gently folded into broad, open folds with low dips, and are not metamorphosed. Most commonly, they are more intensely folded into a series of tight drag-folds on the limbs of larger folds, with high dips, and with development of strong fracture cleavage in the shaly beds. Near their contacts with younger intrusive rocks, the Cambrian shales are generally changed by contact metamorphism into a dense hornfels.

Lithological development is fairly constant so that stratigraphic units can be traced over large areas without marked changes in lithology. Important facies changes do occur on the north shore of Fortune Bay, however, where the Middle Cambrian rocks are more coarsely clastic than those farther southeast, and the Upper Cambrian beds are finer grained than their equivalents elsewhere in the area. Less important facies changes, which are described in the detailed description of formations, were noted at a few localities.

Distribution of Cambrian Rocks

Conception Bay

From Topsail Head to Duffs, Cambrian rocks outcrop in a strip up to 2 miles wide along the southeast shore of Conception Bay. They rest with angular unconformity on Precambrian Harbour Main rocks, and their strike is nearly parallel to the shore, with dip at angles as much as 15 degrees beneath the bay. They are not metamorphosed. The Cambrian outcrop is cut off by a high-angle fault to the northeast, and by the waters of Holyrood Bay on the southwest. Lower, Middle, and Upper Cambrian beds are all represented; in addition, Lower Ordovician beds are believed to underlie the floor of Conception Bay between the mainland and Kellys Island, but are not exposed on shore. The Ordovician rocks of Kellys, Bell, and Little Bell Islands, which have previously been described (Rose, 1952), were not restudied.

On the west side of Conception Bay, outcrops occur at Chapel Cove Point; in Salmon Cove, Gasters Bay; at Bacon Cove; near Marysvale, just west of Colliers Bay; and on each side of the entrance to Brigus Harbour. Only Lower Cambrian and earliest Middle Cambrian rocks are represented. They are more strongly folded than on the east side of Conception Bay, and are somewhat metamorphosed with development of strong cleavage intersecting the bedding at a high angle.

Trinity Bay

Outcrops occur in a broad synclinorium about the head of Trinity Bay. The east limb of the fold is exposed along the east shore of the bay from Heart's Desire to Heart's Delight, and from Heart's Delight to the north shore of Whiteway Bay. It outcrops again on the Red Rocks in Whiteway Bay; on the point north of Greens Harbour; on Hopeall Island; Hopeall Head; and on the Dildo Islands.

The entire synclinorium is well exposed along the south shore of Trinity Bay. The eastern limb outcrops from the middle point of Spread Eagle Bay westward past McLeod Point and along the east shore of Chapel Arm. The axis of the synclinorium lies along Chapel Arm, and the western limb is exposed along the west shore of the arm past Chapel Point into Long Cove. Both limbs are complicated by a series of tight drag-folds. The synclinorium plunges northeastward under Trinity Bay. Its extension inland has been traced by McCartney (1956) just beyond the right-of-way of the Canadian National Railways (Newfoundland Division), where it pinches out.

Cambrian strata underlie several smaller areas inland from the head of Trinity Bay, and outcrop farther west from the head of Collier Bay to Thornlea, on the west side of that Bay.

The main Trinity Bay synclinorium exposes the entire Lower and Middle Cambrian sequence, and the lowest beds of the Upper Cambrian. The other outcrops are thought to expose only the Lower Cambrian. Throughout the area, the Cambrian rocks are tightly folded and the shaly beds are metamorphosed into strongly cleaved slates.

St. Marys Bay

Outcrops occur at Cape Dog, Barachois Point, and on the north shore of Jigging Cove. Two small synclines northwest of St. Marys Bay also expose Cambrian rocks. A large outcrop, with interbedded diorite sills, extends in a series of folds from the north side of Red Head past Branch, Red Cove, Gull Cove, Point Lance, Bull Island Point, and into Golden Bay. Along this shore, the Cambrian rocks outcrop in the bays, whereas the points are underlain by massive, thick diorite sills which intrude the Cambrian. The exact inland extension of this basin was not determined, but Cambrian rocks outcrop over a wide area on both sides of Branch River for several miles above its mouth. Lower, Middle, and early Upper Cambrian rocks are present in this area. Another Cambrian basin in which only Lower Cambrian rocks were recognized outcrops on the east shore of Placentia Bay, near St. Bride's. This basin extends inland as a narrow syncline for about 5 miles to its termination immediately south of Gooseberry Cove (McCartney, unpublished).

Throughout this region, the Cambrian rocks are thrown into broad open folds, and well-developed slaty cleavage is present in the shaly beds. Near their contacts with the younger intrusive rocks, the Cambrian slates are metamorphosed over a distance of a few feet into a dense, compact, dark hornfels.

Placentia Bay

Cambrian rocks occur on Red Island, Merasheen Island, near North Harbour, and at Come by Chance. They also outcrop at Sunnyside, on Trinity Bay, just across the peninsula from Come by Chance, and near Goobies, in the central part of the peninsula.

In this area, the Cambrian rocks are strongly folded and faulted, and moderately metamorphosed. In some localities, they are intruded by granite and have undergone strong contact metamorphism. The complex structure and metamorphism, coupled with a lack of continuously exposed sections, made it impossible to work out the exact sequence of Cambrian rocks in this area. Only Lower Cambrian beds were recognized on Merasheen Island and near the head of Placentia Bay, but Middle Cambrian and probably Upper Cambrian rocks are also present on Red Island.

Clarenville Area

One of the most important Cambrian basins in southeastern Newfoundland lies on the western tip of Random Island, Trinity Bay, and on the adjacent mainland north of Smith Sound, near Clarenville. Other smaller basins occur farther east along the shores of Smith and Random Sounds, and at Ocean Pond, northeast of Clarenville. These outcrops lie within the Bonavista map-area, and their distribution is shown on the geological map of that area (Christie, 1950).

The large Cambrian outcrop on the western tip of Random Island occurs in a broad, faulted syncline, with a subsidiary anticlinal fold in the central part. The entire Cambrian sequence is represented, and early Ordovician (Tremadocian) rocks are also present. Around the margins of the basin, the rocks dip fairly steeply and regularly inward, but in the central part, where the Upper Cambrian and Tremadocian rocks outcrop, they are closely folded and contorted into many small drag-folds, so that the detailed structural pattern is obscured. The presence of an anticlinal fold in the central part of the basin is inferred from the palæontological evidence. The rocks are not metamorphosed in this basin.

Outcrops on Smith and Random Sounds occur in fairly tightly folded and commonly faulted synclines. Only Lower and Middle Cambrian beds are represented, and they have undergone a low grade of regional metamorphism with the development of strong cleavage in the argillaceous beds.

Bonavista Bay

Christie (1950) found Lower Cambrian rocks outcropping in a tightly folded syncline at Keels, on the south shore of Bonavista Bay. This represents the northernmost known occurrence of these rocks in eastern Newfoundland, and their only definitely known exposure in the Bonavista Bay region. However, both Christie and Jenness report (personal information) that a few feet of green shales, with limestone nodules, occur on two small islands off the northwest side of Lockers Flat Island, far to the north on the west side of Bonavista Bay. Lockers Flat Island itself is underlain mainly by green siltstones, with minor white quartzite, which are probably referable to the Random formation. The probable Cambrian rocks either overlie these strata, or are faulted against them; on both structural and lithological evidence, therefore, these shale beds probably represent the base of the Cambrian system (S.E. Jenness, personal communication). If this is true, then Cambrian deposition must have extended well to the north in Bonavista Bay.

Burin Peninsula

Cambrian rocks outcrop in several different localities on Burin Peninsula between Placentia Bay and Fortune Bay. Within the St. Lawrence map-area, on the southeast side of the peninsula, Cambrian beds are exposed on both sides of Burin Bay Arm, around Salmonier Pond, on the northwest side of Little Lawn Harbour, on Duck Point and Drunkard's Point, between Little Lawn and Great Lawn Harbours and on Ragged Head, west of Great Lawn Harbour (vanAlstine, 1948). Farther west, in Grand Bank map-area, at the west tip of Burin Peninsula, Cambrian rocks underlie the point east of Lords Cove, part of the valley of Salmonier Brook, and the valley which extends from Little Dantzic Cove northeastward across the peninsula to the town of Fortune (Walthier, 1948). Farther west, Cambrian rocks are exposed on the island of Langlade, in the French possession of St. Pierre and Miquelon (Aubert de la Rue, 1941). These occurrences represent synclinal downfolds, or downfaulted blocks, where the Cambrian has been preserved in structurally low areas.

Exposures on Burin Peninsula are stratigraphically, lithologically, and palæontologically similar to those on Avalon Peninsula, and the same formational units can be recognized in both areas. Only Lower and Middle Cambrian rocks are known on Burin Peninsula, although it is possible that unfossiliferous black shales in the uppermost part of the Cambrian on Burin Bay Arm and in Fortune Brook valley may represent the lowest beds of the Upper Cambrian.

Structurally, the Cambrian rocks of Burin Peninsula are more deformed than those elsewhere in eastern Newfoundland. They are commonly disturbed by many small folds and by numerous steep-angle faults of small displacement; for these reasons, and because outcrops are generally discontinuous, no unbroken section of these rocks is known. Several partial sections were measured and described, however. Despite the stronger folding to which they have evidently been subjected, Cambrian rocks in this area are less metamorphosed than their counterparts on Avalon Peninsula. Slaty cleavage is lacking or very poorly developed in the shaly beds. Finer bedding features, such as ripple-marks and laminations, which are commonly destroyed by metamorphism elsewhere in the region, are well exhibited in the Cambrian beds on Burin Peninsula.

North Shore of Fortune Bay

Cambrian rocks are sparingly exposed in a few areas on the north shore of Fortune Bay. They are evidently lacking in the Terrenceville map-area at the head of the Bay, but farther west, they outcrop in Youngs Cove, Bay d'Est, and in Cinq Isles Bay and Corbin Bay, in Belle Bay (White, MS. 1939). Still farther to the west, in Hermitage Bay map-area, Cambrian rocks outcrop in Blue Pinion Cove, along the east side of Great Bay de l'Eau, at St. John's Head, and on Sagona Island (Widmer, MS. 1950).

Lower Cambrian has not been definitely identified north of Fortune Bay, and is believed to be lacking. A sequence of unfossiliferous red and green siltstones and sandstones in the Belle Bay area was referred to the Lower Cambrian by White and by Widmer, but these rocks are lithologically more like the Proterozoic (Hodgewater and Musgravetown groups) rocks of other parts of eastern Newfoundland, and in the absence of palæontological evidence of their Cambrian age, the writer prefers to regard them as Proterozoic. Middle and Upper Cambrian, and Lower Ordovician (Tremadocian) rocks are, on palæontological evidence, all known to be represented. They are lithologically different from the beds of the same age elsewhere in the region and cannot be classified into the same formations. These differences are described, and their significance discussed, in a later section of this report (pp. 45-47).

The Cambrian rocks of Fortune Bay outcrop in a different structural setting from those elsewhere in eastern Newfoundland. They occur in small, structurally high areas, surrounded by large outcrops of younger rocks, rather than in structurally low areas. The rocks have been strongly folded and faulted and are intruded by later igneous rock masses at many localities. They have undergone a moderate degree of regional metamorphism, so that most primary bedding features have been destroyed. The sandy and silty beds have recrystallized to quartzites, and slaty cleavage has developed in the argillaceous beds. Near the younger intrusive rocks, the Cambrian beds have undergone strong contact metamorphism.

Chapter III

CAMBRIAN STRATIGRAPHY OF AVALON-BURIN PENINSULAS

Previous workers have classified the Cambrian rocks of southeastern Newfoundland into numerous formations for purposes of description and mapping. The present study has shown that, in general, the lithological sequence of these deposits is remarkably uniform throughout the region, so that a common set of formational names can be applied everywhere except on the north shore of Fortune Bay. In that area, the Cambrian sequence is different lithologically and a separate sequence of formational names is needed. The classification believed by the author to be best suited to the description and geological mapping of these rocks throughout the region is shown in the following table of formations. The stratigraphy of the area north of Fortune Bay is described in Chapter IV.

Description of Formations

Lower Cambrian Formations

Bonavista Formation

Name. Van Ingen (1914) proposed the name Bonavista for the lowest formation of the Cambrian rocks in the area about Conception and Trinity Bays. He described the rocks as comprising red and green shales with limestone nodules, containing the *Coleoloides* fauna which had previously been described by Matthew (1899). No type section was designated and the name is not an apt one, as these beds are not known to outcrop near the town of Bonavista. Indeed their only known outcrop in the entire Bonavista Bay region is at the village of Keels, some 20 miles south and west of Bonavista. This occurrence was first recognized by Christie in 1949, and could not therefore have been known to van Ingen. It seems likely that van Ingen had studied these rocks at the famous Smith Sound section on Trinity Bay, which was well known because of the earlier work by Walcott and Matthew, and that he applied the name Bonavista to them on the mistaken assumption that they should be well exposed in the Bonavista region. The writer therefore regards the section of these rocks in Smith Sound, which comprises beds 2e to 2j of Walcott's (1900a) section, as the type section. However, van Ingen's term Bonavista formation has been retained, even though it is poorly chosen, because it has been widely used and any change would cause confusion in the literature.

Distribution and thickness. The Bonavista formation is best developed and thickest in its northernmost outcrops. At Keels on the south shore of Bonavista Bay, Christie measured 465 feet of beds referable to the formation, with an unknown thickness of beds lacking at the top of the section. In the section at Smith Sound, here

Table of Formations (Avalon-Burin Peninsulas)

Epoch	Group	Formation	Lithology	Palæontological Zones
Lower Ordovician			Grey to black, micaceous shale, minor green and grey quartzitic siltstone	*Shumardia* *Dictyonema flabelliforme*
Possible disconformity — no angular discordance				
Upper Cambrian	Elliott Cove		Grey, green, to black silty, micaceous shale or slate and siltstone, rare grey or black cone-in-cone limestone concretions	*Peltura* *Parabolina* *Olenus* *Agnostus pisiformis*
Probable disconformity — no angular discordance				
Middle Cambrian		Manuels River	Grey to black shale or slate, with numerous thin beds and lenses of grey or black limestone, locally includes Chapel Arm volcanic rock member	*Paradoxides forchammeri* *P. davidis* *P. hicksi*
		Chamberlain's Brook	Green shale or slate, with minor limestone, locally includes red members near base and basal black manganiferous bed	*Paradoxides bennetti*
Probable disconformity — no angular discordance				
Lower Cambrian		Brigus	Red, purple, green shale or slate, minor red or pink limestone as thin beds or nodules	*Protolenus*? *Callavia*
		Smith Point	Pink, red, or green, wavy bedded locally algal limestone	
		Bonavista	Red, green or purple shale or slate, minor pink or green limestone, locally with basal conglomerate	*Coleoloides*
Major angular unconformity in Conception Bay area, disconformity elsewhere				
Proterozoic	Various groups and formations underlie Lower Cambrian rocks		Sedimentary and volcanic rocks of varying lithology	None

designated the type section, the upper 444 feet of beds are exposed, but these rocks are separated by an unexposed interval from the lowest beds of the formation, which rest on Random rocks farther along the shore. From a comparison with other partial sections studied nearby, the writer estimates that about 200 feet of beds are lacking in this section, so that the thickness of the formation in its type area is probably about 650 feet. The formation is well exposed but much thinner around the head of Trinity Bay, where it measures 171 feet at Heart's Delight, 101 feet on Hopeall Head, and 77 feet in Long Cove, Chapel Arm. At Brigus, on the west shore of Conception Bay, it comprises 100 feet of beds, but at Duffs and at Manuels, on the east shore of the Bay, the formation is lacking. It is very thin near the head of St. Marys Bay, measuring 28 feet at Cape Dog and 18 feet at Barachois, and is entirely lacking in Jigging Cove on the southwest shore of St. Marys Bay. A few miles to the west, however, the formation thickens to 215 feet at Cuslett, on the east shore of Placentia Bay. To the north, near the head of Placentia Bay, it is at least 225 feet thick although its true thickness could not be determined because of lack of continuously exposed sections. On Burin Peninsula, the formation is represented by an estimated minimum thickness of 50 feet of beds around St. Lawrence and Lawn, but is lacking at Little Dantzic Cove, on the west tip of Burin Peninsula, and on the north shore of Fortune Bay. The isopach map (Fig. 2) shows the distribution and thickness of this formation.

Lithology. The Bonavista formation comprises mainly red, green, purple, and variegated shale or slate, with many nodules and thin beds of grey, pink, or red limestone. A bed of red or white quartz-pebble conglomerate generally with a limestone cement is commonly present at the base. This bed is only a few inches thick at most localities, but locally is as much as 4 feet thick. Thin, local, lenses of red massive siltstone and sandstone were observed near the base of this formation at several localities. A persistent bed of dark grey to black, silty shale or slate 2 to 3 feet thick comprises the uppermost bed of this formation in the area near the head of Trinity Bay, but it has not been seen elsewhere. Details of the lithology of the formation are given in the measured sections in the appendix.

Structure. The Bonavista formation rests with a minor disconformity on the white quartzites of the Random formation. The evidence for the existence of this disconformity is presented in detail in the section of this report dealing with the base of the Cambrian (p. 41). Throughout the region, the Bonavista formation is overlain conformably by the Smith Point formation.

Age and correlation. Matthew (1899) described a small fauna of hyolithids and brachiopods from the rocks of this formation at Smith Sound, Trinity Bay. A similar fauna was found by the writer on Trinity Bay at Sunnyside and at Chapel Arm, and on Placentia Bay at Come by Chance and on Rose au Rue Island. Christie collected similar fossils at Keels, Bonavista Bay. Elsewhere, the formation is apparently unfossiliferous. No trilobites have ever been found in these rocks. Matthew referred the fauna to his Etcheminian system, which he regarded as a fossiliferous system below the Cambrian. Later workers, however, have regarded the Etcheminian

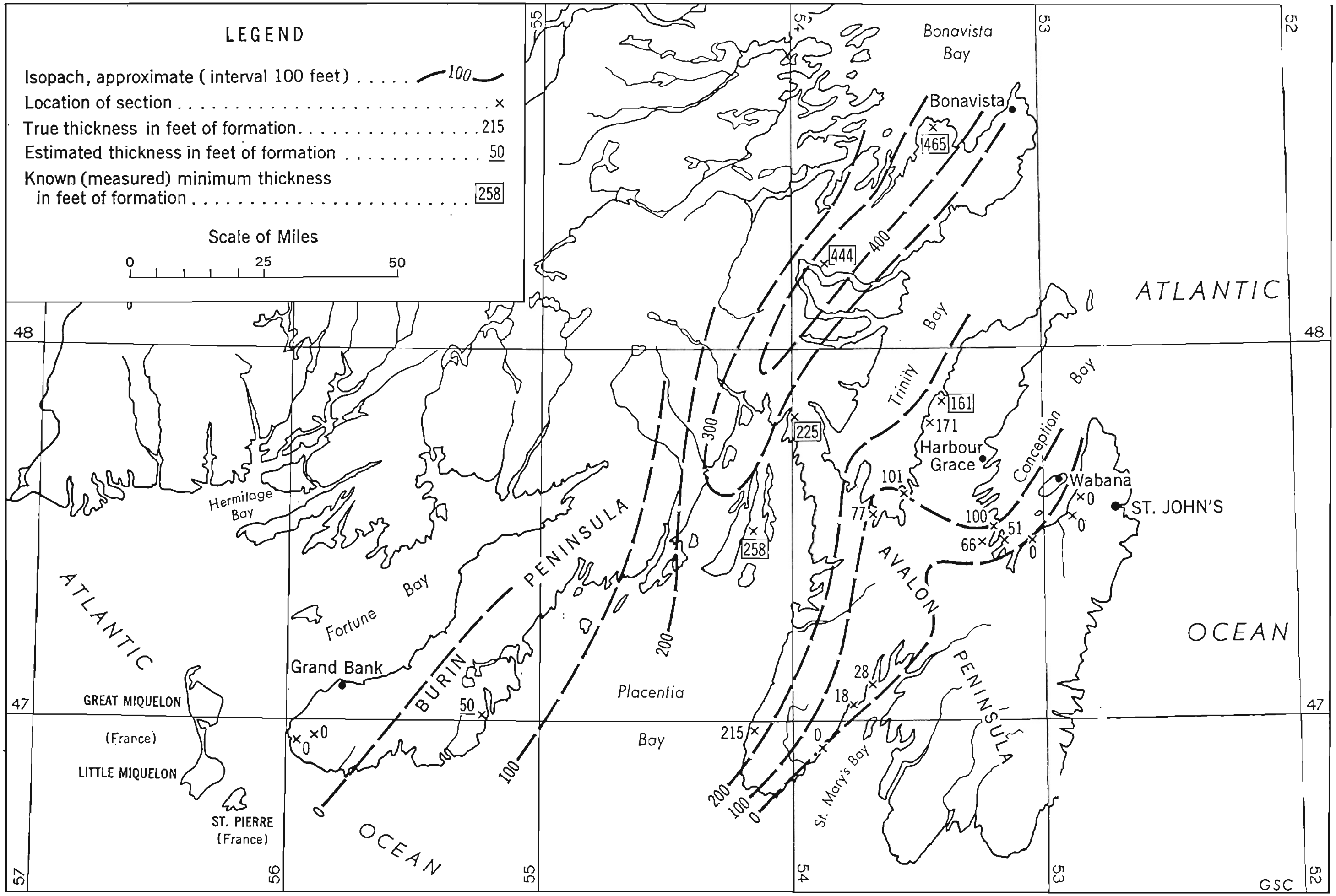

Figure 2. *Isopach map of Bonavista formation.*

faunas as basal Cambrian and the writer concurs in this opinion. The Bonavista is therefore classified as the earliest Cambrian formation of the region, and its fauna, typified by the primitive hyolithid-like organism, *Coleoloides,* is regarded as the most primitive Cambrian fauna. It is considered to mark a pre-trilobite Cambrian faunal zone throughout the area.

The Bonavista formation cannot be firmly correlated on palæontological evidence with any other Cambrian rocks in Canada, because the fauna which it contains has not been found elsewhere in the country. However, from its stratigraphic position, it may well be equivalent, in whole or in part, to unfossiliferous sandstone sequences elsewhere in Eastern Canada, such as the Morrison River formation of Cape Breton Island, the Ratcliffe Brook formation of New Brunswick, and the Bradore formation of northwestern Newfoundland. Each of these forms the basal unit of a Cambrian sequence which, higher up, carries marine trilobite faunas similar to those occurring in the rocks above the Bonavista formation. A fauna much like that of the Bonavista formation occurs in the *Obolella groomi* grit and the lower part of the Lower Comley sandstone of Comley, Shropshire, England (Cobbold and Pocock, 1934). Like the Bonavista formation, these rocks occur at the base of the Cambrian sequence, and are overlain by beds carrying *Callavia.* On the basis of similar stratigraphic position and faunal content, the Bonavista formation is correlated with these English formations, and probably also with the lowest Cambrian rocks of the Boston region, which contain a similar fauna (Grabau, 1901).

Smith Point Limestone

Name. Early workers of the Newfoundland Geological Survey noted a prominent bed of red limestone at many localities within the Lower Silurian (Cambrian) areas of southeastern Newfoundland. However, Walcott (1900a) was the first worker to apply a formal name to this unit, which he studied and measured in the well-exposed section along the north shore of Smith Sound, Trinity Bay. The type section is at Smith Point, just east of Broad Cove.

Stratigraphic position. Considerable confusion has arisen in the literature about the stratigraphic position of the Smith Point limestone. An inspection of Walcott's (1900a) original published section shows that the limestone formation to which he applied the name Smith Point occurs above a sequence of shale and shaly limestone (Bonavista formation of later writers) that lacks trilobites, and is overlain by a formation of lithologically similar rocks (Brigus formation of later authors) that contains marine trilobite faunas of Lower Cambrian age. The Smith Point was, in fact, the only limestone bed of substantial thickness in this entire measured section, although limestone beds as much as a few inches thick occur within the Bonavista and Brigus formations at this locality. The stratigraphic position of this formation was thus clearly understood and presented by Walcott when he first named it. Later, however, van Ingen (1914) in his table of formations located the Smith Point limestone above a formation of "red shales with nodular limestone", containing *Callavia broeggeri* (Walcott) and *Strenuella strenua* (Billings), which he named the Brigus formation. This he showed as resting on the basal Cambrian, non-trilobite-bearing Bonavista formation. In the sections at Smith Point and at Brigus, careful and prolonged collecting failed to disclose any trilobite fragments in the beds below the Smith Point limestone, which are evidently completely unfossiliferous at Brigus, and contain only the primitive fauna already discussed under the Bonavista formation in the Smith Sound section. At both localities, and in all other sections studied by the writer, the earliest trilobites occur either in the uppermost bed of the Smith Point, or in the lowest overlying red shale beds. Walcott was, therefore, correct in his original description of this sequence, and van Ingen erred in believing that the Smith Point limestone overlay the trilobite-bearing Brigus formation. This error has led several later workers to incorrectly correlate the Smith Point with formations elsewhere containing the *Strenuella-Callavia* fauna, or the succeeding *Protolenus* fauna. Professor B. F. Howell of Princeton University states (personal correspondence) that van Ingen believed the *Callavia*-bearing red shales exposed at several localities on the east shore of Conception Bay, to be older than the Smith Point limestone as exposed at Brigus. He may well have mistaken one of the thin red limestone beds, exposed within the Brigus formation east of Conception Bay, for a "wedge edge" of the Smith Point, and thus erred in interpreting its stratigraphic position.

Distribution and thickness. The Smith Point formation is present in all Cambrian areas about Trinity, St. Marys and Placentia Bays, and on the west shore of Conception Bay. It is lacking on the east shore of Conception Bay, on the western tip of Burin Peninsula, and about Fortune Bay. It may be present at Keels, Bonavista Bay, but if so, it is concealed below sea-level. This formation is 24 feet thick at the type section, but thickens to the southeast across Trinity Bay, where it attains its greatest known thickness of 50 feet at Heart's Desire and 42 feet at Heart's Delight. From there it thins eastward to 34 feet at Brigus, Conception Bay; 18 feet at Cape Dog, 15 feet at Barachois, and 14 feet at Jigging Cove Head, all in St. Marys Bay. It likewise thins to the west, measuring about 8 feet at Burin Bay Arm, and it is lacking in sections farther to the west. Its known thickness and distribution are shown in the isopach map (Fig. 3).

Lithology. The Smith Point formation typically comprises brick-red weathering, well-bedded, dense limestone, with shaly red partings, with or without included beds of red shale or slate containing numerous nodules of pink limestone. In the Trinity, Conception, and St. Marys Bay areas, it is commonly massive limestone, with only thin shaly partings, but about the head of Placentia Bay, and on the islands in that bay, it includes a 4- to 7-foot red shale or slate bed between two massive limestone members. It is commonly salmon-pink to reddish brown on fresh surface, but locally, near the head of Trinity Bay, the lower beds exhibit pale green or pink and green mottled colours.

The formation is fossiliferous throughout, although the fossils are commonly fragmentary and difficult to collect because the rock is so dense. At most localities, it contains numerous concentrically layered cabbage-shaped heads, presumably of algal origin. Locally these are so numerous as to form entire beds.

Its unusual, easily recognized lithology, coupled with the fact that it forms massive ridges with numerous outcrops, makes this formation the most useful

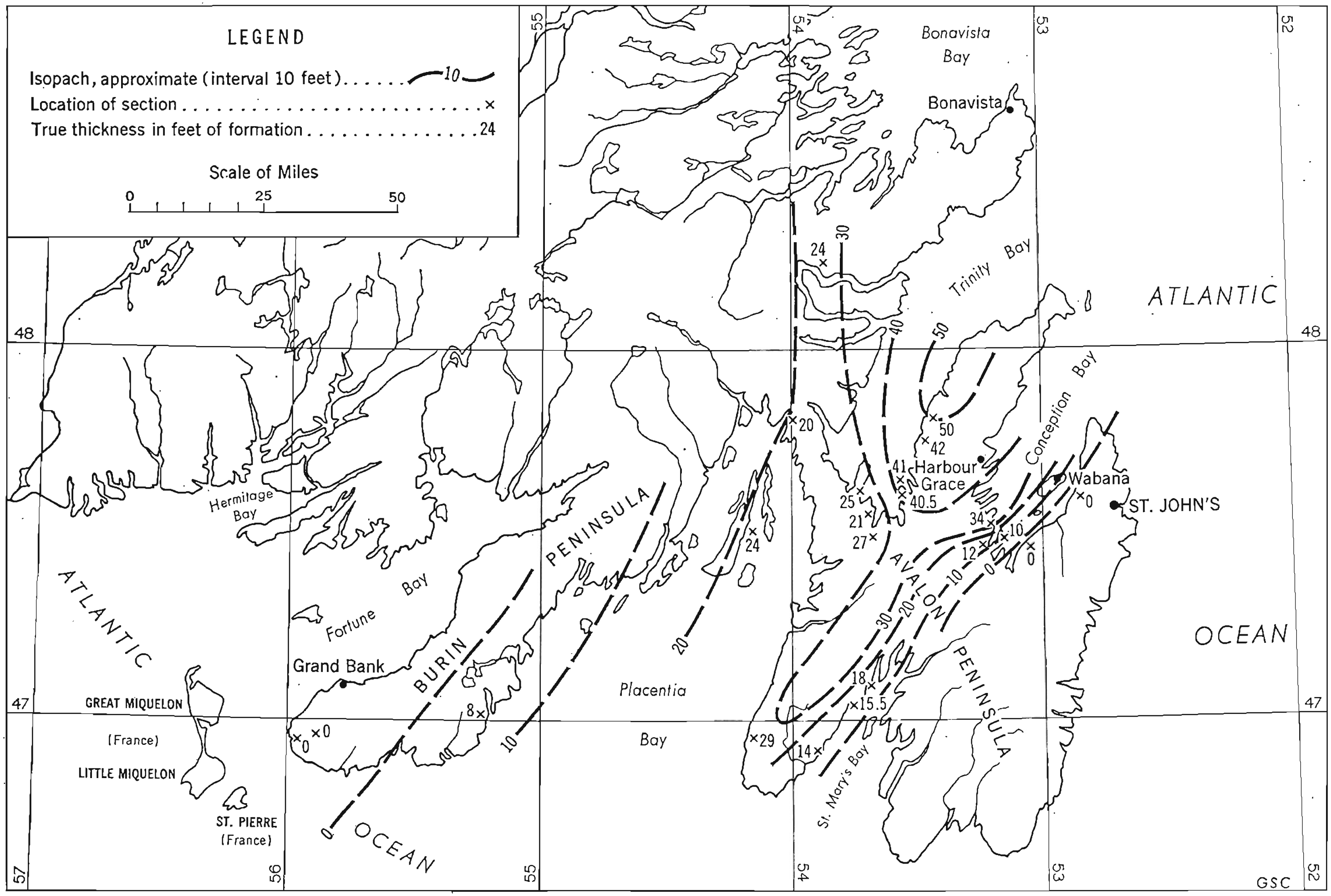

Figure 3. Isopach map of Smith Point formation.

horizon marker within the Cambrian sequence. It has been successfully traced throughout many of the inland outcrop areas of the Cambrian, where the other formations rarely outcrop and has thus enabled the distribution and structure of these rocks to be easily determined in areas where such results would otherwise have been difficult.

Structure. The Smith Point limestone conformably overlies the Bonavista formation and is in turn conformably overlain by the Brigus formation. At one locality, Jigging Cove Head on the west shore of St. Marys Bay, the underlying Bonavista formation is lacking, and the Smith Point begins with a one-foot bed of fine quartz-pebble conglomerate, with pink matrix, which rests with no visible angular discordance but with probable disconformity on crossbedded red sandstone and white quartzite of the Random formation.

Age and correlation. The Smith Point limestone is abundantly fossiliferous. Most of the formation contains only a primitive fauna of inarticulate brachiopods and hyolithids, similar to that found in the underlying Bonavista rocks, but the uppermost beds at several localities contain fragmentary trilobites, including a large olenellid (probably *Callavia broeggeri*), *Strenuella strenua,* and *Dipharus attleborensis.* The formation is, therefore, clearly of early Lower Cambrian age. The upper part is referable to the *Callavia* zone and the lower part to the pre-trilobite *Coleoloides* zone. The uppermost part, with its *Callavia* fauna, is readily correlated on palæontological evidence with the basal deposits of the *Callavia* zone elsewhere in the North Atlantic area, such as the red *Callavia* shale of the Boston area, Massachusetts, and with the *Callavia* limestone of Comley, Shropshire, England.

Brigus Formation

Name. The name Brigus formation was proposed by van Ingen (1914) for a sequence, which he described as red shales with nodular limestone, containing *Callavia broeggeri* and *Strenuella strenua,* and which he showed in his table of formations as occurring between the Bonavista and Smith Point formations. Neither the thickness of the formation nor the location of the type section was stated. However, the name must have been derived from the town of Brigus, on the west shore of Conception Bay, and the type section is here chosen within the completely exposed section of Lower Cambrian rocks that outcrop along the west shore of Conception Bay just south of the entrance to Brigus Harbour. As already explained, van Ingen was mistaken in placing the Smith Point limestone stratigraphically above the trilobite-bearing beds of the Brigus formation, for in all sections examined by the writer, trilobites occur only above the Smith Point. Because of this confusion in the stratigraphic position of the formation, the impossibility of determining exactly which beds van Ingen intended to include in this formation, and the varied use of the term Brigus since van Ingen first proposed it, the Brigus formation is here re-defined as the sequence of red and green shales and nodular limestones overlying the Smith Point formation, and underlying the widespread manganiferous shale and limestone at the base of the Middle Cambrian.

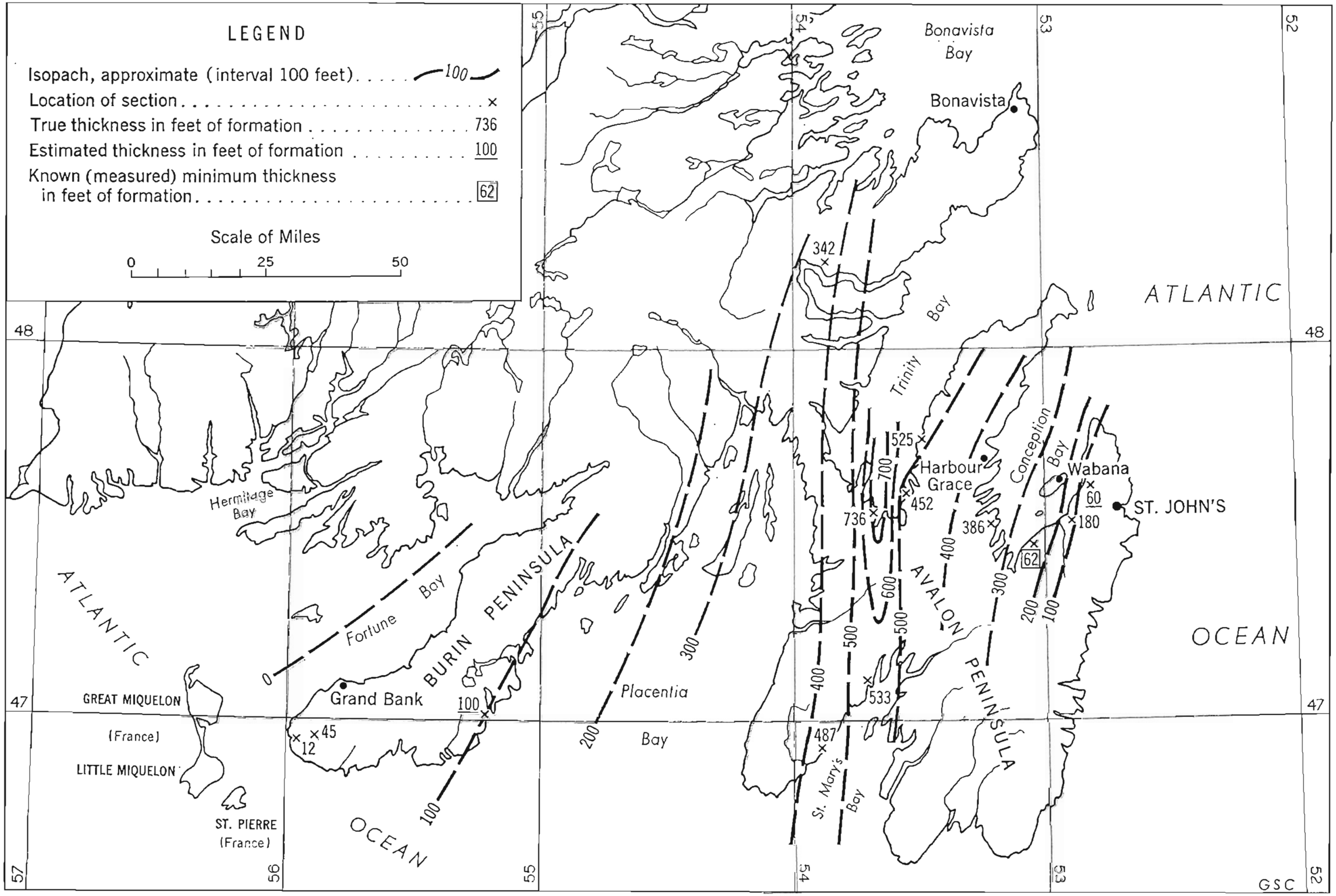

Figure 4. Isopach map of Brigus formation.

Distribution and thickness. The Brigus formation is known throughout the Cambrian areas of southeastern Newfoundland, except at Keels on Bonavista Bay, where if present it is concealed beneath the water of that bay, and on the north shore of Fortune Bay, where it is believed to be lacking, probably by non-deposition. The thickness of the formation varies considerably throughout the area (*see* Fig. 4). The formation attains a maximum thickness of 736 feet at Chapel Head, Trinity Bay, and thins in every direction from there. To the south, it measures 533 feet at Cape Dog, 487 feet at Jigging Cove Head, St. Marys Bay, and at least 62 feet at Cuslett, Placentia Bay. To the north, it measures 452 feet on the south side of Hopeall Head, and 332 feet in the section at Smith Point. To the east, it is 386 feet thick in the type section at Brigus, Conception Bay, and 60 feet at Manuels. No well-exposed sections of these rocks are known to the west, but the Brigus is probably not more than 200 feet thick around Burin Bay Arm and certainly is less than 60 feet at Little Dantzic Cove, on the tip of Burin Peninsula.

Lithology. The formation typically comprises red, pink, and green shale or slate with nodules and thin beds of pink, green, or grey nodular limestone. A basal conglomerate bed is included in the Brigus formation where it locally overlaps the older Cambrian formations and rests directly upon Precambrian rocks. Red and green slates are interbedded throughout the formation in thick beds and lenses, but red members commonly predominate in the lower part, whereas green members comprise most of the upper part. The limestone-bearing members are much more numerous in the lower part of the formation than they are in the upper part.

Locally, a conglomerate bed occurs at the base of the Brigus formation. The famous basal Cambrian conglomerate on Manuels River, Conception Bay, which has been described by several workers, is here referred to the Brigus. It comprises about 20 feet of coarse, well-bedded conglomerate, composed of pebbles and small boulders derived mostly from the underlying volcanic rocks of the Harbour Main group (Rose, 1952). This occurrence is unique, however, for at all other localities where the Brigus is known to rest on Precambrian rocks, the basal bed comprises only a foot or 2 feet of very fine quartz-pebble conglomerate of coarse quartzose sandstone, commonly with a red limestone matrix. Such a conglomerate occurs at Manuels Station, only a few hundred feet south of the occurrence on the river, at several other localities east of Conception Bay, and in the Cambrian area on the western end of Burin Peninsula. These basal Cambrian conglomerate beds are further discussed in the section dealing with the problem of the base of the Cambrian system (p. 42).

On the east shore of Conception Bay, on the north side of Smith Sound, Trinity Bay, in the adjacent outcrop on the west end of Random Island, and on the west tip of the Burin Peninsula, the formation comprises unmetamorphosed shale. Elsewhere, it has been metamorphosed to slate, with well-developed cleavage intersecting the bedding, generally at a sharp angle. More detailed descriptions of the lithology of this formation are given in Appendix I.

Structure. The Brigus formation conformably overlies the Smith Point limestone throughout the area, except east of Conception Bay and on the west end of the Burin

Peninsula, where it overlaps the older Cambrian formations and rests unconformably on Precambrian rocks. It is overlain, probably with minor disconformity but without angular discordance, by the Middle Cambrian Chamberlain's Brook formation.

Age. The Brigus formation ranges in age from medial to late Lower Cambrian, and is sparingly fossiliferous. The fossils occur mainly in pink limestone beds and nodules, and less commonly in calcareous shale beds stratigraphically close to the limestones, in those areas where the shale beds have not been metamorphosed to slate.

The lower part of the formation contains a typical early Cambrian *Callavia* zone fauna including *Callavia broeggeri, Strenuella strenua,* and species of *Micmacca, Atops, Serrodiscus,* and *Dipharus.* The upper part of the formation yielded few fossils. It contains an eodiscid (*Serrodiscus*?), a species of *Strenuella* (probably not *strenua*) and a *Protolenus*-like species, all represented only by fragmentary specimens. Walcott's *Solenopleura harveyi* from the Brigus formation near Manuels has been referred to *Protolenus* by Howell (1925, p. 26), with which the present writer is in agreement, following an examination of Walcott's type specimens of this species, though the specimens are not good. Olenellids are apparently lacking in the upper part of the Brigus formation.

It seems likely, therefore, that the upper part of the Brigus formation represents the latest Lower Cambrian zone of the North Atlantic region, the *Protolenus* zone, although the presence of the *Protolenus* fauna is not conclusively proven owing to the rarity and poor preservation of fossils in these beds.

Correlation. The lower part of the formation is correlated with the *Callavia* beds of the Boston area, and the *Callavia* limestone of Comley, Shropshire, England. It is probably also equivalent to part of the Ratcliffe Brook formation or the lower Hanford Brook formation, or both, of New Brunswick, and to the Morrison River formation, or some part of the MacCodrum formation of the Mira Valley, Cape Breton Island.

The upper part of the Brigus formation can be correlated with the Hanford Brook formation of New Brunswick, probably with the MacCodrum formation of Cape Breton Island, with the *Protolenus* limestone of Comley, Shropshire, with the *Protolenus* beds of Poland, and, less certainly, with other formations reported to contain *Protolenus* or *Protolenus*-like genera in various parts of the world.

Middle Cambrian Formations

Chamberlain's Brook Formation

Name. The name Chamberlain's Brook formation was proposed by Howell (1925, p. 60) for the sequence of green shale, with minor limestone, which he found to comprise the oldest Middle Cambrian rocks on the east shore of Conception Bay. He studied and measured in great detail the type section on Manuels River.

The lowest Middle Cambrian formation throughout the Avalon-Burin area consists of green shale or slate, although locally some red shale, pink limestone, and black manganiferous shale members are interbedded with these rocks. The name

Chamberlain's Brook formation is therefore accepted and used by the present author to include the early Middle Cambrian green shale or slate, with interbedded members of differing lithology, throughout Avalon and Burin Peninsulas. However, it is necessary to extend the formation to contain not only the rocks originally included in it — beds 1 to 35 of Howell's (1925) section — but also the thin sequence of black manganiferous shale immediately beneath these beds. Howell (1925, table 1) recognized the presence of these underlying beds, but, because their age was then unknown, he referred them to an unnamed formation of uncertain but probably of latest Early Cambrian age. This manganiferous bed occurs in all the Cambrian sections about Conception and Trinity Bays, but it is evidently lacking elsewhere. It is commonly unfossiliferous, but *Paradoxides bennetti* was collected from it at Brigus South Head, Conception Bay, and at Norman's Cove, Trinity Bay. Its age is therefore established as early Middle Cambrian. The manganese bed attains a maximum thickness of only 15 feet, and is generally thinner; for this reason, and because of its restricted distribution, the writer prefers to classify it as a local basal member of the Chamberlain's Brook formation rather than as a separate formation. This increases the thickness of the formation at the type section by 10 feet to 246 feet.

Distribution and thickness. The Chamberlain's Brook formation is present throughout the Cambrian areas of southeastern Newfoundland, except at Keels, Bonavista Bay, and on the north shore of Fortune Bay. At Keels, these beds, if present, are concealed beneath sea-level, but north of Fortune Bay, rocks of the same age but of different lithology take their place. The thickness of this formation is not so well known as that of the Lower Cambrian formations, because fewer complete sections were found. However, the isopach map (Fig. 5) shows the variations in thickness as well as possible.

Lithology. The formation comprises mainly olive-grey to green or bluish green shale or slate, with nodules and thin beds of green, grey, or pinkish limestone. The basal manganiferous bed is represented only around Conception and Trinity Bays. It is commonly a red and green shale with manganiferous nodules, though many outcrops are stained black by manganese oxides. Occasionally, however, it occurs as a manganiferous limestone bed. In some sections, especially around Trinity Bay, beds of red slate as much as 10 feet thick as well as thin beds and nodules of pink limestone are included in this formation.

On the east shore of Conception Bay, in the area around Clarenville, Trinity Bay, and on the west tip of Burin Peninsula, the shales are rather thick bedded and of blocky weathering, in comparison with the more fissile shales of overlying and underlying formations; at all other places, however, they are metamorphosed to well-cleaved, highly fissile slate. More detailed descriptions are given in Appendix I.

Structure. The Chamberlain's Brook formation overlies the Brigus formation with no angular discordance. At most localities, the basal manganiferous member rests on a regular surface but rarely the contact is slightly irregular, and a half-inch bed of shale pebble conglomerate, lithologically like an edgewise conglomerate, occurs at the base of the manganese beds. This is believed to represent a disconformity on the

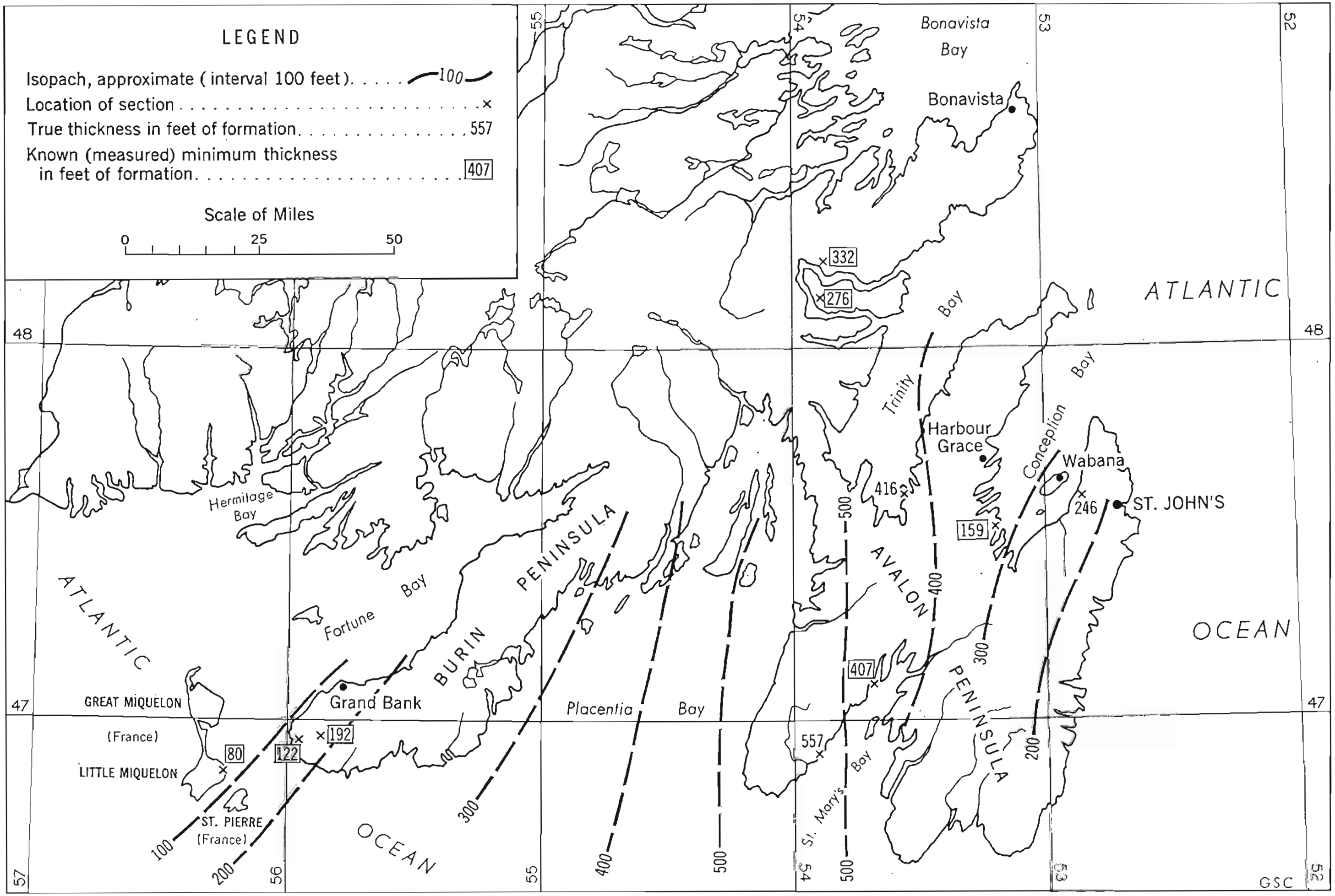

Figure 5. *Isopach map of Chamberlains Brook formation.*

basis of the lithological change and the marked faunal break that occur at this horizon. Nevertheless, conclusive field evidence of the presence of a disconformity is lacking.

The base of the Chamberlain's Brook formation is easily recognized in all the Cambrian sections in Trinity and Conception Bays regions, because of the basal manganese member. Elsewhere, this member is lacking, and the contact must be drawn on the basis of the colour change from the light green and red shales of the Brigus formation to the darker olive-grey to green shales of the Chamberlain's Brook formation, which also, locally, contains interbedded red shales. In certain sections in the St. Marys Bay region, this colour change is gradational over several tens of feet of unfossiliferous beds, with the result that the position of the contact is uncertain, though it is not probably greatly misplaced. The Chamberlain's Brook formation is overlain conformably by the black shale of the Manuels River formation.

Age and correlation. Well-preserved trilobite faunas have been collected at many localities. In unmetamorphosed sections, fossils are scarce in the lower part of the formation, where they occur only in limestone or calcareous shale beds, which are separated by thick beds of non-fossiliferous shale. The upper part of the formation is uniformly fossiliferous, although fossils are more common in the calcareous beds. At most localities, the shales have been metamorphosed to slates; fossils can be collected only from the limestone beds, although distorted fossils can commonly be seen on the bedding planes of the slate.

All the faunas collected from this formation contain trilobites belonging to the earliest Middle Cambrian faunal zone of the North Atlantic region. In Newfoundland, these faunas include an unusually large trilobite, *Paradoxides bennetti* Salter, which was chosen by Howell (1925) to typify this zone. *Paradoxides eteminicus* Matthew is also common in this formation, and *Paradoxides lamellatus* Hartt occurs rarely in the upper part.

The Chamberlain's Brook formation is therefore of early Middle Cambrian age. It is correlated with the lower part of the Trout Brook formation of Cape Breton Island, which contains *P. eteminicus* (Hutchinson, 1952a), with the Fossil Brook formation of New Brunswick, also containing *P. eteminicus* (Hayes and Howell, 1937), and with the Braintree formation near Boston, Massachusetts, which contains *P. harlani* Green, a species very similar to *P. bennetti*. It is further correlated with the Solva beds of Wales, with the *P. oelandicus* beds of Scandinavia; and less certainly, with the *Paradoxides pusillus* zone of Bohemia and with other early Middle Cambrian formations of various parts of the world.

In New Brunswick, Hayes and Howell (1937) divided the earliest Middle Cambrian zone into two subzones, the lower characterized by *P. eteminicus,* and the upper by that species and, in addition, *P. lamellatus*. This subdivision seems valid in Newfoundland also; however, *P. lamellatus* is so rare that it is of little use for correlation between various sections. Thus no useful purpose would be served in subdividing the *bennetti* zone in Newfoundland, and the writer prefers to regard it as a single faunal unit.

Manuels River Formation

Name. The later Middle Cambrian rocks of southeastern Newfoundland comprise a sequence of relatively uniform grey to black shale or slate, with numerous lenses and thin beds of grey or black fossiliferous limestone. In the well-exposed, unmetamorphosed section on Manuels River, Conception Bay, Howell (1925) was able to subdivide these rocks into two formations, the Long Pond and Kelligrew Brook formations, whose lithology, though similar, was sufficiently distinctive to be recognized in other exposures near their type sections on Manuels River. Howell's formations were discriminated mainly on finer sedimentational features of these rocks, particularly upon the relative proportions of grey and black shale, the thickness of the bedding, and the relative abundance of limestone nodules.

Unfortunately, in most other Cambrian areas of eastern Newfoundland, the Cambrian shales have been metamorphosed into a sequence of uniform, strongly cleaved slates, and the finer sedimentary features have been destroyed. Moreover, the writer's field work has shown that the abundance and exact stratigraphic position of the limestone nodules in these rocks vary greatly from area to area. In practice, the writer found that Howell's formations could be recognized only in the immediate type area, and with some doubt in the area about Clarenville, Trinity Bay. Elsewhere, the necessary criteria for discriminating the finer lithological divisions are lacking, and the sequence of black slate overlying the Chamberlain's Brook formation can be subdivided only on palæontological evidence. From the regional point of view, therefore, this sequence is best regarded as a single formational unit, for which a new name is required. The best exposed, best known, and most readily accessible section of these rocks is the one studied in such detail by Howell on Manuels River. This is, therefore, designated as the type section. Unfortunately, the name Manuels formation has already been used by van Ingen (1914) in a slightly different sense to include the entire Middle Cambrian series as exposed on Manuels River. This usage was rejected by Howell (1925, p. 57) who proposed that it be regarded only as a series name, and it never found wide acceptance in geological literature. As its revival and redefinition in a different sense might lead to confusion, the name Manuels River formation is proposed for the sequence of black shale overlying the Chamberlain's Brook formation in southeastern Newfoundland. The type section on Manuels River is 68 feet thick and includes beds 26 to 125 of Howell's 1925 section.

Howell's Long Pond and Kelligrew Brook formations are recognized as valid lithological units in the area east of Conception Bay, but are here classed as locally recognizable members of the Manuels River formation, because they cannot be distinguished lithologically elsewhere in Newfoundland.

Distribution and thickness. The Manuels River formation is known to occur in the area east of Conception Bay, on the east shore and around the head of Trinity Bay, on Random Island and adjacent parts of the west shore of Trinity Bay, near Branch, St. Marys Bay, on Red Island, Placentia Bay, and on Burin Peninsula. The same beds are present on the island of Langlade (Little Miquelon), in the French possession of St. Pierre and Miquelon. This formation is believed to have been deposited throughout eastern Newfoundland, except in the region north of Fortune Bay; however, it has been removed from most of the area by subsequent erosion. Despite its wide distribution, few completely exposed sections of these beds are known; at many localities these soft shale beds have been closely folded, faulted, and metamorphosed by post-Cambrian orogenic movements. This renders the accurate determination of their thickness difficult or impossible in many sections. The true thickness at Manuels River is 68 feet, at Highland Cove, Trinity Bay, 110 feet, and at Fosters Point, Random Island, 95 feet. The thickness is thought to vary little throughout the region.

Lithology. The Manuels River formation comprises a fairly uniform sequence of medium grey to black shale or slate, with thin beds and lens-shaped concretions as much as several feet in diameter of grey to black dense massive limestone. In the area around the heads of St. Marys and Trinity Bays, and on the isthmus between them, a volcanic rock member is interbedded with the slate beds of the Manuels River formation.

East of Conception Bay, and in the Clarenville region, Trinity Bay, the rocks of this formation are unmetamorphosed. In these areas, the lower shale beds are mainly grey, fairly thick bedded, and contain little limestone, whereas the upper beds are mainly black, thin-bedded shale with more limestone. However, at most localities, the rocks of this formation have been metamorphosed to slate, with well-developed cleavage intersecting the bedding at a high angle. The limestone beds generally remain unmetamorphosed.

The proportion of limestone in this formation varies greatly. Limestone nowhere comprises more than an estimated 2 per cent of the rock: in the Trinity Bay region it tends to be fairly well distributed throughout the formation, elsewhere it occurs mainly in the upper part.

These limestone beds and nodules are commonly fossiliferous and the fossils are generally undistorted by metamorphism and are well preserved, although difficult to collect because the rock is so dense. Fossils are also visible at some localities on the bedding planes of the slate beds, but these are invariably so cut by the cleavage as to be uncollectible, and commonly they are too distorted by metamorphism to be identifiable in place with certainty.

At most localities, the attitude of the bedding can be determined from the alignment of the limestone nodules, or from the attitude of fossils lying on the bedding planes. At some localities, however, the bedding could not be recognized.

The formation is exposed along the northwest shore of Red Island, Placentia Bay, near the contact of a post-Cambrian granitic rock. There, the rocks of this formation have been metamorphosed to a dense, thick-bedded, black hornfels, with numerous garnets and various lime silicate minerals in the calcareous beds. Fossils are pyritized, but undistorted and easily identifiable.

Structure. The Manuels River formation conformably overlies the Chamberlain's Brook formation. The contact is marked by an abrupt change from grey-green shale to dark grey or black shale, as well as by a striking faunal change, but there is no physical evidence of a disconformity at this horizon in any of the sections examined, and the faunal change, though great, is not complete, as a few species of trilobites are common to both formations. The writer considers that the lithological and faunal changes were caused by a change in the conditions of sedimentation, accompanied by the succession of a new fauna into the depositional area, rather than by a break in deposition.

The upper contact of the Manuels River formation coincides with the Middle Cambrian-Upper Cambrian series boundary. Its description is discussed with the overlying Elliott Cove group.

Age. The Manuels River formation ranges in age from medial Middle Cambrian to late Middle Cambrian. The formation is abundantly fossiliferous; in unmetamorphosed sections, numerous well-preserved trilobites can be collected both from the shale beds and from the limestone beds and nodules, whereas in most metamorphosed sections the trilobites are preserved in the limestones. As Howell (1925) has shown, the lower part of the formation (Long Pond formation of Howell) contains *Paradoxides hicksi* fauna and the upper part (Kelligrew Brook formation of Howell) contains a *Paradoxides davidis* fauna.

In one section, post-*davidis* Middle Cambrian faunas were collected from the uppermost beds of this formation. This locality is on the east shore of Trinity Bay, about a mile south of Long Point, in a small bay, and is evidently the locality named Highland Cove by Matthew (1896), although the bay is referred to by the local residents as Black Rock Cove. The post-*davidis* zone faunas were found in limestone nodules within the upper 20 feet of beds referred to this formation. These faunas contain several new species, including a large *Paradoxides,* an *Elyx,* a *Bailiaspis* and several agnostids, all of late Middle Cambrian type. The fauna is very similar to the *Paradoxides forchhammeri* fauna of Scandinavia, and is believed to represent the same late Middle Cambrian zone, even though *P. forchhammeri* itself has not been found.

The youngest Middle Cambrian fauna of Europe, the *Lejopyge laevigata* fauna, has not been found in Newfoundland; its zone may be represented by unfossiliferous beds, or it may be lacking because of non-deposition. This problem is discussed in more detail in the description of the Middle Cambrian-Upper Cambrian contact (p. 27).

Correlation. The Manuels River formation is easily correlated on palæontological evidence with the rocks in other Cambrian areas throughout the North Atlantic region. The lowest zone of the formation, containing the *Paradoxides hicksi* fauna, is correlated with the central part of the Trout Brook formation of Cape Breton Island, and with the Porter Road formation of New Brunswick, as well as with the *Paradoxides hicksi* beds of England and Wales, and equivalent beds elsewhere in Europe. The overlying *Paradoxides davidis* beds are correlated with the upper part of the Trout Brook formation of Cape Breton Island, with the Hastings Cove formation of New Brunswick, and with the *P. davidis* beds of England and Wales. The nodules at Highland Cove, Trinity Bay, contain a fauna of *P. forchhammeri* age, and the beds from which they came are therefore correlated with the MacLean Brook formation of Cape Breton Island, and with the rocks of the *P. forchhammeri* zone of Scandinavia.

Upper Cambrian Rocks

Elliott Cove Group

Name. The name Elliott Cove was proposed by van Ingen (1914) as a formational name for the Upper Cambrian rocks about Conception and Trinity Bays. No type section was designated but Elliott's Cove lies on the west shore of Random Island, and the Upper Cambrian rocks are exposed along this shore for about 2 miles south of Elliott's Cove. These exposures are therefore regarded as the type section. This name is accepted by the writer to designate all the Upper Cambrian rocks of southeastern Newfoundland, except those north of Fortune Bay. However, as described below, these rocks are a heterogeneous lithological assemblage, and will probably be subdivided into three or more formations in the future when more detailed studies of them are made. For this reason, the writer prefers to regard the Elliott's Cove rocks as a group rather than as a formation, and the name is used as a group name in this report.

Distribution and thickness. The Elliott Cove rocks were probably deposited throughout the Avalon-Burin peninsula area, but they have been removed from most of this region by subsequent erosion. The complete sequence is thought to be preserved in the Clarenville area, on the west shore of Trinity Bay, but even in that area the middle and upper parts of the group are much disturbed by close folding and small-scale faulting, and no completely exposed section was located. The lower beds of this group outcrop along the lower part of Manuels River, Conception Bay, and in isolated outcrops nearby, and the rest of the sequence is probably concealed beneath the water of Conception Bay, between the shore and Kellys Island. Elsewhere, only the lower beds of the group are known, although the higher parts may be present below sea-level. These rocks outcrop on the east shore of Trinity Bay at the locality known as Highland Cove near Long Point at Little Ridge in Chapel Arm, Trinity Bay, and in Gull Cove, on the south shore of the peninsula between St. Marys Bay and Placentia Bay.

Little is known about the thickness of the rocks of this group because of the lack of well-exposed sections. Two partial sections of the lower beds were measured, one at the type section north of Elliott's Cove is 393 feet thick, and the other on Manuels River is 617 feet thick.

Lithology. The rocks of the Elliott Cove group comprise a somewhat heterogeneous sequence of clastic sedimentary rocks. In the type section, the lowest beds assigned to this group outcrop along the southwest shore of Random Island, about half a mile north of Fosters Point. They are light grey, silty, micaceous, thin-bedded shales, with interbedded dark grey to black shales, containing rare, rusty weathering black nodules of very fine grained, impure limestone, which commonly exhibit cone-in-cone structure. These black shales greatly resemble the underlying Manuels River rocks; however, they can be distinguished from them in the field by the presence of interbedded grey, micaceous shales, by being thinner bedded, by the scarcity and different lithology of the limestone nodules, and by a general lack of fossils in both the limestone nodules and the shales as opposed to the abundantly fossiliferous Manuels River formation.

Higher in the rocks of this group, as they are progressively exposed northward along the shore towards Elliott's Cove, black shale beds are less common and thinner, the predominant rock type being a silty, grey, micaceous shale with thin massive beds of grey quartzitic siltstone. In this part of the section, the shales commonly exhibit mud-cracks, and the siltstones are crossbedded. Farther north along the shore, black shale beds are lacking and thick beds of massive grey or green crossbedded quartzitic siltstone are interbedded with silty, grey slate containing numerous mud-cracks and tubular branching structures, possibly worm borings. These rocks grade upward by a gradual increase in the shale content into another sequence, very similar to the lowest beds in which grey micaceous shale predominates, with a few thin green siltstone beds and with some interbedded grey to black slate with cone-in-cone concretions of impure, fine-grained black limestone. The next overlying beds are poorly exposed in small intermittent outcrops along the shore for a distance of about half a mile; most of the exposures are of soft, grey, micaceous, thin-bedded silty shale with a very few thin siltstone beds. The highest rocks assigned to this group are exposed along the shore immediately south of Elliott's Cove; they comprise mainly grey, micaceous shales, with a few half-inch siltstone beds and with minor black shale beds which contain rare nodules of black impure limestone.

All the lithological changes described above are gradational. The Elliott Cove rocks thus appear to represent a sequence of marine sediments that accumulated during a period of gradual change from fairly deep water conditions to shallower-water, near-shore conditions, and then back to deeper-water conditions.

The rocks of the Elliott Cove group are unmetamorphosed in the type region near Clarenville, Trinity Bay, and in the area east of Conception Bay. Near the head of Trinity Bay, these rocks are tightly folded and the shaly beds are metamorphosed to closely cleaved, highly fissile slates, with the cleavage cutting the bedding at a sharp angle. The rare limestone nodules remain unmetamorphosed. At Gull Cove, St. Marys Bay, the lower beds of this group have been intruded by numerous thin sills and dykes of fine-grained, massive diabase. The Elliott Cove rocks of this locality have been metamorphosed to a dense, thick-bedded, dark grey to black hornfels.

The Elliott Cove group is sparingly fossiliferous. Most of the fossils collected occur in black shale beds a few inches thick in the lower and upper parts of the sequence. Such beds at several localities are abundantly fossiliferous, although commonly only one or two species of fossils are present in any one bed. The fossiliferous beds are separated by great thicknesses of apparently unfossiliferous rocks. The rare limestone nodules are commonly unfossiliferous, but at two localities a few trilobites were found in these nodules. The middle siltier part of the Elliott Cove sequence yielded no trilobite fossils despite careful search.

Structure. The base of the Elliott Cove group coincides with the boundary between the Middle Cambrian and the Upper Cambrian series. The nature of this boundary was carefully investigated in the field at each locality where the rocks between the Middle Cambrian *davidis* zone and the Upper Cambrian *Agnostus pisiformis* zone are exposed. The beds throughout this interval appear perfectly conformable, and no evidence of any break in deposition, which might represent a disconformity, was found. As pointed out above, however, there is a slight but apparently consistent lithological change from fairly thick bedded, abundantly fossiliferous shale (or slate) with numerous grey, fossiliferous limestone nodules of the Middle Cambrian to mainly grey, silty shale, with interbedded black beds with rare, unfossiliferous black limestone nodules. This lithological change corresponds with a palæontological break. The late Middle Cambrian *Paradoxides forchammeri* fauna has been found at only one locality at the top of the Manuels River formation, and the succeeding *Lejopyge* fauna is evidently completely lacking. The evidence thus suggests that a break in depositon may have occurred before the deposition of the Elliott Cove rocks. However, the presence of a palæontological break is by no means proven, for the lowest beds of the Elliott Cove group are unfossiliferous in all their exposures and may represent the missing palæontological zones. Physical evidence for such a break would be difficult to detect in the field because the rocks above and below it differ only slightly in their lithologies.

On the basis of all available evidence the writer favours the hypothesis that the Middle Cambrian-Upper Cambrian contact in southeastern Newfoundland is marked by a disconformity, which coincides with the contact between the Elliott Cove and the Manuels River rocks.

The Elliott Cove rocks are overlain by shale, silty shale and siltstone of Tremadocian (Lower Ordovician) age, which are not described in this report. The actual contact between these two rock groups has not been recognized in the field, but regional mapping by Christie (1950) suggests that no angular discordance occurs between them. The contact is certainly not marked by an abrupt lithological change, as the lowest Ordovician rocks are very similar to the latest Cambrian ones. However, a sharp faunal break occurs at this horizon in Newfoundland, as it does elsewhere in the North Atlantic region, so that a disconformity is commonly assumed.

Age and correlation. The lowest shale beds of the Elliott Cove group are unfossiliferous. They are thought to represent a lower unfossiliferous part of the *Agnostus pisiformis* zone, but, as already noted, they may represent the *Lejopyge* zone of Europe. The beds overlying them are sparingly fossiliferous; they have yielded an *Agnostus pisiformis* fauna in the type section just north of Fosters Point, on Manuels River, Conception Bay, and at Little Ridge, Trinity Bay. These faunas were all found in black shale beds or in limestone nodules within black shales, which are interbedded with grey micaceous shales that contain no fossils. This part of the Elliott Cove group is therefore correlated with the Agnostus Cove formation of New Brunswick and with the *pisiformis* beds of various parts of Europe.

The next overlying beds of similar lithology have yielded *Olenus* in the type section, on Manuels River, and at Gull Cove, St. Marys Bay. They are correlated with the Black Shale Brook formation of New Brunswick, and with the widespread *Olenus*-bearing beds of various parts of Europe.

The *Olenus*-bearing shales are overlain along Manuels River and in the type section south of Elliott's Cove by a sequence of grey, silty shale and siltstone in which no diagnostic fossils have been found. This sequence probably includes the upper part of the *Olenus* zone and the lower part of the *Parabolina* zone. The overlying shale beds along the shore south of Elliott's Cove contain very few fossils, but a thin bed of black shale containing numerous specimens of *Parabolina spinulosa* was found in a small cove about a mile south of Elliott's Cove. *Parabolina* itself was not found elsewhere in Newfoundland, but on Manuels River the uppermost beds exposed on the west shore contain the brachiopod *Orusia lenticularis,* which occurs in the *Parabolina* zone of Scandinavia. These beds are therefore believed also to represent the *Parabolina* zone. The part of the Elliott Cove group that contains the *Parabolina* fauna is correlated with the lower part of the MacNeil formation of Cape Breton Island, with the lower part of the Narrows formations of New Brunswick, and with the *Parabolina* beds of various parts of Europe.

The *Leptoplastus* fauna, which marks the zone above *Parabolina* in Europe, Cape Breton Island, and New Brunswick, has not been found in Newfoundland. However, the beds overlying the *Parabolina* zone in the section south of Elliott's Cove are poorly exposed, and on Manuels River are entirely concealed. Despite the lack of fossils, these beds, which are mainly grey, micaceous shales along the shore of Random Island, are believed to represent the *Leptoplastus* zone on the basis of their stratigraphic position, and they are tentatively correlated with the beds containing this fauna elsewhere in Eastern Canada and Europe.

Fossils are exceedingly rare in the upper grey micaceous shales of the Elliott Cove group; however, the writer collected a poorly preserved fauna containing *Ctenopyge pecten* and a species of *Peltura* on the west shore of Random Island about a fifth of a mile south of Elliott's Cove, and Christie in 1951 collected similar fossils from three other localities on Random Island and on the adjacent shores of Smith Sound. The upper part of this group is therefore of *Peltura* zone age, and is correlated with the latest Cambrian *Peltura*-bearing strata which have been reported from the upper part of the MacNeil formation of Cape Breton Island, the upper part of the Narrows formation near Saint John, New Brunswick, and from various parts of Europe.

Chapter IV

CAMBRIAN ROCKS ON THE NORTH SHORE OF FORTUNE BAY

Cambrian rocks outcrop at several localities north of Fortune Bay, from Belle Bay westward as far as St. John's Head. They are much disturbed by folding, faulting, and by the intrusion of younger igneous rocks. In addition, the Cambrian outcrops are interrupted and limited, owing largely to concealment beneath younger volcanic and sedimentary rocks over large parts of the area, so that no well-exposed continuous sections were found. The following account of the Cambrian stratigraphy is, therefore, interpreted from somewhat limited stratigraphic, structural, and palæontological evidence.

Table of Formations

Cambrian and Possibly Cambrian Rocks North of Fortune Bay

Epoch	Formation	Lithology	Palæontological Zone
Upper Cambrian	Salmonier Cove	Black, thin-bedded shale, with black fossiliferous limestone concretions	*Peltura* *Olenus* *Agnostus pisiformis*
Nature of contact unknown (probable disconformity)			
Middle Cambrian	Young's Cove	Green to grey micaceous silty shale and siltstone, minor grey shale	*Paradoxides bennetti*, —may include some younger rocks
Probable disconformity			
Precambrian or possibly Middle or Lower Cambrian	Blue Pinion	White crossbedded sandstone and conglomerate	No fossils known
Probable disconformity			
Late Precambrian or possibly Lower Cambrian	Chapel Island	Green, silty micaceous shale, siltstone, and sandstone, minor red beds	No fossils known
Conformable contact			
	Doten Cove	Red and purple sandstone, siltstone and silty shale	No fossils known

Middle and Upper Cambrian rocks are certainly known, from palæontological evidence, to occur north of Fortune Bay. They are lithologically different from rocks of the same ages elsewhere in eastern Newfoundland, and must be referred to different formations. In addition, previous workers have included various sequences of non-fossiliferous sedimentary rocks, whose exact ages are still uncertain, within the Cambrian system on the basis of lithology or stratigraphic position. In this chapter, the two formations known to be of Cambrian age are first described, then three other formations of uncertain but possibly Cambrian age are discussed. Most of these formations were originally named and described in unpublished manuscript theses by D. E. White and K. Widmer, and their original descriptions are quoted at length in the following sections.

Description of Formations

Known Cambrian Rocks

Young's Cove Formation — Middle Cambrian

Name. The name Young's Cove was first applied by D. E. White (MS. 1939) to a group of dark quartzites and slates in the Rencontre East map-area. The type exposures lie around the shore of Young's Cove, in Bay d'Est, Belle Bay. White believed this group to contain both Middle and Upper Cambrian and possibly Lower Ordovician rocks and suggested that, "With more detailed investigation, the Young's Cove group probably will be separated into several formations, on the basis of slight variations in lithology and upon additional faunal evidence, which is probably present in the metamorphosed slates and quartzites".

Later Widmer studied the adjacent Hermitage Bay map-area, where similar rocks occur. He was able to separate Upper Cambrian from Middle Cambrian rocks both lithologically and palæontologically; however, rather than retain Young's Cove as a group name — as White had defined it — and subdividing it into formations, he chose to redefine it as follows "The name Young's Cove group is here redefined to include only those shales above the white sandstone that contain Middle Cambrian fossils and the related rocks of Middle Cambrian age" (Widmer, MS. 1950). The white sandstone to which he refers is described as the Blue Pinion formation and the problem of its age is discussed later in this chapter.

The writer accepts Widmer's redefinition of the name Young's Cove to include all the known Middle Cambrian rocks north of Fortune Bay; these rocks, however, comprise a fairly uniform sequence of rocks and are not likely to be subdivided on lithological differences. They are therefore regarded as a formation rather than a group.

Widmer (MS. 1950) mapped Sagona Island, off the entrance to Harbour Breton Bay, and showed that it is underlain by about 800 feet of brown weathering, grey flaggy sandstone, with some white weathering beds, overlain by a few feet of silty, grey fossiliferous shale. He collected a fauna of inarticulate brachiopods from this shale, which were determined by Howell to be probably of Tremadocian age. Widmer therefore believed these rocks to be younger than the Young's Cove beds, and named them the Sagona Island formation. However, the writer collected

Paradoxides lamellatus from the same fossil locality. The upper shales are therefore of Middle Cambrian age and are regarded as the unmetamorphosed equivalent of the Young's Cove formation. The underlying flaggy grey sandstone is referred to the Blue Pinion formation. The name Sagona Island formation is here discarded as a synonym of these formations.

Distribution. In Belle Bay, the Young's Cove rocks outcrop along the shore of Young's Cove in Bay d'Est, the type section on the southwest shore of Cinq Isles Bay, and on the south side of Corbin Bay. To the west, in Hermitage map-area, Widmer mapped similar rocks along the northeast shore of Great Bay de l'Eau from Bufford Cove to Red Cove, and referred them to the Young's Cove group solely on the basis of their lithology. In the same map-area, the Middle Cambrian shale described by Dale (1927) at Blue Pinion Cove, certainly is referable to the Young's Cove formation.

Finally, as mentioned above, the *Paradoxides lamellatus*-bearing shales on Sagona Island, off the entrance to Harbour Breton, are also included in the Young's Cove formation. No other exposures of these rocks are known.

Thickness. As no completely exposed section of the Young's Cove formation is known, its thickness is uncertain. White (MS. 1939) estimated the thickness of the Young's Cove 'group' in the Rencontre East map-area at about 2,000 feet. When Widmer redefined the formation, he restricted it by removing some of the rocks both above and below the fossiliferous Middle Cambrian which had been included in it by White. Widmer made no firm estimate as to the thickness of the (restricted) Young's Cove formation, but stated "a thickness of 5,000 feet or more for the Young's Cove group is indicated by the section from Bufford Cove to Red Cove but this may be a section that is repeated by isoclinal folding and it may also be a continuous section extending up into Lower Ordovician rocks".

It is difficult to make an approximate estimate of the thickness of this formation. In the type area at Young's Cove, some drag-folding and minor faults were observed, and the outcrops are discontinuous so that no section could be measured. The writer estimates that at least 600 feet of beds referable to this formation are exposed at that locality; this is taken as an estimated minimum thickness for the Young's Cove formation in the Belle Bay region. The true thickness is certainly greater, but no better estimate can be made on the evidence available.

Lithology. White originally described the Young's Cove group as follows:

> Lithologically, the group is quite homogeneous, consisting essentially of interbedded dark quartzites and slates. The thickness of the individual beds is usually less than a foot, and is commonly only several inches, but some zones consist of thicker, occasionally massive beds of quartzite. The quartzite generally contains fine-grained mica, oriented parallel to the stratification. The interbedded slates are black, dark grey, and dark greenish grey.

His description applies equally well to these rocks as restricted by Widmer. The writer would add that many of the quartzite bands exhibit crossbedding, and that the slate beds are uniformly silty and micaceous. The formation is sparsely fossiliferous.

Structure. The Young's Cove rocks overlie a massive formation of white quartzitic sandstone and fine conglomerate, the Blue Pinion formation, without angular discordance. At most localities, this contact is sharp, and marked by an abrupt lithological change, but at Bufford Cove, it appears gradational, as a few massive white sandstone beds are interbedded near the base of the overlying slate of the Young's Cove formation. The writer believes that the Blue Pinion formation is probably of late Precambrian age, and that the lower contact of the Young's Cove formation represents a disconformity; it may, however, be a conformable contact.

The upper contact of the Young's Cove formation is not known to be exposed; the nature of its contact with the Salmonier Cove formation, which, on the basis of the palæontological evidence, must succeed it, is therefore unknown. However, the apparent palæontological break between the two formations suggests that the contact is probably disconformable.

The Young's Cove formation is everywhere sharply folded; the rocks commonly dip steeply or vertically; they are much disturbed by small-scale drag-folding and, in most localities, are cut by steeply dipping shear zones and small faults. Throughout most of the area, the rocks have been subjected to fairly strong regional metamorphism; slaty cleavage is present in most of the shale beds, and the silty beds have been metamorphosed to massive quartzites. Locally, as on Sagona Island, and on the south shore of Corbin Bay, Belle Bay, the rocks are unmetamorphosed, though steep dipping. At such localities, fairly well preserved marine faunas are present in some of the darker shale beds.

Age. As restricted by Widmer and as here used, the Young's Cove formation is of Middle Cambrian age. Fossils have been found at four localities. White collected a fauna from the southern side of Corbin Bay, about half a mile northwest of the settlement of Corbin, and approximately 750 feet west of the southern head of Corbin Bay. The trilobites from this locality were identified by Howell (*in* White, MS. 1939) as follows:

Paradoxides eteminicus Matthew
Paradoxides bennetti Salter
Bailiella ornata Resser
Liostracus ouangondianus (Hartt)

The writer revisited this locality and collected all the above species and in addition *Liostracus tener* (Hartt). However, the *Bailiella* that occurs at this locality and at many other localities in eastern Newfoundland is not Resser's *ornata* but a new species described in this report as *B. manuelensis* n. sp.

White also collected fragments of *Paradoxides eteminicus* from the north shore of Young's Cove, Bay d'Est. The writer was unable to find any identifiable trilobite fragments at that locality.

Dale (1927) reported *Paradoxides davidis* from rocks here referred to the Young's Cove formation at Blue Pinion Cove. The writer examined these rocks in detail, and collected a sparse fauna containing mainly inarticulate brachiopods; however, several specimens of *Paradoxides eteminicus* Matthew, well enough preserved to permit certain identification, were found. This *eteminicus* fauna occurs about 80 feet below the top of the exposed Cambrian section, at approximately the locality indicated by Dale.

Professor B. F. Howell examined Dale's fossils at the time they were found and in reply to an enquiry by the writer sent the following communication:

> I have a carbon copy of a report on his fossils which I sent to Dale in 1920. I quote from this report "The only good head you brought from Blue Pinion is a *Paradoxides*, but of a type which ranges all through the *Paradoxides* beds . . ." This type which ranges all through the *Paradoxides* beds was probably *Paradoxides eteminicus*. I do not know where Dale got the idea that it was *Paradoxides davidis*.

It therefore seems certain that Dale's report of *P. davidis* is erroneous and based on a misidentification of specimens of *P. eteminicus*.

The fourth fossil locality, at Sagona Island, was found by Widmer (MS. 1950). The fossils occur in silty, grey shale, at the east end of the main harbour, within the settlement of Sagona Island. The present writer collected well-preserved specimens of *Paradoxides lamellatus* Hartt in these beds, which are therefore referable to the *bennetti* zone.

Thus all the Middle Cambrian fossils in the Young's Cove formation are referable to a single zone, the earliest Middle Cambrian *bennetti* zone. However, the fossiliferous beds at Young's Cove, and in Corbin Bay, are conformably overlain by a considerable, but unknown thickness of quartzites and slates in which no fossils have been found. The exact age of these beds is uncertain. Their clastic lithology suggests rapid deposition, within a short timespan, so that they may all have been deposited within *bennetti* zone time. However, it seems equally probable that some of them may post-date the *bennetti* zone, so that the Young's Cove formation may include some post-*bennetti* zone Middle Cambrian rocks.

Correlation. The lower fossiliferous part of the Young's Cove formation is correlated with the Chamberlain's Brook formation of Avalon-Burin Peninsulas, which, although of different lithology, contains exactly the same trilobites. Elsewhere in eastern North America, the Young's Cove formation is correlated with the lower part of the Trout Brook formation of Cape Breton Island, with the Fossil Brook formation near Saint John, New Brunswick, and with the Braintree shale near Boston, Massachusetts, all of which contain similar faunas of about the same age. These beds are also correlated with the early Middle Cambrian rocks of Europe. The upper part of the Young's Cove formation is probably slightly young, and is tentatively correlated with some part of the Manuels River formation of Avalon-Burin Peninsulas; no firmer correlation is possible until fossils are found in these rocks.

Salmonier Cove Formation — Upper Cambrian

Name. Widmer (MS. 1950) proposed the name Salmonier Cove formation for "all the black shales outcropping along the east side of Great Bay de l'Eau in the Hermitage Bay area". The name, which was chosen from a small cove on the south-east side of Great Bay de l'Eau, is accepted and used in this report as defined by Widmer.

Distribution and thickness. The Salmonier Cove formation is known to outcrop at only three localities, all in Great Bay de l'Eau. The best exposures at the type area lie along the south shore of Salmonier Cove. The Cambrian rocks outcrop for a few hundred feet along the shore in the core of an anticline. Along the crest of the fold, they are overlain inland and only a few feet above sea-level by the basal conglomerate of the post-Cambrian Cinq Isles group, which reaches sea-level on both limbs within a short distance of the axis of the fold, cutting off the Cambrian exposures. The other two outcrops referred to this formation, both very small exposures of black shale, lie on the east and north sides of St. John's Head, at the western entrance to Great Bay de l'Eau.

Some of the unfossiliferous black slate beds noted by White (MS. 1939) in Belle Bay, and included by him in his Young's Cove group, may represent metamorphosed equivalents of the Salmonier Cove rocks. However, all the black slates seen in Belle Bay by the writer were silty and micaceous, whereas those in Great Bay de l'Eau are free of silty material; the Belle Bay slates are therefore included in the Young's Cove formation in this report.

It is impossible, because of the very poor outcrops, to determine the thickness of the Salmonier Cove formation. Widmer (MS. 1950) estimated that at least 100 feet of black shale is exposed in the type area; the writer agrees with this estimate, although the rocks are so strongly contorted that no useful section can be measured. To this 100 feet must be added a further, but unknown, thickness of beds for the outcrops at St. John's Head, which are known, on palæontological evidence, to be somewhat older than the rocks at Salmonier Cove. It is therefore reasonable to assume a minimum thickness of at least 200 feet for this formation, but no more accurate estimate can be made.

Lithology. The Salmonier Cove formation comprises soft, thin-bedded, fissile, black micaceous shale. The rocks have been closely folded, but are not metamorphosed to slate. The upper part of the formation at Salmonier Cove contains a few small lenses of black, fine-grained, impure, massive, fossiliferous limestone. In contrast to the Elliott Cove rocks in Avalon Peninsula, which are of the same age, the Salmonier Cove rocks contain no silty or sandy material, and are black instead of grey. The formation is abundantly fossiliferous.

Structure. The lower contact of the Salmonier Cove formation is not exposed; however, it is believed to be disconformable because of the evident lack of all post-*bennetti* Middle Cambrian faunal zones to the north of Fortune Bay.

In Great Bay de l'Eau, the Salmonier Cove formation is overlain with pronounced angular unconformity by volcanic rocks of the Cinq Isles group, which were doubtfully referred by Widmer (MS. 1950) to the Ordovician.

White (MS. 1939) has reported early Ordovician rocks in Cinq Isles Bay, which he named the Shine Cove formation. The dating is based on a single fauna of inarticulate brachiopods collected from silty shales near Shine Cove. These fossils were examined by Howell (*in* White), who suggested that they could be of early Ordovician (Tremadocian or Arenig) age. White's geological mapping suggests that the Shine Cove rocks are more likely part of the Young's Cove formation, and the present writer believes that they should be included in the Young's Cove unless better evidence for an Ordovician age can be found. Whatever the age of these Shine Cove rocks, their relationship to the Salmonier Cove formation cannot be determined, because the Salmonier Cove rocks do not outcrop in Cinq Isles Bay. However, future workers in the area should recognize the possibility that Ordovician rocks may be represented.

Age. The black shales of the Salmonier Cove formation contain marine Upper Cambrian fossils at each of the three localities where they are known to outcrop.

Trilobites collected by Widmer from both outcrops on St. John's Head were determined by Howell (*in* Widmer, MS. 1950), as follows:

> The fossils from this locality (east side of St. John's Head in a cove on the southeast side of St. John's Tolt) are all referable to a single species of Agnostian trilobite. The species is a new *Agnostus* closely related to *Agnostus pisiformis* (Linné) . . . the axis of its pygidium is a little larger in all its dimensions than that of *Agnostus pisiformis,* and more triangular in form . . . the beds are undoubtedly of about the same age as the *Agnostus pisiformis* beds of Sweden . . . . The trilobites from this locality (north side of St. John's Tolt) are two species of *Olenus, Olenus truncatus* (Brunnich) and *Olenus gibbosus* (Wahlenberg) and two species of agnostians, *Homagnostus obesus* (Belt) and the new *Agnostus* found in the cove on the southeastern side of St. John's Head . . . . The beds at St. John's Head are undoubtedly of approximately the same age as those of the *Olenus* zone of northwestern Europe.

The outcrops of Salmonier Cove contain abundant faunas referable to the *Peltura* zone, including *Peltura* itself, *Lotagnostus trisectus* (Salter) and a species of *Ctenopyge.* This fauna was first collected by Widmer, and its age determined by Howell, who published a brief note (Howell, 1939) recording the occurrence. It was later re-collected by the present writer. The Salmonier Cove formation, therefore, ranges in age from early to late Upper Cambrian. The *Parabolina spinulosa* and *Leptoplastus* faunas have not been found north of Fortune Bay, so that it is uncertain whether rocks of these ages were deposited in the region. However, it is believed that these zones are present but concealed below sea-level, because they are represented elsewhere in eastern Newfoundland and in Cape Breton Island, where Upper Cambrian rocks are better exposed.

Correlation. The rocks of the Salmonier Cove formation are readily correlated, on palæontological evidence, with the Cambrian rocks elsewhere in the north Atlantic region. The beds at St. John's Tolt, which Howell referred to the *Agnostus pisiformis* zone, are correlated with the lowest part of the Elliott Cove group in Avalon Peninsula. Rocks of this zone are unknown in Cape Breton Island, but the St. John's Head rocks are correlated with the Agnostus Cove formation near Saint John, New Brunswick, which contains the same fauna, and with the *Agnostus pisiformis* beds of Wales and Scandinavia.

The *Olenus*-bearing shales at St. John's Head are correlated with the *Olenus* zone occurrences in eastern North America and Europe, including the lower-middle part of the Elliott Cove group elsewhere in eastern Newfoundland, the Black Shale Brook formation of Saint John, New Brunswick, and the numerous exposures of rocks containing the same fauna in Wales, Sweden, Denmark, and Norway.

The beds at Salmonier Cove with the *Peltura* fauna are correlated with the upper part of the Elliott Cove group near Clarenville, Trinity Bay, with the upper part of the MacNeil formation of Cape Breton Island, with the Narrows formation of Saint John, New Brunswick, and with the *Peltura* zone rocks which outcrop in various parts of Wales and Scandinavia.

Rocks of Possible Cambrian Age

Previous workers along the north shore of Fortune Bay have referred several other rock groups in that area to the Cambrian system. More recent work by officers of the Newfoundland Geological Survey and of the Geological Survey of Canada has shown conclusively, by structural and palæontological evidence, that most of these rocks are actually much younger than Cambrian age. Formations now known to be post-Cambrian are not further discussed in this report.

However, the known Cambrian rocks of the region are underlain by three separate mappable units of sedimentary rocks. These were named the Doten Cove, Chapel Island, and Blue Pinion formations in unpublished reports by White and Widmer. Each formation is briefly described and problems of age and correlation are discussed in the following section.

Doten Cove Formation

Name. White (MS. 1939) proposed the name Doten Cove formation for a considerable thickness of red sandstone that he found to form the base of the oldest sedimentary sequence in the Rencontre East map-area. The type exposures are at Doten Cove, in the southwest part of the area. Widmer later found these rocks to extend to the south and west into the adjacent map-area, where he applied the same name to them.

Distribution and thickness. The formation is exposed at Doten Cove, along the northwest shore of Corbin Bay, and about a mile west of Smith Hole, all in Belle Bay. To the south, it is well exposed on Chapel Island, and its metamorphosed equivalent was recognized by Widmer (MS. 1950) northeast of the head of Great Bay de l'Eau, near the north margin of an intrusive mass of granite. In addition similar rocks, which are probably referable to this formation, outcrop extensively on Brunette Island, near the mouth of Fortune Bay.

White estimated the formation to be about 2,000 feet thick in the exposures around Belle Bay, whereas Widmer estimated its thickness on Chapel Island as about 700 feet. The base of the formation is not exposed in either locality.

Lithology. The original description of these rocks by White, which applies equally well to the exposures on Chapel Island, is in part as follows:

> The lithology is characterized by well-stratified, red, arkosic, micaceous sandstone, commonly in beds of a foot or less in thickness, separated by thinner beds of deeper red, micaceous, fine-grained sandstone and siltstone. Cross-bedding is locally present. The lowest known beds of the Corbin Bay section consist in part of light red, medium and coarse grained sandstones which are commonly cross-bedded and which grade into light purplish-grey and greenish-grey, coarse, arkosic sandstones.

Structure. The lower contact of the Doten Cove formation is not exposed. The upper contact is well exposed; the red sandstones of this formation grade upward by a gradual lithological change through an interbedded sequence into the overlying Chapel Island rocks. This contact is therefore conformable. The age of the formation is discussed after the description of the Chapel Island and the Blue Pinion formations (p. 40).

Chapel Island Formation

Name. The name Chapel Island formation was proposed by Widmer (MS. 1950) for a sequence of siltstone and silty shale that overlies the Doten Cove formation. These rocks had been included by White (MS. 1939) in the lower part of his Young's Cove group, but they form an easily recognized mappable unit, and are correctly classified as a separate formation, as proposed by Widmer. The type section is on Chapel Island, off the mouth of Belle Bay.

Distribution and thickness. The Chapel Island formation outcrops on Chapel Island, at Blue Pinion Cove, along the shore of Great Bay de l'Eau from Salmonier Cove eastward to Bufford Cove, and in Cinq Isles Bay, Belle Bay. It is probably also present on Brunette Island in Fortune Bay. Its thickness on Chapel Island was estimated by Widmer as about 1,700 to 2,000 feet; as a fairly complete section is exposed there, this estimate is accepted as reliable.

Lithology. Widmer's original description of the Chapel Island formation is as follows:

> Conformably above the Doten Cove formation on Chapel Island there are more than 1,700 feet of hard, red, green, and greyish-green sandy shale. The lower sixty feet of these strata consist of a transitional zone of alternating red and green sandy shales. The next 200 feet of beds are predominantly green shales with an occasional bed, usually about two feet thick, of red sandstone or shale. A sixty-foot thickness of red siltstone is the highest of the red sediments in the formation. At least 1,400 feet of green and greyish-green sandy shales follow this last red sandstone.

It should be added that most of the siltstone beds display crossbedding.

Structure. The Chapel Island formation overlies the Doten Cove formation conformably. It is overlain by a massive, white, quartzitic sandstone, the Blue Pinion formation. This contact between the Doten Cove and Blue Pinion formations is abrupt and locally is slightly irregular. For these reasons, and because of the sharp lithological change which occurs there, Widmer considered this contact to be disconformable. The writer has examined the various exposures of this contact, and agrees with Widmer's interpretation. The age and correlation of this formation is discussed on page 40.

Blue Pinion Formation

Name. The name Blue Pinion formation was proposed by Widmer (MS. 1950) for a sequence of massive, white quartzitic sandstone and conglomerate that overlies the Chapel Island rocks and underlies the Young's Cove formation north of Fortune Bay. The type section first described by Dale (1927) is on the west shore of Blue

Pinion Cove on the north shore of Fortune Bay, just west of the mouth of Belle Bay. The same rocks in the Belle Bay area were included by White in his Young's Cove group, but these rocks clearly constitute a valid formation, and Widmer's formational name is accepted in this report.

Distribution and thickness. The Blue Pinion formation is best exposed at the type section, and at Bufford Cove in Great Bay de l'Eau. Less complete exposures occur in Belle Bay and possibly on Brunette Island. In addition, the massive white sandstone that underlies most of Sagona Island, though of slightly different lithology, occupies the same stratigraphic position, and is believed to represent an unmetamorphosed equivalent of the Blue Pinion beds. The Sagona Island rocks are therefore referred to the Blue Pinion formation.

The thickness of the Blue Pinion formation at Blue Pinion Cove is given by Widmer as at least 600 feet, and at Bufford Cove as at least 1,000 feet. On Sagona Island, the formation is estimated to be 600 to 800 feet thick.

Lithology. Widmer (MS. 1950) described the lithology of the Blue Pinion formation as follows:

> The Blue Pinion formation is a medium to coarse equigranular white to grey crossbedded sandstone. In the vicinity of Blue Pinion it is an extremely even grained white crossbedded quartz sandstone, with scattered dark grains up to 1.16 inch in size. At Bufford Cove, Great Bay de l'Eau, and on Brunette Island, the basal phases of the Blue Pinion formation are moderately coarse conglomerate. The conglomerate contains subrounded to rounded black to purple-red fine grained sandstone fragments up to two inches in length, round quartz pebbles up to one inch in size, and a matrix of round to subrounded grains of quartz, pink orthoclase, black shale, brown chert, red sandstone and occasional micas. Some of the smaller fragments have a uniform red to brown colour and are probably felsites.

The writer would add that most beds of this formation break with an even subconchoidal fracture through the individual grains; the rock is therefore better described as a quartzite than as a sandstone. The rocks of this formation on Sagona Island, however, are not metamorphosed to quartzite. They comprise white to brown rusty weathering, white to grey, coarse-grained, quartzose sandstone with minor pebble-conglomerate bands. The rocks are commonly crossbedded and vary from thin-bedded, flaggy sandstone to massive, thick-bedded sandstone.

Structure. The Blue Pinion formation is believed to overlie the Chapel Island rocks disconformably. The nature of the contact between the Blue Pinion and the overlying Middle Cambrian, Young's Cove formation, is of critical importance in determining the age of the Blue Pinion and of the formations that underlie it. This contact is exposed at three localities. At Blue Pinion Cove, the lower shales of the Young's Cove formation overlie the Blue Pinion quartzites along a sharp but regular contact. The lithological change at the contact is abrupt. A few thin beds of fine siltstone occur in the lower shales of the Young's Cove formation, but these beds are fine grained, micaceous, green to pink, and do not resemble the Blue Pinion rocks lithologically.

On Sagona Island, a similar abrupt lithological change occurs at the contact of the Blue Pinion formation with the overlying shaly beds of the Young's Cove formation. At this locality, the contact appears to be slightly irregular, but no conclusive evidence of a disconformity was found.

At Bufford Cove, the third known exposure of this contact, the relations are slightly different. Above the uppermost massive quartzite bed of the Blue Pinion formation is a sequence of interbedded shale and sandstone. Some of the sandstone beds are grey and resemble the Blue Pinion rocks, but they are finer grained and less massive than the typical Blue Pinion quartzites, and the lowest shaly bed rests with a regular but sharp contact on the highest massive quartzite bed.

The sharp lithological break at two localities suggests that the contact is disconformable; however, the sequence at Bufford Cove could be interpreted, as was done by Widmer (MS. 1950) as a gradational contact zone, indicating a conformable contact. The field evidence, therefore, does not definitely establish the nature of this contact.

Age and correlation. A careful search at each locality where the Blue Pinion formation is exposed failed to locate any fossils. As fossils would not be expected in rocks of this lithology however, this lack cannot be used as an argument for the Precambrian age of the formation. The age of the formation must therefore be inferred from indirect evidence. If the Blue Pinion formation underlies the Middle Cambrian Young's Cove formation disconformably, as field evidence suggests, the formation is of pre-Middle Cambrian age.

Throughout the Trinity Bay-Placentia Bay-Burin Peninsula areas, fossiliferous Lower Cambrian rocks overlie a massive sequence of white quartzite, the Random formation, and at least in the Trinity Bay-Placentia Bay areas, the Cambrian-Random contact is disconformable (*see* p. 42). The writer therefore regards the Random formation as of latest Precambrian age. The Blue Pinion formation is lithologically identical with the Random formation, and, like the Random, it overlies a thick sequence of red and green clastic sedimentary rocks with probable disconformity. However, the Blue Pinion formation is overlain by Middle Cambrian rather than by Lower Cambrian rocks.

An inspection of the isopach maps for the Bonavista, Smith Point, and Brigus formations (*see* Chap. III, Figs. 2, 3, 4) shows that the thickness of the Lower Cambrian series thins westward from about 800 feet in the Trinity Bay region to about 60 feet on the west tip of Burin Peninsula, where the two lower formations are completely lacking. Thus on the west end of Burin Peninsula, the Middle Cambrian *bennetti* zone rocks are separated from the Random quartzites by only 60 feet of Lower Cambrian beds. If the Lower Cambrian strata continued to thin towards the northwest across Fortune Bay, as seems likely, they would wedge out before reaching the north shore of Fortune Bay, and Middle Cambrian strata would then overlie Precambrian strata in this area. This suggestion would explain the absence of Lower Cambrian rocks beneath the Young's Cove formation (Middle Cambrian) and would permit considering the Blue Pinion formation as latest Precambrian, comparable to the Random formation farther east. The writer believes this explanation best accounts for the stratigraphic differences between the sequences north of Fortune Bay and those farther east.

The Blue Pinion formation is correlated with the Random formation elsewhere in southeastern Newfoundland for reasons given above. On the basis of its stratigraphic position and assumed age, it could also be correlated with various other latest Precambrian formations elsewhere in Eastern Canada, but in the absence of better evidence, such correlations would be tenuous.

Age of the Doten Cove and Chapel Island Formations

The Doten Cove and Chapel Island formations comprise a conformable sequence of rocks, disconformably underlying the Blue Pinion formation. Both White (MS.) and Widmer (MS.) classified these formations as Lower Cambrian, because they underlie known Middle Cambrian rocks without angular discordance. However, throughout the entire Trinity Bay-Placentia Bay-Burin Peninsula region, the base of the Cambrian system is marked at most by a slight disconformity. This contact is an angular unconformity only in the Conception Bay area. The lack of an angular unconformity, above the Doten Cove and Chapel Island formations, north of Fortune Bay is therefore not sufficient evidence for classifying these formations as Cambrian.

The isopach maps of the Lower Cambrian formations given above clearly show that these rocks thin greatly to the north and west of a line through Trinity Bay and Placentia Bay, and that the total Lower Cambrian series is represented by less than 60 feet of beds in the area near Fortune, at the west end of Burin Peninsula. It therefore seems very unlikely that the Lower Cambrian should be represented by more than 2,500 feet of rocks north of Fortune Bay, as White and Widmer would have us believe.

The Lower Cambrian rocks in southeastern Newfoundland are all fossiliferous; even in regions where these rocks have been metamorphosed to slate, some fragmentary fossils can commonly be found. On the other hand, the Chapel Island formation, although of relatively unmetamorphosed shaly lithology wherein fossils could be preserved is evidently completely unfossiliferous, as is the Doten Cove formation. This lack of fossils suggests a Precambrian age for these formations.

Finally, the Chapel Island and Doten Cove rocks are unlike Lower Cambrian beds elsewhere in eastern Newfoundland both in thickness and in lithology, but they greatly resemble the late Precambrian sedimentary rocks that underlie the Random formation on Burin Peninsula. It is therefore reasonable to assume that they are part of the same sequence and that they are of late Precambrian age.

For the above reasons, the writer considers the Doten Cove and Chapel Island formations to be almost certainly of late Precambrian age. They are correlated with the upper part of the Musgravetown rocks on nearby Burin Peninsula, and in the area west of Trinity Bay and with the upper part of the Hodgewater group to the east and south of Trinity Bay.

Chapter V

BASE OF THE CAMBRIAN SYSTEM IN SOUTHEASTERN NEWFOUNDLAND

Throughout most of North America, the oldest Palæozoic rocks are relatively unmetamorphosed and rest with profound angular unconformity upon more or less highly metamorphosed rocks of Precambrian age. In such areas, geologists all agree upon the proper position of the Precambrian-Palæozoic boundary. In parts of the Appalachian geosyncline, however, the earliest Palæozoic (commonly Cambrian) rocks rest without major unconformity upon various sequences of late Precambrian sedimentary rocks that have not been subjected to a noticeably higher grade of metamorphism than the Palæozoic rocks. In such areas the proper location of the Precambrian-Palæozoic contact is difficult to determine, and the classification of various rock formations stratigraphically near this contact has been the subject of much discussion in recent geological literature. The Cambrian rocks of most regions of southeastern Newfoundland rest without major unconformity upon relatively unmetamorphosed Precambrian sedimentary rocks, and previous workers have drawn the Precambrian-Cambrian contact at different horizons; it therefore seems necessary to discuss the problem of the base of the Cambrian system in southeastern Newfoundland in some detail.

Various criteria have been adopted by different workers for recognizing the base of the Cambrian system. Wheeler (1947) suggested that in all areas the base of the biozone marked by the olenellid trilobites should be chosen as the base of the Cambrian. However, if this horizon were used in southeastern Newfoundland, it would result in the classification of the Bonavista formation and the lower part of the Smith Point formation as Precambrian. At Brigus, both these formations underlie rocks containing the earliest olenellid trilobite *(Callavia),* but are clearly part of the Cambrian cycle of deposition. They overlie the Precambrian rocks with major unconformity and through the area they are lithologically similar to the overlying, olenellid-bearing strata, and they contain a few, non-trilobite fossils. Wheeler's suggestion, therefore, cannot reasonably be applied in eastern Newfoundland.

Other workers have suggested that the first major angular unconformity below the olenellid biozone should be chosen as the base of the Cambrian system. If this criterion were applied, all sedimentary rocks above the chosen unconformity would be classified as Cambrian even though they might be totally different in lithology and stratigraphically greatly distant from the overlying olenellid-bearing Cambrian rocks. In the writer's opinion, this criterion is patently inapplicable. Many regions are known where great thicknesses of sedimentary rocks, representing several geological systems, form continuous sequences unbroken by any major angular unconformity. Many systemic boundaries are marked by only minor disconformities. Therefore, it is clear that the lack of such an unconformity in a stratigraphic sequence is insufficient grounds for classifying the entire sequence within the same geological system.

The writer prefers to draw the Precambrian-Cambrian contact at the first demonstrable regional disconformity below the olenellid biozone. It has been amply shown in many stratigraphic studies that a disconformity may commonly represent a break in deposition of great magnitude, so that such a disconformity where present provides a logical base for the Cambrian system; thus avoiding both the exclusion from the Cambrian of fossiliferous rocks that clearly form part of the Cambrian depositional cycle, and the inclusion in the Cambrian of great thicknesses of non-fossiliferous rocks of varying lithology that have no evident affinity with the true Cambrian rocks. The writer has therefore drawn the base of the Cambrian system throughout the region at the first disconformity in the stratigraphic sequence below the rocks of the *Callavia* zone.

Conception Bay Region

At most localities where they are exposed around Conception Bay the Lower Cambrian rocks rest with major angular unconformity upon the highly folded volcanic and interbedded sedimentary rocks of the Harbour Main group, the oldest rocks recognized in Avalon Peninsula. At Duffs, on the east shore of Conception Bay, the Cambrian rocks overlie unconformably the Precambrian Holyrood granite. Accordingly, the base of the Cambrian rocks is readily drawn at this major unconformity.

Remainder of Avalon-Burin Peninsulas

Except in Conception Bay area, the fossiliferous Cambrian rocks of Avalon-Burin Peninsulas rest without angular discordance on the Random formation of predominantly white, locally conglomeratic, crossbedded quartzite, with minor grey to green and red quartzite, siltstone and silty shale. The Random rocks, in turn, overlie thick sequences of clastic sedimentary rocks referred to the Musgravetown and Hodgewater groups. However, geological mapping on Avalon Peninsula by McCartney (1956, 1957) and by the writer (1953) has shown that the pre-Random rocks were folded prior to the deposition of the Random and the overlying Cambrian rocks. This is shown by the fact that in Harbour Grace and Dildo map-areas the Hodgewater strata are folded into broad, open anticlines and synclines that do not affect the Random and Cambrian rocks but plunge to the southwestward beneath them. The actual contact between the Hodgewater and the Random rocks is not known to be exposed, but it must be unconformable, at least in this region. The Hodgewater, and the equivalent Musgravetown rocks, are therefore clearly of Precambrian age.

The age of the Random formation has been controversial among geologists working in eastern Newfoundland. The formation was originally described and named by Walcott (1900). He stated that it lay disconformably below the Cambrian and accordingly classified it as Precambrian. Later workers including Hayes (1948) and Christie (1950) referred to the Random as "late Proterozoic or early Cambrian", thus by implication, questioning the presence of this unconformity. Rose (1948) suppressed the Random as a separate formational name and classified its white quartzites as Lower Cambrian by including them in the Brigus formation. However, none of these workers adduced any new evidence as to the physical nature of the contact between the Random and Bonavista formations in the field.

This contact is, in fact, well exposed at many localities in southeastern Newfoundland. At most exposures the two formations exhibit parallel bedding and the contact is regular. It is marked by a sharp lithological change from massive quartzite of quartzitic sandstone of the Random to a bed of fine quartz-pebble conglomerate with pink limestone cement, which commonly forms the basal bed of the Bonavista formation. This conglomerate bed is commonly less than a foot thick but is locally thicker; it is lacking at one or two localities. This thin conglomerate bed is overlain by the lower shale or slate beds of the Bonavista formation.

At a few localities, notably at Keels on Bonavista Bay and at Little Dantzic Cove on Burin Peninsula, a few beds of pink or grey quartzite are included in the lower part of the Bonavista formation. These beds could well have formed in the early Cambrian sea bottom by the reworking of loose sand derived by the weathering of the Random formation; their presence, therefore, does not necessarily show that the Random-Bonavista contact is gradational.

There are, however, three localities where the contact between the Random and Bonavista formations is apparently not simple and conformable. On the east shore of Placentia Bay, south of Cuslett, the uppermost bed of the Random formation — a massive, white quartzite — is cut by a channel about 4 feet deep and 12 feet wide. This channel is filled by a fine quartz-pebble conglomerate, with a pink limestone cement, identical in lithology with the basal bed of the Bonavista formation which, outside the area of the channel, is about 6 inches thick and rests with regular contact on the quartzite. Again, the contact is well exposed along the east side of Cape Dog, St. Marys Bay. The bedding in the two formations appears to be parallel, and the plane of contact is regular. However, close examination shows that the basal bed of the Bonavista formation — a fine quartz-pebble conglomerate with pink limestone matrix — truncates the bedding of the Random formation at a very slight angle, and cuts across about 4 feet of Random rocks in a distance of some 150 feet along strike. Finally, on the west shore of Long Cove, Trinity Bay, a similar quartz-pebble conglomerate at the base of the Bonavista formation rests on the upper bed of the Random (a red slaty siltstone at this locality) along a very uneven surface, filling low spots as much as 4 inches deep on the upper surface of the Random rocks; in addition, small local projections on the Random rocks rise several inches into the quartz-pebble conglomerate.

The outcrops described above show that the Random formation was deposited, indurated and, at least at Cape Dog, slightly tilted, before the deposition of the Bonavista formation began. The writer concludes that the lower contact of the Bonavista formation is disconformable in southeastern Newfoundland; the disconformity is marked by slight channelling, local irregularities and bevelling of the surface of the underlying Random rocks at some localities, and by a sharp lithological change throughout the area. The writer, therefore, regards the Random formation as of late Precambrian age, and chooses this disconformity to mark the base of the Cambrian system in the Avalon-Burin Peninsulas region.

Chapter VI

CAMBRIAN GEOLOGICAL HISTORY

The present study provides fairly clear evidence as to the sequence of geological events that took place in southeastern Newfoundland during the Cambrian period. The writer therefore believes it worthwhile to present a picture of the Cambrian history of the region, and to attempt to coordinate it with the history of adjacent regions. More detailed future work may add to our knowledge of this history, and may well alter the present conclusions in certain respects.

Lower Cambrian

At the beginning of Cambrian time, most of southeastern Newfoundland was evidently a relatively flat, low-lying land area, underlain mainly by flat-lying or gently folded sedimentary rocks of late Precambrian age. However, to the east and southeast of Conception Bay, the more resistant, highly folded volcanic rocks of the Harbour Main group, and the Holyrood granite that intrudes them, probably formed a range of low hills projecting above the general lowland surface.

Very early in the Cambrian period, marine waters transgressed into the region, probably as the result of a gradual downwarping of the land to form a broad, open depositional basin (a part of the so-called Acadian geosyncline) whose axis trended slightly east of north through Placentia Bay and along the west shore of Trinity Bay to the vicinity of Keels, Bonavista Bay. The sea evidently entered this basin from the north, and transgressed gradually southward along the axis of the basin, where deposition of the red and green limy shales and thin limestones of the Bonavista formation began. Later, in Bonavista time, the sea spread westward to a point beyond Burin Bay arm and eastward to the west shores of Conception and St. Marys Bays, as shown in the isopach map of the Bonavista formation (*see* Fig. 2). However, extreme eastern Avalon Peninsula, as well as the western part of Burin Peninsula and the region north of Fortune Bay, remained above sea-level. The fauna of the Bonavista formation shows that it was deposited before any other known Cambrian formation of the Acadian region of eastern North America (thus substantiating the theory that the sea entered the Acadian basin of deposition from the northeast). However, equivalent rocks may be present in the Comley region, Shropshire, England.

The thin limestones of the Smith Point formation were deposited, so far as is known, over the same region as the youngest beds of the Bonavista formation; there is, however, a suggestion from the isopach map of this formation (*see* Fig. 3) that by Smith Point time the axis of the basin had shifted somewhat farther to the east, to a position near the east shore of Trinity Bay. No particular significance is attached to the deposition of limestone during this part of Early Cambrian time; the

Smith Point is, in fact, merely the thickest and most widespread of a number of massive, pink limestone beds in the Lower Cambrian sequence; it was described as a separate formation mainly because it forms a useful horizon marker. Late in Smith Point time, the first trilobites apparently appeared in the region.

After deposition of the Smith Point limestone, the seas continued a gradual transgression, so that the sediments of the Brigus formation covered the entire Burin Peninsula to the west, and extended eastward at least as far as Topsail Head, on the east shore of Conception Bay. There is no evidence that the Lower Cambrian seas ever covered the higher areas of resistant rocks east of Conception Bay, although they may well have done so. However, the writer believes that no Early Cambrian sediments were deposited in the region north of Fortune Bay.

During Brigus time, the Early Cambrian seas of the Acadian region attained their maximum distribution, as marine deposition is known to have occurred simultaneously in Cape Breton Island (Hutchinson, 1952a), New Brunswick (Hayes and Howell, 1937), and in Massachusetts (Grabau, 1901), as well as in parts of Western Europe. Throughout Lower Cambrian time, the land both east and west of the basin of deposition must have been too low in relief to furnish any coarse detrital material to the Cambrian sediments, because, except for conglomerates, and rare locally distributed siltstone lenses near the base of the Bonavista formation, the sedimentary rocks deposited in the Early Cambrian seaway were entirely fine-grained limy shales, and more or less muddy limestones.

After the deposition of the Brigus formation, the seas probably retreated rather rapidly from the area, leaving Lower Cambrian deposits which attained a thickness of at least 1,000 feet in the Trinity Bay region, but which thinned rapidly to the east and west, with less than 100 feet being preserved near Manuels, on the east shore of Conception Bay, and on the west tip of Burin Peninsula.

Middle Cambrian

Early in Middle Cambrian time, southeastern Newfoundland was submerged by a seaway which spread rapidly beyond the boundary of the maximum Early Cambrian basin of deposition, to cover the entire Avalon-Burin Peninsulas, with the possible exception of the highlands east of Conception Bay, also to cover the area north of Fortune Bay, which had remained above sea-level throughout the Early Cambrian. The presence of a thin manganiferous member at the base of the Middle Cambrian around Trinity and Conception Bays, but lacking elsewhere, suggests that deposition began first in that area. In any case, the entire region was submerged by early *Paradoxides bennetti* zone time, and a fairly uniform thickness of green shale with minor limestone of the Chamberlain's Brook formation was deposited throughout the Avalon-Burin areas, while siltstone and silty shale of the Young's Cove formation were being laid down north of Fortune Bay. Late in Chamberlain's Brook time, a local volcanic episode resulted in the deposition of a thin, volcanic breccia on the east shore of Trinity Bay. These facts suggest that the land to the east of the depositional basin at this time remained low, and provided only fine mud to the basin, whereas the land to the west had risen enough to erode more rapidly, thus providing the coarser silts of the Young's Cove sediments to the westerly part of the basin. This submergence in eastern Newfoundland coincided with widespread marine invasion of the Acadian region, during which contemporaneous formations were deposited in Cape Breton Island (Hutchinson, 1952a), in New Brunswick (Hayes and Howell, 1937), and in the Boston region (Grabau, 1901).

About the close of *Paradoxides bennetti* time, deposition of green shale gave way to grey and black, more limy shale of the Manuels River formation, which was deposited throughout *Paradoxides hicksi* and *Paradoxides davidis* zone time over the entire Avalon-Burin Peninsulas region. Rocks of this age are not known certainly north of Fortune Bay; it seems likely that the upper part of the Young's Cove formation, in which no trilobites have yet been found, may belong to one or both of these zones. If so, it appears that coarser detrital material was being supplied to the western margin of the depositional basin than to its more easterly parts, suggesting that the land to the west was rising fairly rapidly, whereas the eastern borders remained low lying.

Late in Middle Cambrian time, a significant volcanic episode occurred near the head of Trinity Bay, with the deposition of pillow lavas and massive, vesicular flows, mainly andesitic in composition, as much as 100 feet thick within the *Paradoxides davidis* zone about the head of Trinity Bay.

About the close of *Paradoxides davidis* time, the seaway probably retreated from most of the region. However, the area along the east shore of Trinity Bay remained submerged long enough for a few feet of grey shale and limestone, containing a *Paradoxides forchhammeri* zone fauna, to be deposited there. These rocks are the youngest known Middle Cambrian deposits of eastern Newfoundland. It seems probable that after their deposition the sea withdrew from the region, and that the region remained a very low land area for the rest of the Middle Cambrian epoch.

Upper Cambrian

Early in Upper Cambrian time, marine waters again invaded southeastern Newfoundland. Their incursion must have been rapid, because deposits of the earliest Upper Cambrian beds containing *Agnostus pisiformis* occur throughout the region, even in the relatively positive areas east of Conception Bay and north of Fortune Bay. Deposition is believed to have continued through the entire Upper Cambrian over the whole area.

Earliest deposits in the region were black shales with limestone nodules, and deposition of the same rocks continued north of Fortune Bay. However, before the close of *Agnostus pisiformis* time, silty, grey, micaceous shales were being deposited elsewhere. Later, towards the end of *Olenus* zone time, deposition of shallow-water, crossbedded siltstone and silty shales occurred in the Avalon-Burin region; similar deposits were laid down during *Parabolina* zone time, and likely continued through *Leptoplastus* zone time, although palæontological proof is lacking. Later, towards the close of the Upper Cambrian (in *Peltura* zone time) finer, grey shale with only minor thin silty beds was deposited in the Avalon-Burin area. Meanwhile, deposition of a — probably much thinner — sequence of black, silt-free shale with thin beds and nodules of limestone continued north of Fortune Bay. After the deposition of the beds of the *Peltura* zone, the Cambrian seas probably withdrew from the entire region.

Thus, the changing facies of the Upper Cambrian deposits suggests that the sediments in the eastern part of the depositional basin were derived from a land mass which furnished only fine mud to the basin of deposition at the beginning of the epoch. This land mass probably rose gradually and provided more and more coarse silty detritus until about the middle of the epoch. Crossbedding, ripple-marks, and mud-cracks in the rocks of the *Parabolina* zone show that the sea was shallow and land probably lay nearby to the east during that time. Later, however, the land mass was gradually reduced by erosion, until only a minor amount of silt was being carried into the basin at the close of Cambrian deposition in the area.

The rocks north of Fortune Bay evidently originated in quiet water, where only fine-grained mud was being furnished to the basin of deposition, suggesting that the land area to the northwest, which had furnished a lot of silt to the Middle Cambrian deposits, was now so low that it provided only fine-grained sediments.

Summary

During the Cambrian period, southeastern Newfoundland was the site of a broad, intermittenly sinking basin of deposition, whose axis probably trended slightly east of north through Placentia Bay, thence along the west shore of Trinity Bay and into Bonavista Bay. The sequence of Cambrian faunas suggests that this basin of deposition had direct connections with Nova Scotia, southern New Brunswick, and the Boston area to the southwest, and with Wales, England, and Scandinavia to the northeast. The faunas of this region are almost totally unlike those found elsewhere in North America, including northern and western Newfoundland, the St. Lawrence region, Gaspé, and the Appalachian Mountains. Brief incursions of these Atlantic-type faunas took place into Vermont (Howell, 1937), and Gaspé (Hutchinson, 1952b), during late Middle Cambrian time, but no occurrences of any of the faunas characteristic of the interior of North America have been found in southeastern Newfoundland.

The Cambrian basin of deposition in eastern Newfoundland was miogeosynclinal in type. The exact thickness of the Cambrian deposits is not known, but they probably attained a maximum thickness near the centre of the basin of no more than 4,000 feet of dominantly shaly rocks, with lesser proportions of fine-grained siltstone and shaly limestone. Thin volcanic beds were deposited twice during Middle Cambrian time in the area east of, and about the head of Trinity Bay.

The exact margins of the basin of deposition are known only for the Lower Cambrian, when the southeastern margin of the basin extended up to, but probably not far beyond, the east shore of Conception Bay, and the northwestern margin covered the tip of Burin Peninsula but did not extend north of Fortune Bay.

The seas extended farther to the west during both Middle and Upper Cambrian time to cover the north shore of Fortune Bay. It is not known how much farther these seas spread to the north and west, but the writer believes that the central part of Newfoundland remained above sea-level throughout the period. This belief is based on the absence of known Cambrian deposits in the metamorphosed Palæozoic sequence of central Newfoundland, on the shallow-water characteristics of the Young's Cove formation, which suggests that it was deposited fairly close to a shoreline which must, therefore, have lain immediately northwest of the north shore of Fortune Bay, and in addition, on the total dissimilarity between the Cambrian faunas of northwestern and southeastern Newfoundland which strongly suggests that the rocks containing them were deposited in separate, unconnected seaways. This belief is supported by recent work by E. R. W. Neale of the Geological Survey of Canada, in the Baie Verte area (Neale, 1958), where rocks of Ordovician age rest with angular unconformity on Precambrian gneisses. Such a land area in central Newfoundland, if it did exist, as believed, must have been low, as it provided only fine-grained silty and shaly sediments to the depositional basin; it may, indeed, have been briefly submerged somewhere along its length late in the Middle Cambrian. This would account for the sudden incursion of an Atlantic-type fauna in the Gaspé and in Vermont at that time.

There is no evidence to suggest whether or not the entire Avalon Peninsula was submerged during Middle and Upper Cambrian time, although, as noted above, the facies of the Upper Cambrian rocks there suggests near-shore deposition, so that the shoreline probably lay not far to the southeast.

This depositional basin persisted at least into early Ordovician time before being folded, since early Ordovician sedimentary rocks, of similar facies to the late Cambrian deposits, rest without angular discordance upon Cambrian rocks in the Conception Bay area (Rose, 1952) and on the west shore of Trinity Bay (Christie, 1950).

Chapter VII

DISCUSSION OF CAMBRIAN TRILOBITE FAUNAS

General Nature of the Cambrian Trilobite Faunas

The Cambrian faunas of southeastern Newfoundland are dominated both in number of individuals and number of species by trilobites. Brachiopods, gastropods, hyolithids and conchostracoid crustaceans are also present, but archaeocyathids, so numerous in the Lower Cambrian rocks of northwestern Newfoundland, are not represented. All the trilobites are referable to genera known elsewhere in eastern North America and northwestern Europe within the so-called Atlantic faunal realm; no trilobites known from the Pacific faunal realm, which includes the rest of North America, are represented. The non-trilobite fossils were not studied in detail and their faunal relationships were not determined.

The Lower Cambrian rocks are sparingly fossiliferous. They have been metamorphosed to slate throughout most of the region, so that any fossils in the original shale beds have been destroyed. However, well-preserved fossils can be collected from beds and nodules of limestone. Such limestone comprises the entire Smith Point formation, and is common in the upper part of the Bonavista formation and in the lower part of the Brigus formation, so that the best faunas were collected from this part of the Lower Cambrian section. The rest of the section, especially the upper part of the Brigus formation, contains very little limestone, so that only a very few, commonly fragmentary fossils, were obtained from these beds, and their faunas remain largely unknown.

East of Conception Bay and near Clarenville, Trinity Bay, the Lower Cambrian rocks are unmetamorphosed, and a few identifiable fossils were obtained from red shale beds of the Brigus formation. However, exposures are limited and the fossils poorly preserved, so that little additional information was obtained.

The Middle Cambrian rocks of the Avalon-Burin Peninsulas are abundantly fossiliferous, except for the lower part of the Chamberlain's Brook formation, which yielded very few fossils. This formation contains very little limestone and most of the fossils obtained from it were obtained from shale beds in the well-exposed unmetamorphosed section on Manuels River. Although somewhat flattened, these fossils are commonly well preserved. Elsewhere in the area this formation has been metamorphosed to slate, and its fossils have been either destroyed or so badly distorted as to be unidentifiable.

The Manuels River formation yielded well-preserved trilobites in shale beds on Manuels River, and also numerous excellently preserved fossils from limestone nodules throughout the region. The entire formation is fossiliferous.

Middle Cambrian rocks north of Fortune Bay are sparingly fossiliferous, but fossils were found in some of the soft black shales. They are similar to fossils of the same age elsewhere in eastern Newfoundland.

The Upper Cambrian rocks throughout most of the region comprise a sequence of siltstone and silty shale (Elliott Cove group) with very few fossils. However, at most localities, fairly well preserved trilobites were found in some of the darker, less silty, shale beds. The Salmonier Cove formation, north of Fortune Bay, contains dark grey limestone nodules that yielded numerous well-preserved trilobites.

Faunal Zonation

Lower Cambrian Faunal Zones

Three faunal zones are, with some doubt, recognized in the Lower Cambrian series. These are, in ascending order, the *Coleoloides,* the *Callavia,* and the *Protolenus.*

The *Coleoloides* zone comprises the Bonavista formation and all except the uppermost 2 feet of the Smith Point formation. Fossils are scarce in these rocks and no trilobites have ever been found in them. However, a small fauna of hyolithids, brachiopods and gastropods have been described from the Bonavista formation at Smith Sound by Matthew (1899), and the same fauna has since been found in the Bonavista and Smith Point formations at several other localities. This fauna, named for the primitive hyolithid genus *Coleoloides* Matthew, its most common fossil, is here recognized as marking the earliest Cambrian faunal zone of southeastern Newfoundland. The deposition of the rocks containing it evidently occurred before the first trilobites appeared in this region.

The *Coleoloides* fauna is succeeded by a fauna containing the large olenellid trilobite *Callavia broeggeri* Walcott as its most common species. This fauna commonly occurs in the lower, most fossiliferous part of the Brigus formation, and, at a few localities, in the uppermost beds of the Smith Point formation. The boundary between the *Coleoloides* and *Callavia* zones is therefore drawn about 2 feet below the top of the Smith Point limestone, immediately below the earliest known occurrence of the *Callavia* fauna.

The *Callavia* fauna, in addition to *Callavia broeggeri,* commonly includes *Strenuella strenua* (Billings), *Micmacca* sp., *Triangulaspis vigilans* (Matthew), *Serrodiscus bellimarginatus* (Shaler and Foerste), and *Dipharus planus* n. sp. Also present, but very rare, are *Dipharus attleborensis* (Shaler and Foerste), another, unnamed, species of *Serrodiscus,* and *Pseudatops* cf. *reticulatus* (Walcott). At least two genera of inarticulate brachiopods, several hyolithids, and small cone-shaped gastropods of the genus *Scenella* also occur in the *Callavia* zone. They have not been studied in detail.

A third Lower Cambrian fauna probably occurs in the upper part of the Brigus formation, where fossils are extremely rare and generally fragmentary. Most of the species collected by Walcott east of Conception Bay and described by him in various publications have not been found associated with species of the *Callavia* fauna, and probably form part of a distinct post-*Callavia* Lower Cambrian fauna which is poorly represented in the collections of the Geological Survey of Canada. The writer was unable to locate most of Walcott's localities, and those that were found yielded only fragmentary fossils. The fauna includes a trilobite described by Walcott as

Solenopleura harveyi, which is probably a *Protolenus, Solenopleura*? *howleyi* Walcott, and species of *Strenuella* (not *strenua*), *Avalonia* and *Calodiscus.*

Our collections from the upper part of the Brigus formation contain a poorly preserved eodiscid trilobite (*Calodiscus*?) a species of *Strenuella,* and a few fragmentary specimens, too incomplete for certain identification, which may represent *Protolenus.* The writer has not collected any specimens of *Callavia* from these beds nor have any of the above species described by Walcott been found with species of the *Callavia* zone anywhere in the region. Walcott's original description of *Callavia broeggeri* does not give the locality precisely enough to permit determination of its exact stratigraphic position, but it seems likely that his *Callavia* locality must have been below the beds from which he collected the other fossils he described.

The writer, therefore, recognizes a zone at the top of the Lower Cambrian series containing a distinctive fauna which lacks olenellid trilobites. It occupies the same stratigraphic position as the *Protolenus* zone of New Brunswick, and as a species of *Protolenus* is probably present, it is referred to in this report as the *Protolenus* zone. The exact boundary between the *Protolenus* zone and the underlying *Callavia* zone cannot be drawn with certainty, because the upper part of the Brigus formation contains so few fossils, but it must lie somewhere about the middle of the Brigus formation.

The Lower Cambrian faunal succession is further complicated by the occurrence of still another fauna. At Duffs, on the east shore of Conception Bay, a small fauna containing an olenellid trilobite that is not referable to *Callavia* was found in a thin limestone bed. This bed forms part of a small, discontinuously exposed section which yielded no other trilobites. This section is certainly part of the Brigus formation but cannot accurately be correlated with better sections of that formation elsewhere. The exact stratigraphic position of this fauna in relation to the *Protolenus* and *Callavia* zones is therefore unknown. It probably antedates the *Protolenus* fauna, which contains no olenellids either in Newfoundland or in New Brunswick. It may merely represent the occurrence of another species of olenellid within the *Callavia* zone, or it may mark the presence of another, post-*Callavia* pre-*Protolenus* Lower Cambrian zone that is represented elsewhere in the region by unfossiliferous beds. The present writer does not wish to propose a new zone on such limited evidence but the possibility that such a zone exists should be noted.

Middle Cambrian Faunal Zones

Four faunal zones are recognized in the Middle Cambrian series, named in ascending order, the *Paradoxides bennetti, Paradoxides hicksi, Paradoxides davidis,* and *Paradoxides forchhammeri* zones.

The Middle Cambrian series as developed in the well-exposed fossiliferous section on Manuels River, east of Conception Bay was studied in great detail by Howell (1925). He published an exact bed-by-bed lithological and faunal description of these rocks and recognized that they could be divided faunally into three zones, each of which was characterized by a distinctive species of *Paradoxides.* Each zone was found to correspond with a distinct lithological unit, which he classified as a formation. The present study confirmed the validity of Howell's stratigraphic and faunal zonation and the same three *Paradoxides* zones were found to occur in the Middle Cambrian rocks throughout southeastern Newfoundland. For reasons given in Chapter III, however, it was found desirable to classify two of Howell's formations as members of a new, larger formation. The present author therefore agrees with Howell in recognizing the *Paradoxides bennetti, Paradoxides hicksi,* and *Paradoxides davidis* faunal zones as the best zonal subdivision of these rocks. Howell has described the composition of these faunas and given detailed ranges for each species so that no further discussion is necessary.

A fourth Middle Cambrian fauna was found above the *davidis* zone on Trinity Bay in rocks either represented by unfossiliferous beds, or entirely lacking in the section described by Howell. This fauna contains many species of agnostid and conocoryphid trilobites which are identical with, or closely related to, species known from the late Middle Cambrian *Paradoxides forchhammeri* zone of Scandinavia, although the *Paradoxides* which it contains is not *forchhammeri,* but a large species with long eyelobes somewhat resembling *Paradoxides bennetti,* which is named *Paradoxides freboldi* in this report. However, in order to emphasize the close faunal similarity between, and the identical stratigraphic position of the Newfoundland and Scandinavian faunas, the name *forchhammeri* is applied in a zonal sense to the Newfoundland succession. The *forchhammeri* zone comprises the uppermost known Middle Cambrian rocks in eastern Newfoundland. It is known only near the head of Trinity Bay where it occurs through about 20 feet of beds at the top of the Manuels River formation, although it may be represented by unfossiliferous beds elsewhere in the region.

Upper Cambrian Faunal Zones

The earliest Upper Cambrian rocks of the region comprise sparingly fossiliferous grey to black shales. They contain a rather sparse fauna of trilobites, inarticulate brachiopods, hyolithids, and conchostracoid crustaceans, dominated by the trilobite *Agnostus pisiformis.* The *Agnostus pisiformis* fauna marks a widespread zone near the base of the Upper Cambrian series throughout Europe and eastern North America, and the Newfoundland rocks are, accordingly, referred to the same zone. In addition to *A. pisiformis,* the fauna yielded a large trilobite resembling *Proceratopyge,* rare specimens of a new agnostid here named *Phalacroma bairdi,* and at one locality only, numerous specimens of *Schmalenseeia.* The non-trilobite fossils have not been studied in detail.

The *pisiformis* zone is succeeded by a sequence of grey, silty shale or slate with some black shale, in which fossils are rare. However, specimens of *Olenus* were obtained at three localities on Avalon Peninsula and at one locality north of Fortune Bay, in association with *Agnostus pisiformis obesus* and *Phalacroma bairdi* n. sp., as well as inarticulate brachiopods and conchostracoid crustaceans. These beds are therefore, referred to the *Olenus* faunal zone.

The rocks above the *Olenus* zone on Avalon Peninsula comprise a thick sequence of silty grey shales with thin massive siltstone beds; equivalent rocks are not known to be exposed north of Fortune Bay. These rocks are commonly unfossiliferous, although, at some localities a few inarticulate brachiopods were collected. The only trilobites found were a few specimens of *Parabolina spinulosa,* all from a single locality in the lower part of this sequence of rocks. This discovery permits the reference of the rocks containing *Parabolina* to the *Parabolina spinulosa* faunal zone which overlies the *Olenus* zone elsewhere in the North Atlantic region.

The beds above the *Parabolina*-bearing locality are thought to be unfossiliferous equivalents of the *Leptoplastus* zone of Europe, Nova Scotia, and New Brunswick. However, no species of the *Leptoplastus* fauna were found in Newfoundland, so that the presence of the *Leptoplastus* zone is inferred from the stratigraphic and faunal evidence and cannot be regarded as proven.

The uppermost part of the Upper Cambrian series both in Avalon Peninsula and north of Fortune Bay contains specimens of the trilobite genus *Peltura.* These rocks are therefore referred to the *Peltura* zone, the youngest Cambrian faunal zone of the North Atlantic region. In eastern Newfoundland the *Peltura* fauna contains only a few species of trilobites, namely, *Peltura scarabaeoides, Ctenopyge pecten, Ctenopyge* sp., and *Lotagnostus trisectus.*

The Cambrian rocks are overlain by fossiliferous Tremadocian (early Ordovician) strata. The stratigraphy of these rocks, and the contained fossils, are not described in this report.

Chapter VIII

PALÆONTOLOGY

Introduction

This chapter presents systematic palæontological descriptions of most of the species of Newfoundland Cambrian trilobites. It had been proposed to describe in this memoir all the Cambrian trilobites, but the study of the fossils was interrupted by the resignation of the writer from the Geological Survey of Canada in 1956, so that some of the trilobites remain unstudied. The systematic descriptions here presented were all prepared prior to 1956 and have not been revised to date. For this reason, it has been impossible to refer to some more recently published studies. It is hoped to complete the study at a later date.

The trilobites are classified into families only. The classification adopted for the agnostid trilobites is that of Westergard (1946), and for the polymerid trilobites, that of Henningsmoen (1951). The terminology used in the descriptions is that recommended by Howell, *et al.* (1947), except that the term glabella is used in its more usual sense to include the occipital ring. Except where otherwise stated, all figured specimens were collected by the writer and are in the type collections of the Geological Survey of Canada. All photographs, unless otherwise stated, were taken by the photographic section of the Geological Survey of Canada. A table summarizing the stratigraphic distribution of the trilobites described in this chapter follows. A list of the localities in southeastern Newfoundland from which Cambrian trilobites were collected, with the Geological Survey of Canada locality numbers, is given in Appendix II.

Descriptions of Species

Family Eodiscidae Raymond, 1913

The nomenclatural history and classification of the eodiscid trilobites has been thoroughly discussed by Rasetti (1952). The writer agrees with his conclusion that this group is sharply distinct from the agnostids, and also with his statement that it makes little difference whether this fact is acknowledged by setting off the eodiscids as an order or as a superfamily. The classification of eodiscids used here is that used by Rasetti (op. cit.).

Table I

Stratigraphic Distribution of Trilobites

Species	Bona-vista fm.	Smith Point fm.		Brigus fm.		Chamberlain's Brook fm.	Manuels River fm.			Elliott Cove group			
	Coleoloides	zone		*Callavia* zone	*Protolenus* zone	(*P. bennetti* zone)	*P. hicksi* zone	*P. davidis* zone	*P. forchhammeri* zone	*Agnostus pisiformis* zone	*Olenus* zone	*Parabolina* zone	*Peltura* zone
Serrodiscus bellimarginatus (Shaler and Foerste)				x									
Serrodiscus sp.				x									
Eodiscus scanicus (Linnarsson)							x						
Eodiscus punctatus (Salter)								x					
Eodiscus armatus n. sp.									x				
Calodiscus helena (Walcott)					x(?)								
Dipharus attleborensis (Shaler and Foerste)			x										
Dipharus planus n. sp.				x									
Triangulaspis vigilans (Matthew)				x									
Condylopyge carinata Westergard						x							
Condylopyge cf. *C. spinigera* Westergard						x	x						
Condylopyge rex (Barrande)							x	x					
Condylopyge sp. A							x						
Condylopyge sp. B								x					
Pleurectinium granulatum (Barrande)						x	x	x					
Pleurectinium bifurcatum (Illing)								x					
Pleurectinium tuberculatum (Illing)							x	x					
Peronopsis trilobata (Matthew)						x							
Peronopsis cf. *P. quadrata* (Tullberg)								x	x				
Peronopsis fallax (Linnarsson) subsp. *P. depressa* Westergard							x	x					
Peronopsis howelli n. sp.							x						
Peronopsis (Acadagnostus) inarmata n. sp.						x							
Peronopsis (Acadagnostus) matthewi n. sp.								x					

Table I — continued

Stratigraphic Distribution of Trilobites

Species	Bonavista fm.	Smith Point fm.		Brigus fm.		Chamberlain's Brook fm.	Manuels River fm.			Elliott Cove group			
	Coleoloides	zone		*Callavia* zone	*Protolenus* zone	Chamberlain's Brook fm. (*P. bennetti* zone)	*P. hicksi* zone	*P. davidis* zone	*P. forchhammeri* zone	*Agnostus pisiformis* zone	*Olenus* zone	*Parabolina* zone	*Peltura* zone
Peronopsis (Acadagnostus) scutalis (Salter *in* Hicks)							x	x					
Hypagnostus parvifrons (Linnarsson)							x	x					
Hypagnostus parvifrons (Linnarsson) var. *H. mammillatus* (Broegger)								x					
Hypagnostus cf. *H. truncatus* (Broegger)								x					
Hypagnostus? sp.								x					
Cotalagnostus lens (Groenwall)								x					
Cotalagnostus lens (Groenwall) subsp. *C. claudicans* Westergard							x	x					
Tomagnostus fissus (Lundgren MS., Linnarsson)							x						
Tomagnostus perrugatus (Groenwall)							x	x					
Diplagnostus planicauda (Angelin) forma *D. bilobatus* Kobayashi								x	x				
Diplagnostus nordengi n. sp.								x					
Oidalagnostus cf. *O. trispiniger* Westergard									x(?)				
Ptychagnostus (Triplagnostus) stenorrachis (Groenwall)								x					
Ptychagnostus grandis n. sp.							x	x					
Ptychagnostus (Triplagnostus) hybridus (Broegger)								x	x				
Ptychagnostus atavus (Tullberg)							x	x					
Ptychagnostus punctuosus (Angelin)								x	x				
Ptychagnostus ciceroides (Matthew)							x	x					
Doryagnostus incertus (Broegger)								x					

Ciceragnostus barlowi (Belt) var. *C. definatus* (Howell)						x						
Ciceragnostus cicer (Tullberg)									x			
Phalacroma nudum (Beyrich)								x				
Phalacroma bairdi n. sp.										x	x	
Phalacroma? howsei n. sp.									x			
Phalacroma? sp.								x				
Agnostus pisiformis (Linnaeus)										x		
"*Agnostus*" sp. A									x			
"*Agnostus*" sp. B									x			
"*Agnostus*" sp. C							x					
"*Agnostus*" sp. D								x				
"*Agnostus*" sp. E							x					
Pseudatops cf. *P. reticulatus* (Walcott)				x								
Ctenocephalus (Harttella) terranovicus Resser						x						
Ctenocephalus howelli Resser								x				
Ctenocephalus resseri n. sp.									x			
Ctenocephalus excavatus Resser							x					
Elyx matthewi n. sp.									x			
Conocoryphe terranovica Resser								x				
Bailiaspis venusta Resser						x						
Bailiaspis prominens Resser						x						
Bailiaspis howelli n. sp.									x			
Bailiaspis cf. *B. howelli* n. sp.								x				
Bailiaspis latigenae n. sp.							x(?)					
Bailiaspis sp.								x				
Bailiella ornata Resser							x	x				
Bailiella tenuicincta (Linnarsson)							x					
Bailiella manuelensis n. sp.						x						
Bailiella sp.								x(?)				
Meneviella venulosa (Salter)							x	x				
Acontheus inarmatus n. sp.								x				
Hartshillia terranovica n. sp.								x				
Holocephalina americana Resser								x				
Clarella venusta (Billings)							x					
Clarella sp.								x				
Anapolenus henrici Salter								x	x			
Paradoxides lamellatus Hartt *in* Dawson						x						
Paradoxides hicksi Salter							x					
Paradoxides eteminicus Matthew						x						
Paradoxides davidis Salter								x				
Paradoxides cf. *P. rugulosus* Corda								x				
Paradoxides freboldi n. sp.									x			
Paradoxides bennetti Salter						x						
Callavia broeggeri (Walcott)			x	x								
Paradoxides parvoculus Howell						x						

Genus ***Serrodiscus*** R. and E. Richter, 1941

Serrodiscus bellimarginatus (Shaler and Foerste)

Plate I, figures 1a-e, 2

1888. *Microdiscus bellimarginatus* Shaler and Foerste, Harvard Mus. Comp. Zool. Bull., vol. 16, No. 2., p. 35, Pl. 2, figs. 19, 19a.
1899. *Microdiscus bellimarginatus* Shaler and Foerste mut. *insularis* Matthew, Trans. Roy. Soc. Can., ser. 2, vol. 5, sec. 4, p. 75.
1941. *Eodiscus* (*Serrodiscus*) *bellimarginatus* (Shaler and Foerste); R. and E. Richter, Abh. Senckenberg. naturf. Ges., No. 455, p. 23.
1941. *Eodiscus* (*Serrodiscus*) *insularis* (Matthew); R. and E. Richter, Abh. Senckenberg. Naturf. Ges., No. 455, p. 23.
1950. *Eodiscus* (*Serrodiscus*) *bellimarginatus* (Shaler and Foerste); Shaw, J. Pal., vol. 24, p. 582, Pl. 79, figs. 19-23.
1952. *Serrodiscus bellimarginatus* (Shaler and Foerste); Rasetti, J. Pal., vol. 26, p. 445, Pl. 52, figs. 12-17 (complete synonymy).

Material. Hypotype A, complete, enrolled specimen, GSC No. 12062, from locality 20468; hypotype B, cephalon, GSC No. 12063, from locality 20401.

Discussion. Shaw (1950) has given a complete description of this species. However, the specimen figured as hypotype A is apparently the first complete individual discovered; the thorax, therefore, is known for the first time. As in other species of the genus, it is composed of three segments, with broad axis, wide shallow pleural furrows, and a sharp geniculation near the tips of the pleura. The tips themselves are invisible as the specimen is enrolled.

The author has examined many specimens of this species from Newfoundland, including some from the type locality of Matthew's *insularis,* and he agrees with Rasetti (1952) that there are no specific differences between the Newfoundland forms and those from Massachusetts. Matthew's form is therefore a synonym of *S. bellimarginatus*.

This species is widespread in the Lower Cambrian *Callavia* zone. It has been found at localities 20396, 20399, 20401, 20407, 20448, 20468, 21928, and 21936.

Serrodiscus sp.

Plate I, figures 3a, b

Material. One figured specimen, pygidium, GSC No. 12064, from locality 20403.

Description. General form subtriangular, strongly convex, with long prominent elevated axis marked by nine distinct rings, with traces of two more posteriorly. The rings are set off by very shallow furrows and are only slightly raised, so that, in side view, the contour looks almost smooth. Dorsal furrow shallow, pleural lobes downsloping to shallow marginal furrow. Border narrow, downturned, poorly preserved.

Discussion. One pygidium in the collections is evidently referable to *Serrodiscus,* but it seems to be different from any described species. It is most like *S. speciosus* (Ford) from which it differs in having a very shallow axial furrow, and probably in lacking the small spines beneath the border, which do not appear to be present in this specimen. It differs from *S. bellimarginatus* in lacking nodes on the axial rings, and in having these rings very poorly defined. It was collected somewhat higher in the Lower Cambrian section than *S. bellimarginatus,* but still within the *Callavia* zone.

Genus *Eodiscus* Hartt *in* Walcott, 1884

Rasetti (1952) discussed in detail the history of this name, and the problem of its availability. The author follows him in recognizing *Eodiscus* as a valid and available generic name for these trilobites.

Eodiscus scanicus (Linnarsson)

Plate II, figures 1a-c, 2a-c

1883. *Microdiscus scanicus* Linnarsson, Sver. Geol. Undersök., ser. C, No. 54, p. 29, Pl. 4, figs. 17, 18.
1952. *Eodiscus scanicus* (Linnarsson); Rasetti, J. Pal., vol. 26, Pl. 53, figs. 7-16; Pl. 54, figs. 10-16 (complete synonymy).

Material. Hypotype A, cephalon, GSC No. 12065, from locality 20450; hypotype B, pygidium, GSC No. 12066, from locality 21805.

Discussion. The Newfoundland specimens seem to agree exactly with those from New Brunswick described by Rasetti (1952) and those from Sweden described by Westergard (1946). They are not, therefore, redescribed. This species is very similar to *E. punctatus* (Salter), and some specimens show features intermediate between the two species. The author has found the most useful criterion for separating them to be the occipital spine, which is more erect in *E. scanicus,* and also is usually shorter, though the length of the spine varies in both species.

This is one of the most common species in the faunas of the *hicksi* zone. It has been collected from localities 20417, 20420, 20443, 20450, 20455, 20457, 20477, 20500, 20501, 21803, 21805, 21907, and 21910.

Eodiscus punctatus (Salter)

Plate II, figures 3-7

1864. *Microdiscus punctatus* Salter, Quart. J. Geol. Soc. London, vol. 20, p. 237, Pl. 13, figs. 11a-c.
1952. *Eodiscus punctatus* (Salter); Rasetti, J. Pal., vol. 26, p. 448, Pl. 53, figs. 1-6 (complete synonymy).

Material. Hypotype A, cephalon, GSC No. 12067; hypotype B, large cephalon, GSC No. 12068; hypotype C, small cephalon, GSC No. 12069; hypotype D, pygidium, GSC No. 12070; hypotype E, small pygidium, GSC No. 12071; all from locality 20451.

Discussion. As this species has recently been redescribed by several workers, it seems unnecessary to describe it in detail. The species is abundant in most outcrops of the rocks of the *davidis* zone in Newfoundland. It has been collected from localities 20392, 20451, 21807, 21810, 21913, and 21935.

Eodiscus armatus n. sp.

Plate II, figures 8a-c, 9; Plate III, figures 1a-c, 2

Material. Holotype, cephalon, GSC No. 12072; paratype A, another cephalon, GSC No. 12073; paratype B, pygidium, GSC No. 12074; paratype C, another pygidium, GSC No. 12075; all from locality 21802.

Description. Cephalon semielliptical, about two-thirds as long as broad, posterior corners prolonged into short spines. Axial furrow broad, deep, glabella strongly convex, elevated above level of cheeks posteriorly, but sloping below them anteriorly, unfurrowed; prolonged backwards into a strong spine, broken off in all specimens seen, but which evidently rose backwards at an angle of about 25 degrees. Fixed cheeks inflated, separated in front of glabella by a broad deep furrow. Border horizontal, fairly broad for this genus, crenulated transversely. Thorax unknown.

Pygidium semielliptical, highly convex, length about two-thirds width. Axis prominent, with five prominent segments and traces of two or three less-distinct segments behind. Each of the five segments is strongly elevated. Pleural lobes convex, unfurrowed, horizontal near axis, sloping sharply down to marginal furrow, border very narrow.

Fixed cheeks coarsely tuberculate, pleural lobes of pygidium punctate and tuberculate.

Discussion. This species differs from all others within the genus in having short genal spines, in the unfurrowed glabella and broader border of the cephalon, and in having a broader, more sharply elevated axis, with fewer segments on the pygidium. It is very similar to *E. punctatus,* and was probably derived from that species. This hypothesis is supported by a few specimens from the uppermost part of the *davidis* zone which are intermediate between the two species in having a more elevated pygidial axis, and short points at the posterior corners of the cephalon, though not true spines. This species was collected only at Highland Cove, Trinity Bay, where it is fairly common in the limestone nodules of the *forchammeri* zone (locality 21802).

Genus *Calodiscus* Howell, 1935

Calodiscus helena (Walcott)

1890. *Microdiscus helena* Walcott, Proc. U.S. Nat. Mus., vol. 12, (for 1889), p. 40.
1890. *Microdiscus helena* Walcott; Walcott, 10th Ann. Rept., U.S. Geol. Surv., p. 632, Pl. 81, figs. 1, 1a.
1913. *Eodiscus helena* (Walcott); Raymond, Ottawa Naturalist, vol. 27, p. 103, fig. 6.
1943. *Paradiscus helena* (Walcott); Kobayashi, Proc. Imp. Acad. Tokyo, vol. 19, p. 38.
1944. *Paradiscus helena* (Walcott); Kobayashi, J. Fac. Sci. Univ. Tokyo, sec. 2, vol. 7, Pt. 1, p. 44, Pl. 2, figs. 1a-b.
1952. *Calodiscus helena* (Walcott); Rasetti, J. Pal., vol. 26, p. 443, Pl. 54, figs. 18-22.

Discussion. Rasetti has recently restudied this species, and the writer agrees with him that it should be referred to *Calodiscus*. Walcott's types, which are U.S. National Museum, lot No. 18361, were kindly loaned for study. This is a distinctive species, and must have been collected from the upper part of the Brigus formation.

The writer has not been able to find Walcott's locality, which was given as "600 meters west of Manuels Brook", and this species is not represented in the Geological Survey of Canada collections. It is not illustrated here, as it has recently been adequately figured by Rasetti.

Family Pagetiidae Kobayashi, 1935

Genus *Dipharus* Clarke, 1923

Shaw (1950, p. 585) has recently discussed this genus, and diagnosed it (in part) as follows: "Pagetiidae having a long, inflated conical glabella, flat triangular fixed cheeks, and a wide flat brim." The author would modify this diagnosis to read Pagetiidae with a long, inflated, conical glabella which is always visible on internal mould, but which may be effaced in some species on specimens retaining the test. This altered diagnosis will permit the inclusion of a new species from Newfoundland which is described below as *Dipharus planus*.

Dipharus attleborensis (Shaler and Foerste)

Plate III, figures 3, 4

1888. *Ptychoparia attleborensis* Shaler and Foerste, Harvard Mus. Comp. Zool. Bull., vol. 16, No. 2, p. 39, Pl. 2, fig. 14.

1950. *Dipharus attleborensis* (Shaler and Foerste); Shaw, J. Pal., vol. 24, p. 586, Pl. 79, figs. 15-18 (complete synonymy and description).

Material. Hypotype A, cranidium, GSC No. 12076; hypotype B, pygidium, GSC No. 12077; both from locality 20467.

Discussion. Shaw has recently discussed the complex nomenclatural history of this species, and has shown that it must be referred to the genus *Dipharus*. Specimens of this genus are not uncommon in the Lower Cambrian of Newfoundland, but most of them are referable to a new species *D. planus,* described below. However, one horizon, the Smith Point limestone member, at locality 20467, has yielded a form that agrees exactly with this well-known species, and is here referred to it.

Dipharus planus n. sp.

Plate III, figures 5-9

Material. Holotype, cranidium, GSC No. 12078; paratype A, cranidium, GSC No. 12079; paratype B, internal mould of a cranidium, GSC No. 12080; paratype C, pygidium, GSC No. 12081; paratype D, pygidium, GSC No. 12082; all from locality 21798.

Description. Cranidium small; moderately convex; glabella not defined on specimens retaining test, but visible on internal moulds where it is narrow, cylindrical, bluntly rounded in front, unfurrowed. Front third of cranidium sloping sharply downward to make a broad, concave border; no true marginal furrow present. Fixed cheeks horizontal, posterior limb strongly downsloping, triangular, depressed well below fixed cheeks. Palpebral lobes short, rounded, situated about midlength of cranidium. Facial suture proparian; anterior branch curving inward and backward across the border, rising to the palpebral lobe; posterior branch descending outward and slightly backward to lateral margin. Free cheeks and thorax not known.

Pygidium small, strongly convex, smooth except for a shallow, narrow marginal furrow which cuts off a narrow, downsloping border. Test smooth on both cranidium and pygidium.

Discussion. This species is similar to *D. attleborensis* (Shaler and Foerste), from which it differs in lacking any trace of the glabella on specimens retaining the test, and in having a more concave frontal border on the cranidium. It differs in the same ways from *D. cobboldi* (Resser). This species occurs stratigraphically above *D. attleborensis,* and may have been derived from that species by the effacement of the glabella. It has been collected from the *Callavia* zone at localities 20426, 20445, and 21798. The specific name refers to the smoothness of the shield.

Genus *Triangulaspis* Lermontova, 1940

Lermontova proposed this genus to include pagetid trilobites with a well-defined, short glabella and a prominent triangular brim at the front of the cranidium. The type species is *Ptychoparia meglitzkii* von Toll, and, in a footnote, Lermontova commented that *Pagetia*? *annio* Cobbold, probably belonged to the same genus, and Cobbold himself (1931) had already pointed out that his species was very closely related to a Newfoundland form, Matthew's *Strenuella attleborensis vigilans.* R. and E. Richter (1942, p. 988) suppressed *Triangulaspis* as a junior synonym of their genus *Strenuaeva,* to which they referred all three species mentioned above. Kobayashi (1944, p. 69), who was apparently not acquainted with the work of either Lermontova or Richter, referred these species to *Strenuella.* Later, Shaw (1950, p. 587) quite rightly pointed out that Cobbold's *Ptychoparia annio,* which is proparian, cannot be referred to *Strenuaeva,* the latter being based on a species (*S. primaeva* (Brögger)) with opisthoparian facial sutures. He referred it "with hesitation" to *Dipharus,* but noted that it differed from *Dipharus* in the shape of the glabella and brim. Finally, Rasetti (1952, p. 438) followed the Richters in commenting that *Triangulaspis* is probably not an eodiscid trilobite.

The specimens of Matthew's *Strenuella attleborensis vigilans* in the Survey collections show that it has a well-defined proparian facial suture of pagetid type, and the author therefore recognizes Lermontova's genus as valid, and refers Matthew's species to it. The genus also includes the type species, *T. meglitzkii,* and *T. annio* (Cobbold). The two forms described by R. and E. Richter (1941, pp. 48-49) as *Strenuaeva* cf. *S. vigilans* and *Strenuaeva* cf. *S. annio* are certainly very like those species, but if the Richters are right in interpreting the facial sutures as opisthoparian, these forms cannot be closely related to *Triangulaspis,* and they are probably correctly placed in *Strenuaeva.*

Triangulaspis vigilans (Matthew)

Plate III, figures 10-12

1899. *Strenuella attleborensis* (Shaler and Foerste) mut. *vigilans* Matthew, Trans. Roy. Soc. Can., ser. 2, vol. 5, sec. 4, p. 78, Pl. IV, figs. 4a-c.
1931. *Pagetia* (?) *vigilans* (Matthew); Cobbold, Quart. J. Geol. Soc. London, vol. 87, p. 465, Pl. 38, fig. 2.
1941. *Strenuaeva vigilans* (Matthew); R. and E. Richter, Abh. Senckenberg. Naturf. Ges., No. 455, p. 48, Pl. 4, figs. 72a-b.
1944. *Strenuella vigilans* Matthew; Kobayashi, J. Fac. Sci. Univ. Tokyo, vol. 7, Pl. 1, p. 69.

Material. Matthew's holotype, from Manuels Brook, Royal Ontario Museum of Palæontology No. 7764; hypotype A, cranidium, GSC No. 12083, locality 21936; hypotype B, cranidium, GSC No. 12084, locality 21798.

Description. Cranidium moderately convex, slightly wider than long. Glabella short, broad, slightly tapering forward, acutely rounded in front, sharply convex, occipital furrow lacking, or marked only by faint impressions at side, one pair of faint furrows visible on some specimens. The posterior end of the glabella projects backwards, and bears a short, fine spine which is broken off in most specimens. In front of glabella is a raised, convex, triangular area, bordered posteriorly by a deep, broad furrow that separates it from the fixed cheeks and glabella; no true marginal furrow is present, so that brim and border are not separable. Fixed cheeks horizontal near dorsal furrow, raised towards palpebral lobe, which is narrow, elevated, moderately long, and situated about midlength of cranidium. Ocular ridges narrow, fine, but clearly visible. Posterior limbs short, triangular, sharply downsloping below level of fixed cheeks. Facial suture of proparian type, cutting inward, upward and backward across anterior margin to palpebral lobe, thence downward and outward to cut border well in front of genal angle. The test is smooth. Free cheeks, thorax, and pygidium unknown.

Discussion. This species differs from *T. annio* (Cobbold) in being proportionately narrower, in having a less tapering glabella, with the occipital furrow less well defined, and in having a much more prominent raised anterior brim and border. It differs from *T. meglitzkii* in having a broader, stronger furrow in front of the fixed cheeks, less tapering, more sharply pointed glabella, and more elevated palpebral lobes.

This species is fairly common in the *Callavia* beds, from which it has been collected at localities 20433, 20468, 21798, 21925, 21928, and 21936.

Family AGNOSTIDAE McCoy, 1849

The classification of the agnostid trilobites has been the subject of much discussion since 1935, and several authors have proposed classifications for them. It seems unnecessary to review and compare these classifications. Most of the agnostids here described are from Middle Cambrian rocks, and most of them are referable to genera and families that also occur in Sweden; the most convenient classification is therefore the one used by Westergard (1946) in the study of the Swedish Middle Cambrian Agnostidae. This classification is accordingly used, with a few minor changes and with some additions to allow the incorporation of a few younger forms for the Newfoundland Cambrian agnostids.

Subfamily CONDYLOPYGINAE Raymond, 1913

Genus *Condylopyge* Corda, 1847

Condylopyge carinata Westergard

Plate III, figures 13-15; Plate IV, figures 1-3

1925. *Agnostus* cf. *rex* (Barrande); Howell, Bull. Am. Pal., vol. 11, No. 43, table 4.
1936. *Condylopyge carinata* Westergard; Sver. Geol. Undersök., ser. C, No. 394, p. 27, Pl. 1, figs. 4-8.
1946. *Condylopyge carinata* Westergard; Westergard, Sver. Geol. Undersök., ser. C, No. 477, p. 33, Pl. 2, fig. 2.

Material. Six hypotypes, three cephala and three pygidia, GSC Nos. 12093 to 12098, all from locality 20454.

Discussion. The specimens from Newfoundland agree exactly with Westergard's description and figures of this Swedish species, and are, accordingly, referred to it. The broad axis of the pygidium, with the slightly expanded posterior lobe, separates it from the other species of *Condylopyge* which occur with it. This species has been collected only from locality 20454, where it is common.

Condylopyge cf. *C. spinigera* Westergard

Plate IV, figures 4, 5

Material. Two figured pygidia, GSC Nos. 12099 and 12100, both from locality 20454, collected by R. D. Hutchinson, 1951.

Description. Cephalon and thorax not known. Pygidium subquadrate, length and width about equal. Axis prominent, raised, occupying three-fourths total length; widest anteriorly, narrowing rapidly to first pair of furrows, almost parallel sided behind these furrows, smoothly rounded posteriorly; three pairs of furrows present; anterior pair deep, directed obliquely forward; second and third pairs very faint; a raised, elongated keel lies along the axis, extending from the anterior end to the third pair of furrows. Lateral lobes broad at sides, narrowing behind axis, crossed by a shallow but distinct furrow opposite the anterior furrows of the axis. A broad, shallow furrow runs from the end of the axis to the marginal furrow, separating the lateral lobes. Marginal furrow broad and deep; border narrow at anterior end, broadening backwards, very wide along posterior border, with a pair of small marginal spines at posterolateral corners.

Discussion. The specimens described here differ from the other Newfoundland species of *Condylopyge* in the broad, quadrate outline, and in the presence of furrows crossing the lateral lobes. *Condylopyge spinigera* Westergard, from the *Ptychagnostus atavus* zone of Sweden, has similar shape and furrows, and is closely similar to the Newfoundland specimens. However, in the absence of a well-preserved cephalon, it is impossible to determine whether the cephalic spines are present, hence a definite reference to that species does not seem warranted. A poorly preserved cephalon and pygidium from the *hicksi* zone, locality 21926, are also referred to this species.

Condylopyge rex (Barrande)

Plate IV, figures 6, 7

1846. *Battus rex* Barrande, Notice prelim. sur le syst. Sil. et les Trilobites de Boheme, p. 17.
1847. *Condylopyge rex* (Barrande), Hawle and Corda, Prodrom. Monogr. Böhm. Trilob., p. 50, Pl. 3, fig. 24.
1852. *Agnostus rex* (Barrande); Barrande, Syst. Sil., vol. 1, p. 908, Pl. 49.
1880. *Agnostus rex* (Barrande); Tullberg, Sver. Geol. Undersök., ser. C, No. 42, p. 30, Pl. 2, figs. 21a-b.
1895. *Agnostus rex* (Barrande); Pompeckj, Jahrb. K.K. Reichsanst., vol. 45, p. 523.
1916. *Agnostus rex* (Barrande); Illing, Quart. J. Geol. Soc. London, vol. 71, p. 420, Pl. 32, figs. 15-17; Pl. 33, fig. 1.
1925. *Agnostus rex* (Barrande); Howell, Bull. Am. Pal., vol. 11, No. 43, table 4.
1946. *Condylopyge rex* (Barrande); Westergard, Sver. Geol. Undersök., ser. C, No. 477, p. 35, Pl. 2, figs. 9-13.

Material. Two hypotypes, cephalon, GSC No. 12101, collected by W. D. McCartney from locality 24638, and pygidium, GSC No. 12102, from locality 20501.

Discussion. The specimens from Newfoundland seem to be identical to those from Sweden referred by Westergard to *Condylopyge rex;* they are, accordingly, included in the same species. This is a scarce form, which occurs sparingly in the *hicksi* zone and the lower part of the *davidis* zone. It has been collected from localities 20455, 20501, 21804, and 24638.

Condylopyge sp. A

Plate IV, figure 8

Material. One figured specimen, GSC No. 12125, a crushed, incomplete pygidium, from the *hicksi* zone, locality 21926.

Description. Cephalon and thorax unknown, pygidium subquadrate, posterior corners rounded; these corners are not well enough preserved to show whether they bore spines. Axis broad, prominent, with a prominent keel and three pairs of deep furrows; anterior pair bent obliquely forward, second pair transverse, third pair curving backward, keel extending from end of axis to third pair of furrows, bearing two prominent nodes at ends of two anterior pairs of furrows; posterior lobe slightly expanded, bluntly rounded posteriorly. Surface very finely granulated.

Discussion. This single pygidium is unlike any other specimen in the Newfoundland collections. It is somewhat like *C. rex,* but differs strikingly from that species in the shape of the axis, in having a broader, more prominent keel, bearing two large nodes, and in having more strongly marked furrows. It probably represents a new species of *Condylopyge,* but it seems better not to propose a formal name for it until better type material is found.

Condylopyge sp. B

Plate IV, figure 9

Material. One figured specimen, a small pygidium, GSC No. 13053, from locality 27253.

Description. General form quadrate, length and width almost equal. Axis prominent, strongly raised, broadest at anterior border, thence tapering backward so slightly as to appear almost parallel sided, bluntly rounded posteriorly, occupying about two-thirds total length, with one prominent furrow curving forward over axis near front, rest unfurrowed, bearing an elongated keel-like node about two-thirds back. Lateral lobes strongly downsloping to sides and rear into horizontal platform behind axis where lateral lobes are confluent. Border broad, gently convex, lacking marginal spines. Surface finely granulated.

Discussion. A single pygidium, from locality 27253, is probably referable to *Condylopyge,* but differs enough from the other species to be described separately. The two most evident distinguishing features are the long, gently tapering axis, which exhibits only one furrow, and the position and shape of the keel, which is far back on the axis and unusually short for the genus.

Genus *Pleurectinium* Corda, 1847

Pleurectinium granulatum (Barrande)

Plate IV, figures 10-14

1846. *Battus granulatus* Barrande, Notice prelim. sur le syst. Sil. et les Trilobites de Boheme.
1847. *Pleurectinium granulatum* (Barrande), Hawle and Corda, Prodrom. Monog. Böhm. Trilob., p. 117, Pl. 6, fig. 63.
1852. *Agnostus granulatus* (Barrande); Barrande, Syst. Sil., vol. 1, p. 911, Pl. 49.
1909. *Dichagnostus granulatus* (Barrande); Jaekel, Zeitsch. Deutsch. Geol. Ges., vol. 61, p. 396, text-fig. 13.
1913. *Pleurectinium granulatum* (Barrande); Raymond, Ottawa Naturalist, vol. 26, p. 138.
1915. *Agnostus granulatus* (Barrande); Illing, Quart. J. Geol. Soc. London, vol. 71, p. 419, Pl. 32, figs. 11-13.
1915. *Agnostus granulatus* (Barrande); Nicholas, Quart. J. Geol. Soc. London, vol. 71, p. 458.
1925. *Agnostus granulatus* (Barrande); Howell, Bull. Am. Pal., vol. 11, No. 43, table 4.
1939. *Pleurectinium granulatum* (Barrande); Kobayashi, J. Fac. Sci. Univ. Tokyo., vol. 5, pt. 5, p. 109.

Material. Hypotype A, cephalon, GSC No. 12103; hypotype B, another cephalon, GSC No. 12104; both from locality 21805; hypotype C, pygidium, GSC No. 12105; hypotype D, pygidium, GSC No. 12106; both from locality 20451; hypotype E, cephalon, GSC No. 12107, from locality 20454; numerous unfigured specimens in the Survey collection.

Discussion. The specimens from Newfoundland agree very closely with those from Nuneaton, England, described and figured by Illing (1915). The species is somewhat variable in several respects. Most cephala and pygidia are slightly longer than broad, but occasional specimens are broader than long. The length of the glabella also varies from about two thirds to four fifths of the total length of the cephalon, and the ornamentation varies in strength, the granulation being very fine or quite lacking in some specimens, and fairly strong in others. Since the presence or absence, and strength of this granulation seems to be a variable character, no specific differentiation based upon this variation seems warranted, in view of the fact that no other differences occur concurrently with it. Specimens from the two lowest localities stratigraphically, localities 20454 and 21916 in the *bennetti* zone, lack the slight median indentation of the anterior lobe of the glabella (*see* hypotype E, Pl. IV, fig. 14). As this variation appears to have stratigraphic value, these forms should perhaps be distinguished as a separate species. The author is reluctant to erect a new species differing in only one feature, and accordingly the forms from the *bennetti* zone are included in *P. granulatum.*

P. granulatum, as thus conceived, is fairly common in the Middle Cambrian beds, ranging from the upper part of the *bennetti* zone to the upper part of the *davidis* zone. It has been collected from localities 20446, 20450, 20451, 20454, 20501, 21804, 21805, 21807, 21810, 21913, 21916, 21926, and 21935.

Pleurectinium bifurcatum (Illing)

Plate IV, figures 15a, b, 16a, b

1915. *Agnostus bifurcatus* Illing, Quart. J. Geol. Soc. London, vol. 71, p. 421, Pl. 33, figs. 2-3.
1939. *Pleurectinium bifurcatum* (Illing); Kobayashi, J. Fac. Sci. Univ. Tokyo, vol. 5, pt. 5, p. 109.

Material. Two hypotypes, cephalon, GSC No. 13045, and pygidium, GSC No. 13046, both from locality 27257; several more specimens from the same locality, and also from locality 21927.

Discussion. A few specimens from two localities, both in the uppermost part of the *davidis* zone, differ from the other species of *Pleurectinium* from Newfoundland in being much more strongly granulate, in having a proportionately longer glabella, and in having a double row of coarse nodes on the posterior part of the axis of the pygidium. In these features, they agree closely with Illing's *bifurcatum* from rocks of exactly the same age at Nuneaton, England, differing only in being more strongly convex than the specimens figured by Illing. As these Newfoundland specimens are preserved in limestone, they retain their natural convexity, whereas those from England occurring in shale, would naturally be somewhat flattened. These forms are, therefore, referred to the Illing's species without hesitation.

Pleurectinium tuberculatum (Illing)

Plate V, figures 1, 2

1915. *Agnostus tuberculatus* Illing, Quart. J. Geol. Soc. London, vol. 71, p. 421, Pl. 33, figs. 4-8.
1939. *Pleurectinium tuberculatum* (Illing); Kobayashi, J. Fac. Sci. Univ. Tokyo, vol. 5, pt. 5, p. 109.

Material. Two hypotypes, cephalon, GSC No. 12108, and pygidium, GSC No. 12109, both from locality 21926.

Discussion. A single cephalon and a pygidium in the Survey collections from the *hicksi* zone are quite distinct from *P. granulatum,* the more usual representative of the genus in this zone. These specimens agree exactly with those described by Illing from rocks of the same zone at Nuneaton, England, and are referred to the same species. In Newfoundland, the species is also represented by one cephalon from slightly younger rocks, referable to the lower part of the *davidis* zone, collected by W. D. McCartney from locality 24617. Illing's description of this species, and his comparison of it with other similar species, is excellent; the species is not redescribed here.

Subfamily PERONOPSINAE Westergard, 1936

Genus ***Peronopsis*** Corda, 1847

Agnostids referable to this genus are among the most common fossils throughout the Middle Cambrian rocks of the area. Kobayashi (1939, p. 113) proposed a new genus, *Acadagnostus,* to include those species, generally referred to *Peronopsis,* that have "conical axis and post-axial furrow on rounded pygidium without spines". Westergard (1946, p. 36) summarily dismissed Kobayashi's genus with the comment that "these criteria seem to be of little value". The Newfoundland material, however, shows that two groups of species do occur within this genus, one characterized by rounded pygidia, lacking spines, and with post-axial furrows commonly present; and the second by subquadrate pygidia with spines and lacking post-axial furrows. The author agrees with Westergard, however, that the shape of the glabella is a criterion of little value; in fact, it has proved almost impossible to differentiate the cephala corresponding to the two types of pygidia mentioned above. *Acadagnostus* is not recognized here as a distinct genus, because the cephala are not readily separable from those of *Peronopsis,* but it is recognized as a subgenus of *Peronopsis* to include those forms with spineless, rounded pygidia and post-axial furrows. The writer agrees with Kobayashi and Westergard that *Quadragnostus* Howell, 1935, should be considered a synonym of *Peronopsis.*

These little trilobites proved to be a difficult group to separate into species, because both cephala and pygidia vary considerably, particularly in features of the axial regions, such as the shape of the glabella and its anterior lobe, the size of the basal lobes, and the width and length of the pygidial axis. It was finally decided to classify these forms into a small number of variable species, though many more species or varieties could be separated if minor variations were given more weight. The classification adopted here, which is outlined below, is based largely on characteristics of the pygidium, as the cephala of most of the species are so much alike as to make their separation dubious. However, one new species, *Peronopsis howelli,* is based on an unusual variation of the cephalon. The cephala figured, and referred to the other species, are believed to be correctly identified, but the identifications rest largely on their associations in the same collections with the more readily recognizable pygidia.

Classification of Newfoundland Species of *Peronopsis*

Group A. Cephalon usually subquadrate, sometimes rounded, glabella conical or parallel sided; pygidium subquadrate, spined, post-axial furrow lacking. *Peronopsis* sensu stricto.

1. Pygidial axis parallel sided in anterior part, divided into three lobes by two prominent pairs of furrows. *Peronopsis trilobata* (Matthew).
2. Pygidial axis parallel sided in anterior part, unfurrowed; both cephalon and pygidium unusually large, with broad flat brims. *Peronopsis* cf. *P. quadrata* (Tullberg).

3. Pygidial axis broadest in front, tapering backward, depressed posteriorly. *Peronopsis fallax* (Linnarsson) subsp. *P. depressa* Westergard.
4. Glabella long, with constricted anterior lobe which is as long as broad, surface finely granulate. *Peronopsis howelli* n. sp.

Group B. Cephalon commonly rounded, glabella conical to parallel sided; pygidium rounded, lacking spines, post-axial furrow present. Subgenus *Acadagnostus*.

5. Pygidial axis parallel sided in front, almost reaching rim, post-axial furrow broad, indistinct. *Peronopsis (Acadagnostus) inarmata* n. sp.
6. Pygidial axis broad, parallel sided in front, well separated from border, post-axial furrow narrow, well marked; pygidium evenly convex from front to rear *Peronopsis (Acadagnostus) matthewi* n. sp.
7. Pygidial axis narrow, tapering backward, depressed posteriorly. *Peronopsis (Acadagnostus) scutalis* (Salter *in* Hicks)

In addition to the specimens classified into the above species, specimens of *Peronopsis* which are not identifiable as to species were collected from localities 20417, 20443, 20501, 21907, 21927, and 27257.

Peronopsis trilobata (Matthew)

Plate V, figures 3, 4

1896. *Agnostus fallax* Linnarsson var. *trilobatus* Matthew, Trans. N. Y. Acad. Sci., vol. 15, p. 216, Pl. 15, fig. 9.
1925. *Agnostus* cf. *fallax* Linnarsson var. *trilobatus* Matthew; Howell, Bull. Am. Pal., vol. 11, No. 43, table 4.
1939. *Peronopsis trilobatus* (Matthew); Kobayashi, J. Fac. Sci. Univ. Tokyo, vol. 5, pt. 5, p. 188.

Material. Two hypotype pygidia, GSC Nos. 12110 and 12111, both from locality 20454; numerous unfigured specimens in the Survey collections.

Discussion. Several pygidia from the upper part of the *bennetti* zone agree very well with Matthew's species and are referred to it.

Peronopsis cf. *P. quadrata* (Tullberg)

Plate V, figures 5-7

1880. *Agnostus quadratus* Tullberg; Sver. Geol. Undersök., ser. C, No. 42, p. 34, Pl. 2, figs. 25a-b.
1946. *Peronopsis quadrata* (Tullberg); Westergard, Sver. Geol. Undersök., ser. C, No. 477, p. 40, Pl. 3, figs. 22-29.

Material. Three figured specimens, cephalon, GSC No. 12131, and two pygidia, GSC Nos. 12132 and 12133, all from locality 21917; several other unfigured specimens in the Survey collections.

Description. Cephalon and pygidium unusually large for the genus, subquadrate, with broad, flat rims which widen distally. Cephalon moderately convex, glabella elevated, conical, with rather large, prominent basal lobes; anterior lobe very short, twice as wide as long, bordered posteriorly by transverse furrow which arches backward; posterior lobe long, bearing a median tubercle, indented by a pair of faint lateral furrows just in front of tubercle. Cheeks smooth, downsloping. Pygidium less convex than cephalon; axis broad, tongue-shaped, not reaching rim, bearing a prominent elongated tubercle in anterior part; lateral lobes gently downsloping, confluent behind axis, rim broad, flat, bearing short spines at posterolateral corners.

Discussion. This unusually large species of *Peronopsis* was collected only at localities 27257, 21917, and 21802, the first in the uppermost beds of the *davidis* zone and the last two in post-*davidis* zone rocks. This species differs from all other Newfoundland species in its larger size, its broader rims on both shields, its conical glabella with larger lateral lobes and with the transverse furrow arched backward, and in the shape of the pygidial axis. The cephalon agrees fairly well with Tullberg's species, but the pygidium differs in having a broader, shorter axis. This form may well represent a new species, but, as the specimens are fragmentary, it seems undesirable to propose a formal name for it until better material is available.

Peronopsis fallax (Linnarsson) subsp. *P. depressa* Westergard

Plate V, figures 8-11

1946. *Peronopsis fallax* (Linnarsson) subsp. *depressa* Westergard, Sver. Geol. Undersök., ser. C, No. 477, p. 37, Pl. 2, figs. 25, 26.

Material. Four hypotypes, two cephala and two pygidia, GSC Nos. 12117 to 12120, all from locality 20451; numerous unfigured specimens in the Survey collections.

Discussion. This subspecies occurs commonly in the upper part of the *hicksi* zone, and also in the *davidis* zone. The Newfoundland specimens seem to be identical with the Swedish ones. Collected at localities 20451, 21807, 21926, 21935, and 27245.

Peronopsis howelli n. sp.

Plate V, figures 12a, b, 13

Material. Only two specimens are known, both cephala; the holotype GSC No. 12134 and the paratype GSC No. 12135; both from locality 20450.

Description. Cephalon small convex, subquadrate with rounded corners, widening slightly forward, widest opposite anterior glabella lobe. Glabella long, moderately raised, narrow posterior end, expanding to front posterior lobe, then contracting at anterior lobe, bluntly rounded in front; anterior lobe as long as broad, bordered posteriorly by transverse furrow which arches slightly backward; posterior lobe long, bearing a small round tubercle just back of midpoint, indented by a pair of short furrows anterior to tubercle; basal lobes very small. Fixed cheeks downsloping, border flat, narrow posteriorly, widening anteriorly, surface very finely granulate. Thorax and pygidium unknown.

Discussion. This form differs from any other species of *Peronopsis* in four respects, and warrants recognition as a new species. These differences are (1) the glabella is much longer, occupying four fifths of the total length; (2) the anterior lobe of the glabella is as long as it is wide; (3) the glabella expands forward instead of being conical or parallel sided; (4) the surface is finely granulated. This is a rare fossil; it is known only from the two type specimens, both from the top of the *hicksi* zone at locality 20450. The specific name is given in memory of the late J. E. Howell, Geological Survey of Canada, who was drowned while on field work in 1954.

Peronopsis (Acadagnostus) inarmata n. sp.

Plate V, figures 14, 15

Material. Holotype, a complete specimen, GSC No. 12112; one figured paratype, pygidium, GSC No. 12113; and several unfigured pygidia; all from locality 20454.

Description. Cephalon and pygidium subquadrate, corners rounded. Cephalon convex; glabella tapering slightly forward, bluntly rounded in front, transverse furrow curving slightly backwards, anterior lobe broader than long, posterior lobe with two pairs of faint lateral impressions, lacking a node. Basal lobes small. Dorsal furrow broad, deep, marginal furrow shallow, border fairly broad, flat.

Thorax of two segments, like that of other species of the genus.

Pygidium not so convex as cephalon. Axis prominent, parallel sided in front, tapering sharply in posterior third to a blunt point, bearing a prominent node about one third back, with one anterior pair of very faint furrows directed obliquely forward, other furrows lacking. A broad, shallow furrow, separating the lateral lobes. Marginal furrow broad, shallow, border broad, flat, posterior spines lacking.

Discussion. This species has been compared with the other Newfoundland species of *Peronopsis* in the discussion of the genus above. The specific name refers to the lack of marginal spines on the pygidium.

Peronopsis (Acadagnostus) matthewi n. sp.

Plate V, figures 16-20

1896. *Agnostus laevigatus mamilla* Matthew (partim), Trans. N.Y. Acad. Sci., vol. 15, p. 234, Pl. 17, fig. 3b, (*non* fig. 3a).

Material. Holotype, pygidium GSC No. 12127; paratype A, small cephalon, GSC No. 12128; paratype B, large cephalon, GSC No. 12129; and paratype C, pygidium, GSC No. 12130; all from locality 20449; numerous unfigured specimens. Also figured is a pygidium from the Matthew collection, Royal Ontario Museum Palæontology, No. 27293.

Description. Cephalon and pygidium semielliptical, length about equal to width, corners evenly rounded. Cephalon evenly, gently convex from side to side and from front to back; glabella about two thirds length of cephalon, moderately raised, subcylindrical, rounded anteriorly, anterior lobe short, wider than long, posterior lobe bearing a small, central node. Basal lobes short, but fairly wide, extending inward behind glabella almost to midline; cheeks subequal in width throughout, downsloping, smooth. Thorax unknown.

Pygidium slightly more convex than cephalon; axis broad, unfurrowed, bounded by broad, shallow furrows; almost parallel sided in anterior two thirds, then tapering rapidly to a bluntly pointed or rounded end, bearing a prominent, elongated node about one third from the front. Lateral lobes narrower than axis, evenly downsloping, separated behind axis by a broad, shallow furrow running from tip of axis to marginal furrow; rim narrow, flat; in some specimens projecting slightly forward at midline, evenly rounded, marginal spines lacking.

Discussion. Matthew's *Agnostus laevigatus mamilla*, from the *davidis* zone of Highland Cove, Trinity Bay, was founded on a misassociation of a *Peronopsis* pygidium with a cephalon of some other agnostid, possibly *Ptychagnostus ciceroides* (which see). Matthew's types were not listed in the Royal Ontario Museum Catalogue of types (Fritz, 1945), and were believed lost; however, Dr. Fritz, in response to the author's enquiry, located a pygidium which may be the original of Matthew's figure 3b. The lectotype of *mamilla,* here selected, is the cephalon which is the original of Matthew's figure 3a. Though the specimen cannot be found, it probably belongs to *Ptychagnostus ciceroides.* The pygidium from the Matthew collection is referred to the species here described, and is figured as a hypotype.

In the discussion of the genus this species has been compared with the other Newfoundland species of *Peronopsis.* The form nearest this species is Grönwall's (1902, p. 78) *Agnostus rotundus,* which occurs on the island of Bornholm. It differs in having a narrower axis and a shorter post-axial furrow that does not reach the marginal furrow. Matthew's *Agnostus acadicus declivis* from New Brunswick, also resembles this species, but differs in having a narrower, more sharply tapering axis, with lobed margins.

This species was collected only at localities 20449, 21804, and 21926, all in the upper part of the *davidis* zone.

Peronopsis (Acadagnostus) scutalis (Salter *in* Hicks)

Plate VI, figures 1-5

1872. *Agnostus scutalis* Salter *in* Hicks; Quart. J. Geol. Soc. London, vol. 28, p. 175, Pl. 5, figs. 12, 13, probably figs. 11, 14, *non* figs. 9, 10.
1880. *Agnostus parvifrons* Linnarsson, forma 1 Tullberg, Sver. Geol. Undersök., ser. C, No. 42, p. 35, Pl. 2, fig. 26.
1902. *Agnostus exaratus* Grönwall, Dansk. Geol. Undersog, ser. 2, No. 13, p. 77, Pl. 1, fig. 17.
1906. *Agnostus exaratus* Grönwall; Lake, Pal. Soc., p. 6, Pl. 1, figs. 8-10.
1916. *Agnostus exaratus* Grönwall; Illing, Quart. J. Geol. Soc. London, vol. 71, p. 405, Pl. 28, fig. 1.
1916. *Agnostus exaratus* Grönwall var. *tenuis* Illing, Quart. J. Geol. Soc. London, vol. 71, p. 406, Pl. 28, figs. 2-5.
1925. *Agnostus* cf. *exaratus tenuis* Illing; Howell, Bull. Am. Pal., vol. 11, No. 43, table 4.
1939. *Acadagnostus exaratus* Grönwall; Kobayashi, J. Fac. Sci. Univ. Tokyo, sec. 2, vol. 5, pt. 5, p. 113.
1946. *Peronopsis scutalis* (Salter *in* Hicks); Westergard, Sver. Geol. Undersök., ser. C, No. 477, p. 41, Pl. 4, figs. 4-11.

Material. Five hypotypes, two cephala, GSC Nos. 12121 and 12122, and two pygidia, GSC Nos. 12123 and 12124, all from locality 21926, and a complete external mould, GSC No. 12126, from locality 20458; numerous unfigured specimens in the Survey collections.

Discussion. Illing has given excellent descriptions of the typical form of this species and of his variety *tenuis;* no redescription is necessary. A *Peronopsis* of this type is common in the *hicksi* and *davidis* zones, particularly in the Trinity Bay area, and large collections were available for study. Nevertheless, the writer was unable to distinguish the two varieties recognized by Illing. Pygidia with narrow, pointed axes, similar to variety *tenuis,* are most common, but they generally occur with pygidia whose axes are broader and blunter, as in the typical form, and many intermediate specimens would indicate that, for the Newfoundland material at least, the two types are best classified within one variable species.

Lake showed that Salter's *Agnostus scutalis* included two distinct species, *A. exaratus* Grönwall, and *A. punctuosus* Angelin. He therefore redefined Salter's species by excluding the well-known form *punctuosus,* but he abandoned the name *scutalis* because it had been based on two species, and used Grönwall's later name *exaratus* instead. In this he was followed by all later workers until Westergard, who pointed out that Salter's original name was valid under the International Rules of Nomenclature, and used it in place of *exaratus.* The writer agrees with Westergard, and accordingly refers the Newfoundland species to *scutalis.*

The species is a common one; it has been collected from localities 20392, 20420, 20458, 20500, 21810, 21906, 21913, 21914, 21926, 27243, 27252, 27253, and 27270.

Genus ***Hypagnostus*** Jackel, 1909

Hypagnostus parvifrons (Linnarsson)

Plate VI, figures 6a, b, 7

1869. *Agnostus parvifrons* (Linnarsson), Vet.-Ak. Handl., vol. 8, No. 2, p. 82, Pl. 2, figs. 56, 57.
1925. *Agnostus* cf. *parvifrons* Linnarsson; Howell, Bull. Am. Pal., vol. 11, No. 143, table 4.
1946. *Hypagnostus parvifrons* (Linnarsson); Westergard, Sver. Geol. Undersök., ser. C, No. 477, p. 45, Pl. 4, figs. 27-31 (complete synonymy).

Material. Two hypotypes, cephalon, GSC No. 12140, from locality 24638; and pygidium, GSC No. 12141, from locality 21933.

Discussion. This species is not redescribed, as Westergard's discussion is adequate. This form is very rare in Newfoundland, being represented in the Survey collections only by the two hypotypes, as well as a tiny cephalon from locality 21810 and a single crushed cephalon from locality 24616, all from the top of the *hicksi* zone or the *davidis* zone. Howell (1925) reports *Hypagnostus* cf. *H. parvifrons* from the top of the *hicksi* zone and the lower part of the *davidis* zone at Manuels Brook, where it is also a rare fossil.

Hypagnostus parvifrons (Linnarsson) var. *H. mammillatus* (Broegger)

Plate VI, figures 8-11

1878. *Agnostus parvifrons* Linnarsson var. *mammillata* Brögger, Nyt Mag. Natur., vol. 24, p. 72, Pl. 5, figs. 3a-d.
1925. *Agnostus* cf. *parvifrons mammilatus* Brögger; Howell, Bull. Am. Pal., vol. 11, No. 43, table 4.
1929. *Agnostus parvifrons mammilatus* Brögger; Strand, Norske Geol. Tidsskrift, vol. 10, p. 347, Pl. I, figs. 15, 19.
1946. *Hypagnostus parvifrons mammillatus* (Brögger); Westergard, Sver. Geol. Undersök., ser. C, No. 477, p. 45, Pl. 5, figs. 2-4.

Material. Four hypotypes, two cephala, GSC Nos. 12136 and 12137, and two pygidia, GSC Nos. 12138 and 12139, all from locality 20451; a few unfigured specimens in the Survey collections.

Discussion. A few specimens from the *davidis* zone, locality 20451, agree exactly with this subspecies and are referred to it. The author has not found it at any other locality, but Howell recorded *Agnostus* cf. *A. parvifrons mammilatus* from approximately the same horizon on Manuels Brook. He also (1925, p. 78) described a new variety, *punctifer,* and compared it with *mammillatus,* from which it differs only in having the elevation on the pygidial axis bent backward. This variety is not represented in the Survey collections.

Hypagnostus cf. *H. truncatus* (Broegger)

Plate VI, figure 12

1878. *Agnostus truncatus* Brögger, Nyt Mag. Natur., vol. 24, p. 72, Pl. 6, fig. 8.
1929. *Agnostus truncatus* Brögger; Strand, Norske Geol. Tidsskrift, vol. 10, p. 348, Pl. 1, figs. 9-11.
1939. *Hypagnostus truncatus* (Brögger); Kobayashi, J. Fac. Sci. Univ. Tokyo, sec. 2, vol. 5, pt. 5, p. 123.
1946. *Hypagnostus truncatus* (Brögger); Westergard, Sver. Geol. Undersök., ser. C, No. 477, p. 46, Pl. 5, figs. 9-23.

Material. One figured cephalon, GSC No. 12149, and two unfigured cephala, all from locality 21926.

Discussion. Three small cephala from the *davidis* zone at locality 21926 differ from any other specimens in the collections. The anterior lobe of the glabella is completely effaced, but the posterior lobe is clearly marked, though the furrow bounding it in front is very faint. It is parallel sided, with truncated anterior corners; the furrows bounding it are well marked posteriorly but become fainter towards the front.

This form is very like *Hypagnostus truncatus*, particularly Westergard's *forma* 2, but the furrow bounding the anterior end of the glabella is much fainter. This species is referred to *Hypagnostus* because the glabella is outlined anteriorly, but it stands very close to *Cotalagnostus,* and may represent a transitional form linking the two genera.

Hypagnostus? sp.

Plate VI, figure 13

Material. One figured specimen, pygidium, GSC No. 13050, from locality 27257.

Description. Only the pygidium is known. Shape subquadrate, with well-rounded posterior corners. Axis prominent, strongly raised, about three fourths length of pygidium, unfurrowed, bearing a small node about its midlength, almost parallel sided in front, expanding slightly at midlength, thence tapering evenly, bluntly pointed posteriorly; axial furrow broad, strong, lateral lobes evenly downsloping, separated by a broad post-axial furrow, border flat, of medium width.

Discussion. A single pygidium from the uppermost part of the *davidis* zone cannot be referred to any described agnostid. It most resembles species of *Hypagnostus* in its general aspect, and in having a well-marked post-axial furrow; it differs from the described species of that genus, however, in the shape of the axis, its length, and its complete lack of furrows. As the cephalon is not known, the generic reference is doubtful, hence a specific name is not proposed.

Genus ***Cotalagnostus*** Whitehouse, 1936

Cotalagnostus lens (Groenwall)

Plate VI, figures 14-17

1902. *Agnostus lens* Grönwall, Dansk. Geol. Undersog., ser. 2, No. 13, p. 65, Pl. 1, figs. 8, 9.
1906. *Agnostus barrandei* Salter; Lake, Pal. Soc., p. 13.
1916. *Agnostus lens* Grönwall; Illing, Quart. J. Geol. Soc. London, vol. 71, p. 414, Pl. 31, figs. 3-7.
1929. *Agnostus truncatus lens* Grönwall; Strand, Norske Geol. Tidsskrift, vol. 10, p. 348, Pl. 1, figs. 12, 13.
1934. *Agnostus lens* Grönwall; Cobbold and Pocock, Phil. Trans. Roy. Soc., ser. B, vol. 223, p. 342 Pl. 44, figs. 5-8.
1936. *Cotalagnostus lens* (Grönwall); Whitehouse, Mem. Queensland Mus., vol. 11, pt. 1, p. 92.
1939. *Cotalagnostus lens* (Grönwall); Kobayashi, J. Fac. Sci. Univ. Tokyo, sec. 2, vol. 5, pt. 5, p. 129.
1946. *Cotalagnostus lens* (Grönwall); Westergard, Sver. Geol. Undersök., ser. C, No. 477, p. 53, Pl. 7, figs. 1-7.

Material. Hypotype A, small cephalon, GSC No. 12142; hypotype B, larger cephalon, GSC No. 12143; hypotype C, small pygidium, GSC No. 12144; and hypotype D, large pygidium, GSC No. 12145; all from locality 20451; unfigured specimens from several localities in the Survey collections.

Discussion. Agnostids referable to *Cotalagnostus* occur at several localities in the upper part of the *hicksi* zone and the lower part of the *davidis* zone in the Trinity Bay area. Their speciation is somewhat difficult, as several closely similar species of this genus have been described. Grönwall (1902) described *Agnostus lens,* from Bornholm, but Lake regarded this species as a synonym of *Agnostus barrandei* Salter. Later, Illing (1916, p. 414) recognized both species in material from Nuneaton, England, and listed several differences between them, the most important distinction being the presence of transverse furrows on the pygidial axis of *barrandei.* Kobayashi (1939, p. 126) distinguished the Nuneaton specimens, referred to *barrandei* by Illing, as a separate species, *illingi,* which differs from *barrandei* in having a smooth surface. Finally, Westergard (1946, p. 54) added a new subspecies, *lens claudicans,* which differs from *lens* in having the glabella faintly outlined in front, and in having a post-axial furrow on the pygidium.

In Newfoundland, the earliest cotalagnostids occur sparingly in the upper *hicksi* beds, where pygidia lacking axial furrows, but with a well-developed post-axial furrow, are associated with cephala in which the glabella is not outlined in front. A little higher, in the lower part of the *davidis* zone the cephala are identical with those occurring lower in the section, but a complete transition is shown from pygidia with well-developed post-axial furrows through specimens in which the furrow is very faint to the extreme form in which it is entirely lacking. Thus, the Newfoundland material could reasonably be classified as a single species with a variable pygidium. However, as two subspecies are recognized in Europe, it seems worthwhile to attempt to distinguish them in Newfoundland also. The pygidia are readily separated, and the form with post-axial furrow is treated below as *C. lens claudicans,* whereas the form lacking the post-axial furrow is here described as *C. lens,* it being understood that the two subspecies intergrade. The cephala do not show recognizable differences, and the two specimens figured here as *C. lens* could just as well be *C. lens claudicans,* as they come from a locality where both types of pygidia occur. The cephalon figured as *claudicans* occurs only with pygidia of that variety, and is believed to be correctly identified. *Cotalagnostus lens* has been collected at localities 20451, 21935, and 27253.

Cotalagnostus lens (Groenwall) subsp. *C. claudicans* Westergard

Plate VI, figures 18-20

1946. *Cotalagnostus lens claudicans* Westergard, Sver. Geol. Undersök., ser. C, No. 477, p. 54, Pl. 6, figs. 20-27.

Material. Hypotype A, cephalon, GSC No. 12146; hypotype B, pygidium, GSC No. 12147; both from locality 20450; hypotype C, pygidium GSC No. 12148, from locality 20451; a few unfigured specimens in the Survey collections.

Discussion. This subspecies has been discussed and compared with *C. lens* in the description of that species above. It has been collected from localities 20450, 20451, 21805, 21807, 21931, and 27243.

Subfamily Diplagnostinae Whitehouse, 1936

Genus *Tomagnostus* Howell, 1935

Tomagnostus fissus (Lundgren MS; Linnarsson)

Plate VII, figures 1-5

1879. *Agnostus fissus* (Lundgren MS.); Linnarsson, Sver. Geol. Undersök., ser. C, No. 35, p. 23, Pl. 2, fig. 34.

1935. *Tomagnostus fissus* (Lundgren MS.); Howell, Bull. Wag. Free Inst. Sci., vol. 10, p. 15, Pl. 1, figs. 9-10.

1946. *Tomagnostus fissus* (Lundgren MS.; Linnarsson); Westergard, Sver. Geol. Undersök., ser. C, No. 477, p. 58, Pl. 7, figs. 21-29 (complete synonymy).

Material. Hypotype A, small cephalon, GSC No. 12150; hypotype B, large cephalon, GSC No. 12151; hypotype C, small pygidium, GSC No. 12152; hypotype D, large pygidium, GSC No. 12153; all from locality 21805; hypotype E, a complete specimen, flattened in shale, GSC No. 12154, from locality 20458; many unfigured specimens in the Survey collections.

Discussion. This species is not redescribed because an excellent discussion has been given by Westergard. It is one of the most common fossils of the *hicksi* zone throughout the area, and has been collected from localities 20441, 20450, 20458, 20501, 21805, 21931, 27252, and 27270.

Tomagnostus perrugatus (Groenwall)

Plate VII, figures 6-9

1902. *Agnostus fissus* Lundgren MS., var. *perrugata* Grönwall, Dansk. Geol. Undersog., ser. 2, No. 13, p. 50, Pl. 1, fig. 1.

1915. *Agnostus fissus* var. *perrugatus* Grönwall; Illing, Quart. J. Geol. Soc. London, vol. 71, p. 407, Pl. 28, fig. 9.

1939. *Tomagnostus fissus* var. *perrugata* (Grönwall); Kobayashi, J. Fac. Sci. Univ. Tokyo, sec. 2, vol. 5, pt. 5, p. 149.

1946. *Tomagnostus perrugatus* (Grönwall); Westergard, Sver. Geol. Undersök., ser. C, No. 477, p. 59, Pl. 8, figs. 1-10.

Material. Hypotype A, small cephalon, GSC No. 12155; hypotype B, larger cephalon, GSC No. 12156; both from locality 21935; hypotype C, small pygidium, GSC No. 12157, from locality 21807; hypotype D, larger pygidium, GSC No. 12158, from locality 21926; a few unfigured specimens in the Survey collections.

Discussion. A rather scarce form from Newfoundland agrees closely with this species as illustrated by Westergard and is referred to it. The author agrees with Westergard that *perrugatus* is distinct enough from *fissus* to be regarded as a separate species rather than as a variety of *fissus*.

The shields of this species must have been unusually fragile, as they are commonly crushed and broken, although other agnostids of similar size in the same beds maintain their normal convexity. The species grew much larger than the figured specimens, but all large shields found were too badly crushed to warrant figuring them. In Denmark and Sweden, *T. perrugatus* occurs in the same beds as *T. fissus*, and if Westergard (1946, p. 59) is correct in citing *T. sulcatus* (Illing) as a synonym of *perrugatus*, the two species also occur together in England. However, in Newfoundland, *fissus* is confined to the *hicksi* zone, whereas *perrugatus* generally occurs in the *davidis* zone, though it has been found in the upper *hicksi* beds at one locality. *Perrugatus* is, however, a scarce fossil; it is represented in the collections by a few specimens from localities 20451, 21807, 21907, 21926, 21935, 24638, 27252, and 27257.

Genus *Diplagnostus* Jaekel, 1909

Diplagnostus planicauda (Angelin) forma *D. bilobatus* Kobayashi

Plate VII, figures 10-13

1880. *Agnostus planicauda* Angelin (partim); Tullberg, Sver. Geol. Undersök., ser. C, No. 42, p. 33, Pl. 2, figs. 24a-b (*non* p. 37).
1902. *Agnostus planicauda* Angelin; Grönwall, Dansk. Geol. Undersog., ser. 2, No. 13, p. 71, Pl. 1, fig. 12.
1939. *Diplagnostus planicauda* forma *D. bilobatus* Kobayashi, J. Fac. Sci. Univ. Tokyo, sec. 2, vol. 5, pt. 5, p. 140.
1946. *Diplagnostus planicauda bilobatus* Kobayashi; Westergard, Sver. Geol. Undersök., ser. C, No. 477, p. 62, Pl. 8, figs. 13-21.

Material. Hyptoype A, cephalon, GSC No. 12159; hypotype B, cephalon, GSC No. 12160; hypotype C, pygidium, GSC No. 12161 (on the same rock chip as and partly covering hypotype B); hypotype D, pygidium, GSC No. 12162; all from locality 21917; hypotype E, pygidium, GSC No. 12163, from locality 20451; a few unfigured specimens in the Survey collections.

Discussion. The Newfoundland specimens referred to this subspecies agree with the European ones except in one respect, namely, that the transverse furrows on the axis of the pygidium are commonly weaker and sometimes entirely lacking in the Newfoundland specimens. However, as this feature is somewhat variable in the Swedish material, judging by Westergard's figures, this difference is not regarded as significant. The species is rare in Newfoundland. It is represented by numerous specimens, unfortunately poorly preserved, from a single small limestone nodule from locality 21917 in the *forchammeri* zone, and by one pygidium (hypotype E) from locality 20451 lower in the *davidis* zone.

Diplagnostus nordengi n. sp.

Plate VII, figures 14-16

Material. Holotype, a complete specimen, GSC No. 12168; paratype A, small cephalon, GSC No. 12169, and paratype B, larger incomplete cephalon, GSC No. 12170; all from locality 21926.

Description. Cephalon and pygidium small, of low convexity, width equal to or slightly greater than length, ovate in outline. Glabella bounded by deep axial furrows; posterior lobe parallel sided, with a keel on posterior two-thirds, indented by a pair of depressions opposite front end of keel; transverse furrow deep, arched very gently backward; anterior lobe triangular, widened posteriorly to form broadest part of glabella, tapering sharply forward, indented in front by a broad, shallow furrow extending backward about a third of its length, and extending forward about two thirds of the distance to the border. Fixed cheeks smooth, horizontal near glabella, thence dropping steeply to border, partly separated in front of glabella but still confluent adjacent to border; marginal furrow well defined, border flat, of medium width. Basal lobes small, triangular, not joined behind glabella. Posterior border extended backward to form two short, blunt, spines directed obliquely outward.

The thorax is not well preserved, but shows a fairly wide axis, and a transverse furrow on the lateral lobes.

Pygidium rounded, lacking marginal spines; axis well defined by deep axial furrows, long, of medium width, slightly constricted about one third back, thence widening to the midlength and tapering gently backward, bluntly rounded posteriorly, bearing a short median keel just in front of midlength, unfurrowed. Lateral lobes narrow, convex, rising from the deep axial furrow and then falling to the marginal furrow; separated by a broad furrow rimming from the tip of the axis to the marginal furrow. Border flat, of medium width.

Discussion. This species is included with some hesitation in *Diplagnostus.* The cephalon agrees well with the diagnosis of the genus, but the pygidium is different from that of any other species of *Diplagnostus,* and agrees more closely with the pygidium of *Peronopsis* (subgenus *Acadagnostus*). In fact, had the cephalon and pygidium not been found together in a complete shield, they would have been referred to different genera. The possibility that they do belong to different genera cannot be excluded, but careful examination of the holotype has convinced the author that it represents one entire specimen, broken and slightly displaced between the two thoracic segments. Not only are the cephalon and pygidium the same size, but both thoracic segments are present, though badly preserved, one in front of the pygidium and one behind the cephalon, and so far as can be observed, the two segments are identical. Westergard (1946, p. 31) suggests that *Diplagnostus* evolved from some species of *Tomagnostus,* but the author believes that the present species more likely descended from a *Peronopsis* similar to *P. (Acadagnostus) scutalis* by modifications in the shape of the glabella, the development of posterior spines on the cephalon, and the introduction of a furrow like that of *Diplagnostus.* If this reasoning is correct, the reference of this new species to *Diplagnostus* makes it a polyphyletic genus. This course seems preferable to the introduction of a new generic name, however, at least until a completely articulated specimen is found which will exclude the possibility that the cephalon and pygidium are misassociated. Should such a specimen be found, the author believes that this form would warrant recognition as a new genus.

The cephalon of this species differs from that of any other *Diplagnostus* in the triangular anterior glabella lobe, which is expanded posteriorly, and in the presence of posterior spines. The pygidium closely resembles that of *Peronopsis (Acadagnostus) scutális,* but differs in having an elongated keel on the axis, and in having a somewhat broader axis.

This species is very rare; it is known only from the three type specimens, all from the lower part of the *davidis* zone, locality 21926. The specific name is given in honour of S. Nording, who was the writer's senior assistant in 1952 when this fossil was discovered.

Genus *Oidalagnostus* Westergard, 1946

Oidalagnostus cf. *O. trispiniger* Westergard

Plate VII, figures 17-20

1946. *Oidalagnostus trispiniger* Westergard, Sver. Geol. Undersök., ser. C, No. 477, p. 65, Pl. 9, figs. 4-7.

Material. Four figured specimens: cephalon, GSC No. 12164, and two poorly preserved pygidia, GSC Nos. 12165 and 12166, from locality 20421, and an incomplete external mould of a pygidium, GSC No. 12167, from locality 20422.

Discussion. This species is very rare, and is represented only by the four illustrated specimens, all from the Middle Cambrian-Upper Cambrian transition beds, at Manuels Brook, Conception Bay.

The cephalon is fairly well preserved, though flattened in shale, and agrees well with *O. trispiniger,* but unfortunately all three pygidia are poorly preserved. They show the characteristic enlarged swelling behind the pygidial axis, and the three spines, characteristic of *Oidalagnostus,* and are certainly referable to that genus. In the Newfoundland specimens, the ridge between the tip of the pygidium and the border (shown in only one specimen) is farther forward and bends backward at either end, whereas in *trispiniger* it is close to the border and is evenly concave anteriorly. Otherwise, the two forms seem to agree well. This is probably a separate species or subspecies, but in the absence of a well-preserved pygidium, the writer prefers not to propose a formal name for it.

Subfamily Agnostinae Jaekel, 1909

Genus *Ptychagnostus* Jaekel, 1909

Ptychagnostus (Triplagnostus) stenorrachis (Groenwall)

Plate VIII, figures 1-5

1902. *Agnostus stenorrachis* Grönwall, Dansk. Geol. Undersog., ser. 2, No. 13, Pl. 1, fig. 16.
1939. *Triplagnostus stenorrachis* (Grönwall); Kobayashi, J. Fac. Sci. Univ. Tokyo, sec. 2, vol. 5, pt. 5, p. 146.
1946. *Ptychagnostus* (*Triplagnostus*) *stenorrachis* (Grönwall); Westergard, Sver. Geol. Undersök., ser. C, No. 477, p. 72, Pl. 10, figs. 3, 4.

Material. Hypotypes A and B, GSC Nos. 12171 and 12172, two cephala on the same rock chip; hypotype C, GSC No. 12173, large cephalon; hypotype D, small pygidium, GSC No. 12174; hypotype E, large pygidium, GSC No. 12175; hypotype F, another pygidium, GSC No. 12176; all from locality 21801; several unfigured specimens from the same locality.

Discussion. Grönwall described only the pygidium of this species, and the cephalon remained unknown until Westergard's work was published. In Newfoundland, cephala agreeing with that figured by Westergard are associated with pygidia like the holotype, and there can be no doubt that they are conspecific, even though the cephala are broader than long and the pygidia longer than broad. All the Newfoundland specimens show a pair of short, indistinct furrows opposite the front of the anterior glabellar lobe, which curve obliquely forward parallel to the dorsal furrow, and join the preglabellar furrow. These are not mentioned by Westergard, but are faintly indicated in his figure 3, Plate 10. They probably represent a specific characteristic. The cephala further differ from other members of the genus in having broader, entire basal lobes, and in having the furrow bounding the anterior glabellar lobes bent forward rather than backward at the midline. The cheeks are smooth in large specimens, faintly furrowed in smaller ones. The pygidia differ chiefly in the course of the second axial furrow, which swings backward around the elongated node, and in the unusually long thin axis. This species is common only at one locality 21801, in the uppermost part of the *davidis* zone, where many specimens were found in one limestone nodule. Another locality in the same beds, 21800, yielded two cephala referred to this species.

Ptychagnostus grandis n. sp.

Plate VIII, figures 6-11

Material. Holotype, large pygidium, GSC No. 12177; paratype A, small cephalon, GSC No. 12178; paratype B, larger cephalon, GSC No. 12179; paratype C, very large cephalon, GSC No. 12180; paratype D, small pygidium, GSC No. 12181; paratype E, large pygidium, GSC No. 12182; all from locality 20451; numerous unfigured specimens from the same locality.

Description. Cephalon and pygidium gently convex, broader than long, rounded in outline. Glabella about three fourths length of cephalon, of low convexity, only slightly raised, bordered by shallow axial furrows which are very broad and indistinct in large specimens. Basal lobes broad, short, entire on small specimens, on large ones the furrow bounding the inside of the basal lobe becomes broad and indistinct, so that the lobes merge imperceptibly into the glabella. Posterior lobe about twice length of anterior lobe, lacking distinct node or keel but rising to a broad elevation at midlength, indented by two broad, shallow furrows about one fourth back; anterior lobe subtriangular, tapering forward, bluntly rounded in front; transverse furrow broad, shallow, straight, cheeks subequal in width to glabella, downsloping, separated by a preglabellar furrow which varies in strength from broad and deep to very shallow and indistinct. Cheeks marked by radiating system of shallow furrows, which are better marked in small specimens. Border narrow, flat. Thorax unknown.

Pygidial axis narrow, about four fifths total length, bounded by shallow but distinct furrows. Axis divided by two transverse furrows into three lobes; widest anteriorly thence narrowing to second lobe, then expanding on posterior lobe and finally tapering to tip; the first furrow swings forward at the midline, the second, backward, around the ends of an elongated keel on the second lobe. Posterior lobe long, tongue shaped, crossed by a transverse depression about one third back; bluntly rounded posteriorly. Lateral lobes smooth, slightly narrower than axis, downsloping, confluent behind axis, border narrow, spines lacking.

The specific name refers to the unusually large size of this species. Both cephalon and pygidium are as much as 9 mm long in the largest specimens.

Discussion. This form, from the lower part of the *davidis* zone, is distinct enough to warrant recognition as a separate species. It is considerably larger than any other species of *Ptychagnostus*; it must have been a very flat-bodied, thin-shelled form, because the shields are invariably more or less broken and flattened, although the other agnostids from the same locality retain their full convexity. Despite the general crushing, it is evident that this species was less convex than others of the genus. The smaller cephala are very like *P. atavus* (Tullberg) but larger ones differ in having the furrows and ornamentation partly effaced, and this species lacks the node on the posterior glabellar lobe. The pygidia differ from *P. atavus* in having a longer, proportionately narrower axis, in which they approach *P. stenorrachis,* but the keel on the second lobe is not so prominent, and the second furrow not turned so far backward as in that species. The convexity is also much less than in *P. stenorrachis*.

This species is common at locality 20451, in the lower part of the *davidis* zone; locality 20450 at the top of the *hicksi* zone yielded only a single cephalon.

Ptychagnostus (Triplagnostus) hybridus (Broegger)

Plate VIII, figures 12-15

1878. *Agnostus gibbus* Linnarsson var. *hybrida* Brögger, Nyt Mag. Natur., vol. 24, p. 62, Pl. 5, figs. 4a-b.
1939. *Triplagnostus gibbus hybrida* (Brögger); Kobayashi, J. Fac. Sci. Univ. Tokyo, sec. 2, vol. 5, pt. 5, p. 146.
1946. *Ptychagnostus* (*Triplagnostus*) *hybridus* (Brögger); Westergard, Sver. Geol. Undersök., ser. C, No. 477, p. 71, Pl. 9, figs. 25, 26; Pl. 10, figs. 1, 2 (complete synonymy).

Material. Hypotype A, small cephalon, GSC No. 12183; hypotype B, larger cephalon, GSC No. 12184; hypotype C, small pygidium, GSC No. 12185; hypotype D, large pygidium, GSC No. 12186; several unfigured specimens; all from locality 21917.

Discussion. The Newfoundland specimens agree closely with the Swedish ones figured by Westergard, and are referred to the same species. The cephala are easily distinguished from any other *Ptychagnostus* occurring in Newfoundland by the completely smooth cheeks. The pygidia resemble *P. stenorrachis,* but have wider axes with contracted second lobe, and the second transverse furrow does not bend so sharply backward at the midline of the axis. The species is rare. It is represented in the Survey collections by a few specimens from locality 21917 and a single cephalon from locality 21806, in the *forchhammeri* beds, and from locality 27257, in the upper part of the *davidis* zone.

Ptychagnostus atavus (Tullberg)

Plate VIII, figures 16-22; Plate IX, figures 1-8

1880. *Agnostus atavus* Tullberg, Sver. Geol. Undersök., ser. C, No. 42, p. 14, Pl. 1, figs. 1a-d.
1936. *Triplagnostus atavus* (Tullberg); Whitehouse, Mem. Queensland Mus., vol. 11, pt. 1, p. 85, Pl. 8, figs. 8, 9; Pl. 10, fig. 1.
1939. *Ptychagnostus atavus* (Tullberg); Kobayashi, J. Fac. Sci. Univ. Tokyo, sec. 2, vol. 5, pt. 5, p. 152.
1946. *Ptychagnostus atavus* (Tullberg); Westergard, Sver. Geol. Undersök, ser. C, No. 477, p. 76, Pl. 11, figs. 8-23, (24, 25?).

Material. Hypotypes GSC Nos. 12187 to 12193 inclusive, seven cephala arranged in order of increasing size to show a growth series; hypotypes GSC Nos. 12194 to 12201, eight pygidia in a similar series; all from locality 24638.

Discussion. The Newfoundland specimens agree very well with those illustrated by Whitehouse and Westergard, and are included in the same species.

A large number of immature forms were obtained by W. D. McCartney from locality 24638, in the lowest beds of the *davidis* zone. From these it has been possible to work out a developmental series showing the changes undergone by the shield during growth. No such series had been observed before, though both Westergard and Whitehouse showed that large shields differed from smaller ones in certain respects. The cranidia do not change much during growth, but there is an increase in the strength of the radial ornamentation on the cheeks. The smallest specimen found, about 0.6 mm long, has entirely smooth cheeks. Slightly larger specimens, in the range from 1 to 2 mm long, are variable, some having well-developed ornamentation, others being almost or quite smooth. Specimens larger than 2 mm all show ornamentation, which becomes more prominent with increasing size. The pygidia change much more during development. The smallest, about 0.6 mm long, has a broad flat border, a long, tapering axis with only one transverse furrow and a very weak tubercle behind it. The post-axial furrow is broad and deep, and a pair of furrows cross the anterior part of the lateral lobes. Slightly larger specimens, to 1.2 mm, have a narrower border, but lack the second axial furrow, and the furrows crossing the lateral lobes and the post-axial furrow are prominent. Specimens about 2 mm long have an axis shaped as in the full-grown shield, with the second axial furrow well developed and a prominent node just in front of it. The post-axial furrow is still present, but the furrows on the lateral lobes are lacking. Larger specimens change little, but show a gradual effacement of the post-axial furrow, which is weak or lacking in the largest specimens. In addition to these changes with growth, both cephala and pygidia vary in dimensions from slightly broader than long to considerably longer than broad. This is, apparently, caused by individual variation, and does not depend upon the size of the shield. The shape of the axis also varies in both cephala and pygidia, tending to be wider in the broader shields.

This species has been found associated with *Paradoxides davidis* and *Hypagnostus parvifrons* in the lowest beds of the *davidis* zone and in the upper part of the *hicksi* zone. This is slightly higher than its stratigraphic level in Sweden, where it occurs with *Tomagnostus fissus,* a species which occurs only in the middle part of the *hicksi* zone of Newfoundland. It has been found at localities 20417, 21933, 24638, and 27270.

Ptychagnostus punctuosus (Angelin)

Plate IX, figures 9-19

1851. *Agnostus punctuosus* Angelin, Pal. Suec., fasc. 1, p. 8, Pl. 6, fig. 11.
1878. *Agnostus punctuosus affinis* Brögger, Nyt. Mag. Natur., vol. 24, p. 68, Pl. 5, figs. 2a, b.
1896. *Agnostus punctuosus* Angelin; Matthew, Trans. N.Y. Acad. Sci., vol. 15, p. 232, Pl. 16, figs. 11a, b.
1925. *Agnostus punctuosus* Angelin; Howell, Bull. Am. Pal., vol. 11, No. 43, table 4.
1939. *Ptychagnostus punctuosus* (Angelin); Kobayashi, J. Fac. Sci. Univ. Tokyo, sec. 2, vol. 5, pt. 5, p. 152.
1946. *Ptychagnostus punctuosus* (Angelin); Westergard, Sver. Geol. Undersök., ser. C, No. 477, p. 78, Pl. 11, figs. 34, 35; Pl. 12, figs. 1-7 (complete synonymy).

Material. Matthew's specimens from the *davidis* zone Highland Cove are not listed in the Royal Ontario Museum catalogue of types (Fritz, 1945), but one specimen listed as a cotype of *Agnostus laevigatus terranovicus* is an external mould of a pygidium of *punctuosus,* and is probably one of Matthew's hypotypes. It is figured on Plate IX, figure 19. No cephalon has been found in the Matthew collection. Hypotypes in the GSC collection are: hypotype A, GSC No. 13016, small cephalon; hypotype B, GSC No. 13017, large cephalon; both from locality 21927; hypotype C, GSC No. 13018, large cephalon, from locality 20449; hypotype D, GSC No. 13019, large cephalon, flattened in shale, from locality 20392; hypotype E, GSC No. 13020, small pygidium; hypotype F, GSC No. 13021, larger pygidium; both from locality 21927; hypotype G, GSC No. 13022, larger pygidium, from locality 20449; hypotype H, GSC No. 13023, large pygidium flattened in shale, from locality 20392; hypotype I, GSC No. 13047, very small pygidium; and hypotype J, GSC No. 13048, large pygidium, both from locality 27257.

Discussion. This well-known species was first reported from Newfoundland by Matthew. The Newfoundland collections include forms referable to this species, and to its variety *affinis.* The forms occur together, and have the same range; moreover, transitional forms are present that bridge the differences between the two. It seems desirable, therefore, to classify all the Newfoundland specimens as one variable species, without in the least questioning Westergard's conclusion that in Sweden these two forms warrant separate recognition.

The post-axial furrow on the pygidium is usually lacking or incomplete in larger individuals, however, one large pygidium, hypotype J (Pl. IX, fig. 16) shows a clearly defined furrow behind the axis.

This species occurs sparingly throughout all but the lowest beds of the *davidis* zone, and has also been recognized in post-*davidis* zone beds at one locality (21802). It is known from the localities 20392, 20442, 20449, 21801, 21802, 21804, 21913, 21917, 21927, and 27257.

Ptychagnostus ciceroides (Matthew)

Plate IX, figures 20-23; Plate X, figures 1-8

1896. *Agnostus laevigatus ciceroides* Matthew, Trans. N.Y. Acad. Sci., vol. 15, p. 234, Pl. 17, figs. 3a, b.
1896. *Agnostus laevigatus terranovicus* Matthew, Trans. N.Y. Acad. Sci., vol. 15, p. 233, Pl. 17, figs. 1a, b.
1896. *Agnostus laevigatus mamilla* Matthew (*pars*), Trans. N.Y. Acad. Sci., vol. 15, p. 234, Pl. 17, fig. 3a (*non* fig. 3b).
1902. *Agnostus altus* Grönwall, Dansk. Geol. Undersog., ser. 2, No. 13, p. 58, Pl. 1, figs. 3, 4.
1937. *Cotalagnostus ciceroides* (Matthew); Kobayashi, J. Fac. Sci. Univ. Tokyo, sec. 2, vol. 5, pt. 5, p. 129.

Material. Matthew's types are in the Royal Ontario Museum of Palæontology. Those of *ciceroides* comprise two lots: the holotype, No. 26117, which is figured on Plate IX, figure 20, is a small, complete specimen, and another pygidium, likely a paratype, is No. 8202. The types of *terranovicus* comprise an external mould of an isolated cephalon and pygidium on the same slab, No. 7930. (A third specimen on the slab, which is indicated as a cotype, is an external mould of the pygidium of *Ptychagnostus punctuosus.*) Matthew's types came from the *davidis* zone at Highland Cove, Trinity Bay. Also figured are eleven hypotypes: five cranidia, GSC Nos. 12202 to 12206, and four pygidia, Nos. 12207 to 12209 and 13014, from locality 20451; a large thorax and pygidium, GSC No. 13015, from locality 21926; and a complete specimen, GSC No. 13049, from locality 27252.

Discussion. This species has been well described and illustrated by Grönwall (as *Agnostus altus*), and Matthew's description is also adequate, though his drawings are rather poor. Hence it seems unnecessary to redescribe the species. The generic reference is made with some hesitation. Kobayashi included *ciceroides* in *Cotalagnostus,* but Westergard (1946, p. 73) showed that *altus,* a synonym of *ciceroides,* arose from some species of *Ptychagnostus,* and therefore cannot be included in *Cotalagnostus,* whose type species was derived from *Hypagnostus* and thus is referable to the Peronopsinae, whereas *ciceroides* is on the Agnostinae line of evolution. The Newfoundland material supports Westergard's conclusion, and the species is therefore removed from *Cotalagnostus.*

It seems clear that this species is midway on the evolutionary line between *Ptychagnostus,* in which both cephalon and pygidium have well-defined axes, and some member of the Phalacrominae in which both are effaced. A new genus could be established for this form, but the author feels that there are already more genera than are needed to adequately classify the agnostid trilobites and, therefore, prefers to include *ciceroides* in *Ptychagnostus,* even though it does not quite satisfy the original diagnosis of the genus.

Matthew's two varieties of *Agnostus laevigatus* — *ciceroides* and *terranovicus* — are synonyms, the former being founded on half-grown forms, the latter on mature ones. Under the rules of nomenclature, either name would be valid for the species; *ciceroides* is here selected because its holotype is a complete shield, whereas *terranovicus* was based on less satisfactory specimens. Matthew separated *ciceroides* from *terranovicus* because it was more convex, with a wider pygidial axis, bearing a second furrow and a more prominent node. The present material shows, however, that the smaller specimens are more convex, and have the second axial furrow on the pygidium clearly marked, whereas larger specimens show a gradual effacement of this furrow, and it is entirely lacking in some large specimens. The two varieties can be connected by a complete series of intermediate forms of increasing size. It is therefore concluded that the two are synonymous.

Matthew also described a third variety, which he called *Agnostus laevigatus mamilla*. The types of this variety were not listed in the Royal Ontario Museum catalogue of types (Fritz, 1945), and were believed lost; however in response to the writer's enquiry, Dr. Fritz found a pygidium which agrees well with Matthew's description, and is probably his type. The figured cephalon has not been found. The pygidium is of the peronopsid type, and is referred to *Peronopsis (Acadagnostus) matthewi*. The pygidium cannot therefore be conspecific with the missing cephalon figured by Matthew. It is concluded that *mamilla* is based on a misassociation of a *Peronopsis* pygidium with a cephalon of some smooth agnostid. In the absence of the cephalon, its exact reference must remain doubtful, but it is tentatively referred to *ciceroides,* because it is said by Matthew to have a punctate test, and *ciceroides* is the only punctate agnostid occurring in the *davidis* zone.

Grönwall's *Agnostus altus* agrees with Matthew's species in every respect, and is considered synonymous with it. This species is different from any other Newfoundland species. It is readily distinguished by its large size, high convexity, and punctate shell, although the last feature is rarely preserved. The pygidium somewhat resembles *Agnostus vaningeni* Howell, which differs mainly in having a post-axial furrow, a distinction which seems to be valid, as none of the many specimens of *ciceroides* examined by the author has such a furrow.

This species first occurs in the upper part of the *hicksi* zone, and ranges through the entire *davidis* zone. In the area about the head of Trinity Bay, it is the most common species in these beds, but in other parts of the area it occurs sparingly. It has been collected from localities 20392, 20442, 20449, 20451, 20457, 20501, 21800, 21801, 21805, 21806, 21807, 21810, 21906, 21913, 21914, 21926, 21927, 21932, 21933, 21935, 24617, 24640, 27246, 27252, and 27257.

Genus *Agnostus* Brongniart, 1822

Agnostus pisiformis (Linnaeus)

Plate XII, figures 2-6

1757. *Entomolithus paradoxus pisiformis* Linnaeus, Iter. Scan., p. 122.
1821. *Entomostracites pisiformis* (Linnaeus); Wallenberg, Petr. Tell. Suec., p. 42, Pl. 1, fig. 5.
1822. *Agnostus pisiformis* (Linnaeus); Brongniart, Crust. Foss., p. 38, Pl. 4, fig. 4.
1922. *Agnostus pisiformis* (Linnaeus); Westergard, Sver. Geol. Undersök., ser. C, No. 18, p. 115, Pl. 1, figs. 1-3 (complete synonymy).

Material. Hypotype A, GSC No. 13037, complete specimen; hypotype B, GSC No. 13038, cephalon; hypotype C, GSC No. 13039, pygidium; all from locality 20416; hypotype D, GSC No. 13040, cephalon, flattened in shale; hypotype E, GSC No. 13041, pygidium, flattened in shale; both from locality 20479; numerous unfigured specimens from various localities.

Discussion. This well-known trilobite marks a well-defined fossil zone in Newfoundland, as it does in Europe. It occurs below the undoubted Upper Cambrian *Olenus* zone, and above the Middle Cambrian *Paradoxides* beds. Its correlation has been discussed in an earlier section of this report. The Newfoundland specimens agree exactly with those from Sweden.

Agnostus pisiformis is extremely abundant wherever the rocks of the zone to which it gives its name are exposed. It has been found at localities 20416, 20422, 20423, 20479, 20488, 20489, 20490, 20491, 20494, 20495, 20496, and 21799.

Genus *Doryagnostus* Kobayashi, 1939

Doryagnostus incertus (Broegger)

Plate X, figures 9-11

1878. *Agnostus incertus* Brögger, Nyt. Mag. Natur., vol. 24, p. 70, Pl. 6, figs. 4a, b.
1939. *Doryagnostus incertus* (Brögger); Kobayashi, J. Fac. Sci. Univ. Tokyo, sec. 2, vol. 5, pt. 5, p. 148.
1939. *Ceratagnostus incertus* (Brögger); Whitehouse, Mem. Queensland Mus., vol. 40, pt. 3, p. 255.
1946. *Doryagnostus incertus* (Brögger); Westergard, Sver. Geol. Undersök., ser. C, No. 477, p. 83, Pl. 13, figs. 1-3 (complete synonymy).

Material. Hypotype A, GSC No. 13024, large cephalon, from locality 21810; hypotype B, GSC No. 13025, small pygidium, from locality 24638; hypotype C, GSC No. 13026, large pygidium, from locality 21810; a few unfigured specimens from various localities.

Discussion. This species is rarer in Newfoundland. It occurs in the *davidis* zone at localities 21810, 21927, 21933, 24638, and 27257. In addition, Howell (1925, p. 36) recorded *Agnostus* cf. *A. incertus* from bed 117 of the Manuels Brook section.

Subfamily PHALACROMINAE Corda, 1847

The agnostids with smooth shields are difficult to classify phylogenetically, as the main features used in classifying the other agnostids are lacking. Recent workers have referred all these forms, including *Ciceragnostus, Phoidagnostus,* and *Phalacroma,* to the subfamily Phalacrominae. Westergard, at least suggested that this assemblage may be polyphyletic, as he states (1946, p. 31) "Peronopsidea as well as Agnostidae developed smooth forms". However, for convenience, he retained this subfamily provisionally. The Newfoundland material gives some new information on this problem. As shown below, Howell's (1925, p. 76) *Agnostus barlowi* var. *A. definatus* stands morphologically between *Peronopsis* and *Ciceragnostus,* thus showing that the latter genus arose from the peronopsid evolutionary line. A new species, described below as *Phalacroma*? *howsei,* was likely derived *Ptychagnostus ciceroides* (Matthew), i.e., from the agnostid evolutionary line. Although the generic reference of this new species is questionable, there is no doubt that it is classifiable with the Phalacrominae as that subfamily is construed by modern workers. Thus Westergard's suggestion that this assemblage is polyphyletic is substantiated by the

Newfoundland material. However, we are not yet in a position to assign the other species of *Phalacroma* and those of *Phoidagnostus* to their proper evolutionary position; the writer, therefore, retains the Phalacrominae as a convenient classificatory assemblage for the smooth agnostids, though recognizing that it will have to be discarded when the details of the evolution of these forms are better understood.

Genus *Ciceragnostus* Kobayashi, 1937

Kobayashi classified this genus with *Phoidagnostus* and *Phalacroma* in the Phalacrominae. Westergard (1946, p. 32) acknowledged that this subfamily was probably polyphyletic, but for want of definite evidence to this effect, accepted Kobayashi's classification.

Ciceragnostus barlowi (Belt) var. *C. definatus* (Howell)

Plate X, figures 12-14

1925. *Agnostus barlowi* (Belt) var. *definatus* Howell, Bull. Am. Pal., vol. 11, No. 43, p. 76, Pl. 3, figs. 2, 3.
1939. *Ciceragnostus barlowi* (Belt) var. *definatus* Howell; Kobayashi, J. Fac. Sci. Univ. Tokyo, vol. 5, Pl. 5, see Ii. p. 134.

Material. Three hypotype pygidia, GSC Nos. 12114 to 12116 all from locality 20454; several unfigured pygidia, and two cephala provisionally referred to this variety, from the same locality.

Discussion. Only the pygidium of this variety is known with certainty. Howell's original description is adequate, but needs to be modified in one respect. The largest pygidium in the Survey collections has the posterior part of the axis completely effaced, rather than faintly outlined (*see* Pl. X, fig. 14). Two unfigured cranidia in the Survey collections may belong to this form. They are similar to the one figured by Howell, except that the bilobed glabella is more clearly outlined. If pygidia with partly effaced axial lobes were not present, these would have been classified as *Peronopsis* cephala with unusually weak axial furrows; however, it seems most probable that they represent Howell's variety, and they are tentatively referred to it.

Howell is probably correct in regarding this form as a variety of Belt's species, from which it differs mainly in having the axial parts more clearly outlined. If the cranidia assigned to this variety are correctly identified, they suggest, that it was derived from some species of *Peronopsis* by the partial effacement of the axial parts. The same trend carried further probably gave rise to the typical *Ciceragnostus barlowi,* which occurs in slightly younger rocks, and eventually to one of the completely smooth agnostid genera. Westergard (1946, p. 32) suggested that the subfamily Phalacrominae, as used by Kobayashi to include *Ciceragnostus, Phoidagnostus,* and *Phalacroma,* might be polyphyletic, and, therefore, at least in part, wrongly classified as a subfamily of the Peronopsidae. The material from Newfoundland suggests that *barlowi,* the type species of *Ciceragnostus,* was indeed derived from *Peronopsis,* and that this genus is therefore properly classified with the Peronopsidae.

Ciceragnostus cicer (Tullberg)

Plate X, figures 15, 16a, b; Plate XI, figures 1a, b, 2

1880. *Agnostus cicer* Tullberg, Sver. Geol. Undersök., ser. C, No. 42, p. 26, Pl. 2, figs. 16 a, b.
1902. *Agnostus cicer* Tullberg; Brögger, Dansk, Geol. Undersog., ser. 2, No. 13, p. 59.
1939. *Ciceragnostus cicer* (Tullberg); Kobayashi, J. Fac. Sci. Univ. Tokyo, sec. 2, vol. 5, pt. 5, p. 134.
1946. *Ciceragnostus cicer* (Tullberg); Westergard, Sver. Geol. Undersök., ser. C, No. 477, p. 90, Pl. 14, figs. 4-9.

Material. Hypotype A, GSC No. 13033, small cephalon; hypotype B, GSC No. 13034, larger cephalon; hypotype C, GSC No. 13035, small pygidium; hypotype D, GSC No. 13036, larger pygidium; a few unfigured specimens; all from locality 21917.

Discussion. The Newfoundland specimens differ in one way from the Swedish ones, namely, the axis of the cephalon is completely obsolete instead of being faintly outlined in the posterior part. The pygidia agree exactly. However, as the strength of the axis is known to be a variable feature in all the smooth agnostids, this difference is not believed to be significant. The Newfoundland form is therefore referred with some hesitation to Tullberg's species.

This species is not apt to be confused with any other Newfoundland agnostid. The cephalon is similar to *Phalacroma nudum,* but is more convex; however, the pygidia of these species are markedly different. This species is very like Barrande's *Agnostus bibullatus,* but differs in lacking a border on the cephalon, and in having a parallel-sided axis on the pygidium. This species is very rare in Newfoundland. It was collected only at locality 21917, from the *forchhammeri* zone.

Genus *Phalacroma* Corda, 1847

Only one species of this genus was certainly identified in the Newfoundland Middle Cambrian collections, but one or two other species are probably present. *Phalacroma nudum* (Beyrich) occurs in the *davidis* zone at several localities; it is described below. However, pygidia in which the brim expands backwards, which cannot be referred to *nudum,* were collected from the *hicksi* zone at locality 20500, and from the *davidis* zone at localities 21810 and 21931. As no associated cephala were found, these cannot be referred to any definite species. Other specimens of the genus too poor to be classified into species were found at localities 21799, 21933, 24617, and 27270. Another very small pygidium, questionably referred to the genus, was found with *P. nudum* at locality 21801. It is described below as *Phalacroma*? sp. In addition, a new species of *Phalacroma,* here described as *P. bairdi,* occurs sparingly in the lower part of the Upper Cambrian. Finally, a small, complete enrolled specimen from locality 21802 which may belong to this genus is described below as *Phalacroma*? *howsei.*

Phalacroma? sp.

Plate XII, figure 1

Material. One figured specimen, a very small pygidium, GSC No. 13042, from locality 21801.

Description. Pygidium very small, length 1.3 mm, subquadrate; axis strongly convex, unfurrowed, with elongated median tubercle at midlength; axis about three fourths total length, pointed posteriorly. Lateral lobes downsloping, confluent behind axis, subequal in width throughout. Border lacking.

Discussion. This holaspid pygidium has a much more elevated, more pointed and longer axis than the holaspid of any other *Phalacroma*. It is associated with *P. nudum,* and may represent an aberrant individual of that species; however, in the absence of any specimens transitional between it and the usual form of the species, it seems preferable to describe it separately.

Phalacroma nudum (Beyrich)

Plate XI, figures 3-8

1845. *Battus nudus* Beyrich, uber einige Böhm. Tril., p. 46, fig. 20.
1847. *Phalacroma nudum* (Beyrich); Hawle and Corda, Prodrom einer Monogr. der Böhm. Tril., pp. 43-45, Pl. 3, fig. 20.
1852. *Agnostus nudus* (Beyrich); Barrande, Syst. Sil., vol. 1, p. 903, Pl. 49.
1916. *Agnostus nudus* (Beyrich); Illing, Quart. J. Geol. Soc. London, vol. 71, Pl. 31, fig. 8.
1925. *Agnostus* cf. *nudus* (Beyrich); Howell, Bull. Am. Pal., vol. 11, No. 43, table 4.
1936. *Phalacroma nudum* (Beyrich); Whitehouse, Mem. Queensland Mus., vol. 11, pt. 1, p. 94.
1939. *Phalacroma nudum* (Beyrich); Kobayashi, J. Fac. Sci. Univ. Tokyo, sec. 2, vol. 5, pt. 5, p. 136.

Material. Hypotype A, GSC No. 13027, small cephalon; hypotype B, GSC No. 13028, larger cephalon; hypotype C, GSC No. 13029, large cephalon; hypotype D, GSC No. 13030, small pygidium; hypotype E, GSC No. 13031, larger pygidium; hypotype F, GSC No. 13032, large pygidium; all from locality 20451; numerous unfigured specimens from various localities.

Discussion. The Newfoundland specimens agree very closely with Barrande's description and figures of this species, and are referred to it. The pygidia are almost identical to *P. scanicum* (Tullberg), but the cephala differ in lacking a border. Hypotype A, a small cephalon, shows faintly outlined, broadly triangular basal lobes, but the other specimens are smooth.

This species occurs commonly in the *davidis* zone. It has been collected from localities 20392, 20451, 21801, 21926, 21935, and 27245.

Phalacroma bairdi n. sp.

Plate XI, figures 9-11

Material. Holotype, pygidium, GSC No. 13055; paratype A, cephalon, GSC No. 13056; both from locality 21937; paratype B, pygidium, GSC No. 13057, from locality 27260; and a few other specimens in the Survey collections.

Description. Cephalon well rounded, length and width about equal, strongly convex from side to side, less so from front to rear. All surface furrows and ornamentation lacking, so that the cephalon is merely a smooth, evenly arched shield. Border also lacking. Thorax unknown.

Pygidium well rounded, slightly longer than wide. Axial furrows lacking, so that lateral lobes and axial region coalesce to form a smooth, strongly convex central lobe, bearing a short keel along the midline. Border rather wide, of uniform width, slightly downsloping.

Discussion. This species is sharply distinct from any other *Phalacroma* in its sharply convex form, complete lack of surface markings and border on the cephalon, and in the shape and form of the border on the cephalon. It also differs in its stratigraphic position; it has been found only in the *Agnostus pisiformis* and *Olenus* zones of the Upper Cambrian, whereas the other species of the genus are of late Middle Cambrian age. Some workers would consider these differences important enough to warrant the erection of a new genus for this form; the writer, however, believes that it represents a survival of a slightly modified phalacromid stock into the Upper Cambrian, and accordingly classifies it with *Phalacroma.* The species has been found at localities 21937 and 27260. The specific name is given in honour of D. M. Baird, formerly a provincial geologist of Newfoundland.

Phalacroma? *howsei* n. sp.

Plate XI, figures 12-16

Material. Holotype, a small, complete, enrolled specimen, GSC No. 13058; paratype A, cephalon, GSC No. 13059; paratype B, very large cephalon, GSC No. 13060; paratype C, pygidium, GSC No. 13061; paratype D, another pygidium, GSC No. 13062; all from locality 21802.

Description. Cephalon consisting of a large, evenly convex, completely smooth shield, well rounded anteriorly, slightly longer than wide, all furrows and ornamentation, including border, lacking.

Thorax of two segments, with moderately wide axis, lacking nodes, narrow lateral lobes.

Pygidium consisting of smooth, moderately convex shield, slightly longer than broad, with a narrow, even border which is strongly downsloping in continuation of the even slope of the rest of the shield. No furrows, except a broad shallow one inside the border, and no ornamentation are present.

Discussion. This species is morphologically close to other species of *Phalacroma.* The cephalon is identical, except for a slight difference in shape, with that of *Phalacroma bairdi* n. sp., and closely resembles that of *P. glandiforme* (Angelin). The pygidium, however, differs in lacking any sign of a node or keel, and in having a strongly downsloping, narrow border, rather than the broad, flat border of other species of *Phalacroma.* This difference would not normally be of generic value, but the general appearance of the shield, and the stratigraphic position, strongly suggest that this species may be derived from *Ptychagnostus ciceroides* (Matthew) by further effacement of surface features, resulting in a smooth shield. If this suggestion is correct, the inclusion of the species in *Phalacroma* would make that genus polyphyletic. On the other hand, the author is reluctant to erect a new genus on such slender evidence. It seems best, therefore, to questionably refer this species to *Phalacroma.* This species, which was found only at locality 21802, is named in honour of C. K. Howse, former Deputy Minister of Mines for Newfoundland.

Agnostidae Unassigned to Genera

A few agnostid pygidia from different zones of the Middle Cambrian differ from known species, but cannot be referred to their proper genera because the cephala are unknown. They are figured and briefly described below, but are not formally named.

"*Agnostus*" sp. A

Plate XII, figure 7

Material. One figured specimen, tiny pygidium, GSC No. 13051, locality 21802.

Description. General form subquadrate, with well-rounded posterior corners, length and width equal. Axis prominent, strongly elevated, occupying two thirds length, almost unfurrowed, but with faint indications of one pair of weak furrows indenting sides of axis, bearing an elongated node about midlength, parallel sided in anterior two thirds, thence tapering to a point, lateral lobes evenly downsloping, crossed by pair of transverse furrows near anterior ends, separated by well-marked post-axial furrow. Border fairly broad, flat.

Discussion. This little pygidium most nearly resembles *Hypagnostus brevifrons* from the Andrarum limestone of Sweden, but differs in having a pointed axis and post-axial furrow. It probably represents some species of *Hypagnostus* or one of its allied genera.

"*Agnostus*" sp. B

Plate XII, figure 8

Material. One figured specimen, small pygidium, GSC No. 13052, from locality 21802.

Description. General form rectangular, posterior corners rounded, length one fourth greater than width. Axis prominent, moderately raised, broadest in front, tapering backward, bluntly rounded posteriorly, length about three fifths of total length, bearing a small, rounded node about midlength, unfurrowed. Lateral lobes downsloping gently, confluent behind axis, border unusually broad, flat.

Discussion. This specimen seems to be quite remote from any other Newfoundland agnostid. In its general form, and shape of the axis, it is most similar to some species of *Condylopyge,* but it lacks the spines and furrowed, keeled axis of that genus; moreover, it occurs at a higher stratigraphic horizon. The author is therefore unable to suggest even a tentative generic assignment, and the specimen is simply described without a formal name being proposed.

"*Agnostus*" sp. C

Plate XII, figure 9

Material. One figured specimen, GSC No. 13054, small pygidium, from locality 27270.

Description. General form subquadrate, but with well-rounded posterior corners, strongly convex. Axis prominent, strongly elevated, about three fifths total length of pygidium; almost parallel sided in front, bluntly pointed at rear, with two well-marked furrows which each run almost transversely across the axis, bearing a large node on segment between these furrows. Lateral lobes strongly downsloping, confluent behind axis, border flat, narrow.

Discussion. It is difficult to suggest a generic assignment for this form. It somewhat resembles the pygidium of *Ptychagnostus praecurrens* (Westergard), especially the pygidium figured by Westergard on Plate 9, figure 11 (1946), but it has a proportionally shorter and narrower axis, and the course of the furrows is different. Because of its stratigraphic position in the lower part of the *hicksi* zone, this form might well represent an early species of *Ptychagnostus* in which the pygidium is relatively unspecialized; however, no cephalon suggesting this genus was found at this locality, although large collections were made. It therefore seems better not to formally name this single specimen.

"*Agnostus*" sp. D

Plate XII, figures 10a, b

Material. One figured specimen, pygidium, GSC No. 13063, from locality 21926.

Description. General form subquadrate, posterior corners rounded, length and width about equal. Axis prominent, strongly elevated, narrow in front, widening backward, widest point about two thirds back, thence rounded backward, bluntly pointed behind; sides of axis indented by two pairs of faint furrows near front, which do not cross axis; bearing a poorly defined, elongated keel-like tubercle along midline slightly back of midpoint. Lateral lobes broad at sides, strongly downsloping, narrowing posteriorly because of a slight forward bend of furrow inside border, separated by a post-axial furrow; border fairly broad, flat. Surface smooth.

Discussion. This pygidium most resembles *Hypagnostus,* but differs from described species of that genus in the shape of the axis. The pygidium may possibly represent an aberrant individual of some species of *Hypagnostus,* but as this possibility is quite hypothetical, it is described separately.

"*Agnostus*" sp. E

Plate XII, figure 11

Material. One figured specimen, pygidium, GSC No. 13064, from locality 27270.

Description. General form subquadrate, with well-rounded posterior corners, length and width about equal, convexity low, unusually so for an agnostid. Axis visible only at extreme front, where central part is slightly raised, elsewhere axis and lateral lobes coalesce into uniform smooth surface, border lacking.

Discussion. This pygidium cannot be classified with any genus of smooth agnostid because it lacks a border, and because of the low convexity. The writer does not wish to found a new genus or species based on a single specimen, and it is therefore merely described and not formally named.

Family CONOCORYPHIDAE Angelin, 1854

The classification of the blind Middle Cambrian trilobites has been recently considered by several writers, among others Resser (1937), Thoral (1946), and Westergard (1950). Most workers agree that eyeless forms probably arose independently in several different trilobite stocks; thus if all blind forms are classified in one family, it will be a polyphyletic one. If the various genera are classified with other trilobites, which they resemble to a greater or lesser extent except in lacking eyes, the resulting classification is based on inferred evolutionary trends which, however probable, are most difficult to prove. Neither alternative is satisfactory; however, for the present, the writer prefers to retain the well-known family Conocoryphidae, although admitted that this family as used here is probably polyphyletic.

Genus ***Pseudatops*** Lake, 1940

Pseudatops cf. *P. reticulatus* (Walcott)

Plate XII, figure 12

1890. *Conocoryphe reticulata* Walcott, 10th Ann. Rept. U.S. Geol. Surv., pt. 1, p. 649, pl. 95, figs. 6, 6a.
1936. *Atops reticulatus* (Walcott) var. *comleyensis* Cobbold, Quart. J. Geol. Soc. London, vol. 92, p. 231, pl. 15, figs. 1a-e.
1940. *Pseudatops reticulatus* (Walcott); Lake, Pal. Soc., 1940, p. 293, Pl. 42, figs. 1-3.
1950. *Pseudatops reticulatus* (Walcott); Howell and Stubblefield, Geol. Mag., vol. 87, Pl. 2, fig. 2.

Material. One figured specimen, the right half of a broken cephalon, GSC No. 12009, from locality 21798, bed 24 of the Lower Cambrian section at Brigus, Conception Bay.

Description. Cephalon semicircular, moderately convex. Glabella long, prominent, bordered laterally by deep furrows, but anteriorly merely by a change of slope where it reaches border. Four glabellar furrows present; three posterior ones deeply impressed, anterior one visible only as a slight depression. Occipital furrow strong. Fixed cheek strong, convex; bearing an ocular ridge that starts at dorsal furrow opposite anterior glabellar furrow; it runs laterally and is strongly marked for about 3 mm, then curves backward and dies out before reaching marginal furrow. Border fairly broad, downsloping. Free cheek not known, but facial suture must either have cut off only a very narrow strip of the border, or have been marginal. The fossil is preserved as an internal mould, covered by faintly visible reticulate ornamentation.

Discussion. This fossil agrees closely with *Pseudatops reticulatus*, but differs in having a slightly shorter glabella that does not extend far into the border, and in having a less prominent ocular ridge and weaker ornamentation. Further specimens may prove it to be a distinct form, but the author is unwilling to found a new species on so fragmentary a specimen.

Genus *Ctenocephalus* Hawle and Corda, 1847

Ctenocephalus is a distinct genus of the Conocoryphidae, characterized by the presence of a raised boss in front of the glabella. As Matthew long ago realized, there are two groups of species within the genus. In the type species *C. coronatus* (Barrande), and in several other species, the fixed cheeks rise to form a sharp ridge, then drop steeply to the marginal furrow, giving, as Matthew (1885) said, a "wall-like front to the cheeks and frontal lobe". The other group of species has inflated fixed cheeks, but the sharp ridge and the steep drop to the marginal furrow are lacking. Matthew separated this latter group of forms as a new subgenus which he named *Harttella*. Later writers have disagreed in the status they accord to *Harttella*, some raising it to generic rank, some suppressing it entirely, and others following Matthew in making it a subgenus. The present author believes that all the species of *Ctenocephalus* are closely related, and therefore prefers not to split the genus; the name *Harttella* is retained as a subgenus to indicate the natural grouping of species within the genus. Of the species collected from Newfoundland, only *C. terranovicus* Resser is referable to *Harttella;* all the other species belong to *Ctenocephalus* in the strict sense.

Ctenocephalus (Harttella) terranovicus Resser

Plate XII, figures 13-17

1925. *Harttella matthewi* (Hartt); Howell, Bull. Am. Pal., vol. 11, No. 43, table 4.
1937. *Ctenocephalus terranovicus* Resser, J. Pal., vol. 11, p. 41, Pl. 7, figs. 13, 16, 17.
1937. *Ctenocephalus bucculentus* Resser, J. Pal., vol. 11, p. 41, Pl. 7, figs. 22, 23.

Material. Hypotype A, nepionic cranidium, GSC No. 12010; hypotype B, a slightly larger nepionic cranidium, GSC No. 12011; hypotype C, small cranidium, GSC No. 12012; hypotype D, larger cranidium, GSC No. 12013; hypotype E, full-grown cranidium, GSC No. 12014; numerous unfigured cranidia in the Survey collections. The hypotypes are all from locality 20454, bed 23 of Howell's (1925) section at Manuels Brook. Resser's types are also from Manuels Brook, and probably from the same bed.

Occurrence. This is one of the commonest species in the Middle Cambrian *bennetti* beds throughout the area, and it seems to occur only in the upper part of this zone. It has been collected at localities 20387, 20452, 20454, 20473, 21916, and 21940.

Description. Cranidium somewhat rectangular in outline, with rounded anterior corners. Glabella prominent, tapering sharply forward, truncated in front; occipital furrow strong, narrow and deep on margins of glabella, broader and shallower where it crosses axis; occipital ring bearing a node or short spine; three pairs of sharp, deep, backwardly directed glabellar furrows are present, posterior pair longer and deeper than two anterior pairs. A prominent raised boss is situated in front of glabella; it is bordered by strong, deep continuations of dorsal furrow, which diverge anteriorly so that boss widens forward. Fixed cheeks broad, highly elevated above glabella, highest point about opposite second glabellar furrow. Eyes and ocular ridges lacking. Border upsloping, marginal furrow broad, shallow. Free cheeks consisting of a narrow strip of border and genal spine. Brim, fixed cheeks, glabella, and pre-glabellar boss ornamented by large tubercles, which vary considerably in density on different specimens. Commonly, three or four tubercles are present per square millimetre, but some specimens have more. Tubercles are lacking in the furrows, except that one large tubercle is situated in the dorsal furrow at either end of the occipital furrow.

Two nepionic cranidia referred to this species are figured. In these specimens, the glabella is a narrow ridge, with very slight indications of furrows, extending to the marginal furrow. The pre-glabellar boss is not developed. The cheeks are strongly inflated, as in the adult, but the ornamentation is lacking.

Discussion. This species is different from any other *Ctenocephalus* found in the area. It is very like *C. matthewi* (Hartt) from New Brunswick, and was identified by Howell as that species. Later, Resser described it as a new species, stating that it differed from *C. matthewi* in having more prominent elevated parts, a narrower form, and more strongly developed surface features. The first two differences are meaningless, as the Saint John specimens are flattened in shale, whereas those from Newfoundland retain most of their natural convexity, and appear, consequently, more elevated and narrower. However, the Newfoundland specimens have many more tubercles than do those from New Brunswick, although this feature is variable in both species. Furthermore, the eyeline which is a prominent feature in *C. matthewi,* has not been observed on any specimen of *C. terranovicus.* The author, therefore, accepts Resser's species as valid, with the reservation that it differs less from *C. matthewi* than Resser indicated.

Resser described another species, *C. bucculentus,* which he based on one small cephalon, said to differ from *C. terranovicus* in having a straighter anterior margin, rounder and more prominent boss, the highest point of the fixed cheek farther back, and more numerous, coarser granules. All the smaller specimens of *C. terranovicus* in the Survey collections exhibit the first three of these features, and the fourth varies considerably among different specimens. The author concludes, therefore, that the holotype of *C. bucculentus* is a small specimen of *C. terranovicus,* and that the two species are synonymous.

Ctenocephalus howelli Resser

Plate XII, figures 18a-c

1937. *Ctenocephalus howelli* Resser, J. Pal., vol. 11, p. 41, Pl. 7, figs. 11, 12.
1944. *Ctenocephalus howelli* Resser; Shimer and Shrock, Index Fossils, p. 609, Pl. 253, fig. 13.

Material. One hypotype, cranidium, GSC No. 12018, from locality 21913, *davidis* zone at Manuels Brook, bed 109 of Howell's (1925) section. (Another poorly preserved specimen from locality 20392 is in the Survey collections.)

Description. Cranidium semicircular. Glabella prominent, moderately elevated, tapering forward, truncated in front, with three pairs of backwardly directed furrows. Occipital furrow broad, shallow; occipital ring short, lacking node or spine. Anterior boss rounded, slightly elevated. Fixed cheeks inflated, elevated above glabella, rising to sharp eyeline; dropping sharply at about 70 degrees outside eyeline to marginal furrow. Border narrow, upsloping. There is no furrow inside the eyeline. The ornamentation consists of numerous, closely spaced, fairly coarse granules.

Discussion. Resser's description of this species was very brief, and failed to point out the differences between it and other related species. It differs from *C. coronatus* (Barrande) in having a broader, more tapering glabella and a less elevated anterior boss, in having the fixed cheeks inflated above the level of the glabella, in the less abrupt drop from the eyelines to the marginal furrow, in the lack of a distinct furrow inside the eyelines, in having much more closely spaced ornamentation, and in having an upsloping border. It differs from *C. resseri* n. sp. in having the fixed cheeks elevated above the glabella, in having a proportionally narrower, less tapering glabella, in having an upsloping border, and in having more densely spaced granules. Finally, it differs from *C. excavatus* Resser in having elevated fixed cheeks, less abrupt slope outside the eyelines, and in the lack of a distinct furrow inside the eyelines.

Ctenocephalus resseri n. sp.

Plate XII, figures 19a-c

Material. Holotype, well-preserved cranidium, GSC No. 12019, from locality 21802, the latest Middle Cambrian rocks on the east shore of Trinity Bay, north of Cavendish.

Description. Cranidium semicircular. Glabella prominent, moderately elevated, broad at base, tapering forward, truncated in front, bearing three pairs of furrows. Posterior pair strong, backwardly directed, second pair moderately strong, also backwardly directed, anterior pair very faint, short. Occipital furrow broad, widening where it crosses axis of glabella, occipital ring short, bearing a strong spine. Anterior boss downsloping, not elevated, distinctly pentagonal in outline. Fixed cheeks broad, horizontal inside prominent eyelines, dropping sharply at an angle of about 75 degrees from the eyelines to marginal furrow. A narrow but well-marked furrow is present on the fixed cheek just inside the eyeline. Marginal furrow broad, shallow; border narrow, downsloping. The surface is finely granulated, with numerous irregularly spaced coarser granules on the glabella, fixed cheeks, anterior boss, and border.

Discussion. This species has been compared with *C. terranovicus* in the discussion of that species. It differs from *C. excavatus* in having a gentler slope from the eyeline to the marginal furrow, a downsloping anterior boss, weaker furrow inside the eyeline, and more closely granulated surface.

Ctenocephalus excavatus Resser

Plate XII, figures 20a, b; Plate XIII, figures 1a, b, 2

1937. *Ctenocephalus excavatus* Resser, J. Pal., vol. 11, p. 41, Pl. 7, figs. 14, 15.

Material. Hypotype A, fragmentary cranidium, GSC No. 12015; hypotype B, larger cranidium, GSC No. 12016; hypotype C, free cheek, GSC No. 12017; all from locality 21810, the upper part of the *hicksi* zone on the west shore of Chapel Arm, Trinity Bay. A fragmentary cranidium was also collected from locality 20500, and several specimens were collected from locality 27253.

Description. Cranidium semicircular. Glabella slightly elevated, narrowing forward, truncated in front; occipital furrow strong, occipital ring bearing a long spine; three pairs of well-marked backwardly directed glabellar furrows present; anterior boss sharply elevated. Fixed cheeks slightly elevated but below level of glabella, eyeline sharply raised, prominent, bordered inside by broad furrow. Outside the eyeline the fixed cheeks drop vertically to the marginal furrow and narrow border. The test is finely granulate, with a few scattered coarser granules.

The free cheek, hypotype C, is believed to belong to this species, as it is the only conocoryphid trilobite found at this locality. The cheek comprises only a narrow strip of the border with a long, slightly curved, genal spine.

Discussion. Resser based this species upon a single specimen from Manuels River, probably from the *hicksi* zone. However, he mistook the eyeline for the border, and the furrow inside it for the marginal furrow, and therefore stated that the eyelines and rim were lacking. The present specimens show that this species is a typical *Ctenocephalus,* as it has the sharply developed eyelines and steep drop outside them characteristic of the genus. It differs from the other Newfoundland species in having much less elevated fixed cheeks, which are lower than the glabella, a more elevated boss, stronger occipital spine, and in having a vertical drop from the eyelines to the marginal furrow.

Genus *Elyx* Angelin, 1854

Westergard (1950) has recently discussed the validity of the genus *Elyx,* which some writers have regarded as a synonym of *Ctenocephalus.* He concluded that *Elyx* is a distinct genus, differing from *Ctenocephalus* in having a subrectangular cephalon, with a level anterior margin, preglabellar boss confluent with the border, facial sutures either marginal or lacking, and recurved points on the thoracic pleura. As Howell (1937) pointed out, the two genera also differ in that the fixed cheeks of *Elyx* are much wider. A new species from Newfoundland, described below, is in some respects transitional between the two genera. It agrees with *Elyx* in having broad fixed cheeks, marginal facial sutures if these are present, and preglabellar boss confluent with the border; however, the cranidium is not truly subrectangular, though it is not so evenly rounded as it is in *Ctenocephalus*, and the anterior border is not level, but is arched slightly upward.

Elyx matthewi n. sp.

Plate XIII, figures 3-6

Material. Holotype, large cranidium, GSC No. 12020; paratype A, small cranidium, GSC No. 12021; paratype B, larger cranidium, GSC No. 12022; paratype C, larger cranidium, GSC No. 12023; and many unfigured specimens in the Survey collections; all from locality 21802, in the latest Middle Cambrian rocks at Highland Cove, Trinity Bay.

Description. Cranidium subrectangular, very broad, but with well-rounded anterior corners, moderately convex, slightly indented in front of glabella. Glabella prominent, moderately elevated above level of cheeks, broadest at base, tapering forward, truncated in front, bearing three pairs of furrows, posterior pair longest and deepest, directed backward, second pair shorter, anterior pair very faintly indicated. Occipital furrow broad, deep at sides, shallow in centre, occipital ring bearing a prominent node, evidently the base of a strong spine, which is broken off in all specimens seen. Anterior boss slightly elevated, broadening forward, coalescent with border by lack of marginal furrow in front. Cheeks convex, horizontal near glabella, sloping steeply on margins to marginal furrow, which is broad and well-marked except in front of preglabellar boss. Faint ocular ridges discernible on some specimens, starting opposite anterior glabellar furrow, running almost directly laterally; border narrow, upturned.

The test on the cheeks and glabella is covered with fine, closely spaced granules, and a second set of coarser, irregularly set granules is also present. These are most numerous on the outer parts of the fixed cheeks. The test is smooth over the furrows. On internal casts, the cheeks are covered with a fine reticulate pattern of raised lines. The large tubercles are also visible on the casts. The thorax and pygidium are unknown.

Discussion. This species differs from *Elyx laticeps* (Angelin) in having rounded anterior corners, preglabellar boss widening forward, arched anterior border, and fainter glabellar furrows. Nevertheless, it is strikingly similar to *E. laticeps,* and is believed to be closely related to that species. It differs from the only other American species, *E. americanus* Howell, in having a broader, more tapering glabella, with more distinct furrows, and a broader preglabellar boss which widens forward. The specific name is given in honour of the late Dr. G. F. Matthew, who first studied the Cambrian faunas from Highland Cove.

Genus ***Conocoryphe*** Hawle and Corda, 1847

Conocoryphe terranovica Resser

Plate XIII, figures 7-10

1937. *Conocoryphe terranovica* Resser, J. Pal., vol. 11, p. 39, Pl. 7, figs. 7, 8.
1944. *Conocoryphe terranovica* Resser; Shimer and Shrock, Index Fossils, p. 609, Pl. 253, fig. 5.

Material. Hypotype A, cranidium, GSC No. 12024; hypotype B, larger cranidium, GSC No. 12025; hypotype C, a poorly preserved cranidium with thirteen thoracic segments, GSC No. 12026; hypotype D, a broken pygidium, GSC No. 12027; all from locality 21801, uppermost beds of *P. davidis* zone at Highland Cove, Trinity Bay. Resser's types, which were said to have come from Seal Point Cove, Trinity Bay, are in all probability from the same locality.

Description. Cranidium semicircular in outline, moderately and evenly convex. Glabella well marked, gently elevated above cheeks, broad at base, tapering forward, bluntly rounded in front, with three distinct pairs of backwardly directed furrows. Occipital furrows strong, occipital ring bearing a prominent node. Two shallow, rather indistinct furrows diverge from the anterior corners of the glabella to the marginal furrow, cutting off a narrow transverse bar in front of the glabella from the fixed cheeks. Fixed cheeks fairly broad, gently convex, downsloping, marginal furrow broad, border narrow, raised. The facial suture cuts off only a very thin strip of the border, and does not encroach into the marginal furrow. The entire test is covered by a closely spaced set of fine granules, and, in addition, the cheeks, glabella, and border bear another set of coarse, irregularly set granules.

One specimen, hypotype C, shows part of the thorax, unfortunately poorly preserved. Thirteen segments are present. The axis is elevated, the pleura are fairly broad, and turned down sharply about three fourths of their length from the axis. The anterior margin bears a row of coarse tubercles. The tips of the pleura are recurved, and probably ended in short points.

A pygidium associated with these specimens is believed to belong to the same species. It has a broad, long axis, with two indistinctly marked segments in front, and is unsegmented behind. Two faint pleural furrows are also present. The test is finely granulated.

Discussion. As Resser pointed out, this species is transitional between *Conocoryphe* and *Bailiella* in having the bar in front of the glabella, the distinguishing feature of *Conocoryphe,* very indistinctly developed. It differs in this respect from all the European members of its genus. It is unlike *C. bullata* Howell (1925) from the *bennetti* zone at Manuels, which indeed cannot be a *Conocoryphe,* as Howell states that the free cheeks are confluent in front of the glabella. This species appears to be a *Bailiella. C. terranovica* seems to differ from *C. artagena* Howell (1937) from Vermont in the shape of the fixed cheeks, but an accurate comparison is not possible as the latter species is not well enough known.

Genus *Bailiaspis* Resser, 1936

Bailiaspis venusta Resser

Plate XIII, figures 11, 12

1937. *Bailiaspis venusta* Resser, J. Pal., vol. 11, p. 40, Pl. 7, figs. 24, 25.
1944. *Bailiaspis venusta* Resser; Shimer and Shrock, Index Fossils, p. 607, Pl. 253, fig. 19.

Material. One cranidium, hypotype A, GSC No. 12036; the external mould of the same specimen is GSC No. 12037; and one unfigured specimen in the Survey collections. The specimen was collected at locality 20387, in the *P. bennetti* zone on Manuels River.

Description. General form semielliptical. Glabella prominent, elevated above fixed cheeks, broad at base, tapering forward, bluntly rounded in front, bearing three pairs of furrows, posterior pair deep, narrow, directed inward and backward almost to occipital furrow; two anterior pairs shallow, less oblique. Occipital furrow narrow, deep at margins, broad and shallow over axis, occipital ring short, wide, bearing a small node. Fixed cheeks gently convex, fairly wide. Both margins are broken away, so the course of the facial suture is not shown. Border narrow, upturned, thickening backward in front of glabella. Marginal furrow broad, deep, curving backward to unite with dorsal furrow in front of glabella; thus no brim is present. The surface of all raised parts of the cranidium is covered with two sets of granules, and a coarser, scattered, but still numerous set. Remainder of test unknown.

Discussion. Only two specimens in the collections seem to belong to Resser's species. They were collected in the uppermost beds of the *bennetti* zone, on Manuels Brook. All other specimens of *Bailiaspis* from the *bennetti* zone are referable to *B. prominens* Resser, which is described below. The differences between the two species are slight; *B. venusta* has a slightly broader, more tapering glabella, and more numerous coarse granules. The latter criterion is of little value, however, as the number of coarse granules varies considerably in *B. prominens*. The two forms may be merely different variations of a somewhat variable species; however, all specimens of *B. prominens* were collected from a slightly lower stratigraphic horizon, a little lower in the *bennetti* zone, though still near its top. Since the variation may have stratigraphic value, the writer prefers to recognize both Resser's species, though with considerable hesitation.

Bailiaspis venusta differs from *B. elegans* of New Brunswick in lacking any trace of an eyeline, in having much more strongly marked glabellar furrows, in lacking a brim, and in having many more coarse granules on the surface. It resembles *B. dalmani* from Sweden, but differs in lacking a brim, and in having a more conical, less-rounded glabella.

Bailiaspis prominens Resser

Plate XIII, figures 13, 14

1937. *Bailiaspis prominens* Resser, J. Pal., p. 41, Pl. 7, figs. 5, 6.
1944. *Bailiaspis prominens* Resser; Shimer and Shrock, Index Fossils, p. 607, Pl. 253, fig. 16.

Material. Hypotype A, cranidium, GSC No. 12028; hypotype B, another cranidium, GSC No. 12029; both from locality 20454, in the *bennetti* zone, Manuels Brook. The species was also collected at locality 20411.

Description. General form semielliptical. Glabella prominent, slightly elevated, broad at base, tapering forward, bluntly rounded in front, bearing three pairs of faint, oblique furrows. Occipital ring and furrow not preserved. Fixed cheeks wide, moderately convex, border upturned, thickening backward in front of glabella. Facial suture cutting obliquely across border, cutting off marginal furrow along side. Ornamentation consisting of a set of closely spaced, fine granules, overlain by a set of coarser granules, whose number varies considerably in different specimens. Remainder of test unknown.

Discussion. This species has been compared with *B. venusta* in the discussion of that species. The points of difference already given above between *B. venusta* and other species also hold for *B. prominens.*

Bailiaspis howelli n. sp.

Plate XIV, figures 1-4

Material. Holotype, a large cranidium, GSC No. 12030; paratypes, three smaller cranidia, GSC Nos. 12031 to 12033; all from locality 21802, *forchhammeri* zone, Highland Cove, Trinity Bay. This is the only locality from which this species was collected.

Description. Cranidium evenly semielliptical, moderately convex. Dorsal furrows broad, shallow. Glabella elevated, strongly convex, tapering forward, rounded in front, showing a slight keel on smaller specimens, unfurrowed, or bearing faint traces of one (posterior) pair of furrows. Occipital furrow narrow, bent back at edges, broader and shallower near axis. Occipital ring broad, widening backward at midline, bearing a node. Fixed cheeks wide, horizontal to slightly downsloping near dorsal furrow, sloping fairly sharply to marginal furrow. Brim in front of glabella short, gently downsloping to broad, shallow marginal furrow; border flat to slightly raised, slightly thickened backward in front of glabella, so that marginal furrow is straight to slightly concave across front of cranidium. Facial suture cutting obliquely across border, running obliquely backward along inside edge of marginal furrow. Test very thick. In specimens retaining it, surface smooth microscopically; small specimens are also smooth microscopically, but large specimens show a fine granulation on the border, glabella, and occipital ring, and a series of ridges on the forward edge of the border. Internal casts show faint ocular ridges, and an even fainter network of ridges running forward and backward from the ocular ridge. Free cheeks, thorax, and pygidium not known.

Discussion. This species stands between *Bailiaspis* and *Bailiella,* as the backward thickening of the border in front of the glabella is not prominent. It is referred to *Bailiaspis* for two reasons, first, because the thickening, though slight, is enough to cause an inward bend in the marginal furrow, which is evenly convex in all species of *Bailiella,* and secondly, because it is very similar to *Bailiaspis glabrata* (Angelin), from the Andrarum limestone of Sweden, a species which Westergard (1950, p. 30) redescribed and referred to *Bailiaspis.* It differs from *B. glabrata* in having a rounded, rather than angulate, front border, in the course of the occipital furrow — which is bent backward rather than being straight, and in the course of the facial suture, which cuts across the border into the marginal furrow. It is quite distinct from any other species of *Bailiaspis.*

Bailiaspis cf. *B. howelli* n. sp.

Plate XIV, figures 5a-c, 6

Material. Two figured specimens, both cranidia, one, GSC No. 12034 from locality 20801, the other, GSC No. 12035 from locality 21932. Both localities are in the uppermost beds of the *davidis* zone at Highland Cove, Trinity Bay, but 21932 is about 50 yards farther south along the shore.

Discussion. These two cranidia were collected from a slightly lower horizon than was *Bailiaspis howelli,* and they probably represent a separate, though similar species, differing from *B. howelli* in being less convex, with less strongly elevated glabella, and in having weaker dorsal and marginal furrows. The test is smooth as in *B. howelli,* but internal casts are finely punctate. A specific name is not proposed, however, because these specimens occur in a shaly limestone, and they could possibly be cranidia of *B. howelli* somewhat flattened by pressure. The differences are such that this could have been so, however, the specimens show no sign of distortion, and are believed to have retained their natural shape.

Bailiaspis latigenae n. sp.

Plate XIV, figures 7a, b, 8

Material. Holotype, small cranidium, GSC No. 13043, and one paratype, GSC No. 13044, larger fragmentary cranidium, both from locality 27244. The species was collected only at this locality.

Description. Only the cranidium is known. General form semielliptical, strongly convex, width twice as great as length. Glabella prominent, moderately elevated above broad deep axial furrows, one and one-half times as long as broad, tapering evenly forward, bluntly rounded in front, bearing three pairs of glabellar furrows, the posterior pair directed strongly backward, deeply impressed, second pair trending slightly backward, shallower than posterior pair, anterior pair faint, shallow. Occipital furrow well marked, transverse to glabella, deep and narrow at sides, broad and shallow near axis. Occipital ring nearly four times as broad as long, bearing a strong spine near its anterior margin. Fixed cheeks very broad, one and one-half times as wide as occipital ring, strongly inflated, rising sharply from axial furrows to above level of glabella, thence sharply downsloping to lateral margin. Marginal furrow broad, shallow, border narrow at sides, strongly thickened backward in front of glabella, which is separated from border only by a broad furrow formed by union of dorsal and marginal furrows, no brim present. Test covered by an even, closely spaced network of fine granules, with scattered coarser granules most numerous on border and axial part of glabella.

Discussion. This species is distinct from any other species of *Bailiaspis.* It is unusually broad, being twice as wide as long, whereas in no other described species does the width exceed the length so greatly. The fixed cheeks are also much wider relative to the occipital ring than they are in any other species of the genus. Finally, the cheeks are highly inflated, being elevated above the level of the glabella, so that in front view the species looks at first glance like a *Ctenocephalus.* The species was found only at one locality, in a loose nodule which, from its faunal associations, must have come from the *hicksi,* or the lowest part of the *davidis* zone.

Bailiaspis sp.

Plate XIV, figures 9a, b

Material. One complete but distorted specimen, GSC No. 12039 collected by A. M. Christie from the *davidis* zone on the shore near Burgoynes Cove, Smith Sound, Trinity Bay (locality 21092).

Description. General form elongate-ovate, moderately convex from side, almost level from back to front. Cephalon semielliptical, glabella prominent, raised, tapering slightly forward, rounded in front, with three pairs of well-marked furrows, the two posterior pairs directed obliquely backward, the third pair almost transverse and much shorter. Occipital area indistinctly preserved. Brim and border not well preserved in front of glabella, brim likely narrow or lacking, border apparently thickened backward in front of glabella. Fixed cheeks broad, horizontal near dorsal furrow, sloping steeply to marginal furrow, which is broad and shallow; border broad and downsloping. The exact course of the facial suture is indistinct; but it certainly did not cut far inside the marginal furrow. General angles bearing a short, stout spine. Internal mould of cephalon bearing closely spaced, small pits.

Thorax of sixteen segments, with prominent raised axis, well-marked dorsal furrows, pleura broad, geniculate at distal third, ending in short points, with broad, straight pleural furrows.

Pygidium short, broad, axis prominent, raised, reaching axis and pleural lobes with three well-marked segments; border narrow, downsloping, entire.

Discussion. This single specimen is figured because it is, so far as the author knows, the first reported complete example of a *Bailiaspis.* It is of particular interest, therefore, as it shows the nature of the thorax and pygidium of this genus. The specimen cannot be referred with certainty to any described species and probably represents a new one. A specific name is not proposed because parts of the cranidium, especially the brim, border, ornamentation, and facial sutures, are poorly preserved, and specific differences in this genus are based largely upon the variations of these characters. It seems better, therefore, merely to figure the specimen without formally naming it until better cranidia are found.

Genus ***Bailiella*** Matthew, 1885

Bailiella ornata Resser

Plate XV, figures 1, 2

1925. *Conocoryphe aequalis* Linnarsson; Howell, Bull. Am. Pal., vol. 11, No. 43, table 4.
1937. *Bailiella ornata* Resser, J. Pal., vol. 11, p. 40, Pl. 7, figs. 18-21.

Material. Hypotype A, complete carapace, GSC No. 12041, from locality 20449; hypotype B, cranidium, GSC No. 12042, from locality 20392.

Description. General form of shield elongate-ovate, broad in front, narrower behind, gently convex from side to side but almost horizontal from front to back.

Cephalon forming about one fourth total length, semielliptical, length slightly more than half width. Glabella prominent, broadest at base, tapering slightly forward, bluntly rounded in front; two or three pairs of faint glabellar furrows are usually discernible; posterior pair fairly strong, arching backwards, other two pairs faint, short. Occipital furrow broad, fairly deep, arching slightly backward, occipital ring bearing a node. Brim short, gently convex, fixed cheeks broad, convex, dropping steeply to facial suture. Marginal furrow broad, deep; border narrow, upturned. Facial suture cutting obliquely across border, running along base of fixed cheek inside marginal furrow, curving slightly inward at posterior border. Free cheek very narrow, consisting of the border plus a small strip of the marginal furrow, bearing a short genal spine.

Thorax composed of fourteen segments, widest in front, tapering gently backward. Dorsal furrow deep, pleura sharply geniculate at about half their length out from dorsal furrow. The ends of the pleura are not clear — they are either rounded, or short, blunt points. Pygidium, short, with prominent axis reaching marginal furrow; there are three well-marked segments and a fairly broad border.

The ornamentation of the cephalon consists of a set of fine closely spaced granules, overlain by another, fairly numerous, scattered set of coarser granules. The fine granules are also present on the axis of the thorax and pygidium, and the thoracic pleura bear a few coarse granules on their anterior and posterior borders.

Discussion. Resser, in his original description of this species, stated that it had been identified in published lists as *Bailiella baileyi.* Nevertheless, this must be the species listed by Howell (1925, table 4) as *Conocoryphe aequalis* Linnarsson, because the associated species listed with it from U.S. National Museum locality No. 1 show that it came from the *hicksi* or *davidis* zone, not from the *bennetti* zone from which Howell listed *B.* cf. *baileyi.* Howell listed *Conocoryphe* (now *Bailiella*) *aequalis* from the *hicksi* zone, and this must be the species which Resser later described as *B. ornata.* The Newfoundland species is, in fact, very similar to the Swedish one, but differs in having a cranidium that is slightly longer in proportion to its width, a less-tapering glabella with better-marked furrows, and an occipital node. These differences are all minor, and the two species must be very closely related. *B. ornata* differs from the other Newfoundland species of *Bailiella* in its ornamentation and in the shape of the glabella.

Howell apparently found this species only in the *hicksi* zone on Manuels Brook, but the author has found it also in the lower part of the *davidis* zone, both at Manuels and at Highland Cove, Trinity Bay.

Bailiella tenuicincta (Linnarsson)

Plate XV, figures 3, 4a-d

1879. *Conocoryphe tenuicincta* Linnarsson, Sver. Geol. Undersök., ser. C, No. 35, p. 18, Pl. 2, figs. 23-25.
1950. *Bailiella tenuicincta* (Linnarsson); Westergard, Sver. Geol. Undersök., ser. C, No. 511, p. 26, Pl. 5, figs. 6-8, 9 (?).

Material. Hypotype A, cranidium, GSC No. 12038; hypotype B, another cranidium, GSC No. 12040; both from locality 20450, from the *hicksi* zone at the tip of McLeod Point, Trinity Bay. It has also been collected at locality 21805, from the *hicksi* zone on the west shore of Chapel Arm, Trinity Bay.

Description. Cranidium semielliptical, gently convex, almost twice as wide as long. Glabella prominent, gently convex, slightly elevated above level of cheeks, tapering forward, rounded bluntly in front; two pairs of furrows usually visible, posterior pair long, shallow, arching backward, second pair short, faint, not visible on some specimens. Occipital furrow broad, straight across axis of glabella, narrower, deeper, and bent slightly forward at sides, occipital ring bearing a node. Brim fairly long, convex, fixed cheeks gently, evenly convex, sloping gently to dorsal furrow and more sharply to facial suture. Marginal furrow broad, deep; border narrow upturned. Facial suture curving inward across border, running along inside of marginal furrow. Ornamentation on test consisting of a closely spaced set of fine granules, with sparsely scattered coarser granules. Most specimens show a single, closely spaced row of coarse granules across the brim. Eyelines short, faint on specimens with test preserved; on internal moulds the eyelines are long, arched backward, with a network of raised lines joining them from the anterior side. Only cranidia were collected.

Discussion. The Newfoundland specimens seem to be identical with those from Sweden, and are accordingly referred to the same species. Some specimens show faint traces of furrows running from the anterior corners of the glabella across the brim to the marginal furrow, such as occur in *Conocoryphe.* This feature, together with the course of the facial suture, indicates that this species is likely related to *Parabailiella* (Thoral, 1946) and may indicate a transition between *Bailiella* and that genus. It is not referred to *Parabailiella* because preglabellar furrows are always extremely faint, and are invisible in most specimens.

This species is not likely to be confused with any other Newfoundland trilobite. The cranidium is much broader than in any other *Bailiella,* the shape of the glabella is different, and the ornamentation is distinctive.

Bailiella manuelensis n. sp.

Plate XV, figures 5-7

1925. *Bailiella* cf. *baileyi* (Hartt); Howell, Bull. Am. Pal., vol. 11, No. 43, table 4.

Material. Holotype, GSC No. 12043, an almost complete external mould, lacking the free cheeks; paratype A, large cranidium, GSC No. 12044; both from locality 20387; paratype B, GSC No. 12045, another cranidium, from locality 20454.

Description. General form elongate-ovate, moderately convex. Cranidium almost one third of total length, twice as wide as long, with straight anterior border and broadly rounded anterior corners. Dorsal furrow deep, glabella prominent, broader than fixed cheeks, conical, bluntly rounded in front, elevated slightly above cheeks, bearing three pairs of faint, oblique furrows; the two anterior pairs are not visible on some specimens. Occipital furrow broad, curving slightly backward, occipital node very faint or lacking. Brim narrow, depressed below level of cheeks but still gently convex, downsloping to broad deep marginal furrow. Border narrow, upturned.

Fixed cheeks broad, convex, almost horizontal near dorsal furrow, downsloping to facial suture. The suture curves inward across the border and marginal furrow, then along the base of the fixed cheek, then slightly outward across the posterior marginal furrow, finally curving slightly inward across the border. Free cheeks not known.

Thorax composed of fourteen segments. Axis very broad in front, tapering evenly backward, dorsal furrow well marked, pleura broad, curving in distal third, not sharply geniculate, pleural furrows broad, straight, ends of pleura evenly rounded.

Pygidium small, transverse, with prominent axis reaching marginal furrow; three segments are clearly visible. The border is not preserved.

No ornamentation is visible to the naked eye, but both internal and external moulds show closely spaced, small pits, so that the surface must have been granulated. Part of the test is preserved on the holotype. It is finely punctate. Some internal casts show an eyeline running outward and backward from the anterior corners of the glabella, and a reticulate system of raised lines running forward from it.

Discussion. This species is the commonest *Bailiella* in Newfoundland. It has been collected from numerous localities, all in the *bennetti* zone. Its closest relative seems to be the type species, *B. baileyi* from New Brunswick, from which it differs in having a broader, more conical glabella, narrower brim, straight anterior border, and less well developed occipital node. The ornamentation is also different, as the eyelines are less well developed and the test was, apparently, finely, evenly granulated, but lacked coarser granules. It is unlike the other Newfoundland species of *Bailiella,* and is not likely to be confused with them.

Bailiella sp.

Plate XVI, figures 1a-c

Material. One specimen figured here, broken cranidium, GSC No. 12046, from locality 21809.

Description. Cranidium roughly semicircular, moderately convex, usually large for a conocoryphid trilobite. Glabella very prominent, strongly convex above cheeks, broad, almost parallel sided, rounded in front, lacking glabellar furrows, occipital furrow broad, shallow, straight, occipital node lacking. Anterior to glabella, there is a broad, concave trough rising gradually in front to the sharply elevated border, so that brim, marginal furrow, and border are not distinguishable. Fixed cheeks broad, horizontal near glabella, moderately downsloping towards lateral margins. Facial suture not clearly seen, but it must have cut off only a very thin free cheek. Surface smooth, except for striations along the anterior edge parallel to the border.

Discussion. This specimen is different from any other Newfoundland trilobite. The broad, elevated, cylindrical glabella, absence of a distinct brim, sharply raised border, as well as its unusual size, set it off clearly from any other conocoryphid trilobite known to the author. It clearly falls within the genus *Bailiella*, and must represent a new species. The author does not wish to formally name it at present, because it is known only from one fragmentary specimen of uncertain stratigraphic position.

This specimen was the only fossil found in the Cambrian section measured in the first cove west of Red Cove, on the point between St. Marys and Placentia Bays. It occurs in a sedimentary section between two thick dioritic sills of which the lower is believed to be intruded within the *bennetti* zone. The upper lies within beds of uncertain, but probably still Middle Cambrian age. All that can be said of the age of this fossil, therefore, is that it probably belongs to one of the post-*bennetti* Middle Cambrian zones.

Genus *Meneviella* Stubblefield, 1951

Lake, in 1938, erected a new genus, *Menevia,* to accommodate the trilobite named *Erinnys venulosa* by Salter, to replace *Erinnys* and *Salteria,* another name proposed by Walcott, both of which were preoccupied. Unfortunately, *Menevia* was also preoccupied, and Stubblefield, accordingly, replaced it by *Meneviella.* Several workers had classified this species as a *Bailiella,* but the writer agrees with Lake that it differs too much from other species of that genus to be included in it. The specimens from Newfoundland are identical with those from Europe, and are referred to the same species; the genus, therefore, remains monospecific.

Meneviella venulosa (Salter)

Plate XVI, figures 2-7

1865. *Erinnys venulosa* Salter, Brit. Assoc. Rept., p. 285.
1884. *Salteria venulosa* (Salter); Walcott, U.S. Geol. Surv., Bull. 10, p. 31.
1899. *Erinnys breviceps* (Angelin); Matthew, Trans. Roy. Soc. Can., ser. 2, vol. 5, sec. 4, p. 91, Pl. 4, fig. 9.
1925. *Bailiella venulosa* (Salter); Howell, Bull. Am. Pal., vol. 11, No. 43, table 4.
1936. *Bailiella venulosa* (Salter); Resser, Smith Misc. Coll., vol. 95, No. 4, p. 16.
1938. *Menevia venulosa* (Salter); Lake, Pal. Soc., p. 272, Pl. 39, figs. 4-9 (complete synonymy).
1951. *Meneviella venulosa* (Salter); Stubblefield, Geol. Mag., vol. 88, p. 213.

Material. Hypotype A, very small cranidium, GSC No. 12047, from locality 21810; hypotype B, small cranidium, GSC No. 12048, and hypotype C, cranidium, GSC No. 12049, both from locality 21926; hypotype D, large cranidium, GSC No. 12050, locality 20392; hypotype E, large cranidium, GSC No. 12051, locality 20451; hypotype F, free cheek, GSC No. 12052, locality 21916.

Discussion. As Lake has recently given a complete description of this species, it is not redescribed here. The small cranidia, hypotypes A and B, show that young specimens were much more convex than mature ones, with longer glabella, and with granulated test, but lacking the eyeline and the network of radiating ridges running outward from it.

This species first appears in the upper part of the *hicksi* zone, and ranges to the top of the *davidis* zone. This is a rare species, and although found at numerous localities, it is represented in most collections by only one or two individuals. It was collected from localities 20392, 20449, 20451, 21801, 21804, 21810, 21826, 21916, 21926, 21932, and 27257.

Genus *Acontheus* Angelin, 1851

Acontheus inarmatus n. sp.

Plate XVI, figures 8a, b, 9

Material. Holotype, cranidium, GSC No. 12053, from locality 21935; paratype, cranidium, GSC No. 12054, from locality 21913; eight more unfigured cranidia in the Survey collections.

Description. Cranidium semielliptical, moderately convex. Dorsal furrows deep, glabella prominent, raised, extending to anterior margin, narrow posteriorly, strongly expanding anteriorly, rounded in front, with three pairs of faint furrows which merely indent the edges slightly, occipital furrow broad, occipital ring raised, bearing a node. Dorsal eyes lacking. Cheeks convex, dropping steeply to marginal furrow, which is deep, narrow posteriorly, broader and shallow along sides, lacking in front of glabella. Border downsloping, narrow, with rounded genal angles; thus if a suture was present, it was marginal except posteriorly where it may have cut off a corner of the border, with the genal spine if there was one. The cheeks and glabella are coarsely punctate, the rest of the test smooth. Thorax and pygidium are unknown.

Discussion. This small species is unlike any other Newfoundland trilobite. The only other known form that resembles it at all is the much larger *Acontheus acutangulus* Angelin, from the Andrarum limestone of Sweden, from which it differs in being proportionally narrower, in having the glabella more strongly expanded in front, in having weaker glabellar furrows, especially the posterior pair, in lacking genal spines on the cranidium, and in having a punctate rather than smooth test. According to modern usage, these differences are great enough to warrant generic distinction between the two forms; nevertheless, the writer believes that the species are in all probability closely related, and prefers to retain them in the same genus. The Newfoundland species is, therefore, referred to Angelin's genus.

This species has been found only in the *davidis* zone, at localities 20442, 20451, 20500, 21810, 21913, and 21935, and is thus slightly older than the Swedish species.

Genus *Hartshillia* Illing, 1916

Lake (1938, p. 262) has fully discussed this genus and the similar genus *Holocephalina* Salter, and summarized the differences clearly. Each genus is represented in the Middle Cambrian of Newfoundland by one species.

Hartshillia terranovica n. sp.

Plate XVI, figures 10a, b; Plate XVII, figures 1a, b, 2

1925. ?*Hartshillia inflata* (Hicks); Howell, Bull. Am. Pal., vol. 11, No. 43, table 4.

Material. Holotype, cranidium, GSC No. 12059; paratype A, another cranidium, GSC No. 12060; paratype B, hypostome, GSC No. 12061; all from locality 20451.

Description. Cranidium semielliptical, length about two thirds width, strongly and evenly convex. Dorsal furrow defined posteriorly, dying out anteriorly, glabella very low at rear, confluent with cheeks in front. Fixed cheeks evenly convex, no eyes or facial suture visible on dorsal surface. Occipital furrow shallow, curving forward in middle, occipital ring bearing a strong, broad based spine, which is directed backward and upward at an angle of about 20 degrees. Marginal furrow present only along posterior, where it runs straight out from dorsal furrow as a fairly deep, narrow furrow, curves forward around the genal angles, and then dies out. The genal angles are fairly sharp, but bear no spine. Surface coarsely, evenly punctate.

A hypostome (paratype B) associated on the same rock slab with a cranidium of this species is believed to belong to the species. It consists of an oval, convex plate, broadening forward to join the narrow doublure.

Discussion. This species is the first described American representative of Illing's genus. It differs from *H. inflata* (Hicks) in having a narrower cranidium, in lacking the genal spines, and in having a punctate instead of granulate test.

The species has been collected only in the *davidis* zone at localities 20449, 20451, 21807, 21810, and 21933. Howell (1925) reported *H. inflata* (Hicks) from the *davidis* zone on Manuels Brook, but the Survey collections from Manuels contain no examples of *Hartshillia*. It seems probable, however, that Howell's specimen may belong to this species.

Genus *Holocephalina* Salter, 1864

Holocephalina americana Resser

Plate XVII, figures 3-6

1937. *Holocephalina americana* Resser, J. Pal., vol. 11, p. 42, Pl. 7, figs. 1-4.

Material. Hypotype A, cranidium and thorax, GSC No. 12057; hypotype B, cranidium, GSC No. 12058; both from locality 20392; hypotype C, cranidium, GSC No. 12055, locality 20449; hypotype D, free cheek, GSC No. 12056, locality 20392.

Description. Cranidium semielliptical, length more than two thirds width, gently, evenly convex. Glabella not prominent, slightly raised, bordered by weak dorsal furrow, conical, broadest at base, tapering forward, rounded in front, bearing three pairs of faint furrows; occipital furrow strong, curving slightly forward, occipital ring bearing a small node. Free cheeks and brim evenly convex, gently downsloping. marginal furrow shallow, indistinct on some specimens, curving backward in front of glabella, so that border thickens in front of glabella; marginal furrow not marking a change in slope, so border is downsloping in even continuation of slope of cheeks. Facial suture marginal except at postero-lateral margin, where it curves inward across genal angle cutting off a small corner of cephalon and genal spine. Free cheek very narrow, comprising a strip of the doublure, the postero-lateral corner of the cephalon, and the genal spine, which is short and extends outward and backward. Thorax composed of at least sixteen segments, with narrow, prominently raised axis, and wide pleura which are geniculate just outside the midpoint. Pleural furrows broad, shallow, tips of pleura not clearly shown, probably bearing short curved spines. Pygidium unknown.

The test of the cranidium is very thick, and finely punctate, but otherwise smooth, so that specimens retaining the test appear smooth to the naked eye. Internal moulds, however, are finely granulated, and in addition, the brim and fixed cheeks are covered by a set of fine raised lines radiating outward from the glabella.

Discussion. Resser's brief description of this species failed to distinguish it from other members of the genus. It differs from *H. teres* (Grönwall) in general shape of the cranidium, which is rounded rather than subtriangular, and in having a more sharply tapering glabella; it is otherwise much like Grönwall's species. It differs from *H. primordialis* (Salter) in lacking the geniculate posterior margin of the cranidium, in having a slightly longer glabella, and in having radiating ridges on the fixed cheeks and brim of the internal mould.

The species is rather scarce; it has been found only in the *davidis* zone at localities 20392, 20449, 21800, 21932, and 27246.

Family PARADOXIDAE Emmerich, 1839

Subfamily CENTROPLEURINAE Howell, 1932

Genus *Clarella* Howell, 1933

Clarella venusta (Billings)

Plate XVII, figures 7-10

1874. *Anapolenus venustus* Billings, Paleozoic Fossils, vol. 2, p. 73, fig. 42.
1925. *Centropleura venusta* (Billings); Howell, Bull. Am. Pal., vol. 11, No. 43, table 4.
1933. *Clarella venusta* (Billings); Howell, Medd. Fra Dansk. Geol. Foren, vol. 8, pt. 3, p. 217.

Material. Billings' types were returned to the Newfoundland Geological Survey, St. John's, and are now missing. Casts of two of Billings' cotypes are preserved in the GSC collections, as GSC No. 284 and No. 284a (Pl. XVII, figs. 7, 8). Also figured are hypotype A, GSC No. 13105, large cephalon, from locality 21805; and hypotype B, GSC No. 13106, pygidium, from locality 27243.

Description. Billings' description of the cranidium is complete and accurate, and need not be repeated. It needs modification in only one respect, the anterior border extends farther laterally than Billings realized, so that the anterior branch of the facial suture trends farther, and straighter, inward than his figure indicates. The free cheek and thorax remain unknown.

Pygidium much broader than long, axis broad in front, tapering backward, bluntly rounded posteriorly, occupying about three fifths of total length, with one prominent transverse furrow, and traces of a second. Lateral lobes broad, crossed by a strong, oblique furrow, dropping sharply to a lower level and coalescing behind axis, posterior border bearing two pairs of short, blunt spines, minutely serrate between the spines. The test is ornamented with a series of fine, raised lines.

Discussion. This species, which is rather rare, has been found only in the *hicksi* zone, at localities 20441, 20483, 20501, 21805, 24616, 24637, 27243, and probably at 21803.

Clarella sp.

Plate XVII, figure 11

Material. One figured specimen, cranidium, GSC No. 13107, from locality 20392.

Discussion. The common representative of the Centropleurinae in the *davidis* zone faunas of Newfoundland is *Anapolenus henrici,* but a single cranidium from this zone has sinuous palpebral lobes and is referable to *Clarella.* It differs from *C. venusta* in having a less expanded glabella, and a wider border which expands laterally. Howell (1925, table 4) recorded *Centropleura pugnax,* which he later (1933, p. 217) referred to *Clarella,* from the *davidis* zone. However, as Westergard (1950, p. 6) pointed out, this species is more likely a *Centropleura.* In any case, the present species cannot be referred to *pugnax,* as the shape of the palpebral lobes is quite different. It probably represents a new species, but the writer prefers not to formally name it at present, as only one badly flattened specimen is available.

Genus *Anapolenus* Salter, 1864

Anapolenus henrici Salter

Plate XVII, figures 12-18

1864. *Anapolenus henrici* Salter, Quart. J. Geol. Soc. London, vol. 20, p. 236, Pl. 13, figs. 4, 4b, 4c, 5.
1925. *Centropleura henrici* (Salter); Howell, Bull. Am. Pal., vol. 11, No. 43, table 4.
1933. *Anapolenus henrici* Salter; Howell, Medd. Fra Dansk. Geol. Foren, vol. 8, p. 216.
1934. *Centropleura henrici* (Salter); Lake, Pal. Soc. (for 1932), p. 189, Pl. 24, figs. 1-12 (complete synonymy).

Material. Hypotype A, GSC No. 13108, small cranidium; hypotype B, GSC No. 13109, larger cranidium; hypotype C, GSC No. 13110, very large cranidium; hypotype D, GSC No. 13111, small free cheek; hypotype E, GSC No. 13112, large free cheek; hypotype F, GSC No. 13113, small pygidium; and hypotype G, GSC No. 13114, large pygidium, all from locality 20392.

Discussion. The Newfoundland specimens agree in all essential characteristics with those from England so minutely described by Lake. The species is therefore not redescribed. It occurs in the *davidis* zone at localities 20392, 20442, 20449, 21931, and 27257; moreover, a single pygidium from the post-*davidis* zone nodules at locality 21802 is referred tentatively to the same species.

Subfamily PARADOXINAE Howell, 1933

Genus *Paradoxides* Brongniart, 1822

Paradoxides lamellatus Hartt *in* Dawson

Plate XVIII, figures 1-3

1868. *Paradoxides lamellatus* Hartt, *in* Dawson, Acadian Geology, 2nd ed., p. 656.
1884. *Paradoxides lamellatus* Hartt; Walcott, U.S. Geol. Surv., Bull. 10, p. 25, Pl. 3, figs. 2, 2a.
1885. *Paradoxides lamellatus* Hartt; Matthew, Trans. Roy. Soc. Can., vol. 2, pt. 4, pp. 99-124, figs. 3, 4.
1925. *Paradoxides lamellatus* Hartt; Howell, Bull. Am. Pal., vol. 11, No. 43, table 4.

Material. Hypotype A, GSC No. 13076, cranidium; hypotype B, GSC No. 13077, cranidium; both collected by W. D. McCartney from locality 24624; hypotype C, GSC No. 13078, pygidium, from locality 20409.

Description. Matthew's description of the cranidium is excellent, and agrees exactly with the Newfoundland specimens. However, hypotypes A and B represent the first specimens of this species to be found in limestone, with the natural convexity preserved. These show that the fixed cheeks and the posterior part of the glabella were fairly flat but that the rest of the glabella was strongly inflated, with the anterior end, on which the concentric lamellae occur, dropping vertically to the border, which is strongly depressed below the level of the fixed cheeks. The pygidium, hypotype C, was found at the same horizon as the two cranidia, and is likely of this species. It is fairly flat, with a short, blunt, unfurrowed axis, and wide slightly downsloping lateral lobes.

Discussion. This species is rare in Newfoundland. It has been found at four localities; three of these (Nos. 20409, 24614, and 24624) are in a thin green limestone bed which occurs about a 100 feet below the top of the *bennetti* zone in the area about the head of Trinity Bay. This bed contains innumerable trilobite fragments, but identifiable specimens are very rare. However, in addition to the hypotypes a few other identifiable specimens of *P. lamellatus* were recovered. The other locality (21924) is on Sagona Island, in Fortune Bay. In addition, Howell (1925, table 4) found this species in the *bennetti* zone on Manuels River.

Paradoxides hicksi Salter

Plate XVIII, figures 4-12; Plate XIX, figures 1, 2

1865. *Paradoxides hicksi* Salter, Brit. Assoc. Rep., 1865, p. 285.
1925. *Paradoxides hicksi* Salter; Howell, Bull. Am. Pal., vol. 11, No. 43, table 4.
1934. *Paradoxides hicksi* Salter; Lake, Pal. Soc. (for 1932), p. 196, Pl. 25, figs. 4-9; Pl. 26, figs. 1, 2 (complete synonymy).

Material. Hypotype A, very small cranidium, GSC No. 13065, from locality 21805; hypotype B, small cranidium, GSC No. 13066, from locality 20501; hypotype C, slightly larger, still immature cranidium, GSC No. 13067, from locality 21907; hypotype D, a small cranidium, GSC No. 13068, from locality 20501; hypotypes

E and F, GSC Nos. 13069 and 13070, a normal-sized and a large cranidium, from locality 20450; hypotypes G and H, GSC Nos. 13071 and 13072, characteristic cranidia, flattened in shale, from locality 20417; hypotype I, free cheek, GSC No. 13073, from locality 20417; hypotype J, GSC No. 13074, the posterior five thoracic segments and pygidium of a small specimen from locality 20455; and hypotype K, large pygidium, GSC No. 13075, from locality 21914.

Discussion. This very common species characterizes the second oldest zone of the Middle Cambrian throughout the region, and has been collected from almost every fossiliferous outcrop of rocks of that zone. The Newfoundland specimens agree in all major respects with those figured by Lake (1934) from England, and are referred to the same species. Two minor, but seemingly constant, differences from the English forms were noted, however. In the Newfoundland specimens, the posterior pair of glabella furrows are continuous across the glabella, though very shallow near the axis, whereas, in the English forms, these furrows are not joined. The second difference varies with the size of the specimen. A complete growth series of cranidia from an individual of about 2 mm long to a large adult (hypotypes A-F) has been obtained. These show conclusively, that the length and forward swelling of the glabella increase as the size increases. In the smaller specimens, a broad border is present, which has an evenly convex anterior margin. As the glabella lengthens in larger specimens, the border becomes narrower, and the anterior margin bulges forward, breaking the smooth anterior margin of the cranidium. In the largest specimen, the border is reduced to a very narrow, downsloping rim in front of the glabella, which protrudes markedly forward. In the English specimens, Lake (op. cit.) has noted that the glabella lengthens in larger individuals, but the smooth anterior border is not overridden by it. All Lake's figures, however, illustrate small cranidia; thus it is possible that the same feature may occur in the English form, and that it has escaped notice because of poor preservation of the larger specimens. This species has been collected from localities 20417, 20420, 20446, 20450, 20455, 20457, 20458, 20477, 20499, 20501, 21805, 21906, 21907, 21908, 21914, 24615, 24637, 27243, 27252, and 27270.

Paradoxides eteminicus Matthew

Plate XIX, figures 3-9

1883. *Paradoxides eteminicus* Matthew, Trans. Roy. Soc. Can. (for 1882), vol. 1, pt. 4, p. 92, Pl. 1, figs. 7-12
1884. *Paradoxides eteminicus* Matthew; Walcott, U.S. Geol. Surv., Bull. 10, p. 27, Pl. 3, figs. 1, 1a-g.
1925. *Paradoxides eteminicus* Matthew; Howell, Bull. Am. Pal., vol. 11, No. 43, table 4.

Material. Hypotype A, GSC No. 13089, very small cranidium and hypotype B, GSC No. 13090, cranidium; both from locality 20453; hypotype C, GSC No. 13091, cranidium; hypotype D, GSC No. 13092, large free cheek; hypotype E, GSC No. 13093, small free cheek; hypotype F, GSC No. 13094, pygidium; and hypotype G, GSC No. 13114, pygidium; all from locality 20454.

Discussion. Matthew's original description is adequate and this species is not redescribed. Matthew described several varieties of this species; however, the characteristics on which he based the varietal differences seem to intergrade in the

Newfoundland forms. The writer prefers therefore to group all the Newfoundland forms together in the one species, although not in the least suggesting that Matthew's varieties are not valid for his New Brunswick forms. As thus construed, *Paradoxides eteminicus* includes all the *Paradoxides* in the *bennetti* zone whose eyelobes are elongated, reaching back to the marginal furrow, except those referable to *P. lamellatus*. It varies considerably in the shape of the cranidium, strength and number of glabellar furrows, and shape of the glabella.

This species differs from any other *Paradoxides* in the *bennetti* or *hicksi* zone in its long eyelobe; it is, however, much like *P.* cf. *P. rugulosus,* which occurs in the *davidis* zone. *P.* cf. *P. rugulosus,* however, has a broader, more evenly curved border, and the eyelobe curves more strongly outward before bending backward and does not extend as far backward as in *P. eteminicus*. The two species have the same number of glabellar furrows, which follow about the same course in both species, but tend to be broader and deeper in *P. eteminicus*.

This is a common species in the *bennetti* zone, and was collected from localities 20387, 20391, 20409, 20453, 20454, 20462, 20473, 24633, 27247, 27254, and 27256.

Paradoxides davidis Salter

Plate XIX, figure 10; Plate XX; Plate XXI; Plate XXII, figures 1-5

1863. *Paradoxides davidis* Salter, Quart. J. Geol. Soc. London, vol. 19, p. 274, text-fig.
1925. *Paradoxides davidis* Salter; Howell, Bull. Am. Pal., vol. 11, No. 43, table 4.
1935. *Paradoxides davidis* (Salter); Lake, Pal. Soc. (for 1934), p. 203, Pl. 27, figs. 1, 2; Pl. 28, figs. 1-3; Pl. 29, figs. 1-3 (complete synonymy).

Material. Hypotype A, GSC No. 13079, large cranidium; hypotype B, GSC No. 13080, cranidium and free cheek; hypotype C, GSC No. 13081, thorax and pygidium; hypotype D, GSC No. 13082, large pygidium; hypotype E, GSC No. 13083, small pygidium; hypotype F, GSC No. 13084, hypostome; hypotype G, GSC No. 13085, free cheek; and hypotype H, GSC No. 13088, small pygidium with part of the thorax; all from locality 20392.

Discussion. This well-known European species marks a well-defined zone in the Middle Cambrian. The Newfoundland specimens agree in all respects with those from England, and there is nothing to add to Lake's thorough description and discussion of the species. It has been collected from localities 20392, 20449, 20478, 21800, 21801, 21913, 21927, 21932, 24618, 24619, 24628, 24629, 24638, 24639, 24640, 27255, 27257, and 27263.

Paradoxides cf. *P. rugulosus* Corda

Plate XXIII, figures 1, 2, 3

Material. GSC No. 13095, cranidium; GSC No. 13096, another cranidium, both from locality 20392; GSC No. 13097, large cranidium, from locality 27257.

Discussion. This species of *Paradoxides,* which occurs sparingly in the *P. davidis* zone, differs from *P. davidis* in smaller size, in having much longer eyelobes, and in the shape of the glabella. It must be the one identified by Howell (1925, table 4) as *P. rugulosus* Corda, which it closely resembles, but the writer's specimens show a few differences from those figured by various European authors and this leads him to doubt whether his specimens ought to be included in Corda's species. However, all the specimens available are flattened cranidia, and as the writer does not wish to found a new species without better preserved, more complete material, it seems best merely to figure this species without naming it at present.

The Newfoundland specimens differ from *P. rugulosus* in the course of the two posterior glabellar furrows, which are transverse to the axis or bent backward very slightly, whereas in the European forms these furrows are strongly arched backward. Also, the border is broader and more evenly convex forward in the Newfoundland forms. Of the other species of *Paradoxides* occurring in Newfoundland, this species resembles only *P. eteminicus;* the differences between the two have been described in the discussion of that species. *P.* cf. *P. rugulosus* was collected at localities 20392, 21801, 21918, and 27257.

Paradoxides freboldi n. sp.

Plate XXIII, figures 4-10

Material. Holotype, GSC No. 13098, large, fragmentary cranidium; paratype A, GSC No. 13099, very small cranidium; paratype B, GSC No. 13100, another cranidium; paratype C, GSC No. 13101, small free cheek; paratype D, GSC No. 13102, large free cheek; paratypes E and F, GSC Nos. 13103 and 13104, two pygidia; all from locality 21802.

Description. Cranidium about a third broader than long, gently convex. Glabella prominent, narrowest at posterior border, where it occupies about two fifths of total width, thence expanding evenly forward to widest point, which lies slightly in front of anterior end of eyelobe; thence bluntly rounded in front; occipital furrow, well marked, bending backward at margins but forward across axis, occipital ring bearing a node. Two posterior glabellar furrows crossing axis, bent slightly backward, the posterior one more so; two anterior pairs of furrows not joined across axis, trending obliquely inward and forward. All these furrows are deep and narrow in smaller specimens, broader and shallower in larger ones. In large specimens, the glabella reaches the marginal furrow, and the brim is reduced to two small, flat, triangular areas on either side of the glabella bounded by the axial and marginal furrows. In small specimens (*see* fig. 5, Pl. XXIII), the brim is continuous in front of glabella, border broad at sides, narrower in front of glabella, flat. Fixed cheeks flat, broad; eyelobes long, starting from axial furrow between third and fourth glabellar furrows, curving evenly outward, backward, thence slightly inward, ending slightly forward of marginal furrow. Facial suture cutting backward and curving inward across border, thence inward to anterior end of eyelobe, behind the eyelobe it trends outward and backward to border. Free cheek very large, slightly downsloping, broad, border wide, continuing posteriorly into a strong genal spine. Thorax unknown.

Both a broad and a narrow form of the pygidium occur. The broad form has a prominent axis occupying about three fifths of the length, with one complete transverse furrow, and a weakly marked second furrow; the lateral lobes are narrow in front, but expand backward into a broad flat platform, which narrows abruptly backward, ending in two short, blunt points. The narrow form has a similar axis, but is parallel sided, so that the lateral lobes are not so prominent. It also ends in two blunt points. The surface of the cranidium is smooth, but the free cheek bears a few, irregular anastomosing lines trending across it, and the border is ornamented by parallel raised lines. The pygidium bears a similar pattern of raised lines.

Discussion. This large species is the youngest *Paradoxides* of the area. It is quite distinct from any other *Paradoxides* found in Newfoundland. It is most like *P.* cf. *P. rugulosus,* from which it differs in its larger size, in the course of the facial suture, in the forward bend of the occipital furrow, in being broader, and in having a proportionately shorter, though still unusually long, eyelobe. This species occupies the same stratigraphic position in the Newfoundland sequence as does *P. forchhammeri* in Scandinavia and it is associated with a similar fauna. Nevertheless, the two species are quite different, and are likely unrelated. *P. freboldi* has a much longer eyelobe, a differently shaped pygidium, and lacks the coarse ornamentation of *P. forchhammeri.* The specific name is given in honour of Dr. H. Frebold. This species has been found at localities 20392, 21802, and 27257, in the uppermost part of the *davidis* zone, and the post-*davidis* beds.

Paradoxides bennetti Salter

Plate XXV

1859. *Paradoxides bennetti* Salter, Quart. J. Geol. Soc. London, vol. 15, p. 551, text-fig. 1.
1925. *Paradoxides bennetti* Salter; Howell, Bull. Am. Pal., vol. 11, No. 43, table 4.

Material. Hypotype, GSC No. 13086, large, almost complete specimen, from locality 27247 (this locality is almost certainly the type locality of the species).

Description. General form elongate-ovate, very broad in front, narrowing posteriorly; moderately convex, cranidium subrectangular, glabella prominent, moderately convex, expanding forward, reaching marginal furrow, widest opposite anterior end of eyelobes, thence rounded forward and evenly, gently tapering backward. Occipital furrow prominent, broad, shallow, arched gently forward, the two posterior glabellar furrows are also well marked; they arch slightly forward at the sides of the glabella, but bend slightly backward where they cross the axis; a third pair of furrows start opposite the ends of the eyelobes and trend obliquely inward and forward but do not cross the glabella. Border broad, not raised into a prominent fold, fixed cheeks of moderate width, almost horizontal, eyelobes rather long but not extending back to occipital furrow. Free cheeks broad, with extraordinarily wide, flat border, ornamented by parallel lines, genal spines short, blunt.

Thorax not completely shown. Hypotype shows clearly sixteen segments, but the cephalon has been pushed backward over the thorax, thus one or two more segments may be present. Axis broad in front, tapering evenly backward, pleura broad, with strong pleural furrows, the anterior segments end in short, gently curved spines, but the posterior segments bear longer, reflexed spines. Pygidium large, ovate, axis broad in front, tapering backward, about three fourths of total length, with one transverse furrow near anterior end. Pleural lobes broad, flat, unfurrowed.

This species is remarkable for its large size. Hypotype measures about 10 inches long, but isolated fragments have been found suggesting that the species attained a maximum of about twice this length.

Discussion. This species was selected by Howell (1925) as the marker for the lowest Middle Cambrian zone of eastern Newfoundland. It is a distinctive species, differing strikingly from any other Newfoundland *Paradoxides* in the very broad border on the cephalon, in the short genal spines, and in the size and position of the eyelobes. The eyelobes, although fairly long, are unusually short for such an early member of the genus. Because of its large size, and the fact that through most of the area the beds in which it occurs are strongly cleaved slates, it is difficult to get satisfactory specimens of this form. It is, however, a very common one, and at many localities, entire, but distorted, specimens can be seen along bedding planes in the slate. These unfortunately, because of the cleavage, shatter into fragments when an attempt is made to collect them. The species is therefore poorly represented in the Geological Survey collections. It was collected only at localities 20412, 20440, 20454, 21797, 24620, 24621, 24623, 24632, 27247, and 27256.

Paradoxides parvoculus Howell

Plate XXIV, figures 1-6

1925. *Paradoxides parvoculus* Howell, Bull. Am. Pal., vol. 11, No. 43, p. 89, Pl. 3, figs. 12, 13.

Material. Hypotype A, GSC No. 13115, very small cranidium; hypotype B, GSC No. 13116, small cranidium; hypotype C, GSC No. 13117, a larger, but still small, cranidium; hypotype D, GSC No. 13118, cranidium, one free cheek, and part of thorax of a small individual; hypotype E, GSC No. 13119, cranidium with part of the thorax; hypotype F, GSC No. 13120, large cranidium; all from locality 20454.

Description. Howell's description of the adult cranidium of this species is excellent. However, a series of immature cranidia showing the changes undergone during growth was obtained. On the smallest specimens, the glabella is proportionately much shorter and less expanded anteriorly than it is in the mature specimens, and it bears four pairs of clearly marked furrows, of which the posterior pair is clearly and the next pair faintly indented across the axis of the glabella. Also, the posterior branch of the facial suture is directed backward and only slightly outward, so that the fixed cheek is proportionately much narrower in small specimens than in larger ones. The eyelobes are unusually short for this genus, even in the smallest specimens found.

One small specimen, hypotype D, retains a poorly preserved free cheek, which bears a long, evenly curved genal spine. No other details of the free cheek are preserved.

Parts of the thorax are exhibited by hypotypes D and E. These specimens show that the thorax is composed of at least eleven, and probably several more, segments. The axis is prominent, raised, forming about one third of the total width bearing a node on at least the anterior three segments. The pleurae of third segment are elongated. The pygidium remains unknown.

Discussion. As Howell pointed out, this species has the shortest eyelobes of any Newfoundland *Paradoxides,* and can be easily recognized by this feature, as well as by the distinctive pear-shaped glabella, and the outward course of the posterior branch of the facial suture in larger specimens. This is a well-marked but rare species. The specimens in the GSC collections all came from Howell's original locality, so that this species is still known only from this one locality.

Family Olenellidae Walcott, 1891

Genus *Callavia* Matthew, 1897

Callavia broeggeri (Walcott)

Plate XXIV, figures 7-14

1888. *Olenellus bröggeri* Walcott, Nature, vol. 38, p. 551.
1890. *Olenellus (Mesonacis) bröggeri* Walcott; Walcott, Proc. U.S. Nat. Mus., vol. 12, p. 41.
1890. *Holmia? broeggeri* (Walcott); Marcou, Am. Geol., vol. 5, p. 370.
1890. *Olenellus (Holmia) bröggeri* Walcott; Walcott, 10th Ann. Rept., U.S. Geol. Surv., p. 638, Pl. 91, fig. 1; Pl. 92, figs. 1, 1a-h.
1897. *Callavia bröggeri* (Walcott); Matthew, Am. Geol., vol. 19, p. 397 (footnote).
1910. *Callavia bröggeri* (Walcott); Walcott, Smith, Misc. Coll., vol. 53, p. 279, Pl. 27, figs. 1-6.
1900. *Olenellus (Holmia) bröggeri* Walcott; Burr, Am. Geol., vol. 25, p. 43.
1900. *Olenellus (Holmia) bröggeri* Walcott; Grabau, Occ. Papers Bost. Soc. Nat. Hist., vol. 4, pt. 3, p. 662, Pl. 33, figs. 1a-1j.

Material. Walcott's types of this species are in the U.S. National Museum, Catalogue No. 18331. Dr. G. A. Cooper kindly looked over the specimens, and stated (personal correspondence) that "the species was evidently compiled from a large quantity of material, all of which is very fragmentary". However, he selected the two best specimens, and loaned them for study. The large cephalon, which is evidently the original of figure 1, on Plate 92 of Walcott's 1890 paper, is here selected lectotype. The other paratype examined shows the doublure and hypostome, and is the original of figure 1e, Plate 92, of the same paper. The locality of the types is given merely as Conception Bay, and they probably include specimens from several localities near that bay, as listed by Walcott (1890, p. 640). The species is common in the Survey collections, and several hypotypes are figured, as follows: hypotype A, large cephalon, GSC No. 12085, from locality 20437; hypotype B, smaller cephalon, GSC No. 12086, from locality 20428; hypotype C, another cephalon, GSC No. 12087, from locality 20396; hypotype D, cephalon and part of the thorax, GSC No. 12088, from locality 20396; hypotype E, small cephalon, GSC

No. 12089, from locality 20393; hypotype F, very small cephalon, GSC No. 12090, from locality 20393; hypotype G, protaspid, GSC No. 12091, from locality 20393; and hypotype H, hypostome, GSC No. 12092, from locality 21798.

Description. Walcott's description is adequate, except in a few respects. The species is much more convex than his figures suggest, and the ornamentation is commonly very weak or lacking altogether, even in specimens that are well preserved. Also, the shape of the anterior lobe of the glabella varies with the size; it is bluntly rounded in smaller specimens, but sharply rounded in larger ones. Hypotypes E, F, and G represent smaller cephala than any Walcott had, and show that, in smaller specimens, the width of the border was proportionately less than that of larger ones.

Occurrence. This species is common in the post-Smith Point Lower Cambrian rocks throughout the area. It has been collected from localities 20393, 20396, 20397, 20398, 20399, 20403, 20405, 20408, 20426, 20429, 20430, 20433, 20434, 20436, 20437, 20448, 20468, 21798, 21911, 21925, and 21936.

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APPENDIX I

MEASURED SECTIONS

SECTION 1. Section of rocks of Elliott Cove group exposed along southwest bank of Manuels River, Conception Bay

Bed	Descending Section	Thickness in Feet Bed	Total
	Section ends beneath drift near shore of Conception Bay		
32	Shale, grey to black; thin beds of fine, massive grey siltstone, and of grey, silty, micaceous shale; fossil locality 21938 near middle	18	18
31	Unexposed	22	40
30	Shale, grey to black; minor grey siltstone	4	44
29	Unexposed	20	64
28	Shale, black to grey, silty, micaceous	4	68
27	Unexposed	6	74
26	Shale, black, micaceous; minor grey shale and siltstone	12	86
25	Shale, black, very finely bedded	2	88
24	Shale, black, thick-bedded; minor grey micaceous shale and siltstone	3	91
23	Shale, grey to black, micaceous; siltstone, massive, grey, interbedded	17	108
22	Shale, black, highly fissile	7	115
21	Shale, black, fissile; with minor grey shale and thin massive siltstone beds; containing rare trilobite fragments in upper part, no identifiable fossils found	45	160
20	Siltstone, massive, grey, limy; fossil locality 21939	2	162
19	Shale, black to grey, micaceous; minor massive siltstone	48	210
18	Unexposed	30	240
17	Shale, black; minor grey micaceous shale and thin grey siltstone beds	21	261
16	Unexposed (estimated)	110	371
15	Shale, grey to black, micaceous; rare scattered nodules of black impure limestone	27	398
14	Limestone, black, impure, shaly; fossil locality 21930	½	398½
13	Shale, grey to black, micaceous; rare grey limestone nodules; fossils in nodules 7 feet above base, locality 21929	17	415½
12	Shale, grey to black, micaceous; fossils in black limestone nodules at top, locality 21937	15	430½
11	Shale, black, soft; fossil locality 20498 at top, locality 20497, 13 feet below top	35	465½
10	Shale, black, thin-bedded, with half-inch beds of black limestone, becoming grey and micaceous at top	24	489½
9	Shale, black, very thin bedded	1½	491
8	Limestone, soft, black, micaceous	1	492
7	Shale, black, soft, highly fissile, locally pyritiferous, fossiliferous; fossil locality 20496, 8 feet above base; locality 20495, 5 feet above base; localities 20425 and 20494, 3 feet above base	31	523
6	Shale, soft, black, thin-bedded, pyritiferous, with rare black limestone nodules, fossiliferous; fossil localities as follows: 1 foot above base, 20421; 14 feet above base, 20422; 22 feet above base, 20423; 30 feet above base 20424 and 20491; 33 feet above base, 20488; 37 feet above base, 20489 and 20490	39	562
5	Shale, black; with black limestone concretions; fossil locality 20416	½	562½
4	Shale, black, thin-bedded; fossils 12 feet above base, localities 20415, 27260	20	582½
3	Shale, grey, micaceous; fossil locality 20414 near top	16½	599
2	Shale, soft, black, very thin bedded, pyritiferous	12	611
1	Shale, soft, black; becoming grey, micaceous and silty at top; fossil locality 20394 near base; resting in uppermost bed of Middle Cambrian *davidis* zone	6	617
	Total exposed thickness of Elliott Cove group		617

SECTION 2. Section of Brigus formation exposed along east shore of Conception Bay at Duffs

Bed	Descending Section	Thickness in Feet Bed	Total
13	Shale, red, micaceous	7	7
12	Limestone, massive, pink; fossil locality 27264	½	7½
11	Shale, red, thin-bedded	5	12½
10	Shale, green; rare pink limestone nodules	2	14½
9	Shale, red	4½	19
8	Shale, green	8	27
7	Limestone, massive, pink; fossil locality 27259	½	27½
6	Shale, green, with many large, dense, grey to pink limestone nodules	3	30½
5	Limestone, massive to nodular, pink, pinching and swelling	½	31
4	Shale, deep green	2½	33½
3	Limestone, massive, purplish red; fossil locality 27258	½	34
2	Unexposed (probably red shale from fragments in overburden)	16	50
1	Limestone, pink, massive, resting unconformably on granitic igneous rock	2	52
	Total exposed thickness of Brigus formation		52

SECTION 3. Section of Chamberlain's Brook, Brigus, Smith Point, and Bonavista formations exposed on Brigus South Point, Conception Bay

Bed	Descending Section	Thickness in Feet Bed	Total
	Section ends beneath Conception Bay		
	CHAMBERLAIN'S BROOK FORMATION		
45	Slate, green to grey-green, strongly cleaved (thickness estimated)	100	100
44	Slate, green; with many unfossiliferous green limestone nodules	1	101
43	Slate, green; strongly cleaved, bedding marked by colour banding	24	125
42	Slate, green; with thin limestone beds and phosphatic nodules	3	128
41	Slate, green; with phosphatic nodules	12	140
40	Slate, green; with thin, red limestone beds	8	148
39	Slate, green; containing *Paradoxides bennetti* Salter	2	150
38	Slate, green, siliceous; with manganiferous nodules, stained black on weathered surface; fossil locality 20412	9	159
	Total exposed thickness of Chamberlain's Brook formation		159
	Probable disconformity		
	BRIGUS FORMATION		
37	Limestone, slaty, red, impure; underlying manganiferous green slates, with Middle Cambrian trilobites, either conformably or with minor disconformity	1	1
36	Slate, green, well cleaved	29	30
35	Slate, red, well cleaved; minor green beds	28	58
34	Slate, green, well cleaved	1	59
33	Slate, red; minor green beds and red limestone stringers	29	88
32	Slate, green	11	99
31	Slate, red, well cleaved; minor green slate and red limestone	19	118

Bed	Descending Section	Thickness in Feet Bed	Total
30	Slate, green; with lenses and irregular stringers of red slate and slaty limestone	32	150
29	Limestone, red, slaty, impure	1	151
28	Slate, green	4	155
27	Slate, red, well cleaved; rare, pink limestone nodules	83	238
26	Slate, green; with pink limestone nodules	11	249
25	Slate, red; two thin nodular pink limestone layers	11	260
24	Limestone, pink to green, nodular, slaty	4	264
23	Slate, red; scattered pink limestone nodules near base	35	299
22	Slate, red; many pink to white limestone nodules; fossil localities 20407, 20433, 21798	7	306
21	Limestone, pink to green, slaty, wavy bedded, nodular; fossil localities 20406, 20426, 21911	4	310
20	Slate, green; pink to green limestone nodules	4	314
19	Limestone, slaty, green to pink, wavy bedded, nodular; fossil localities 20405, 20432 near top, 20431 about middle, 20430 near base	10	324
18	Slate, green; with pink limestone nodules	3	327
17	Limestone, pink, wavy bedded, nodular	4	331
16	Slate, red; pink limestone nodules, fossil locality 21912 at top	5	336
15	Slate, red; minor green beds and rare pink limestone nodules	8	344
14	Slate, green; many pink limestone nodules	6	350
13	Limestone, red, wavy bedded, nodular	8	358
12	Slate, red to green, well cleaved	4	362
11	Limestone, green, slaty	1	363
10	Slate, green	6	369
9	Slate, red	5	374
8	Limestone, nodular, red, slaty	1	375
7	Slate, red; scattered limestone nodules	21	396
	Total thickness of Brigus formation		396
	Conformable contact		
	SMITH POINT FORMATION		
6	Limestone, pink, nodular, slaty, wavy bedded	7	7
5	Limestone, pink, massive, wavy bedded; with many algal colonies, and cut by numerous ½-inch white calcite veins	27	34
	Total thickness of Smith Point formation		34
	Conformable contact		
	BONAVISTA FORMATION		
4	Slate, red, strongly cleaved; scattered pink limestone nodules	55	55
3	Conglomerate, fine, red, quartz-pebble; pink limestone cement	3	58
2	Slate, red, well cleaved	41	99
1	Conglomerate, fine, red, quartz-pebble; red limestone cement; filling in low spots on surface of Harbour Main rocks, on which it rests with right-angle unconformity	0-2	99-101
	Total thickness of Bonavista formation		99-101

SECTION 4. Section of Brigus, Smith Point, and Bonavista formations exposed along south shore of Heart's Desire Harbour, Trinity Bay

Bed	Descending Section	Thickness in Feet Bed	Total
	Section ends at synclinal axis		
	BRIGUS FORMATION		
12	Slate, red, strongly cleaved; thin green slate beds; pink, crystalline limestone nodules in bands	40	40
11	Limestone, pink crystalline, nodular	1	41
10	Slate, red, strongly cleaved	12	53
	Total exposed thickness of Brigus formation		53
	SMITH POINT FORMATION		
9	Limestone, red, nodular, wavy bedded; with thin, red, silty bands; fossils in top beds, localities 20393, 20429	35	35
8	Limestone, grey-green to pink, redder near top; with thin beds of green siltstone	12	47
7	Limestone, grey-green, wavy bedded	3	50
	Total thickness of Smith Point formation		50
	Conformable contact		
	BONAVISTA FORMATION		
6	Slate, light green, calcareous; with concretions and irregular beds of green limestone	20	20
5	Slate, strongly cleaved, grey silty	4	24
4	Slate, light green; numerous pink to green limestone concretions and irregular beds	24	48
3	Slate, strongly cleaved, red; numerous concretions of red limestone, chiefly in the lower 20 feet	48	96
2	Slate, strongly cleaved, light green; numerous pink to green limestone nodules near top	65	161
1	Unexposed, about 200 feet to coarse red sandstones of Precambrian Hodgewater group, may be part or all Bonavista rocks	200	361
	Thickness of Bonavista formation — minimum		161
	maximum		361

SECTION 5. Section of Brigus, Smith Point and Bonavista formations exposed along south shore of Heart's Delight Harbour, Trinity Bay

Bed	Descending Section	Thickness in Feet Bed	Total
	Section ends at water's edge		
	BRIGUS FORMATION		
16	Slate, red, strongly cleaved	40	40
15	Slate, green; with one 4-foot band of red slate with fossiliferous limestone nodules near top; localities 20395, 20427	230	270

SECTION 5 — continued

Bed	Descending Section	Thickness in Feet Bed	Total
14	Slate, red, well cleaved; minor green beds	59	329
13	Slate, green	9	338
12	Slate, red, strongly, evenly cleaved	86	424
11	Slate, green	18	442
10	Slate, red, strongly cleaved	68	510
9	Limestone, red, nodular, fossiliferous, localities 20396, 20428	½	510½
8	Slate, red	8	518½
7	Limestone, red, slaty, nodular	½	519
6	Slate, red	6	525
	Total exposed thickness of Brigus formation		525
	Conformable contact		
	SMITH POINT FORMATION		
5	Limestone, red to pink, or mottled pink and green, wavy bedded, with algal colonies	52	52
	Conformable contact		
	BONAVISTA FORMATION		
4	Slate, green; minor pink limestone nodules	27	27
3	Slate, green; many large pink limestone nodules arranged in bands	12	39
2	Slate, red; pink limestone nodules near base	45	84
1	Slate, green; scattered limestone nodules near top, resting with minor disconformity on Random formation	87	171
	Total thickness of Bonavista formation		171

SECTION 6. Section of Elliott Cove group and Manuels River formation exposed at Highland Cove, Trinity Bay

Bed	Descending Section	Thickness in Feet Bed	Total
	Section ends at synclinal axis		
	ELLIOTT COVE GROUP		
22	Slate, grey to black, yellow weathering, strongly cleaved	42	42
21	Slate, black; scattered nodules of grey, impure limestone	1	43
20	Slate, black; strongly cleaved; rare grey limestone nodules	60	103
19	Slate, black; with large grey limestone nodules	1	104
18	Slate, dark grey to black, strongly cleaved; rare limestone nodules	119	223
17	Siltstone, massive, grey, quartzitic; contains fragments of phosphatic brachiopod shells, resting with sharp contact but no evident disconformity on bed below	2	225
	Exposed thickness of Elliott Cove group		225
	Possible disconformity		
	MANUELS RIVER FORMATION		
16	Limestone, grey, conglomeratic, wavy bedded, algal; contains fragments of large trilobites	1	1
15	Siltstone, massive, grey, quartzitic; with phosphatic nodules	6	7

SECTION 6 — continued

Bed	Descending Section	Thickness in Feet Bed	Total
14	Limestone, grey, conglomeratic, wavy bedded	½	7½
13	Sandstone, grey, quartzitic, fossils in rare limy nodules at base; fossil locality 21917	2	9½
12	Limestone, massive, grey, algal; contains trilobite fragments, a ½-inch bed of intraformational conglomerate at base	½	10
11	Slate, black, strongly cleaved; with pyrite nodules up to ½ inch in diameter; distorted trilobites visible on bedding surfaces	6	16
10	Slate, black, strongly cleaved; with fossiliferous grey, slaty limestone nodules; fossil localities 21801, 21932	1	17
9	Slate, black, strongly cleaved; scattered grey to black limestone nodules; fossil localities 21933 near top, 21802 about 4 feet above base	25	42
8	Slate, black; with many large yellow weathering, grey limestone nodules; fossil localities 20449, 21804	1	43
7	Slate, black, well cleaved; rare limestone nodules; fossil localities 21927 near top, 21926 about 3 feet above base	11	54
6	Slate, black, many limestone nodules; fossil locality 21810	1	55
5	Slate, black, well cleaved; locally pyritiferous	24	79
4	Slate, black, strongly cleaved; many black limestone nodules	1	80
3	Slate, black; scattered limestone nodules; fossil locality 21935 at top	25	105
2	Limestone, massive, grey	1	106
1	Slate, grey to black; rare grey limestone nodules; fossil locality 21934	4	110
	Total thickness of Manuels River formation		110
	Base of measured section, resting with conformable contact on an unmeasured section of closely folded green slate of Chamberlain's Brook formation		

SECTION 7. Section of Manuels River, Chamberlain's Brook, Brigus, Smith Point, and Bonavista formations exposed along east shore of Trinity Bay north of New Harbour, along southwest shore of Hopeall Head

Bed	Descending Section	Thickness in Feet Bed	Total
	MANUELS RIVER FORMATION		
36	Slate, dark grey	50	50
35	Slate, grey; a 2-inch bed of massive grey limestone at top	10	60
34	Slate, grey; a 1½-inch bed of grey limestone at top; fossil locality 20411	7	67
33	Slate, grey; a 1-inch grey limestone bed at top	9	76
	Total exposed thickness of Manuels River formation		76
	Conformable contact		
	CHAMBERLAIN'S BROOK FORMATION		
32	Limestone, massive, grey to pink; includes a 4-inch grey slate bed	3	3
31	Slate, grey	9½	12½
30	Limestone, massive, grey; fossil locality 20410	1½	14
29	Slate, dark grey	23	37
28	Breccia, volcanic, fine, massive, white	15	52
27	Slate, greenish grey	95	147

Bed	Descending Section	Thickness in Feet Bed	Total
26	Limestone, massive, pink, includes two 4-inch slate beds; fossil locality 20409	2	149
25	Slate, greenish grey, well cleaved	264	413
24	Limestone, pink to grey; slate, grey interbedded with manganiferous nodules and veinlets; fossil locality 24623	3	416
	Total thickness of Chamberlain's Brook formation		416
	Probable disconformity		
	BRIGUS FORMATION		
23	Slate, greenish grey	59	59
22	Slate, red	63	122
21	Slate, green	13	135
20	Slate, red; minor thin green beds	32	167
19	Slate, green	3	170
18	Limestone, massive, red to green; one 3-inch slate bed; fossil locality 20403	1½	171½
17	Slate, green; a massive 2-inch limestone bed 19 feet above the base has many trilobites; fossil locality 20402	75	246½
16	Slate, red, minor green beds; scattered pink limestone; fossil locality 20401 near base	39	285½
15	Slate, red; with numerous horizons of red and green limestone nodules; fossil locality 20400	10	295½
14	Slate, red to purple	7½	303
13	Slate, green	6½	309½
12	Slate, red; minor red limestone nodules	6	315½
11	Slate, green	19	334½
10	Slate, red; with few thin pink limestone beds, and scattered limestone nodules; fossil locality 20399, 60 feet above base, locality 20398, 40 feet above base	105	439½
9	Slate, red; with 3 inches of red limestone at top	7	446½
8	Limestone, red	1½	448
7	Slate, red, fragmentary fossils; locality 20397	4	452
	Total thickness of Brigus formation		452
	Conformable contact		
	SMITH POINT FORMATION		
6	Limestone, massive, red to red and green mottled, wavy bedded, algal	40½	40½
	Conformable contact		
	BONAVISTA FORMATION		
5	Shale, black, siliceous	2	2
4	Slate, green; with pink limestone nodules	4	6
3	Slate, red, highly cleaved; minor limestone nodules	40	46
2	Slate, green; with massive grey limestone nodules	48	94
1	Conglomerate, red, fine; with pebbles of rhyolite, jasper, quartzite, and vein quartz to ½-inch diameter; matrix sandy at base, becoming limy at top; resting disconformably on massive white quartzite of Random formation	7	101
	Total thickness of Bonavista formation		101

SECTION 8. Section of Manuels River formation exposed on north tip of McLeod Point, Trinity Bay

Bed	Descending Section	Thickness in Feet Bed	Total
	Section starts at base of massive lava bed on tip of point		
	MANUELS RIVER FORMATION		
11	Slate, grey, crumbly	2½	2½
10	Quartzite, massive, grey	½	3
9	Slate, grey; scattered light grey limy, nodules; fossil locality 21800 at top	50	53
8	Slate, grey; with large limestone lenses; fossil locality 21806	1	54
7	Slate, grey, well cleaved	12	66
6	Slate, dark grey; with lenses of black fossiliferous limestone; fossil localities 20451, 21807	1	67
5	Slate, grey	4	71
4	Limestone, massive, grey	1	72
3	Slate, grey	8	80
2	Slate, grey; with large lenses of grey fossiliferous limestone, fossil localities 20450, 21803	1	81
1	Slate, grey	4	85
	Section ends at anticlinal axis		
	Total exposed thickness of Manuels River formation		85

SECTION 9. Section of Elliott Cove and Manuels River rocks exposed on Little Ridge, east shore of Chapel Arm, 1½ miles south of McLeod Point, Trinity Bay

Bed	Descending Section	Thickness in Feet Bed	Total
	Section ends at synclinal axis		
12	Slate, grey; with thin grey siltstone beds becoming thicker and more numerous towards the top	81	81
11	Slate, grey; local limestone lenses	52	133
10	Slate, grey; many large limestone lenses	1	134
9	Slate, grey; silty; rare limestone nodules	27	161
8	Slate, grey; with lenses of dark grey, well-bedded limestone; fossil locality 21799	1	162
7	Slate, grey, silty	6	168
6	Slate, grey; with large grey limestone lenses	1	169
5	Slate, grey; rare silty beds; local limestone concretions	22	191
4	Slate, grey; large concretions of grey to black limestone	1	192
3	Slate, grey, silty; rare thin siltstone beds	28	220
2	Slate, silty, grey; with massive grey siltstone beds	4	224
1	Andesite, massive, light grey, upper 4 feet composed of ellipsoidal pillow lava; rest more or less amygdaloidal; fragmentary fossils in limy inter-pillow rock at top, locality 20487	92	316
	Total exposed thickness of Elliott Cove and Manuels River rocks		316
	Section ends beneath water of Trinity Bay		

In this section, because of relatively strong metamorphism and the scarcity of fossils, and the unusual lithology of the transition beds, the position of the Elliott Cove-Manuels River contact is uncertain. It must, however, lie between bed 8, which contains early Upper Cambrian fossils, and the top of bed 1, which contains late Middle Cambrian fossils.

SECTION 10. Composite section of Chamberlain's Brook, Brigus, Smith Point and Bonavista formations exposed on shores of Long Cove and Chapel Head, Trinity Bay

Bed	Descending Section	Thickness in Feet Bed	Total
	CHAMBERLAIN'S BROOK FORMATION		
74	Slate, grey to green (inaccessible, thickness estimated)	100	100
73	Slate, red	36	136
72	Slate, green	16	152
71	Slate, green to grey; with beds of pink manganiferous nodules; fossil localities 20439, 20440	20	172
	Total exposed thickness of Chamberlain's Brook formation		172
	Probable disconformity		
	BRIGUS FORMATION		
70	Slate, green	24	24
69	Slate, red, with green lenses and stringers	23	47
68	Slate, green	7	54
67	Slate, red and green, finely interbedded	2	56
66	Slate, red	8	64
65	Slate, green	1	65
64	Slate, red, with one 2-inch green bed	18½	83½
63	Slate, green	7	90½
62	Slate, red	12	102½
61	Limestone, grey, slaty, minor red and green slate	1	103½
60	Slate, red	5½	109
59	Slate, red and green, interbedded	9	118
58	Slate, red; rare thin green beds	51	169
57	Slate, red and green, closely interbedded	5	174
56	Slate, red	4	178
55	Slate, red and green, interbedded	2	180
54	Slate, green	7	187
53	Slate, red; rare green stringers and limestone nodules	72	259
52	Limestone, green, slaty	½	259½
51	Slate, red; with pink limestone nodules; fossils near top, locality 20438	12	271½
50	Slate, green	13	284½
49	Slate, green; with lenses of massive, grey unfossiliferous limestone	2	286½
48	Slate, green, well cleaved; with nodules of pyrite	29	315½
47	Limestone, green, massive, coarse grained	½	316
46	Slate, green, poorly cleaved	26	342
45	Slate, red; fragmentary fossils near top	13	355
44	Slate, red, a 1-inch bed of green limestone at top	24	379
43	Slate, red and green, with thin limestone stringers	1	380
42	Slate, red	5	385
41	Slate, red and green; with a 2-inch grey limestone bed at base	1	386
40	Slate, red; many thin beds and nodules of pink fossiliferous limestone; locality 20437	20	406
39	Slate, red; some green lenses; and pink limestone nodules; includes a 3-inch bed of massive pink to green limestone 15 feet above base	24	430
38	Limestone, massive, pink	½	430½
37	Slate, red; fossil locality 20436 just below top	13	443½
36	Slate, green	½	444
35	Slate, red	4½	448½
34	Slate, red; with thin nodular pink limestone beds at top and base; fossil locality 20435	1	449½

SECTION 10 — continued

Bed	Descending Section	Thickness in Feet Bed	Total
33	Slate, red	7½	457
32	Slate, green	1	458
31	Slate, red	3½	461½
30	Slate, green	1	462½
29	Slate, red	11	473½
28	Slate, green	2	475½
27	Slate, red	20	495½
26	Slate, green, thin red beds	8½	504
25	Slate, red	75	579
24	Slate, green	3½	582½
23	Slate, red	1	583½
22	Limestone wavy bedded, pink to red, nodular, slaty; fossil locality 20434	2½	586
21	Slate, red; rare limestone nodules	53	639
20	Slate, red; many beds of pink limestone nodules	2	641
19	Slate, red; rare pink limestone nodules	15	656
18	Limestone, massive, thin-bedded, pink to grey	½	656½
17	Slate, red; with rare limestone nodules	43½	700
16	Limestone, massive, green	½	700½
15	Slate, red	12	712½
14	Slate, red; with thin red limestone beds	1½	714
13	Slate, red	6	720
12	Limestone, red; containing fragmentary fossils	½	720½
11	Slate, red	16	736½
	Total thickness of Brigus formation		736½
	Conformable contact		
	SMITH POINT FORMATION		
10	Limestone, red, massive, composed almost entirely of cabbage-shaped algal nodules	2	2
9	Limestone, red, wavy bedded, massive, thin slaty seams	19	21
	Total thickness of Smith Point formation		21
	Conformable contact		
	BONAVISTA FORMATION		
8	Slate, green to black; with beds of pink limestone nodules	6	6
7	Slate, green; with thin beds of pink and grey limestone	5½	11½
6	Slate, red	23	34½
5	Slate, red; numerous beds of pink limestone nodules	18	52½
4	Slate, green	5	57½
3	Slate, red	15	72½
2	Slate, green	4	76½
1	Conglomerate, quartz-pebble, purple, resting on slightly uneven surface of massive red and green, crossbedded quartzites of Precambrian Random formation	½	77
	Total thickness of Bonavista formation		77

The above section is composite; beds 11 to 74 were measured in in a continuously exposed section along the east shore of Long Cove, and on Chapel Head; beds 1 to 10 are not exposed in the same section and were measured a few hundred yards away on the west shore of Long Cove.

SECTION 11. Section of Chamberlain's Brook, Brigus, Smith Point, and Bonavista formations exposed on Cape Dog, St. Marys Bay

Bed	Descending Section	Thickness in Feet Bed	Total
	Section begins at contact below base of massive lava beds which form the main cliff face		
	CHAMBERLAIN'S BROOK FORMATION		
43	Slate, red (inaccessible on cliff face, thickness estimated)	18	18
42	Slate, green	38	56
41	Slate, deep reddish purple	48	104
40	Slate, purple; with green, massive, impure limestone nodules	2	106
39	Slate, purple; minor thin green beds; scattered limestone nodules	61	167
38	Slate, red; minor limestone nodules; fossils in nodules, locality 21797	19	186
37	Slate, red to purple, minor thin green beds	35	221
36	Slate, red; with limestone nodules	3	224
35	Slate, red; minor green beds	12	236
34	Slate, red; with some limestone nodules	38	274
33	Slate, purple; minor red and green beds, nodules lacking	54	328
32	Slate, red, green and purple, variegated in thin beds	33	361
31	Slate, green	9	370
30	Slate, red, green, and purple, variegated	11	381
29	Slate, green	9	390
28	Slate, green, black weathering; with manganiferous nodules	2	392
27	Slate, green	10	402
26	Slate, green; with manganiferous nodules, large specimens of *Paradoxides bennetti* visible on bedding planes, uncollectable because of cleavage	15	417
	Total exposed thickness of Chamberlain's Brook formation		417
	Possible disconformity		
	BRIGUS FORMATION		
25	Slate, red, green, and purple variegated	12	12
24	Slate, red, and green, with pink and grey limestone nodules	8	20
23	Slate, red	13	33
22	Slate, green	14	47
21	Slate, red; with thin purple beds	55	102
20	Slate, green	2	104
19	Slate, red; with minor green beds	30	134
18	Slate, green and purple, interbedded	9	143
17	Slate, red, minor green beds to 2-feet thick	142	285
16	Unexposed	3	288
15	Slate, red and green interbedded	19	307
14	Slate, red; minor green beds	44	351
13	Limestone, massive, pink; the upper part mainly composed of algal colonies	3	354
12	Slate, red	170	524
11	Slate, green	6	530
10	Slate, red	8	538
9	Slate, red; with green and pink limestone nodules	14	552
8	Slate, red; with thin beds of pink limestone containing trilobite fragments	18	570
7	Limestone, massive, pink	1	571
6	Slate, red; minor thin limestone	2	573
	Total thickness of Brigus formation		573

SECTION 11 — continued

Bed	Descending Section	Thickness in Feet Bed	Total
	Conformable contact		
	SMITH POINT FORMATION		
5	Limestone, massive, pink, wavy bedded algal	18	18
	Conformable contact		
	BONAVISTA FORMATION		
4	Slate, red; with thin beds of massive pink limestone	2	2
3	Limestone, massive, pink to grey; a 2-inch grey slate bed at top	2	4
2	Slate, red to purple; scattered pink and grey limestone nodules	21	25
1	Limestone, pink; sandy to conglomerate at base, with algal colonies at top, white quartz pebbles near base, resting disconformably on an uneven surface of massive grey quartzites of Random formation	1	26
	Total thickness of Bonavista formation		26

SECTION 12. Section of Bonavista, Smith Point, and Brigus Formations exposed at Barachois west shore of St. Marys Bay

Bed	Descending Section	Thickness in Feet Bed	Total
	BRIGUS FORMATION		
14	Slate, red, top concealed by recent beach deposit. (Rocks strike N25°E, dip 40°SE, top normal)	5	5
13	Limestone, pink to grey, slaty, containing hyolithids	3	8
12	Slate, red; scattered pink limestone nodules	50	58
11	Limestone, massive, pink, and red slate interbedded	3	61
10	Slate, red; a 2-inch bed of massive pink limestone near top	24	85
9	Limestone, massive, pink	½	85½
8	Slate, reddish purple	21	106½
7	Slate, green, and purple	3	109½
	Total exposed thickness of Brigus formation		109½
	Conformable contact		
	SMITH POINT FORMATION		
6	Limestone, pink, massive; composed almost entirely of rounded algal masses	2½	2½
5	Limestone, red; containing hyolithids, some rounded algal masses	12	14½
	Total thickness of Smith Point Formation		14½
	Conformable contact		
	BONAVISTA FORMATION		
4	Slate, purple	1	1
3	Limestone, red; containing hyolithids, rare algal colonies	2	3
2	Slate, red	15	18
1	Conglomerate, fine, quartz-pebble, pink limy matrix resting with no visible discordance on massive, quartzitic, crossbedded red sandstone	1	19
	Total thickness of Bonavista formation		19

SECTION 13. *Section of Manuels River, Chamberlain's Brook, Brigus, and Smith Point formations along north side of Jigging Cove Head, St. Marys Bay*

Bed	Descending Section	Thickness in Feet Bed	Total
	Section begins at base of massive sill at tip of Jigging Cove Head		
	MANUELS RIVER FORMATION		
41	Slate, green, contorted; distorted trilobites visible on bedding planes, not collectible because of cleavage; identified in field as *Paradoxides* sp. and *Agraulos* sp.	32	32
	Conformable contact		
	CHAMBERLAIN'S BROOK FORMATION		
40	Limestone, massive, pink to green; trilobite fragments	1	1
39	Slate, red and green, interbedded, strongly cleaved, brecciated, and cut by several basic dykes; locality 27254 near top	157	158
38	Slate, green, less strongly cleaved, minor nodules and thin beds of green limestone	58	216
37	Slate, red and green, interbedded	39	255
36	Slate, green; rare small limestone nodules	5	260
35	Slate, red to green, interbedded, trilobites 20 feet below top; locality 21808	77	337
34	Slate, red and green; with red and green limestone nodules	6	343
33	Slate, red and green, interbedded	70	413
32	Slate, red; occasional green limestone nodules	4	417
31	Slate red, green, and purple, variegated	55	472
30	Slate, red; occasional green beds	35	507
29	Slate, green	3	510
28	Slate, red; minor green beds	6	516
27	Slate, green	2	518
26	Slate, red, thin green stringers	4	522
25	Slate, green; large specimens of *Paradoxides bennetti* visible on bedding, uncollectible because of cleavage	29	551
	Total thickness of Chamberlain's Brook formation		551
	Probable disconformity		
	BRIGUS FORMATION		
24	Slate, red; small pink limestone nodules	1	1
23	Slate, green	15	16
22	Slate, mostly red, with green beds to several feet thick	129	145
21	Slate, red, green, and purple, variegated	9	154
20	Slate, red; minor green beds	28	182
19	Slate, green	10	192
18	Slate, red; thin green beds	160	352
17	Slate, green	8	360
16	Limestone, red, slaty	½	360½
15	Slate, red	4½	365
14	Slate, green	17	382
13	Limestone, massive, grey to green	1½	383½
12	Limestone, massive, pink, with hyolithes shells	2½	386
11	Slate, red	46	432
10	Slate, red; with scattered pink limestone nodules	19	451
9	Limestone, massive, pink	1	452

SECTION 13 — continued

Bed	Descending Section	Thickness in Feet Bed	Total
8	Slate, red; scattered pink limestone nodules	28	480
7	Slate, red; many limestone nodules	1	481
6	Slate, red	3	484
5	Slate, red; many pink limestone nodules	10	494
4	Limestone, pink, nodular	1	495
3	Slate, red	2	497
	Total thickness of Brigus formation		497
	Conformable contact		
	SMITH POINT FORMATION		
2	Limestone, massive, pink, with algal colonies	13	13
1	Conglomerate, quartz-pebble; resting on massive white quartzite of Random formation	1	14
	Total thickness of Smith Point formation		14
	Beds 1-11 of the above section outcrop along a seacliff, where the author was unable to land because of a heavy swell. The lithologies were observed, and the thicknesses estimated, from the boat, and are therefore subject to some error.		

SECTION 14. Section of Elliott Cove, Manuels River, and Chamberlain's Brook rocks exposed on north and west shores of Deep Cove, St. Marys Bay

Bed	Descending Section	Thickness in Feet Bed	Total
	Section starts at base of dioritic sill that forms the northeastern point of the harbour entrance		
	ELLIOTT COVE GROUP		
17	Shale, grey to green, silty, micaceous; minor grey, silty limestone; metamorphosed to dense grey hornfels near intrusive sills. Includes a 4-foot diorite sill 15 feet below top, and a 2-foot sill 22 feet below top	139	139
	Possible disconformity		
	MANUELS RIVER FORMATION		
16	Shale, black; minor grey limestone	9	9
15	Limestone, grey to black; fossil locality 27246	1	10
14	Shale, black, fissile; many trilobite fragments including *Paradoxides davidis*	37	47
13	Shale, black; with large grey limestone nodules; fossil locality 27245	1	48
12	Shale, black; scattered grey to black limestone nodules, no fossils seen	75	123
11	Shale, black; with large black limestone nodules; fossil locality 27243	6	129
10	Shale, black; with distorted trilobite fragments	24	153
9	Shale, grey to black, somewhat slaty but cleavage less prominent than in lower beds	30	183
	Total thickness of Manuels River formation		183

SECTION 14 — continued

Bed	Descending Section	Thickness in Feet Bed	Total
	Conformable contact		
	CHAMBERLAIN'S BROOK FORMATION		
8	Slate, green, well cleaved, becoming grey towards top and grading into bed above; distorted fossil fragments	30	30
7	Limestone, light grey, nodular	1	31
6	Slate, green, well cleaved; distorted trilobite fragments at several horizons	74	105
5	Slate, red; minor green beds	25	130
4	Slate, green, strongly cleaved	10	140
3	Slate, red; minor green beds; distorted fragments of large trilobites	25	165
2	Slate, red, green, purple, interbedded	7	172
1	Slate, green, strongly cleaved; with large distorted specimens of *Paradoxides bennetti,* uncollectible because of cleavage	28	200
	Total exposed thickness of Chamberlain's Brook formation		200
	Section ends at overburden at head of cove		

SECTION 15. *Section of Brigus, Smith Point, and Bonavista formations exposed along east shore of Placentia Bay, about ½ mile south of Cuslett*

Bed	Descending Section	Thickness in Feet Bed	Total
	Section ends at top of cliff face		
	BRIGUS FORMATION		
17	Slate, red, well cleaved and well bedded; thin beds of pink weathering nodular limestone (inaccessible, thickness estimated)	40	40
16	Limestone, pink, nodular	2	42
15	Slate, red; with thin beds of pink nodular limestone	20	62
	Exposed thickness of Brigus formation		62
	Conformable contact		
	SMITH POINT FORMATION		
14	Limestone; massive, pink nodular, wavy bedded; with hyolithids and algal colonies	29	29
	Conformable contact		
	BONAVISTA FORMATION		
13	Slate, red and green, interbedded, minor discontinuous beds and lenses of pink nodular limestone	11	11
12	Slate, red, well cleaved, locally well bedded; numerous thin beds and nodules of pink massive limestone to 1 foot thick	110	121
11	Limestone, pink, nodular	3	124
10	Limestone, massive, dense, grey and green mottled	6	130
9	Slate, brick red, well cleaved	11	141
8	Slate, green and purple; mottled minor limestone nodules	5	146
7	Slate, grey-green, calcareous; many limestone nodules	8	154

SECTION 15 — continued

Bed	Descending Section	Thickness in Feet Bed	Total
6	Slate, grey-green; occasional red limestone nodules and a few algal colonies	27	181
5	Limestone, pink; scattered algal colonies of *"Collenia"* type to 2 inches in diameter	3	184
4	Slate, red, well cleaved, cut by small diabasic dykes	25	209
3	Slate, green and purple	1½	210½
2	Limestone, pink, nodular, with thin red slate partings	2½	213
1	Conglomerate, red, containing small well-rounded pebbles of quartz in red sandy matrix, locally with minor pink limestone and black manganiferous nodules resting with apparent conformity on white quartzite and interbedded green silty slate of Random formation	2	215
	Total thickness of Bonavista formation		215

SECTION 16. Section of Bonavista formation rocks exposed on southeast shore of Come by Chance Harbour, Placentia Bay

Bed	Descending Section	Thickness in Feet Bed	Total
	Section ends beneath water of Come by Chance Harbour		
	BONAVISTA FORMATION		
33	Shale, green; scattered pink limestone nodules near base (exposed only at low tide)	10	10
32	Shale, red, with local green patches	16	26
31	Limestone, nodular, in 3-to-6-inch beds, some thin red shale partings	5	31
30	Shale, red, many pink limestone nodules, includes a 6-inch bed of pink limestone near top	11	42
29	Limestone, massive, pink	4	46
28	Shale, green	21	67
27	Shale, red and green interbedded	4	71
26	Limestone, massive, pink	½	71½
25	Shale, red; scattered pink limestone nodules	2	73½
24	Shale, green	2	75½
23	Shale, red	1	76½
22	Limestone, massive, pink	½	77
21	Shale, red	2	79
20	Shale, green	2	81
19	Shale, red; with two 1-inch limestone beds	1	82
18	Limestone, massive, pink	1	83
17	Shale, red; with thin limestone beds	3	86
	Section here is cut by a vertical fault — drag along fault indicates that the movement has concealed an undetermined, but probably small, thickness of beds. Section continues across fault.		
16	Shale, green	6	92
15	Unexposed	18	110
14	Shale, red	2	112
13	Unexposed	22	134
12	Shale, red	8	142

SECTION 16 — continued

Bed	Descending Section	Thickness in Feet Bed	Total
11	Shale, green	2	144
10	Shale, red; rare pink limestone nodules	3	147
9	Shale, green; scattered massive grey limestone nodules	7	154
8	Shale, red; rare pink limestone nodules	18	172
7	Shale, green	1	173
6	Shale, red	9	182
5	Limestone, pink, nodular	1	183
4	Shale, red	26	209
3	Shale, green; rare small limestone nodules	8	217
2	Limestone, massive, red; fossil locality 27267	2	219
1	Shale, red, with 2 inches red sandstone near base, resting with no visible disconformity on a massive 4-foot bed of white quartzite	6	225
	Total exposed thickness of Bonavista formation		225

SECTION 17. Section of rocks of Elliott Cove group, and Manuels River and Chamberlain's Brook formations exposed along west shore of Random Island, Trinity Bay, south of Elliott's Cove and north of Fosters Point

Bed	Descending Section	Thickness in Feet Bed	Total
	Section ends beneath recent shoreline deposits		
	ELLIOTT COVE GROUP		
34	Shale, soft, grey to black; fossil locality 20480	20	20
33	Unexposed	10	30
32	Shale, grey, micaceous; minor grey siltstone	8	38
31	Siltstone, massive, grey, quartzitic	2	40
30	Shale, silty, grey micaceous; minor, grey, massive siltstone	42	82
29	Unexposed	10	92
28	Shale, grey, micaceous, silty; with massive siltstone beds; bedding contorted, thickness estimated	20	112
27	Unexposed (estimated)	20	132
26	Shale, black; thin siltstone beds	15	147
25	Shale, black to grey, micaceous; bedding highly contorted, thickness estimated	30	177
24	Shale, black to grey, micaceous; with black limestone nodules and thin beds of crossbedded grey siltstone; bedding fairly regular, locally contorted	80	257
23	Shale, grey to black	10	267
22	Siltstone, massive, grey, crossbedded	1	268
21	Shale, soft, black; with thin zones of grey micaceous shale and ½-inch grey siltstone beds	31	299
20	Shale, grey and black, micaceous; and siltstone, massive, grey, crossbedded in beds to 1 foot thick; fossil locality 20479 at base	33	332
19	Unexposed	10	342
18	Shale, grey, micaceous; thin grey siltstone beds	18	360
17	Shale, soft, black, thin-bedded; with black limestone nodules; a 2-inch bed of fine yellow weathering conglomerate with small fragments of black shale at base	33	393
	Total exposed thickness of Elliott Cove group		393

SECTION 17 — continued

Bed	Descending Section	Thickness in Feet Bed	Total
	Possible disconformity		
	MANUELS RIVER FORMATION		
16	Shale, black, thin-bedded; trilobite fragments in lower part	30	30
15	Shale, black; with grey limestone nodules; fossil locality 20478	1	31
14	Shale, black, slaty, finely bedded	35	66
13	Limestone, light grey, fossiliferous; fossil locality 20483	1	67
12	Shale, black, slaty, breaking into blocks	5	72
11	Limestone, massive, grey; fossil locality 20477	1	73
10	Shale, black, slaty; distorted trilobites on bedding surfaces	17	90
9	Shale, massive blocky, grey-black; with pyrite concretions and fragmentary fossils	5	95
	Total thickness of Manuels River formation		95
	Conformable contact		
	CHAMBERLAIN'S BROOK FORMATION		
8	Shale, green, slaty, becoming grey-green near top, cleaving into narrow, long, thin fragments	87	87
7	Shale, red, slaty, soft	42	129
6	Shale, green, slaty	35	164
5	Shale, soft, red, slaty; minor green beds in lower part	58	222
4	Shale, soft, green	30	252
3	Shale, soft, red, well bedded	14	266
2	Limestone, red, massive; with fragmentary fossils	1	267
1	Shale, red	9	276
	Section ends at base of continuous exposure, lower beds are sporadically exposed in poor outcrops along shore to Foster's Point.		
	Total exposed thickness of Chamberlain's Brook formation		276

SECTION 18. Section of rocks of Chamberlain's Brook, Brigus, Smith Point, and Bonavista formations, exposed along north shore of Smith Sound, Trinity Bay, east and west of Smith Point (after Walcott, 1900, restudied and modified but not remeasured by the writer)

Bed	Bed. No. (Walcott)	Descending Section	Thickness in Feet Bed	Total
		CHAMBERLAIN'S BROOK FORMATION		
20	1a	Shale, green, argillaceous, minor grey bands; 4 inches pink limestone at base; fossil locality 20391	110	110
19	1b (part)	Shale, green	60	170
18	1b (part)	Shale, red, argillaceous	20	190

Bed	Bed. No. (Walcott)	Descend Section	Thickness in Feet Bed	Total
17	1c	Limestone, pink, nodular, interbedded red shale; fossil locality 20390	4	194
16	1d	Shale, red, with thin green and purple beds	135	329
15	1e	Limestone, pink, manganiferous, nodular; thin red shale interbeds; fossil locality 20389	3	332
		Total exposed thickness of Chamberlain's Brook formation		332
		Probable disconformity		
		BRIGUS FORMATION		
14	2a	Shale, mainly red, some green and purple beds	284	284
13	2b	Limestone, green at top, pink below; many trilobite fragments; fossil locality 20388	2	286
12	2c	Shale, red to purple	56	342
		Total thickness of Brigus formation		342
		Conformable contact		
		SMITH POINT FORMATION (type section)		
11	2d (part)	Limestone, red to pink, massive to wavy bedded	24	
		Conformable contact		
		BONAVISTA FORMATION (type section)		
10	2d (part)	Shale, red	2	2
9	2d (part)	Limestone, pink, massive	1	3
8	2e	Shale, green	23	26
7	2f	Limestone, massive, pink, nodular; minor purple shale interbeds	4½	30½
6	2g (part)	Shale, green; with pink limestone nodules	9	39½
5	2g (part)	Limestone, pink, nodular; green shale interbeds	2	41½
4	2g (part)	Shale, green; numerous pink massive limestone nodules	51	92½
3	2h	Shale, red to purple; minor thin green beds, with numerous nodules and thin beds of massive green or pink limestone	136	228½
2	2i	Shale, green, with thin purple beds; scattered pink limestone nodules	30½	259
1	2j	Shale, red to purple, thin green bands; many nodules and thin beds of pink limestone	185	444
		Section ends beneath modern beach deposits		
		Exposed thickness of Bonavista formation		444

SECTION 19. Section of Bonavista formation exposed at Rose au Rue on east shore of Merasheen Island, Placentia Bay

Bed	Descending Section	Thickness in Feet Bed	Total
	Section begins at shore of Placentia Bay		
	BONAVISTA FORMATION		
23	Slate, green	2	2
22	Limestone, massive, red	1	3
21	Unexposed	7	10
20	Limestone, pink, wavy bedded, nodular	8	18
19	Shale, red, slaty; many pink limestone nodules	7	25
18	Limestone, pink, nodular; minor red slates	9	34
17	Slate, red; scattered limestone nodules	3	37
16	Slate, green; some pink limestone nodules	3	40
15	Limestone, massive, pink	2	42
14	Slate, red; with thin limestone beds	2	44
13	Limestone, pink, massive	2	46
12	Slate, red	1	47
11	Slate, green	4	51
10	Slate, red	2	53
9	Limestone, massive, pink	1	54
8	Slate, red	4	58
7	Limestone, pink, two thin beds with red slate between	1½	59½
6	Slate, red	3	62½
5	Slate, green	3	65½
4	Limestone, nodular, green	½	66
3	Slate, green; with buff limestone nodules	12	78
2	Slate, red, with some thin beds and nodules of pink limestone exposed intermittently along shore (thickness estimated)	100	178
1	Slate, green, with one 3-foot red band, poorly exposed in small outcrops along shore, to end of outcrop (thickness estimated)	80	258
	Total exposed thickness of Bonavista formation		258

SECTION 20. Section of Chamberlain's Brook and Brigus formations exposed at Little Dantzic Cove, Burin Peninsula

Bed	Descending Section	Thickness in Feet Bed	Total
	CHAMBERLAIN'S BROOK FORMATION		
	Section ends at synclinal axis		
20	Shale, grey (visible only at low tide)	10½	10½
19	Limestone, massive, grey; trilobite fragments	3½	14
18	Shale, grey	12	26
17	Shale, green	30	56
16	Shale, red; minor green beds	46	102
15	Shale, green, nodular	9	111
14	Limestone, massive, grey; trilobite fragments	4	115
13	Shale, green; with manganiferous nodules	6	121
12	Shale, red	26	147
11	Unexposed	30	177
10	Limestone, massive, green; fossil locality 21905	3	180
9	Shale, grey	12	192
	Exposed thickness of Chamberlain's Brook formation		192

SECTION 20 — continued

Bed	Descending Section	Thickness in Feet Bed	Total
	Possible disconformity		
	BRIGUS FORMATION		
8	Shale, red	18	18
7	Limestone, massive, pink	1	19
6	Shale, red	1	20
5	Limestone, massive, pink	2	22
4	Shale, red	13	35
3	Shale, red; with many pink limestone nodules	4	39
2	Limestone, massive, pink; fossil locality 21904	5	44
1	Sandstone, massive, red, quartzitic; with lenses and thin beds of pink limestone, resting with probable disconformity on Precambrian Random formation	1	45
	Total thickness of Brigus formation		45

SECTION 21. Section of Manuels River, Chamberlain's Brook, and Brigus formations exposed along Little Dantzic Cove Brook, Burin Peninsula (in part after Walthier, MS.)

Bed	Descending Section	Thickness in Feet Bed	Total
	MANUELS RIVER FORMATION		
15	Shale, black, fissile; with fossiliferous limestone nodules	80	80
14	Shale, grey to black, fissile	42	122
	Total exposed thickness of Manuels River formation		122
	Conformable contact		
	CHAMBERLAIN'S BROOK FORMATION		
13	Limestone, grey, nodular	2	2
12	Shale, grey to green; fossil locality 21940 near top	36	38
11	Shale, red	55	93
10	Limestone, massive, grey-green	1½	94½
9	Shale, red and grey interbedded	5	99½
8	Shale, grey, fissile	10½	110
7	Limestone, grey to red, nodular	3½	113½
6	Shale, red	32	145½
5	Limestone, nodular, red to grey	1	146½
4	Shale, grey and red, interbedded	10½	157
	Total thickness of Chamberlain's Brook formation		157
	Probable disconformity		
	BRIGUS FORMATION		
3	Shale, red, with grey limestone nodules	10	10
2	Shale, green to grey	2	12
1	Siltstone, fine-to-medium-grained, grey to green and silty green shale, resting with abrupt contact on white quartzite of Random formation	26	38
	Total thickness of Brigus formation		38

SECTION 22. Section of Bonavista formation exposed along east shore of point northeast of Keels, Bonavista Bay (measured by A. M. Christie, 1950)

Bed	Descending Section	Thickness in Feet Bed	Total
	BONAVISTA FORMATION		
13	Slate, green; some limestone nodules	70	70
12	Slate, red; becoming green on top	80	150
11	Slate, green to pink	15	165
10	Slate, red	10	175
9	Slate, green	16	191
8	Slate, red	35	226
7	Slate, red and green; rare limestone nodules	45	271
6	Slate, green; rare bands and nodules of limestone	120	391
5	Limestone; irregular, nodular	½	391½
4	Slate, red; minor green bands; a few limestone nodules	25	416½
3	Slate, red; pink quartzite bands up to 1 foot thick	8	424½
2	Slate, pink to green; with limestone nodules	20	444½
1	Slate, green; resting on white quartzite of Random formation	20	464½
	Total exposed thickness of Bonavista formation		464½

APPENDIX II

List of Geological Survey of Canada Localities for Cambrian Trilobites from Southeastern Newfoundland

20387. East bank of Manuels River, Conception Bay, about 12 feet stratigraphically below top of *bennetti* zone (Hutchinson, 1950[1]).

20388. Shore of Broad Cove, Smith Sound, Trinity Bay, in bed 2b of Walcott's (1900) section (Hutchinson, 1950).

20389. As 20388, bed 1e of section (Hutchinson, 1950).

20390. As 20388, bed 1c of section (Hutchinson, 1950).

20391. As 20388, bed 1a of section (Hutchinson, 1950).

20392. East bank of Manuels River, Conception Bay, 15 feet stratigraphically below top of *davidis* zone (Hutchinson, 1950).

20393. South shore of Heart's Desire Harbour, Trinity Bay, bed 9 of section 4 (Hutchinson, 1950).

20395. South shore of Heart's Delight Harbour, Trinity Bay, bed 15 of section 5 (Hutchinson, 1950).

20396. As 20395, bed 9 of section 5 (Hutchinson, 1950).

20397. South side of Hopeall Head, Trinity Bay, bed 7 of section 7 (Hutchinson, 1950).

20398. As 20397, 40 feet above base of bed 10 of section 7 (Hutchinson, 1950).

20399. As 20397, 60 feet above base of bed 10 of section 7 (Hutchinson, 1950).

20400. As 20397, bed 15 of section 7 (Hutchinson, 1950).

20401. As 20397, bed 16 of section 7 (Hutchinson, 1950).

20402. As 20397, 19 feet above base of bed 17 of section 7 (Hutchinson, 1950).

20403. As 20397, bed 18 of section 7 (Hutchinson, 1950).

20405. Brigus South Point, Conception Bay, top of bed 19 of section 3 (Hutchinson, 1950).

20406. As 20405, bed 21 of section 3 (Hutchinson, 1950).

20407. As 20405, bed 22 of section 3 (Hutchinson, 1950).

20408. North shore of Island Cove, Trinity Bay, 50 feet above top of Smith Point formation (Hutchinson, 1950).

20409. As 20397, bed 26 of section 7 (Hutchinson, 1950).

20410. As 20397, bed 30 of section 7 (Hutchinson, 1950).

20411. As 20397, bed 34 of section 7 (Hutchinson, 1950).

20412. As 20405, bed 38 of section 3 (Hutchinson, 1950).

20414. West bank of Manuels River, Conception Bay, bed 3 of section 1 (Hutchinson, 1950).

20415. As 20414, bed 4 of section 1 (Hutchinson, 1950).

20416. As 20414, bed 5 of section 1 (Hutchinson, 1950).

20417. West bank of Manuels River, Conception Bay, about 10 feet stratigraphically below top of *hicksi* zone (Hutchinson, 1950).

20419. East shore of Trinity Bay, about 0.4 mile south of Heart's Desire, 30 feet stratigraphically above top of Smith Point formation (Hutchinson, 1950).

20420. East bank of Manuels River, about 4 feet below top of *hicksi* zone (Hutchinson, 1951).

20421. West bank of Manuels River, Conception Bay, 1 foot above base of bed 6 of section 1 (Hutchinson, 1951).

20422. As 20421, 14 feet above base of bed 6 of section 1 (Hutchinson, 1951).

20423. As 20421, 22 feet above base of bed 6 of section 1 (Hutchinson, 1951).

20424. As 20421, 30 feet above base of bed 6 of section 1 (Hutchinson, 1951).

20425. As 20421, 3 feet above base of bed 7 of section 1 (Hutchinson, 1951).

20426. Same locality as 20406 (Hutchinson, 1951).

20427. Same locality as 20395 (Hutchinson, 1951).

20428. Same locality as 20396 (Hutchinson, 1951).

20429. Same locality as 20393 (Hutchinson, 1951).

20430. As 20405, 6 inches above base of bed 19 of section 3 (Hutchinson, 1951).

[1]Names and dates in parentheses refer to collector and field season.

20431. As 20405, 4 feet above base of bed 19 of section 3 (Hutchinson, 1951).
20432. As 20405, 6 feet above base of bed 19 of section 3 (Hutchinson, 1951).
20433. As 20405, bed 22 of section 3 (Hutchinson, 1951).
20434. East side of Chapel Head, Trinity Bay, bed 22 of section 10 (Hutchinson, 1951).
20435. As 20434, bed 34 of section 10 (Hutchinson, 1951).
20436. As 20434, bed 37 of section 10 (Hutchinson, 1951).
20437. As 20434, bed 40 of section 10 (Hutchinson, 1951).
20438. As 20434, bed 51 of section 10 (Hutchinson, 1951).
20439. As 20434, bed 71 of section 10 (Hutchinson, 1951).
20440. On shore just north of Norman's Cove, Trinity Bay, in same bed as 20439 (Hutchinson, 1951).
20441. West shore Chapel Arm, Trinity Bay, in small bay about 1 mile south of Norman's Cove, limestone nodules in black slate just below lava flow (Hutchinson, 1951).
20442. West shore Chapel Arm, Trinity Bay, in small bay about 1.3 miles south of Norman's Cove, limestone nodules in black slate just below lava flow (Hutchinson, 1951).
20443. West shore of Chapel Arm, Trinity Bay, about ½ mile south of 20442 (Hutchinson, 1951).
20444. Chapel Cove, Conception Bay, about 20 feet above top of Smith Point formation (Hutchinson, 1951).
20445. Marysvale, Conception Bay, just above top of Smith Point formation (Hutchinson, 1951).
20446. East shore Trinity Bay, on north side of Long Point (Hutchinson, 1951).
20447. As 20446, about 200 yards to west (Hutchinson, 1951).
20448. As 20446, but about ¼ mile to west (Hutchinson, 1951).
20449. Highland Cove, Trinity Bay, bed 8 of section 6 (Hutchinson, 1951).
20450. First small bay east of tip of McLeod Point, Trinity Bay, bed 2 of section 8 (Hutchinson, 1951).
20451. As 20450, bed 6 of section 8 (Hutchinson, 1951).
20452. East bank of Manuels River, Conception Bay, 8 feet above top of bed 25 of Howell's 1925 section (Hutchinson, 1951).
20453. As 20452, bed 25 of Howell's 1925 section (Hutchinson, 1951).
20454. East bank of Manuels River, Conception Bay, bed 23 of Howell's 1925 section (Hutchinson, 1951).
20455. West bank of Manuels River, Conception Bay, 22 feet above base of *hicksi* zone (Hutchinson, 1951).
20456. As 20455, 12 feet above base of *hicksi* zone (Hutchinson, 1951).
20457. As 20455, 5 feet above base of *hicksi* zone (Hutchinson, 1951).
20458. As 20455, base of *hicksi* zone (Hutchinson, 1951).
20459. East bank of Manuels River, highest beds exposed (Hutchinson, 1951).
20460. As 20459, 15 feet stratigraphically lower (Hutchinson, 1951).
20462. South shore of Corbin Bay, Fortune Bay, about 20 feet below unconformable contact of volcanic rocks (Hutchinson, 1951).
20463. West shore Blue Pinion Cove, Fortune Bay (Hutchinson, 1951).
20467. Broad Cove, Smith Sound, Trinity Bay, bed 2d of Walcott's (1900) section (Hutchinson, 1951).
20468. As 20467, lower part of bed 2c of Walcott's (1900) section (Hutchinson, 1951).
20470. As 20467, bed 1e of Walcott's (1900) section (Hutchinson, 1951).
20471. As 20467, from bed 1c of Walcott's (1900) section (Hutchinson, 1951).
20472. As 20467, from base of bed 1a of Walcott's (1900) section (Hutchinson, 1951).
20473. As 20467, 50 feet below top of bed 1a of Walcott's (1900) section (Hutchinson, 1951).
20474. West shore Random Island, Trinity Bay, just north of Bar Mead (Hutchinson, 1951).
20475. West shore of Random Island, just north of Brown Mead (Hutchinson, 1951).

20476. West shore of Random Island, Trinity Bay, just south of Brown Mead (Hutchinson, 1951).

20477. West shore of Random Island, south of Elliott's Cove, bed 11 of section 17 (Hutchinson, 1951).

20478. As 20477, bed 15 of section 17 (Hutchinson, 1951).

20479. As 20477, bed 20 of section 17 (Hutchinson, 1951).

20480. As 20477, bed 34 of section 17 (Hutchinson, 1951).

20481. West shore of Random Island, just south of Elliott's Cove (Hutchinson, 1951).

20482. West shore of Random Island, about ¼ mile south of Brown Mead (Hutchinson, 1951).

20483. As 20477, bed 13 of section 17 (Hutchinson, 1951).

20484. North shore of Smith Sound, Trinity Bay, about ½ mile west of mouth of Rider's Brook (Hutchinson, 1951).

20485. East shore of Conception Bay, below Topsail Head (Hutchinson, 1951).

20486. Northernmost outcrop on east bank of Manuels River, Conception Bay (Hutchinson, 1951).

20487. South side of Little Ridge, Chapel Arm, Trinity Bay, bed 1 of section 9 (Hutchinson, 1951).

20488. West bank of Manuels River, Conception Bay, 33 feet above base of bed 6 of section 1 (Hutchinson, 1951).

20489. As 20488, 37 feet above base of bed 6 of section 1 (Hutchinson, 1951).

20490. Same as 20489, about 20 yards west along outcrop (Hutchinson, 1951).

20491. As 20488, 30 feet above base of bed 6 of section 1 (Hutchinson, 1951).

20494. As 20488, 3 feet above base of bed 7 of section 1 (Hutchinson, 1951).

20495. As 20488, 5 feet above base of bed 7 of section 1 (Hutchinson, 1951).

20496. As 20488, 8 feet above base of bed 7 of section 1 (Hutchinson, 1951).

20497. As 20488, 13 feet below top of bed 11 of section 1 (Hutchinson, 1951).

20498. As 20488, top of bed 11 of section 1 (Hutchinson, 1951).

20499. West shore Chapel Arm, Trinity Bay, in small bay near head of arm (Hutchinson, 1951).

20500. West shore, Chapel Arm, Trinity Bay, ¼ mile south of 20499 (Hutchinson, 1951).

20501. West shore Chapel Arm, Trinity Bay, about 200 yards south of 20500 (Hutchinson, 1951).

21797. East shore of Cape Dog, St. Marys Bay, bed 38 of section 11 (Hutchinson, 1952).

21798. Brigus South Point, Conception Bay, bed 22 of section 3 (Hutchinson, 1952).

21799. Little Ridge, Chapel Arm, Trinity Bay, bed 8 of section 9 (Hutchinson, 1952).

21800. First small bay east of tip of McLeod Point, Trinity Bay, bed 9 of section 8 (Hutchinson, 1952).

21801. Highland Cove, Trinity Bay, bed 10 of section 6 (Hutchinson, 1952).

21802. As 21801, bed 9 of section 6 (Hutchinson, 1952).

21803. As 21800, bed 2 of section 8 (Hutchinson, 1952).

21804. As 21801, bed 8 of section 6 (Hutchinson, 1952).

21805. West shore of Chapel Arm, Trinity Bay, limestone nodules in small bay about ¾ mile north of head of bay (Hutchinson, 1952).

21806. As 21800, bed 8 of section 6 (Hutchinson, 1952).

21807. As 21800, bed 6 of section 6 (Hutchinson, 1952).

21808. North side of Jigging Cove Head, on west shore of St. Marys Bay, bed 35 of section 13 (Hutchinson, 1952).

21809. On east shore of small bay west of Red Cove, on peninsula between St. Marys and Placentia Bays (Hutchinson, 1952).

21810. As 21801, bed 6 of section 6 (Hutchinson, 1952).

21904. Little Dantzic Cove, Burin Peninsula, bed 2 of section 20 (Hutchinson, 1952).

21905. As 21904, bed 10 of section 20 (Hutchinson, 1952).

21906. North side of Salmonier Cove, Burin Bay Arm, first outcrop east of bridge at head of cove (Hutchinson, 1952).

21907. West shore of Bull Island Point, St. Marys Bay (Hutchinson, 1952).

21908. Shore of Redland Head, St. Marys Bay (Hutchinson, 1952).

21909. As 21907, about 150 feet stratigraphically lower (Hutchinson, 1952).

21910. Branch River, St. Marys Bay.

21911. Brigus South Point, bed 21 of section 3 (Hutchinson, 1952).

21912. As 21911, bed 16 of section 3 (Hutchinson, 1952).

21913. Manuels River, Conception Bay, east bank, just above river level beside small island (Hutchinson, 1952).

21914. Manuels River, Conception Bay, on west bank (same locality as 20417) (Hutchinson, 1952).

21916. Manuels River, Conception Bay, bed 25 of Howell's (1925) section, on west bank (Hutchinson, 1952).

21917. Highland Cove, Trinity Bay, bed 13 of section 6 (Hutchinson, 1952).

21918. Blue Pinion Cove, Fortune Bay, west shore, about 60 feet stratigraphically above base of Young's Cove formation (Hutchinson, 1952).

21919. As 21918, but 25 feet stratigraphically lower (Hutchinson, 1952).

21920. As 21918, but 45 feet stratigraphically lower (Hutchinson, 1952).

21921. As 21919, but 55 feet stratigraphically lower (Hutchinson, 1952).

21922. Salmonier Cove, Great Bay de l'Eau, south shore, at west end of black shale outcrop (Hutchinson, 1952).

21923. As 21922, but 5 feet eastward along shore (Hutchinson, 1952).

21924. Sagona Island, Fortune Bay, on shore of northeasternmost bay of harbour (Hutchinson, 1952).

21925. Cavendish, Trinity Bay, on north shore of harbour (Hutchinson, 1952).

21926. Highland Cove, Trinity Bay, bed 7 of section 6 (Hutchinson, 1952).

21927. As 21926, but 7 feet stratigraphically higher (Hutchinson, 1952).

21928. Topsail Head, Conception Bay, north wall of small quarry about 100 yards northeast of mouth of Topsail Brook (Hutchinson, 1952).

21929. Manuels River, Conception Bay, bed 13 of section 1 (Hutchinson, 1952).

21930. As 21929, bed 14 of section 1 (Hutchinson, 1952).

21931. Highland Cove, Trinity Bay, north shore of cove, in beds equivalent to bed 1 or 2 of section 6 (Hutchinson, 1952).

21932. As 21931, bed 10 of section 6 (Hutchinson, 1952).

21933. As 21931, bed 9 of section 6 (Hutchinson, 1952).

21934. As 21931, bed 1 of section 6 (Hutchinson, 1952).

21935. As 21931, bed 3 of section 6 (Hutchinson, 1952).

21936. Small quarry just east of Canadian National Railways track, about 1½ miles south of Manuels Station (Hutchinson, 1952).

21937. Manuels River, Conception Bay, bed 12 of section 1 (Hutchinson, 1952).

21938. As 21937, bed 32 of section 1 (Hutchinson, 1952).

21939. As 21937, bed 20 of section 1 (Hutchinson, 1952).

21940. Little Dantzic Cove Brook, Burin Peninsula, bed 12 of section 21 (Hutchinson, 1952).

24614. West arm of Chapel Arm, Trinity Bay, at south end of bay, about 280 yards southeast of Long Harbour road junction (McCartney, 1954).

24615. As 24614, but 78 yards farther east on shore (McCartney, 1954).

24616. As 24614, on west shore of bay west of prominent point (McCartney, 1954).

24617. Chapel Arm, Trinity Bay, mid-head of bay, just north of point (McCartney, 1954).

24618. Chapel Arm, Trinity Bay, west edge of point at head of bay, on shore (McCartney, 1954).

24619. Chapel Arm, Trinity Bay, on west shore 170 yards north of gravel beach (McCartney, 1954).
24620. Northeast shore of Hopeall Bay, Trinity Bay, 1,000 feet southeast of end of point (McCartney, 1954).
24621. As 24620, but 4 feet stratigraphically lower (McCartney, 1954).
24622. As 24620, but 500 feet southward along shore (McCartney, 1954).
24623. Northeast shore of New Harbour, Trinity Bay, 1.15 miles south of Hopeall Head lighthouse (bed 24 of section 7) (McCartney, 1954).
24624. Northeast shore of Cavendish Bay, Trinity Bay, ¾ mile northwest of stream mouth at Cavendish (McCartney, 1954).
24625. Northwest shore of point between Greens Harbour and Whiteway, Trinity Bay, about 300 feet above Smith Point limestone (McCartney, 1954).
24626. East shore of Trinity Bay, 1.2 miles south of Long Point (McCartney, 1954).
24627. As 24626, 1 mile south of Long Point (McCartney, 1954).
24628. As 24627, but 450 feet north along shore (McCartney, 1954).
24629. As 24628, but 5 feet stratigraphically lower (McCartney, 1954).
24630. As 24629, but 7 feet stratigraphically lower (McCartney, 1954).
24631. As 24628, but 1½ feet stratigraphically higher (McCartney, 1954).
24632. West shore of Spread Eagle Bay, 3,000 feet north of south end of bay (McCartney, 1954).
24633. As 24632, 400 feet north along shore (McCartney, 1954).
24634. As 24633, about 1,300 feet north along shore (McCartney, 1954).
24635. As 24632, about 1.2 miles north of stream mouth at south end (McCartney, 1954).
24636. West shore of small cove (Marleys Cove) about 1,200 feet east of McLeod Point, Trinity Bay (McCartney, 1954).
24637. As 24636, 92 feet below base of massive lava bed (McCartney, 1954).
24638. Chapel Arm, Trinity Bay, 2,000 feet north of mouth of brook, on southeast shore (McCartney, 1954).
24639. As 24638, 33 feet stratigraphically higher (McCartney, 1954).
24640. Chapel Arm, Trinity Bay, on west shore 2 miles south of Normans Cove (McCartney, 1954).
27243. Deep Cove, St. Marys Bay, bed 11 of section 14 (Hutchinson, 1955).
27244. As 27243, loose limestone nodule on beach (Hutchinson, 1955).
27245. As 27243, bed 13 of section 14 (Hutchinson, 1955).
27246. As 27243, bed 15 of section 14 (Hutchinson, 1955).
27247. St. Marys Bay, on west shore ½ mile south of harbour head at Branch (Hutchinson, 1955).
27248. Gull Cove, St. Marys Bay on shore at head of cove (Hutchinson, 1955).
27249. Rose au Rue, Merasheen Island, Placentia Bay, on south shore of harbour (Hutchinson, 1955).
27250. L'Anse aux Soldats, island of Langlade, St. Pierre and Miquelon on shore at head of cove (Hutchinson, 1955).
27251. As 27250, but 20 feet southward along shore (Hutchinson, 1955).
27252. Branch River, St. Marys Bay, on large northward bend about 3 miles above mouth (Hutchinson, 1955).
27253. South shore of Little Harbour, St. Marys Bay (Hutchinson, 1955).
27254. Jigging Cove Head, Trinity Bay, bed 39 of section 13 (Hutchinson, 1955).
27255. As 27253, about 20 feet eastward along shore (Hutchinson, 1955).
27256. Bay west of Bullisland Point, St. Marys Bay, at head of bay (Hutchinson, 1955).
27257. Manuels River, Conception Bay, west bank, bed 115 of Howell's (1925) section (Hutchinson, 1955).
27258. Duffs, Conception Bay, bed 3 of section 2 (Hutchinson, 1955).

27259. As 27258, bed 7 of section 2 (Hutchinson, 1955).

27260. Manuels River, Conception Bay, bed 4 of section 1 (Hutchinson, 1955).

27261. Bull Arm, Trinity Bay, southeast shore (Hutchinson, 1955).

27263. Red Island, Placentia Bay, west shore about ⅓ mile south of northernmost point (Hutchinson, 1955).

27264. Duffs, Conception Bay, bed 12 of section 2 (Hutchinson, 1955).

27265. Road-cut on Conception Highroad, just east of brook at Foxtrap, Conception Bay, from loose blocks of red shale in glacial till (Hutchinson, 1955).

27266. Same as 21928 (Hutchinson, 1955).

27267. Come-by-Chance, Placentia Bay, bed 2 of section 16 (Hutchinson, 1955).

27268. Come-by-Chance, Placentia Bay, northwest shore of harbour about 1½ miles southwest of head (Hutchinson, 1955).

27269. As 27268, first outcrop on shore southwest of head of bay (Hutchinson, 1955).

27270. Highland Cove, Trinity Bay, same locality as 21931 (Hutchinson, 1955).

PLATES I to XXV

Plate I

Serrodiscus bellimarginatus (Shaler and Foerste) (Page 58.)

Figures 1a-e. Dorsal, ventral, anterior, lateral, and posterior views of complete enrolled specimen; hypotype A, GSC No. 12062, x10.

Figure 2. Cephalon; hypotype B, GSC No. 12063, x4.

Serrodiscus sp. (Page 58.)

Figures 3a, b. Top and side view of pygidium; GSC No. 12064, x4.

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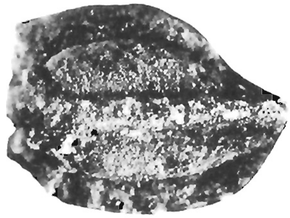

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Plate II

Eodiscus scanicus (Linnarsson) (Page 59.)

Figures 1a-c.	Dorsal, oblique, anterior, and lateral views of cephalon; hypotype A, GSC No. 12065, x4.
Figures 2a-c.	Dorsal, anterior, and lateral views of pygidium; hypotype B, GSC No. 12066, x9.

Eodiscus punctatus (Salter) (Page 59.)

Figures 3a-c.	Dorsal, anterior, and lateral views of cephalon; hypotype A, GSC No. 12067, x4.
Figure 4.	Cephalon; hypotype B, GSC No. 12068, x4.
Figure 5.	Cephalon; hypotype C, GSC No. 12069, x10.
Figures 6a-c.	Dorsal, anterior, and lateral views of pygidium; hypotype D, GSC No. 12070, x4.
Figure 7.	Pygidium; hypotype E, GSC No. 12071, x10.

Eodiscus armatus n. sp. (Page 60.)

Figures 8a-c.	Dorsal, anterior, and lateral views of cephalon; holotype, GSC No. 12072, x4.
Figure 9.	Cephalon; paratype A, GSC No. 12073, x4.

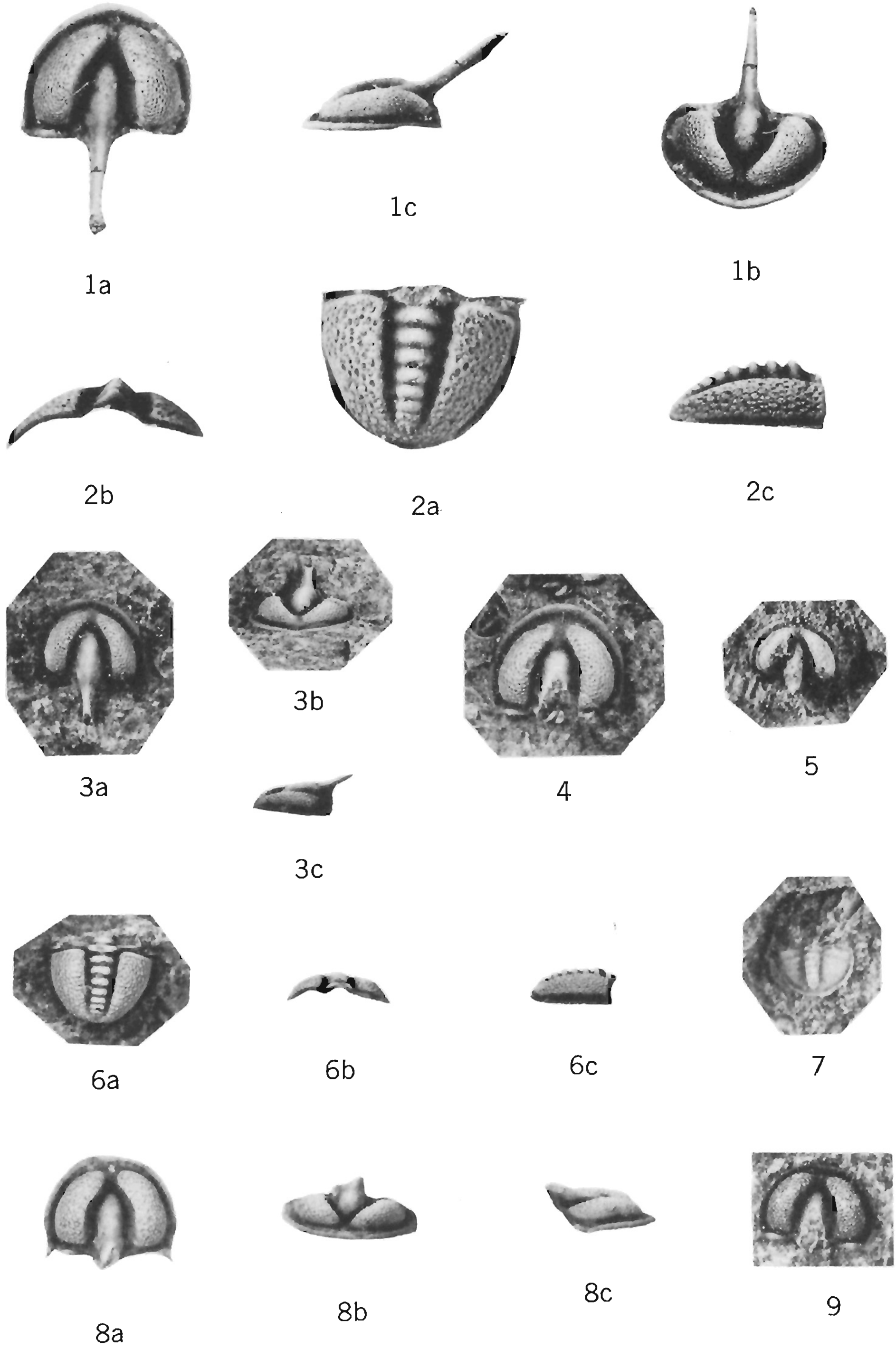
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PLATE III

(All x4 except where otherwise stated.)

Eodiscus armatus n. sp. (Page 60.)

Figures 1a-c.	Dorsal, posterior, and lateral views of pygidium; paratype B, GSC No. 12074.
Figure 2.	Pygidium; paratype C, GSC No. 12075.

Dipharus attleborensis (Shaler and Foerste) (Page 61.)

Figure 3.	Cranidium; hypotype, GSC No. 12076.
Figure 4.	Pygidium; hypotype, GSC No. 12077.

Dipharus planus n. sp. (Page 61.)

Figures 5a-c.	Dorsal, anterior, and lateral views of cranidium; holotype, GSC No. 12078, x9.
Figure 6.	Cranidium; paratype A, GSC No. 12079.
Figure 7.	Cranidium; paratype B, GSC No. 12080.
Figures 8a-c.	Dorsal, anterior, and lateral views of pygidium; paratype C, GSC No. 12081.
Figure 9.	Pygidium; paratype D, GSC No. 12082.

Triangulaspis vigilans (Matthew) (Page 63.)

Figure 10.	Cranidium; holotype, Roy. Ont. Mus. Palæont. No. 7764.
Figures 11a, b.	Dorsal and anterior views of cranidium; hypotype, GSC No. 12083.
Figure 12.	Cranidium; hypotype, GSC No. 12084.

Condylopyge carinata Westergard (Page 64.)

Figures 13a, b.	Dorsal and lateral views of cephalon; hypotype, GSC No. 12093.
Figure 14.	Cephalon; hypotype, GSC No. 12094, x2.
Figure 15.	Cephalon; hypotype, GSC No. 12095.

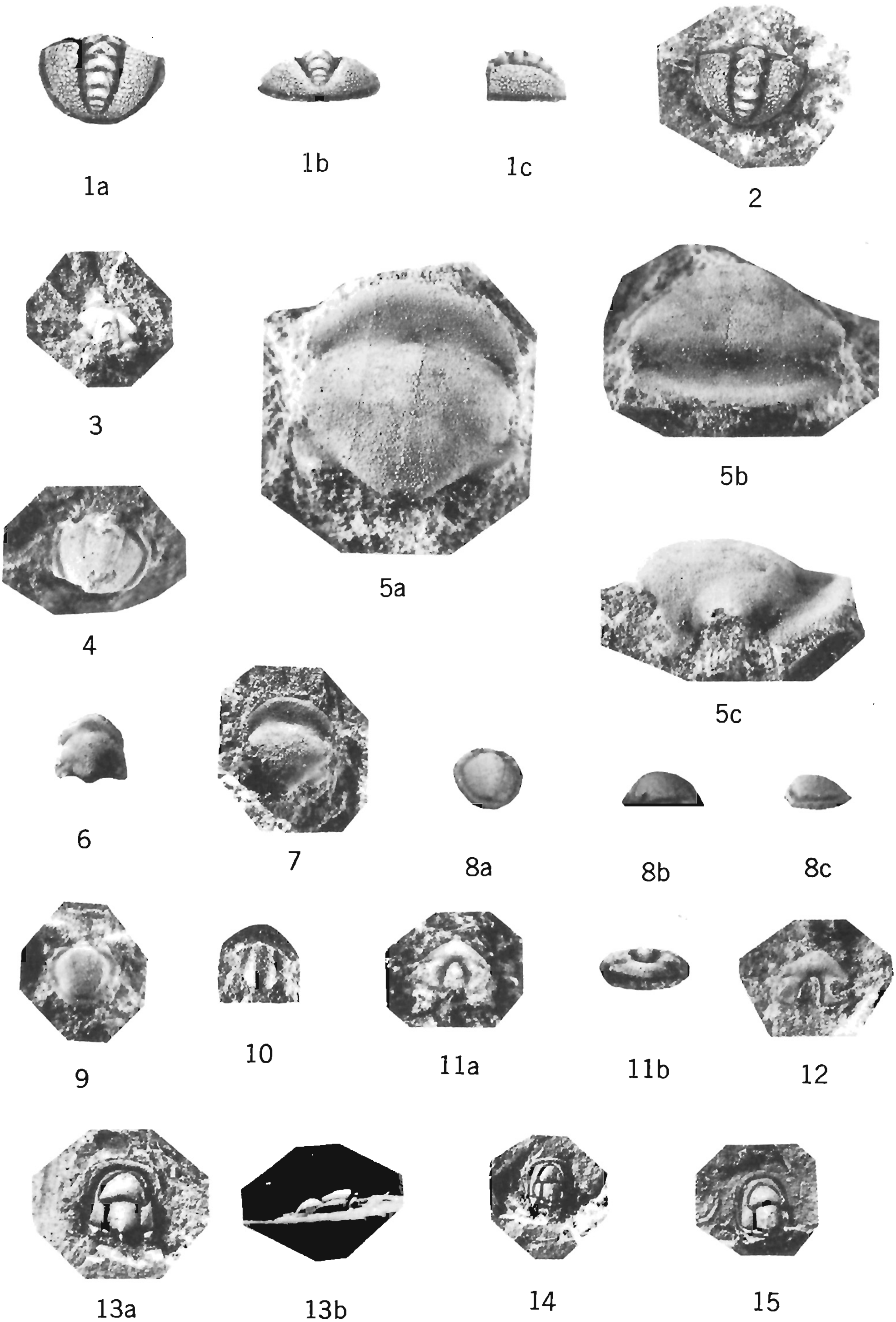
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Plate IV

(All x4 except where otherwise stated.)

Condylopyge carinata Westergard (Page 64.)

Figure 1.	Pygidium; hypotype, GSC No. 12096, x2.
Figure 2.	Pygidium; hypotype, GSC No. 12097.
Figure 3.	Pygidium; hypotype, GSC No. 12098.

Condylopyge cf. *C. spinigera* Westergard (Page 64.)

Figure 4.	Pygidium; GSC No. 12099.
Figure 5.	Pygidium; GSC No. 12100.

Condylopyge rex (Barrande) (Page 65.)

Figure 6.	Cephalon; hypotype, GSC No. 12101.
Figure 7.	Pygidium; hypotype, GSC No. 12102, x6.

Condylopyge sp. A (Page 65.)

Figure 8.	Pygidium; GSC No. 12125, x2.

Condylopyge sp. B (Page 65.)

Figure 9.	Pygidium; GSC No. 13053, x12.

Pleurectinium granulatum (Barrande) (Page 66.)

Figures 10a-c.	Dorsal, anterior, and lateral views of cephalon; hypotype, GSC No. 12103.
Figure 11.	Cephalon; hypotype, GSC No. 12104.
Figures 12a-c.	Dorsal, lateral, and posterior views of pygidium; hypotype, GSC No. 12105.
Figure 13.	Pygidium; hypotype, GSC No. 12106.
Figure 14.	Cephalon; hypotype, GSC No. 12107, x8.

Pleurectinium bifurcatum (Illing) (Page 67.)

Figures 15a, b.	Dorsal and lateral views of cephalon; hypotype, GSC No. 13045.
Figures 16a, b.	Dorsal and lateral views of pygidium; hypotype, GSC No. 13046.

PLATE IV

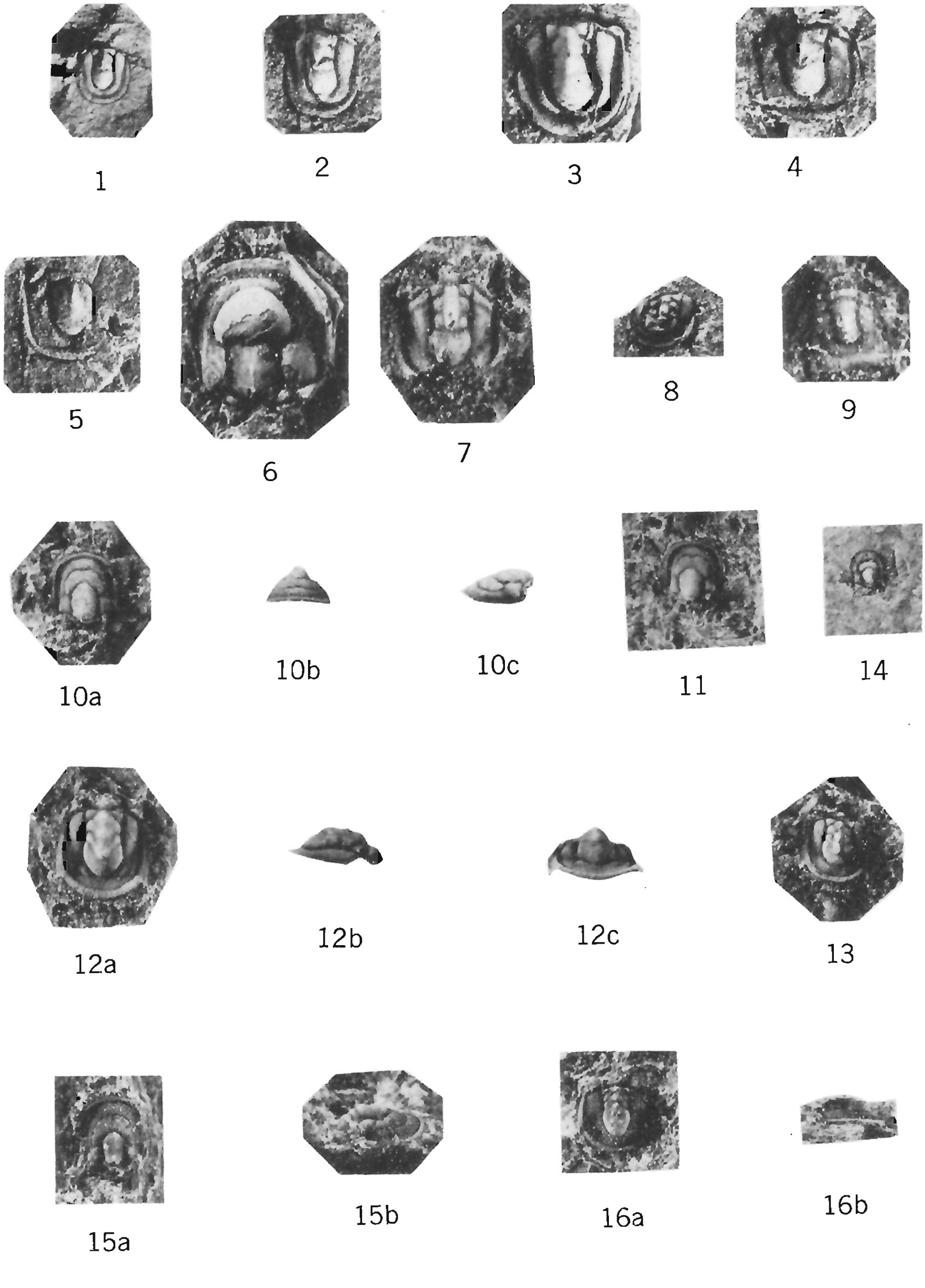

Plate V

Pleurectinium tuberculatum (Illing) (Page 67.)

Figure 1. Cephalon; hypotype, GSC No. 12108, x4.
Figure 2. Pygidium; hypotype, GSC No. 12109, x4.

Peronopsis trilobata (Matthew) (Page 69.)

Figure 3. Pygidium; hypotype GSC No. 12110, x3.
Figure 4. Pygidium; hypotype, GSC No. 12111, x3.

Peronopsis cf. *P. quadrata* (Tullberg) (Page 69.)

Figures 5a, b Dorsal and lateral views of cephalon; hypotype, GSC No. 12131, x3.
Figure 6. Pygidium; hypotype, GSC No. 12132, x3.
Figure 7. Pygidium; hypotype GSC No. 12133, x3.

Peronopsis fallax (Linnarsson) subsp. *P. depressa* Westergard (Page 70.)

Figures 8a, b. Dorsal and lateral views of cephalon; hypotype, GSC No. 12117, x3.
Figure 9. Cephalon; hypotype, GSC No. 12118, x3.
Figure 10. Pygidium; hypotype, GSC No. 12119, x3.
Figure 11. Pygidium; hypotype, GSC No. 12120, x6.

Peronopsis howelli n. sp. (Page 70.)

Figures 12a, b. Dorsal and lateral views of cephalon; holotype GSC No. 12134, x8.
Figure 13. Cephalon; paratype, GSC No. 12135, x4.

Peronopsis (Acadagnostus) inarmata n. sp (Page 71.)

Figure 14. Holotype; GSC No. 12112, x4.
Figure 15. Pygidium; paratype, GSC No. 12113, x4.

Peronopsis (Acadagnostus) matthewi n. sp. (Page 71.)

Figures 16a, b. Dorsal and lateral views of pygidium; holotype, GSC No. 12127, x2.
Figure 17. Cephalon; paratype, GSC No. 12128, x6.
Figures 18a, b. Dorsal and lateral views of cephalon; paratype, GSC No. 12129, x3.
Figure 19. Pygidium; paratype, GSC No. 12130, x2.
Figure 20. Pygidium; hypotype, Roy. Ont. Mus. Palæont. No. 27293, x4.

Plate V

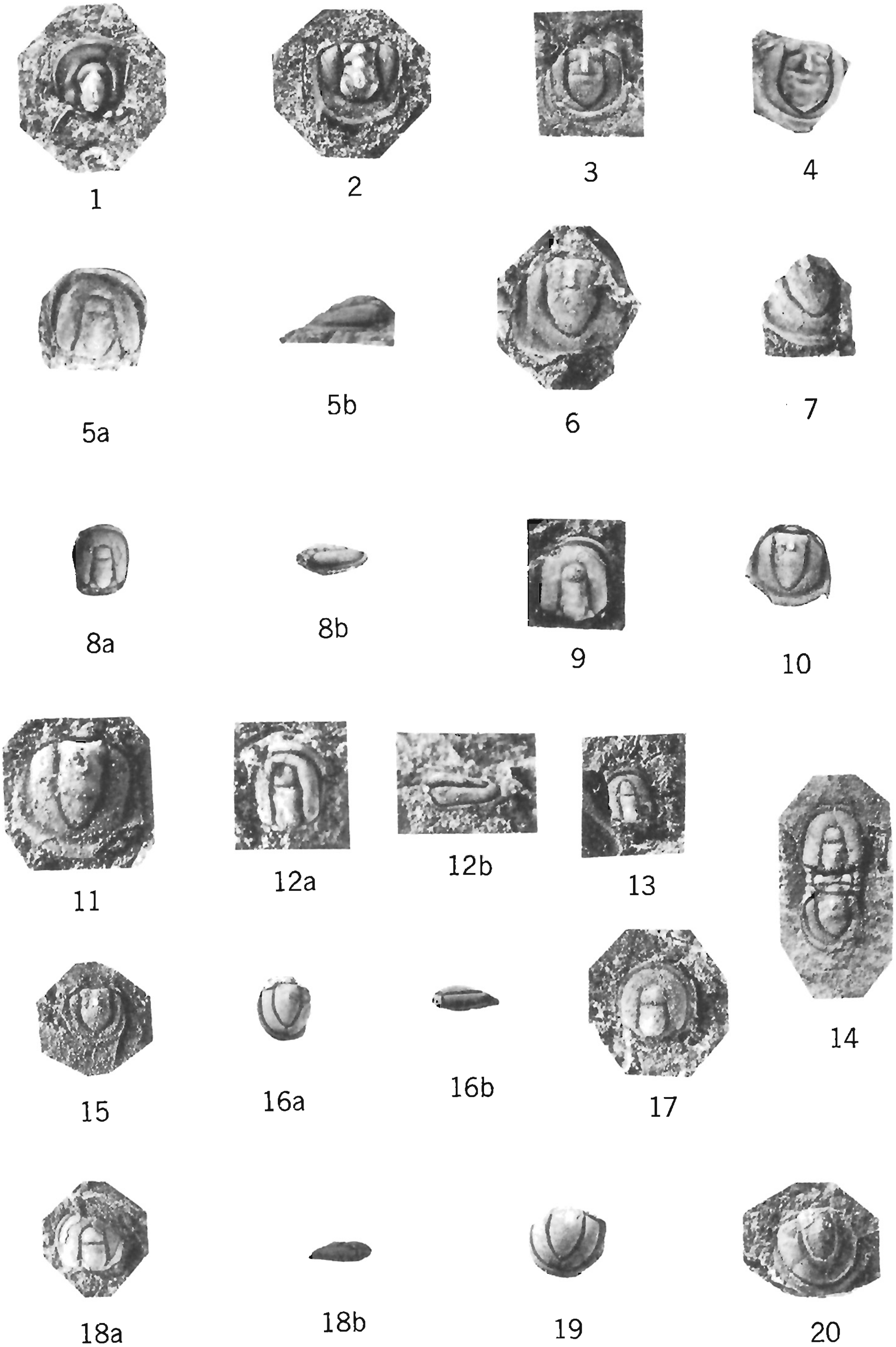

Plate VI

(All x4 except where otherwise stated.)

Peronopsis (Acadagnostus) scutalis (Salter *in* Hicks) (Page 72.)

Figure 1.	Cephalon; hypotype, GSC No. 12121, x3.
Figures 2a, b.	Dorsal and lateral views of cephalon; hypotype, GSC No. 12122, x6.
Figures 3a, b.	Dorsal and lateral views of pygidium; hypotype, GSC No. 12123, x3.
Figure 4.	Pygidium; hypotype, GSC No. 12124.
Figure 5.	Hypotype; GSC No. 12126.

Hypagnostus parvifrons (Linnarsson) (Page 73.)

Figures 6a, b.	Dorsal and lateral views of cephalon; hypotype, GSC No. 12140.
Figure 7.	Pygidium; hypotype, GSC No. 12141, x12.

Hypagnostus parvifrons (Linnarsson) var. *H. mammillatus* (Broegger) (Page 74.)

Figures 8a, b.	Dorsal and lateral views of cephalon; hypotype, GSC No. 12136.
Figure 9.	Cephalon; hypotype, GSC No. 12137.
Figures 10a, b.	Dorsal and lateral views of pygidium; hypotype, GSC No. 12138.
Figures 11a, b.	Dorsal and lateral views of pygidium; hypotype, GSC No. 12139.

Hypagnostus cf. *H. truncatus* (Broegger) (Page 74.)

Figure 12.	Figured specimen; GSC No. 12149, x8.

Hypagnostus? sp. (Page 74.)

Figure 13.	Figured specimen; GSC No. 13050.

Cotalagnostus lens (Groenwall) (Page 75.)

Figure 14.	Cephalon; hypotype, GSC No. 12142.
Figures 15a, b.	Dorsal and lateral views of cephalon; hypotype, GSC No. 12143.
Figure 16.	Pygidium; hypotype, GSC No. 12144.
Figures 17a, b.	Dorsal and lateral views of pygidium; hypotype, GSC No. 12145.

Cotalagnostus lens (Groenwall) subsp. *C. claudicans* Westergard (Page 76.)

Figure 18.	Cephalon; hypotype, GSC No. 12146.
Figures 19a, b.	Dorsal and lateral views of pygidium; hypotype, GSC No. 12147.
Figure 20.	Pygidium; hypotype, GSC No. 12148.

PLATE VI

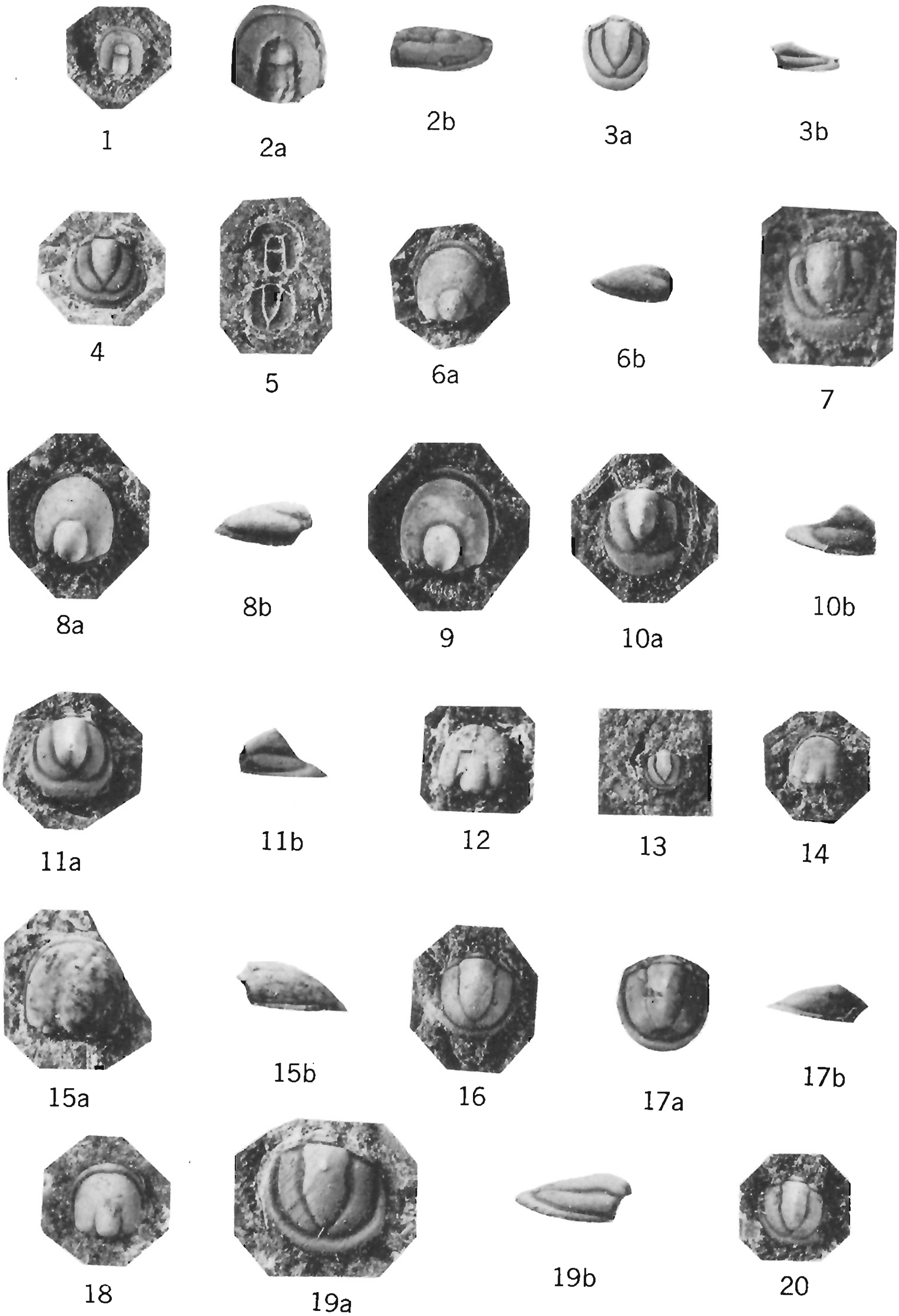
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PLATE VII

(All x4 except where otherwise stated.)

Tomagnostus fissus (Lundgren MS; Linnarsson) (Page 76.)

Figure 1. Cephalon; hypotype, GSC No. 12150, x8.
Figures 2a, b. Dorsal and lateral views of cephalon; hypotype, GSC No. 12151.
Figure 3. Pygidium; hypotype, GSC No. 12152, x8.
Figures 4a, b. Dorsal and lateral views of pygidium; hypotype, GSC No. 12153.
Figure 5. Dorsal shield; hypotype, GSC No. 12154

Tomagnostus perrugatus (Groenwall) (Page 77.)

Figure 6. Cephalon; hypotype, GSC No. 12155.
Figures 7a, b. Dorsal and lateral views of cephalon; hypotype, GSC No. 12156.
Figure 8. Pygidium; hypotype, GSC No. 12157.
Figures 9a, b. Dorsal and lateral views of pygidium; hypotype, GSC No. 12158.

Diplagnostus planicauda (Angelin) forma *D. bilobatus* Kobayashi (Page 78.)

Figures 10a, b. Dorsal and lateral views of cephalon; hypotype, GSC No. 12159.
Figure 11. Cephalon, hypotype, GSC No. 12160; and pygidium, hypotype, GSC No. 12161.
Figure 12. Pygidium; hypotype, GSC No. 12162.
Figures 13a, b. Dorsal and lateral views of pygidium; hypotype, GSC No. 12163.

Diplagnostus nordengi n. sp. (Page 78.)

Figure 14. Dorsal shield; holotype, GSC No. 12168, x6.
Figure 15. Cephalon; paratype, GSC No. 12169, x12.
Figure 16. Cephalon; paratype, GSC No. 12170, x12.

Oidalagnostus cf. *O. trispiniger* Westergard (Page 80.)

Figure 17. Figured cephalon; GSC No. 12164, x2.
Figure 18. Figured pygidium; GSC No. 12165.
Figure 19. Figured pygidium; GSC No. 12166.
Figure 20. Figured pygidium (external mould); GSC No. 12167.

PLATE VII

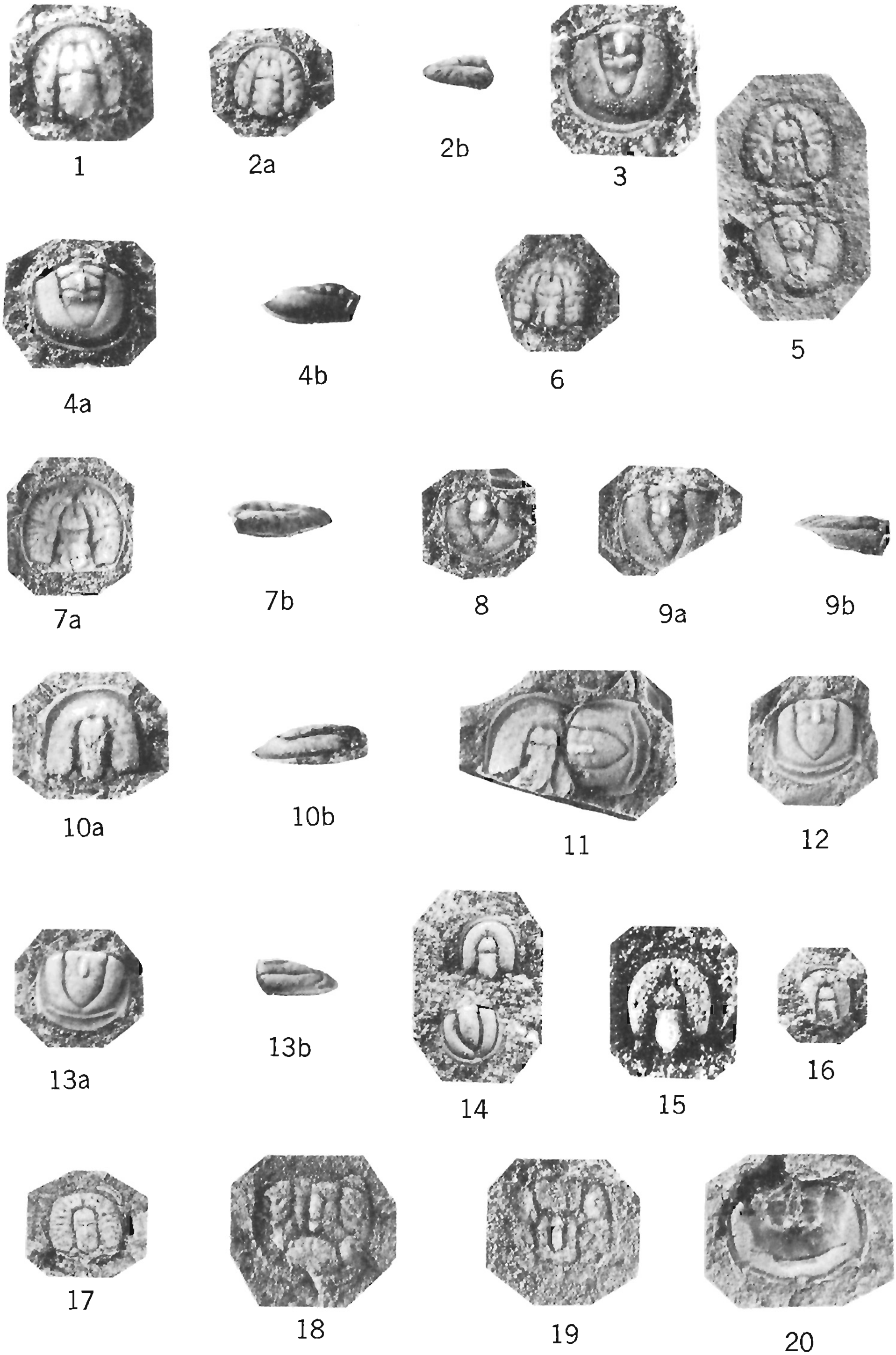
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Plate VIII

Ptychagnostus (Triplagnostus) stenorrachis (Groenwall) (Page 80.)

Figures 1a, b.	Cephala; hypotype, GSC No. 12171 (smaller cephalon) and dorsal and lateral views of GSC No. 12172 (larger cephalon), x4.
Figure 2.	Cephalon; hypotype, GSC No. 12173, x3.
Figure 3.	Pygidium; hypotype, GSC No. 12174, x4.
Figures 4a, b.	Dorsal and lateral views of pygidium; hypotype, GSC No. 12175, x3.
Figure 5.	Pygidium; hypotype, GSC No. 12176, x3.

Ptychagnostus grandis n. sp. (Page 81.)

Figures 6a, b.	Dorsal and lateral views of pygidium; holotype, GSC No. 12177, x2.
Figure 7.	Cephalon: paratype, GSC No. 12178, x4.
Figure 8.	Cephalon; paratype, GSC No. 12179, x4.
Figures 9a, b.	Dorsal and lateral views of cephalon; paratype, GSC No. 12180, x2.
Figure 10.	Pygidium; paratype, GSC No. 12181, x4.
Figure 11.	Pygidium; paratype, GSC No. 12182, x2.

Ptychagnostus (Triplagnostus) hybridus (Broegger) (Page 82.)

Figure 12.	Cephalon; hypotype, GSC No. 12183, x4.
Figures 13a, b.	Dorsal and lateral views of cephalon; hypotype, GSC No. 12184, x4.
Figure 14.	Pygidium; hypotype, GSC No. 12185, x4.
Figure 15.	Pygidium; hypotype, GSC No. 12186, x2.

Ptychagnostus atavus (Tullberg) (Page 83.)

Figure 16.	Cephalon; hypotype, GSC No. 12187, x9.
Figure 17.	Cephalon; hypotype, GSC No. 12188, x6.
Figure 18.	Cephalon; hypotype, GSC No. 12189, x6.
Figure 19.	Cephalon; hypotype, GSC No. 12190, x4.
Figure 20.	Cephalon; hypotype, GSC No. 12191, x4.
Figures 21a, b.	Dorsal and lateral views of cephalon; hypotype, GSC No. 12192, x3.
Figure 22.	Cephalon; hypotype, GSC No. 12193, x3.

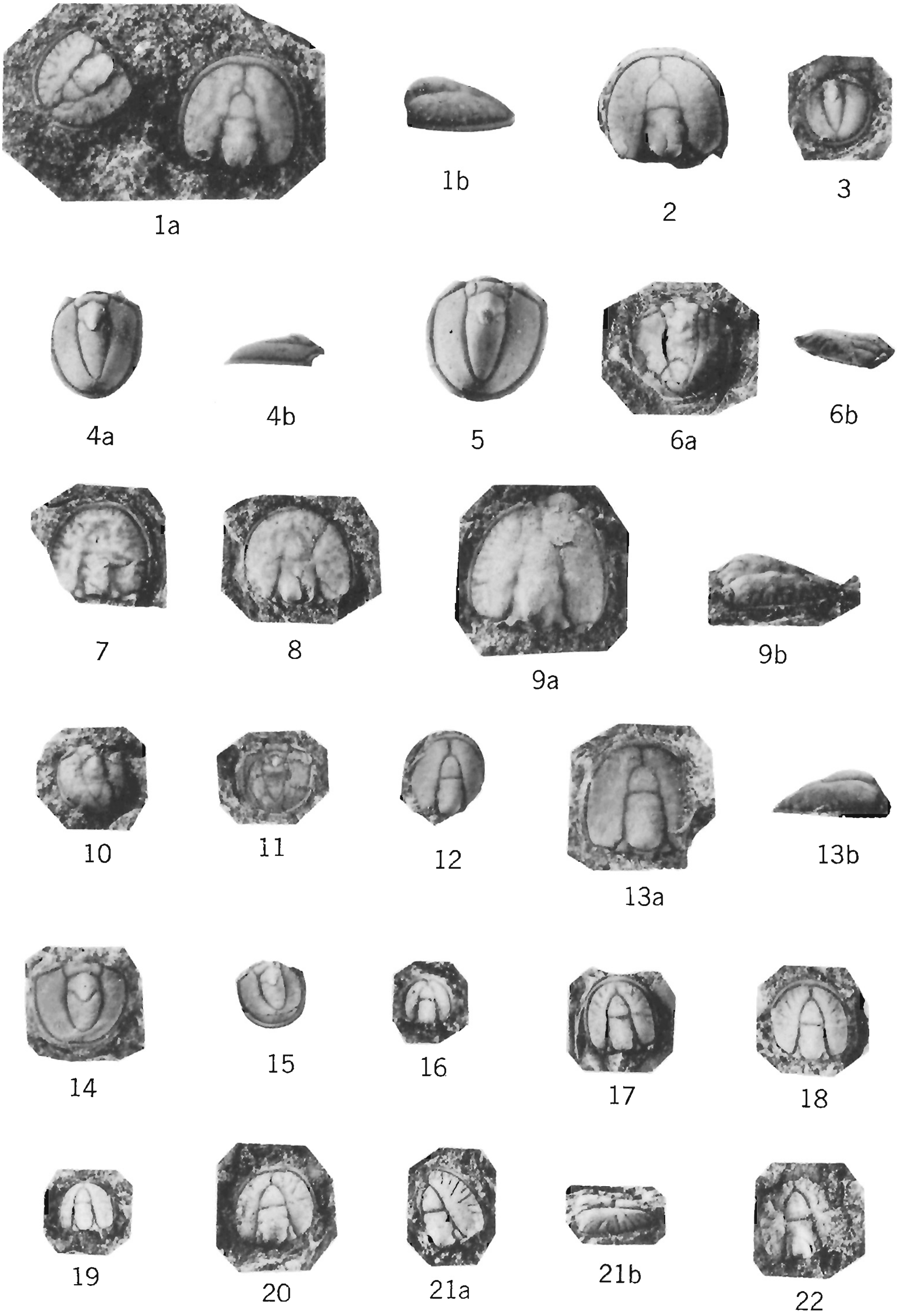
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Plate IX

Ptychagnostus atavus (Tullberg) (Page 83.)

Figure 1.	Pygidium; hypotype, GSC No. 12194, x9.
Figure 2.	Pygidium; hypotype, GSC No. 12195, x9.
Figure 3.	Pygidium; hypotype, GSC No. 12196, x6.
Figure 4.	Pygidium; hypotype, GSC No. 12197, x6.
Figure 5.	Pygidium; hypotype, GSC No. 12198, x6.
Figure 6.	Pygidium, hypotype, GSC No. 12199, x4.
Figure 7.	Pygidium: hypotype, GSC No. 12200, x4.
Figures 8a, b.	Dorsal and lateral views of pygidium; hypotype, GSC No. 12201, x4.

Ptychagnostus punctuosus (Angelin) (Page 84.)

Figure 9.	Cephalon; hypotype, GSC No. 13016, x6.
Figure 10.	Cephalon; hypotype, GSC No. 13017, x4.
Figures 11a, b.	Dorsal and lateral views of cephalon; hypotype, GSC No. 13018, x4.
Figure 12.	Cephalon; hypotype, GSC No. 13019, x3.
Figure 13.	Pygidium; hypotype, GSC No. 13047, x6.
Figure 14.	Pygidium; hypotype, GSC No. 13020, x4.
Figures 15a, b.	Dorsal and lateral views of pygidium; hypotype, GSC No. 13021, x4.
Figure 16.	Pygidium; hypotype, GSC No. 13048, x3.
Figure 17.	Pygidium; hypotype, GSC No. 13022, x3.
Figure 18.	Pygidium; hypotype, GSC No. 13023, x3.
Figure 19.	Pygidium in Matthew collection; Roy. Ont. Mus. Palæont. No. 7930, x4.

Ptychagnostus ciceroides (Matthew) (Page 85.)

Figure 20.	A dorsal shield; holotype, Roy. Ont. Mus. Palæont. No. 26117, x4.
Figure 21.	Cephalon; hypotype, GSC No. 12202, x9.
Figure 22.	Cephalon; hypotype, GSC No. 12203, x6.
Figures 23a, b.	Dorsal and lateral views of cephalon; hypotype, GSC No. 12204, x4.

Plate IX

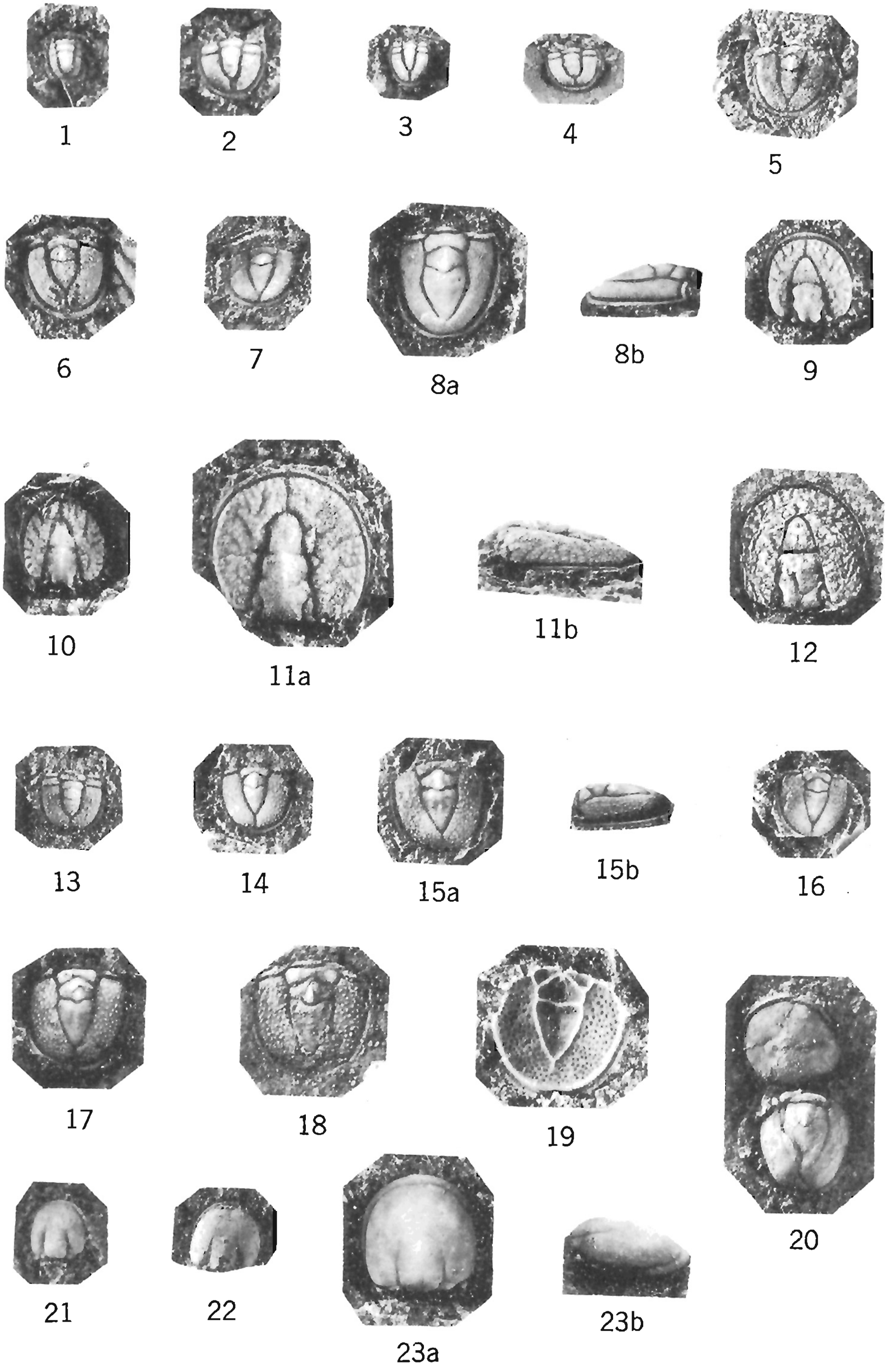
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Plate X

Ptychagnostus ciceroides (Matthew) (Page 85.)

Figure 1.	Cephalon; hypotype, GSC No. 12205, x3.
Figures 2a, b.	Dorsal and lateral views of cephalon; hypotype, GSC No. 12206, x2.
Figure 3.	Pygidium; hypotype, GSC No. 12207, x9.
Figure 4.	Pygidium; hypotype, GSC No. 12208, x4.
Figures 5a, b.	Dorsal and lateral views of pygidium; hypotype, GSC No. 12209, x4.
Figures 6a, b.	Dorsal and lateral views of pygidium; hypotype, GSC No. 13014, x3.
Figure 7.	Thorax and pygidium; hypotype, GSC No. 13015, x2.
Figures 8a, b.	Dorsal and lateral views of complete dorsal shield; hypotype, GSC No. 13049, x2.

Doryagnostus incertus (Broegger) (Page 87.)

Figures 9a, b.	Dorsal and lateral views of cephalon; hypotype, GSC No. 13024, x3.
Figure 10.	Pygidium; hypotype, GSC No. 13025, x8.
Figures 11a, b.	Dorsal and lateral views of pygidium; hypotype, GSC No. 13026, x3.

Ciceragnostus barlowi (Belt) var. *C. definatus* (Howell) (Page 88.)

Figure 12.	Pygidium; hypotype, GSC No. 12114, x10.
Figure 13.	Pygidium; hypotype, GSC No. 12115, x6.
Figure 14.	Pygidium; hypotype, GSC No. 12116, x4.

Ciceragnostus cicer (Tullberg) (Page 89.)

Figure 15.	Cephalon; hypotype, GSC No. 13033, x4.
Figures 16a, b.	Dorsal and lateral views of cephalon; hypotype, GSC No. 13034, x4.

PLATE X

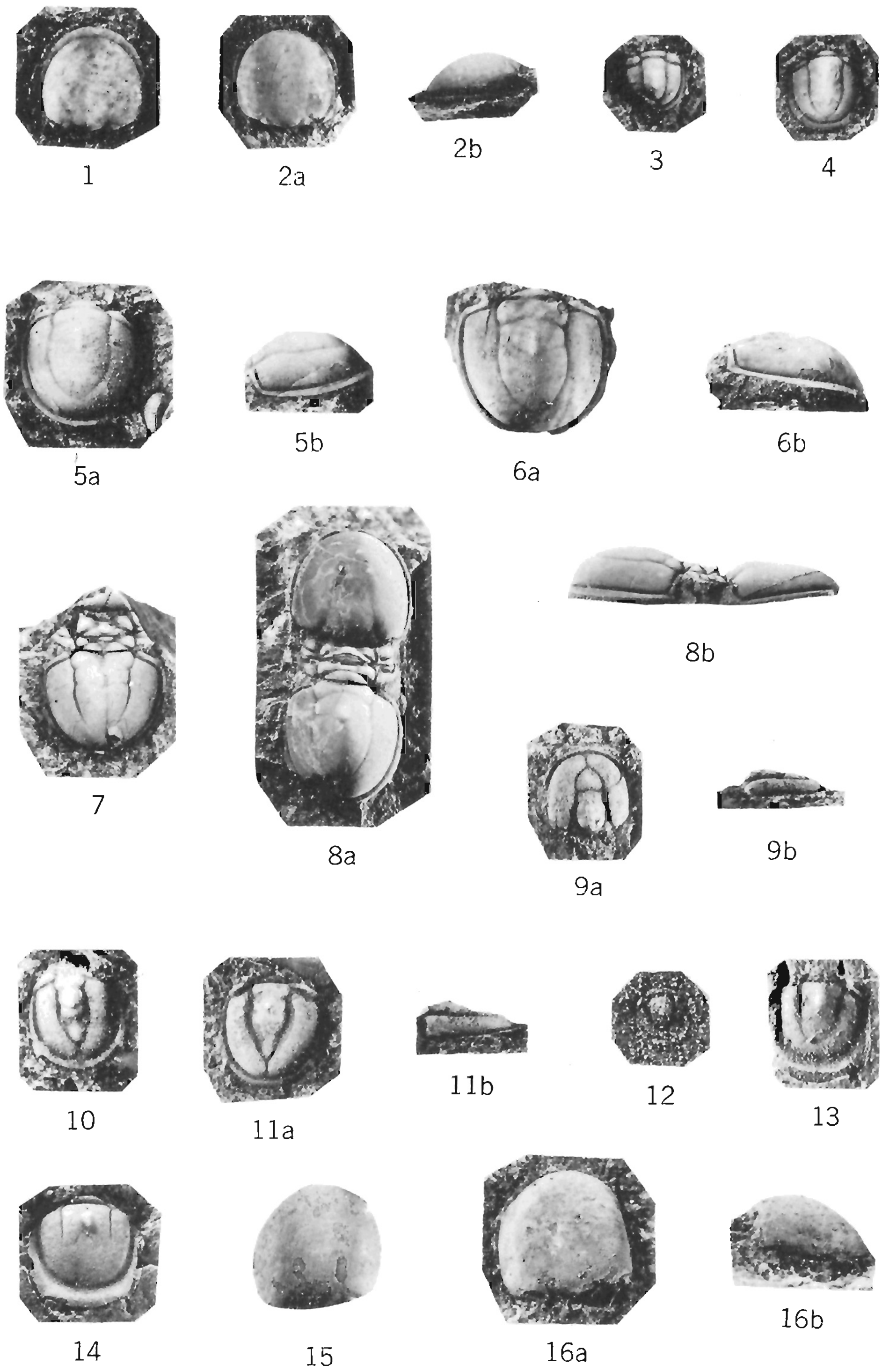

Plate XI

(All x4 except where otherwise stated.)

Ciceragnostus cicer (Tullberg) (Page 89.)

Figures 1a, b.	Dorsal and lateral views of pygidium; hypotype, GSC No. 13035.
Figure 2.	Pygidium; hypotype, GSC No. 13036.

Phalacroma nudum (Beyrich) (Page 90.)

Figure 3.	Cephalon; hypotype, GSC No. 13027, x6.
Figure 4.	Cephalon; hypotype, GSC No. 13028.
Figures 5a, b.	Dorsal and lateral views of cephalon; hypotype, GSC No. 13029.
Figure 6.	Pygidium; hypotype, GSC No. 13030.
Figure 7.	Pygidium; hypotype, GSC No. 13031.
Figures 8a, b.	Dorsal and lateral views of pygidium; hypotype, GSC No. 13032.

Phalacroma bairdi n. sp. (Page 90.)

Figures 9a, b.	Dorsal and lateral views of pygidium; holotype, GSC No. 13055.
Figures 10a, b.	Dorsal and lateral views of cephalon; paratype, GSC No. 13056.
Figure 11.	Pygidium; paratype, GSC No. 13057.

Phalacroma? howsei n. sp. (Page 91.)

Figures 12a-d.	Dorsal, ventral, lateral, and posterior views of holotype; GSC No. 13058.
Figures 13a, b.	Dorsal and lateral views of cephalon; paratype, GSC No. 13059.
Figure 14.	Cephalon; paratype, GSC No. 13060, x2.
Figure 15.	Pygidium; paratype, GSC No. 13061.
Figures 16a, b.	Dorsal and lateral views of pygidium; paratype, GSC No. 13062, x2.

Plate XI

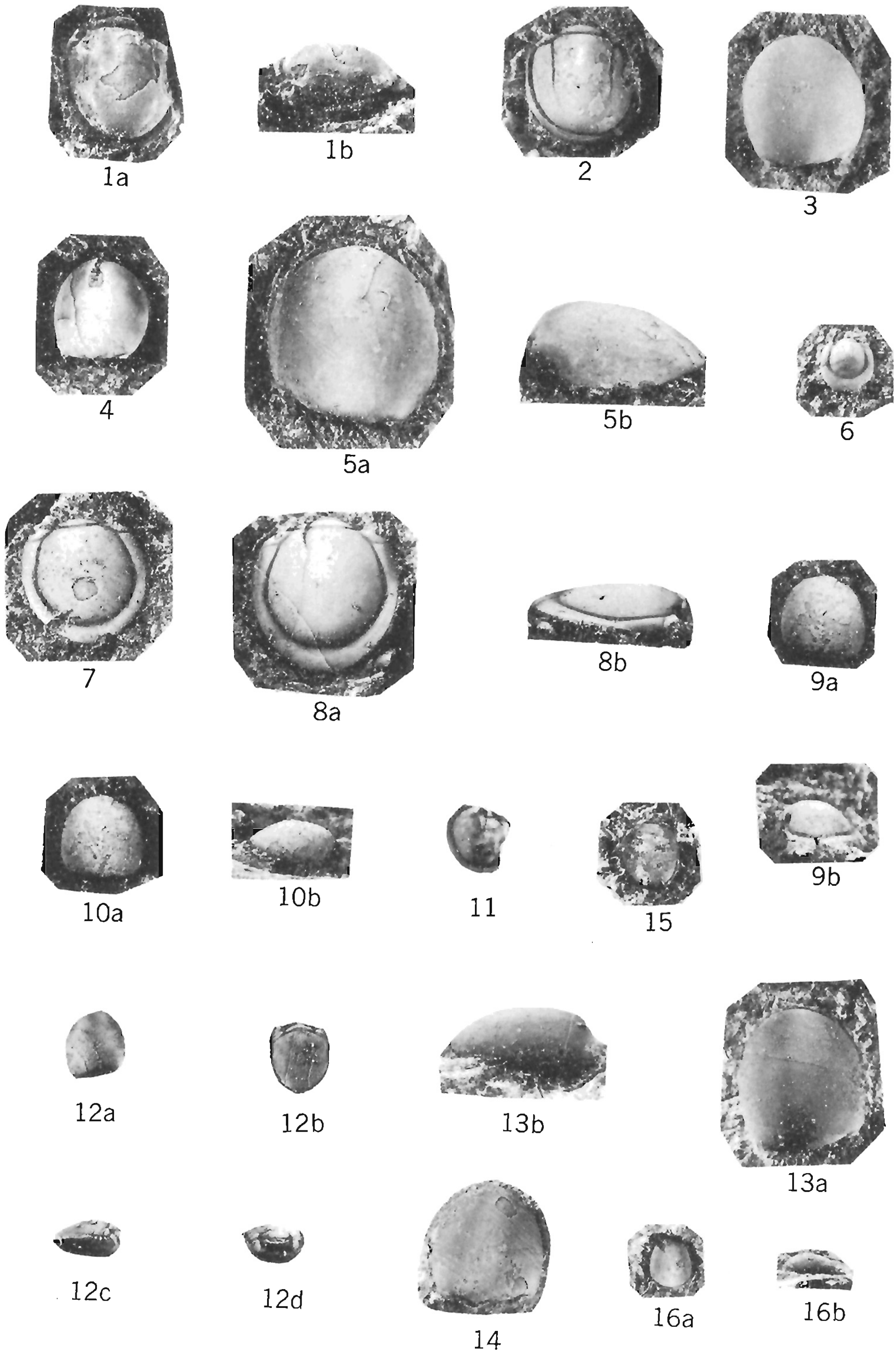
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Plate XII

Phalacroma? sp. (Page 89.)

Figure 1. Figured pygidium; GSC No. 13042, x9.

Agnostus pisiformis (Linnaeus) (Page 86.)

Figure 2. Dorsal shield; hypotype, GSC No. 13037, x4.
Figure 3. Cephalon; hypotype, GSC No. 13038, x4.
Figure 4. Pygidium; hypotype, GSC No. 13039, x4.
Figure 5. Cephalon; hypotype, GSC No. 13040, x4.
Figure 6. Pygidium; hypotype, GSC No. 13041, x4.

"*Agnostus*" sp. A (Page 92.)

Figure 7. Figured pygidium; GSC No. 13051, x12.

"*Agnostus*" sp. B (Page 92.)

Figure 8. Figured pygidium; GSC No. 13052, x12.

"*Agnostus*" sp. C (Page 92.)

Figure 9. Figured pygidium; GSC No. 13054, x8.

"*Agnostus*" sp. D (Page 93.)

Figures 10a, b. Dorsal and lateral views of figured pygidium; GSC No. 13063, x8.

"*Agnostus*" sp. E (Page 93.)

Figure 11. Figured pygidium; GSC No. 13064, x8.

Pseudatops cf. *P. reticulatus* (Walcott) (Page 94.)

Figure 12. Figured specimen; GSC No. 12009, x2.

Ctenocephalus (Harttella) terranovicus Resser (Page 95.)

Figure 13. Nepionic cranidium; hypotype, GSC No. 12010, x8.
Figure 14. Cranidium; hypotype, GSC No. 12011, x8.
Figure 15. Cranidium; hypotype, GSC No. 12012, x2.
Figure 16. Cranidium; hypotype, GSC No. 12013, x2.
Figure 17. Cranidium; hypotype, GSC No. 12014.

Ctenocephalus howelli Resser (Page 96.)

Figures 18a-c. Dorsal, anterior, and lateral views of cranidium; hypotype, GSC No. 12018.

Ctenocephalus resseri n. sp. (Page 97.)

Figures 19a-c. Dorsal, oblique anterior, and lateral views of cranidium; holotype, GSC No. 12019.

Ctenocephalus excavatus Resser (Page 98.)

Figures 20a, b. Dorsal and oblique anterior views of cranidium; hypotype, GSC No. 12015.


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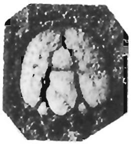
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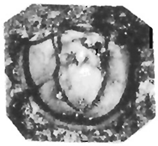
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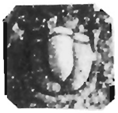
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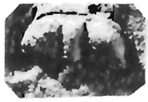
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18c


20a


19a


19b


19c


20b

PLATE XIII

Ctenocephalus excavatus Resser (Page 98.)

Figures 1a, b. Dorsal and oblique anterior views of cranidium; hypotype, GSC No. 12016.
Figure 2. Free cheek; hypotype, GSC No. 12017.

Elyx matthewi n. sp. (Page 99.)

Figure 3. Holotype; GSC No. 12020.
Figures 4a, b. Dorsal and lateral views of paratype; GSC No. 12021.
Figures 5a-c. Dorsal, anterior, and lateral views of paratype; GSC No. 12022.
Figures 6a, b. Dorsal view, x1, and enlarged view of part of right fixed cheek, x3, of paratype; GSC No. 12023.

Conocoryphe terranovica Resser (Page 99.)

Figures 7a-c. Dorsal, anterior, and lateral views of cranidium; hypotype, GSC No. 12024.
Figures 8a, b. Dorsal view, x2, and part of left fixed cheek, x4, of cranidium; hypotype, GSC No. 12025.
Figure 9. Dorsal view of cranidium and part of thorax; hypotype, GSC No. 12026.
Figure 10. Pygidium; hypotype, GSC No. 12027.

Bailiaspis venusta Resser (Page 100.)

Figure 11. Cranidium; hypotype, GSC No. 12036.
Figure 12. Cast from external mould of cranidium; hypotype, GSC No. 12037.

Bailiaspis prominens Resser (Page 101.)

Figure 13. Cranidium; hypotype, GSC No. 12028.
Figure 14. Cranidium; hypotype, GSC No. 12029.

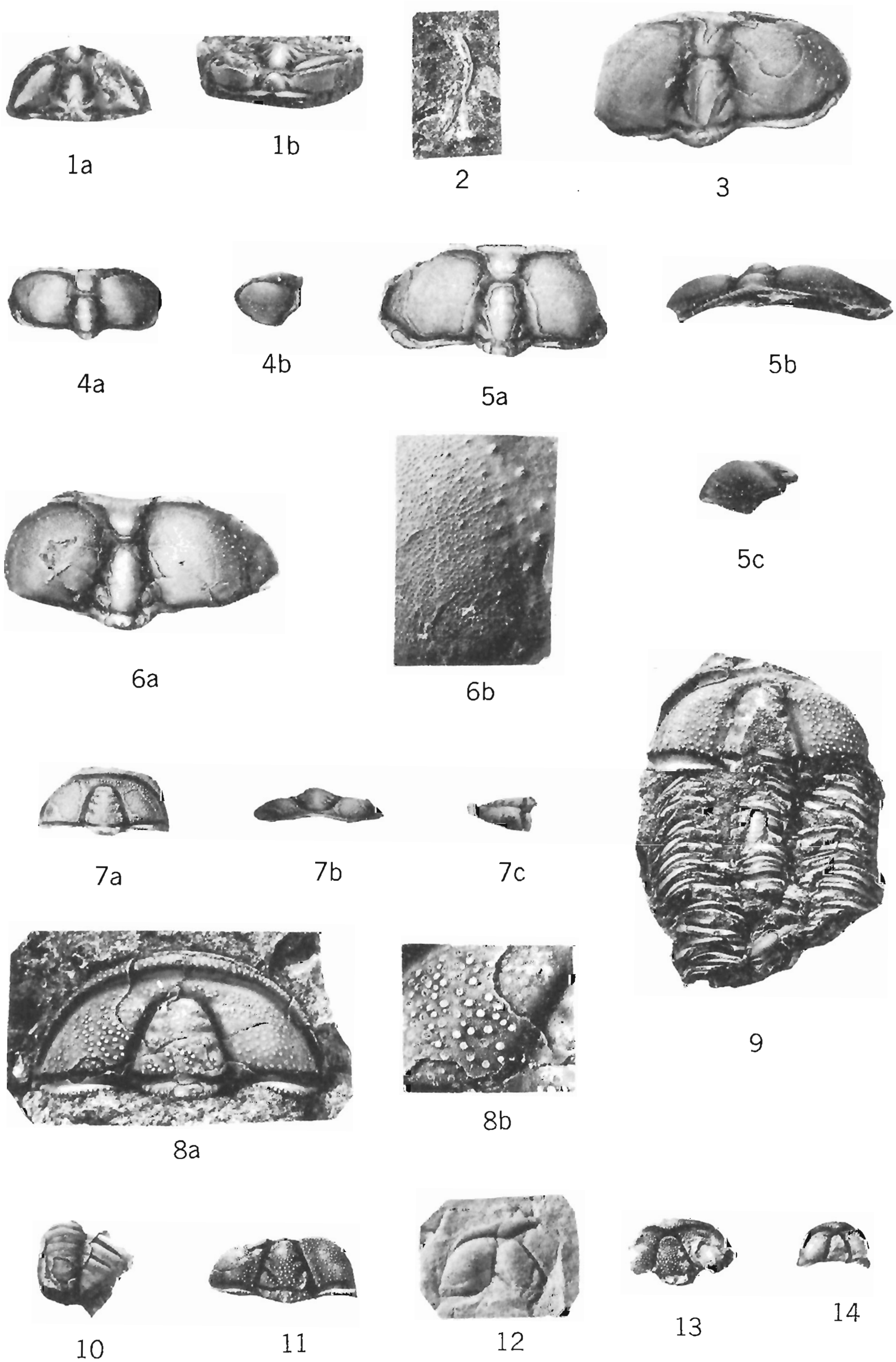
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Plate XIV

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Figure 2.	Cranidium; paratype, GSC No. 12031, x4.
Figure 3.	Cranidium; paratype, GSC No. 12032, x4.
Figures 4a-c.	Dorsal, anterior, and lateral views of cranidium; paratype, GSC No. 12033.

Bailiaspis cf. *B. howelli* n. sp. (Page 103.)

Figures 5a-c.	Dorsal, anterior, and lateral views of cranidium; GSC No. 12034.
Figure 6.	Figured cranidium; GSC No. 12035.

Bailiaspis latigenae n. sp. (Page 103.)

Figures 7a, b.	Dorsal and anterior views of holotype; GSC No. 13043.
Figure 8.	Cranidium; paratype, GSC No. 13044.

Bailiaspis sp. (Page 104.)

Figures 9a, b.	Dorsal and lateral views of figured specimen; GSC No. 12039.

Plate XIV


1a


1b


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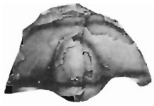
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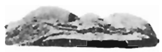
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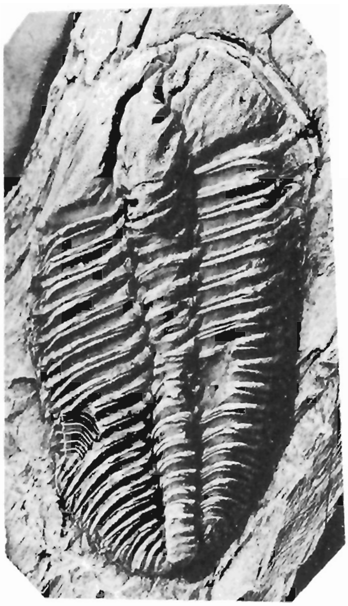
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Plate XV

Bailiella ornata Resser (Page 104.)

Figure 1.	Dorsal shield; hypotype, GSC No. 12041.
Figure 2.	Cranidium; hypotype, GSC No. 12042.

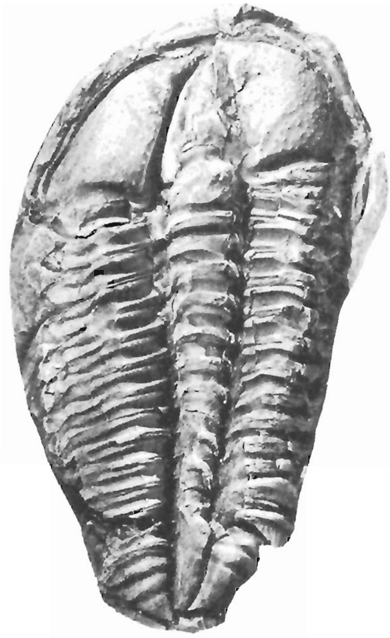
Bailiella tenuicincta (Linnarsson) (Page 105.)

Figure 3.	Cranidium, enlarged to show ornamentation; hypotype, GSC No. 12038, x3.
Figures 4a-d.	Dorsal, anterior, and lateral views, natural size, and part of left fixed cheek, x6, of cranidium; hypotype, GSC No. 12040.

Bailiella manuelensis n. sp. (Page 106.)

Figure 5.	Cast of holotype; GSC No. 12043.
Figure 6.	Cranidium; paratype, GSC No. 12044.
Figures 7a-c.	Dorsal, anterior, and lateral views of cranidium; paratype, GSC No. 12045.

Plate XV



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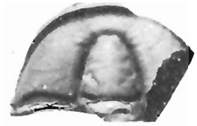

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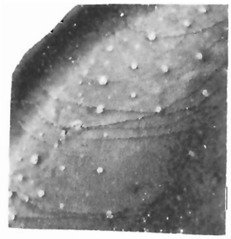

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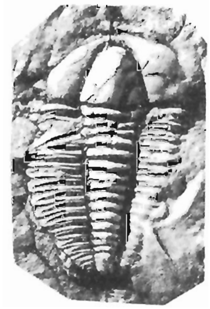

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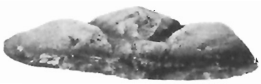

7b

7c

Plate XVI

Bailiella sp. (Page 107.)

Figures 1a-c.	Dorsal, anterior, and lateral views of cranidium; GSC No. 12046.

Meneviella venulosa (Salter) (Page 108.)

Figure 2.	Cranidium; hypotype, GSC No. 12047, x4.
Figure 3.	Cranidium; hypotype, GSC No. 12048, x4.
Figure 4.	Cranidium; hypotype, GSC No. 12049.
Figure 5.	Cranidium; hypotype, GSC No. 12050.
Figures 6a, b.	Dorsal view, x2, and part of right fixed cheek, x2, of cranidium; hypotype, GSC No. 12051.
Figure 7.	Free cheek; hypotype, GSC No. 12052, x4.

Acontheus inarmatus n. sp. (Page 109.)

Figures 8a, b.	Dorsal and lateral views of cranidium; holotype, GSC No. 12053, x10.
Figure 9.	Cranidium; paratype, GSC No. 12054, x4.

Hartshillia terranovica n. sp. (Page 109.)

Figures 10a, b.	Cranidium, x4; and enlarged to show ornamentation, x10; holotype, GSC No. 12059.

PLATE XVI

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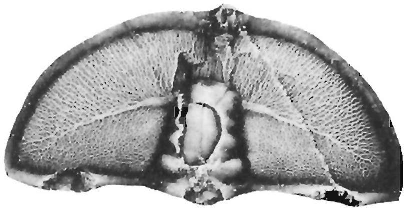

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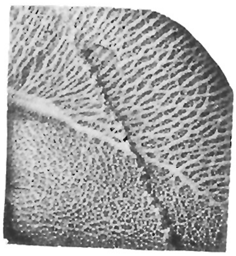

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8a

10b

8b

Plate XVII

Hartshillia terranovica n. sp. (Page 109.)

Figures 1a, b. Dorsal and lateral views of cranidium; paratype, GSC No. 12060, x4.
Figure 2. Hypostome; paratype, GSC No. 12061, x4.

Holocephalina americana Resser (Page 110.)

Figure 3. Cranidium and thorax; hypotype, GSC No. 12057.
Figure 4. Cranidium; hypotype, GSC No. 12058, x2.
Figures 5a, b. Dorsal and anterior views of cranidium; hypotype, GSC No. 12055, x2.
Figure 6. Free cheek; hypotype, GSC No. 12056.

Clarella venusta (Billings) (Page 111.)

Figure 7. Cast of one of Billings' cotypes; GSC No. 284.
Figure 8. Cast of one of Billings' cotypes; GSC No. 284a.
Figures 9a, b. Dorsal and lateral views of cranidium; hypotype, GSC No. 13105.
Figure 10. Pygidium; hypotype, GSC No. 13106, x2.

Clarella sp. (Page 112.)

Figure 11. Cranidium; GSC No. 13107.

Anapolenus henrici Salter (Page 112.)

Figure 12. Cranidium; hypotype, GSC No. 13108, x2.
Figure 13. Cranidium; hypotype, GSC No. 13109.
Figure 14. Cranidium; hypotype, GSC No. 13110.
Figure 15. Free cheek; hypotype, GSC No. 13111.
Figure 16. Free cheek; hypotype, GSC No. 13112.
Figure 17. Pygidium; hypotype, GSC No. 13113, x2.
Figure 18. Pygidium; hypotype, GSC No. 13114.

PLATE XVII

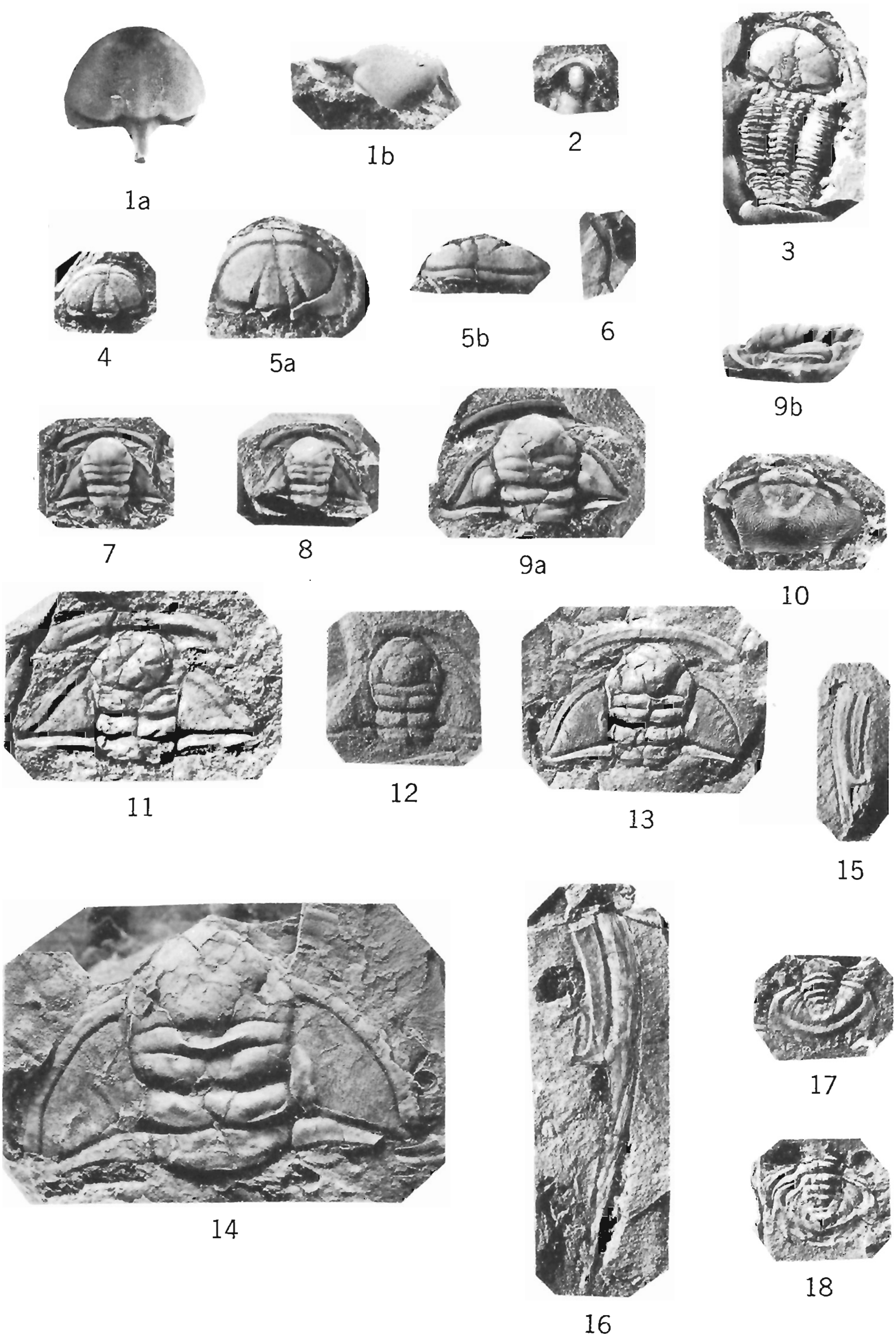

PLATE XVIII

Paradoxides lamellatus Hartt *in* Dawson (Page 113.)

Figures 1a, b.	Dorsal and lateral views of cranidium; hypotype, GSC No. 13076.
Figure 2.	Cranidium; hypotype, GSC No. 13077.
Figure 3.	Pygidium; hypotype, GSC No. 13078, x3.

Paradoxides hicksi Salter (Page 113.)

Figure 4.	Cranidium; hypotype, GSC No. 13065, x6.
Figure 5.	Cranidium; hypotype, GSC No. 13066, x6.
Figure 6.	Cranidium; hypotype, GSC No. 13067, x4.
Figure 7.	Cranidium; hypotype, GSC No. 13068, x3.
Figures 8a-c.	Dorsal, anterior, and lateral views of cranidium; hypotype, GSC No. 13069.
Figures 9a-c.	Dorsal, anterior, and lateral views of cranidium; hypotype, GSC No. 13070.
Figure 10.	Cranidium; hypotype, GSC No. 13071.
Figure 11.	Cranidium; hypotype, GSC No. 13072.
Figure 12.	Free cheek; hypotype, GSC No. 13073.

PLATE XVIII


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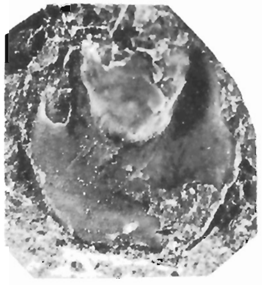
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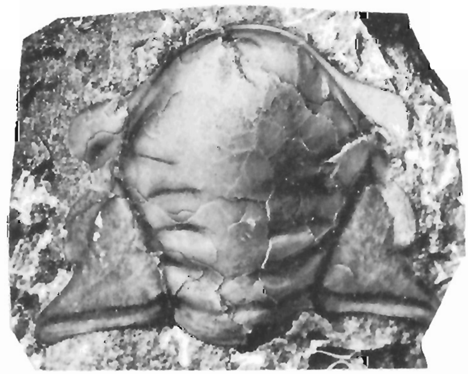
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Plate XIX

Paradoxides hicksi Salter (Page 113.)

Figure 1. Part of thorax and pygidium; hypotype, GSC No. 13074, x2.
Figure 2. Pygidium; hypotype, GSC No. 13075.

Paradoxides eteminicus Matthew (Page 114.)

Figure 3. Cranidium; hypotype, GSC No. 13089, x4.
Figure 4. Cranidium; hypotype, GSC No. 13090.
Figure 5. Cranidium; hypotype, GSC No. 13091.
Figure 6. Free cheek; hypotype, GSC No. 13092.
Figure 7. Free cheek; hypotype, GSC No. 13093.
Figure 8. Pygidium; hypotype, GSC No. 13094.
Figure 9. Pygidium; hypotype, GSC No. 13114.

Paradoxides davidis Salter (Page 115.)

Figure 10. Cranidium and free cheek; hypotype, GSC No. 13080.


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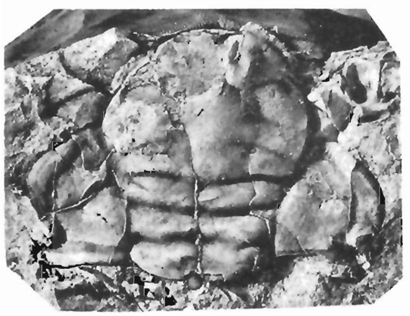
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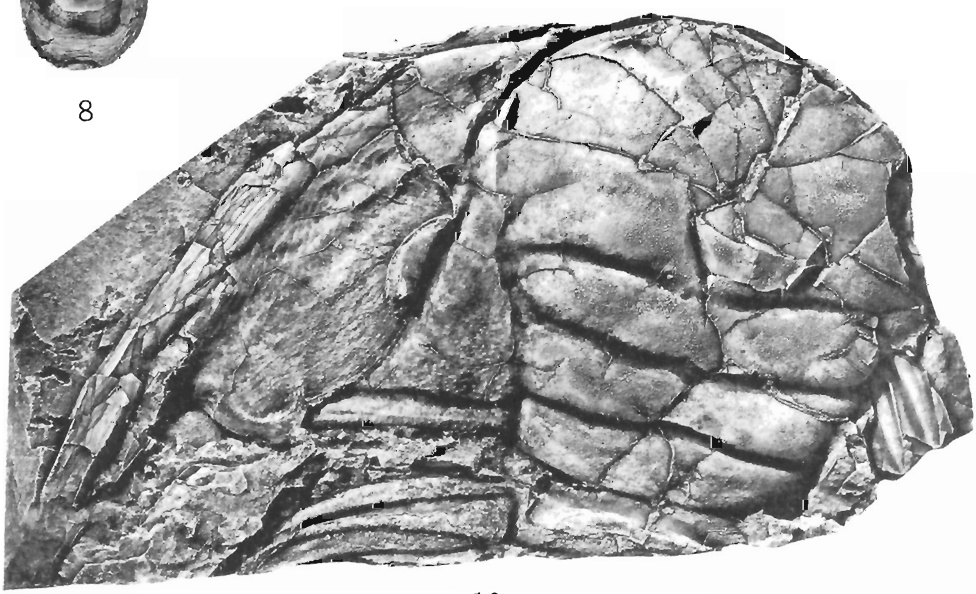
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PLATE XX

Paradoxides davidis Salter (Page 115.)

Cranidium; hypotype, GSC No. 13079, x1.

PLATE XXI

Paradoxides davidis Salter (Page 115.)
Thorax and pygidium; hypotype, GSC No. 13081, x1.

PLATE XXI

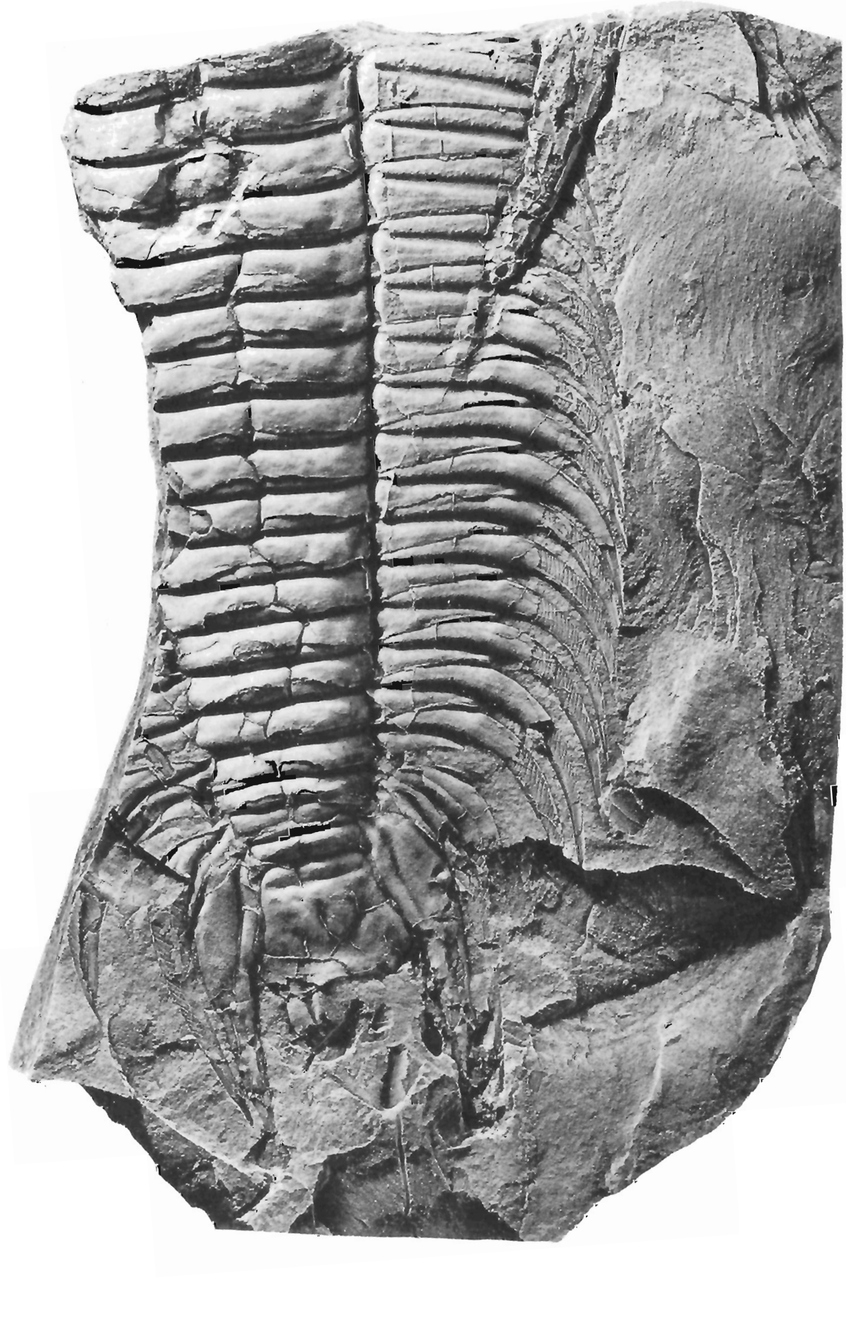

Plate XXII

Paradoxides davidis Salter (Page 115.)

Figure 1.	Pygidium; hypotype, GSC No. 13082.
Figure 2.	Part of thorax and pygidium; hypotype, GSC No. 13083.
Figure 3.	Hypostome; hypotype, GSC No. 13084.
Figure 4.	Free cheek; hypotype, GSC No. 13085.
Figure 5.	Part of thorax and pygidium; hypotype, GSC No. 13088.

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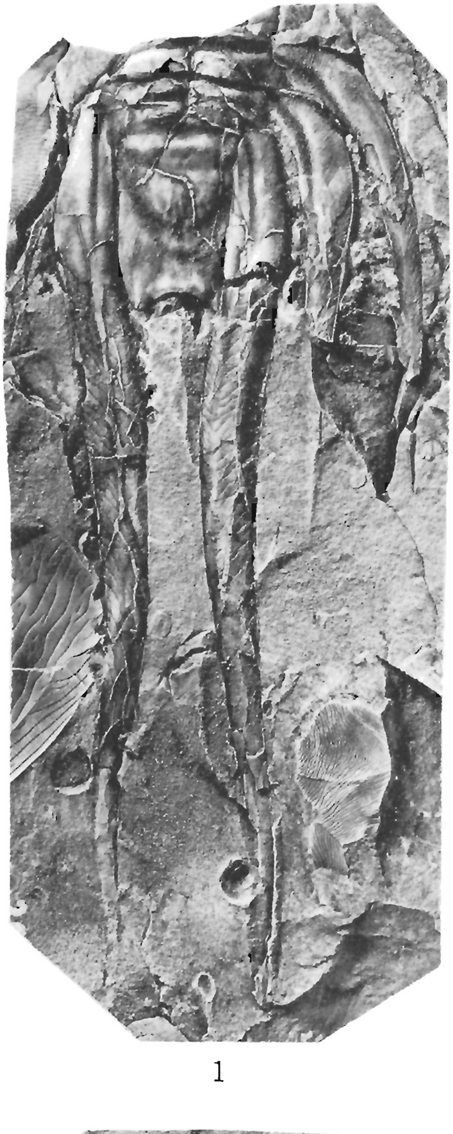

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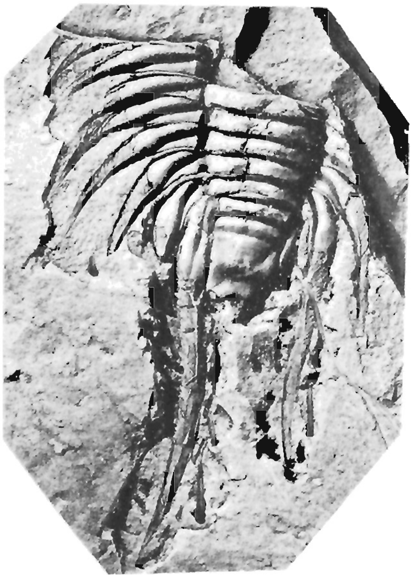

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PLATE XXIII

Paradoxides cf. *P. rugulosus* Corda (Page 115.)

Figure 1.	Cranidium; GSC No. 13095.
Figure 2.	Cranidium; GSC No. 13096.
Figure 3.	Cranidium; GSC No. 13097.

Paradoxides freboldi n. sp. (Page 116.)

Figures 4a, b.	Dorsal and lateral views of cranidium; holotype, GSC No. 13098.
Figure 5.	Cranidium; paratype, GSC No. 13099, x6.
Figure 6.	Cranidium; paratype, GSC No. 13100.
Figure 7.	Free cheek; paratype, GSC No. 13101.
Figure 8.	Free cheek; paratype, GSC No. 13102.
Figure 9.	Pygidium; paratype, GSC No. 13103.
Figure 10.	Pygidium; paratype, GSC No. 13104.

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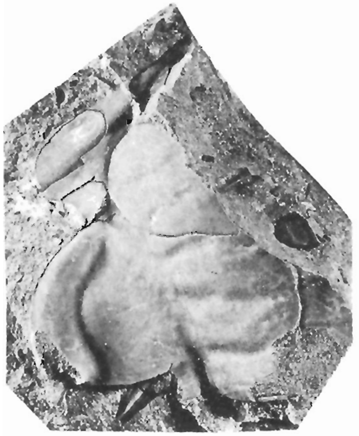

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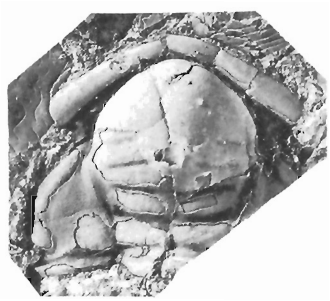

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Plate XXIV

Paradoxides parvoculus Howell (Page 118.)

Figure 1.	Cranidium; hypotype, GSC No. 13115, x4.
Figure 2.	Cranidium; hypotype, GSC No. 13116, x4.
Figure 3.	Cranidium; hypotype, GSC No. 13117, x4.
Figure 4.	Cranidium and part of thorax; hypotype, GSC No. 13118, x4.
Figure 5.	Cranidium and part of thorax; hypotype, GSC No. 13119, x2.
Figure 6.	Cranidium; hypotype, GSC No. 13120.

Callavia broeggeri (Walcott) (Page 119.)

Figures 7a, b.	Dorsal and oblique anterior-lateral view, cephalon; hypotype, GSC No. 12085.
Figure 8.	Cephalon; hypotype, GSC No. 12086.
Figure 9.	Cephalon; hypotype, GSC No. 12087.
Figures 10a-c.	Dorsal, anterior, and lateral views of cephalon; hypotype, GSC No. 12089, x2.
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Figure 12.	Protaspid; hypotype, GSC No. 12091, x10.
Figure 13.	Hypostome; hypotype, GSC No. 12092.
Figure 14.	Cephalon and part of thorax; hypotype, GSC No. 12088.

PLATE XXIV

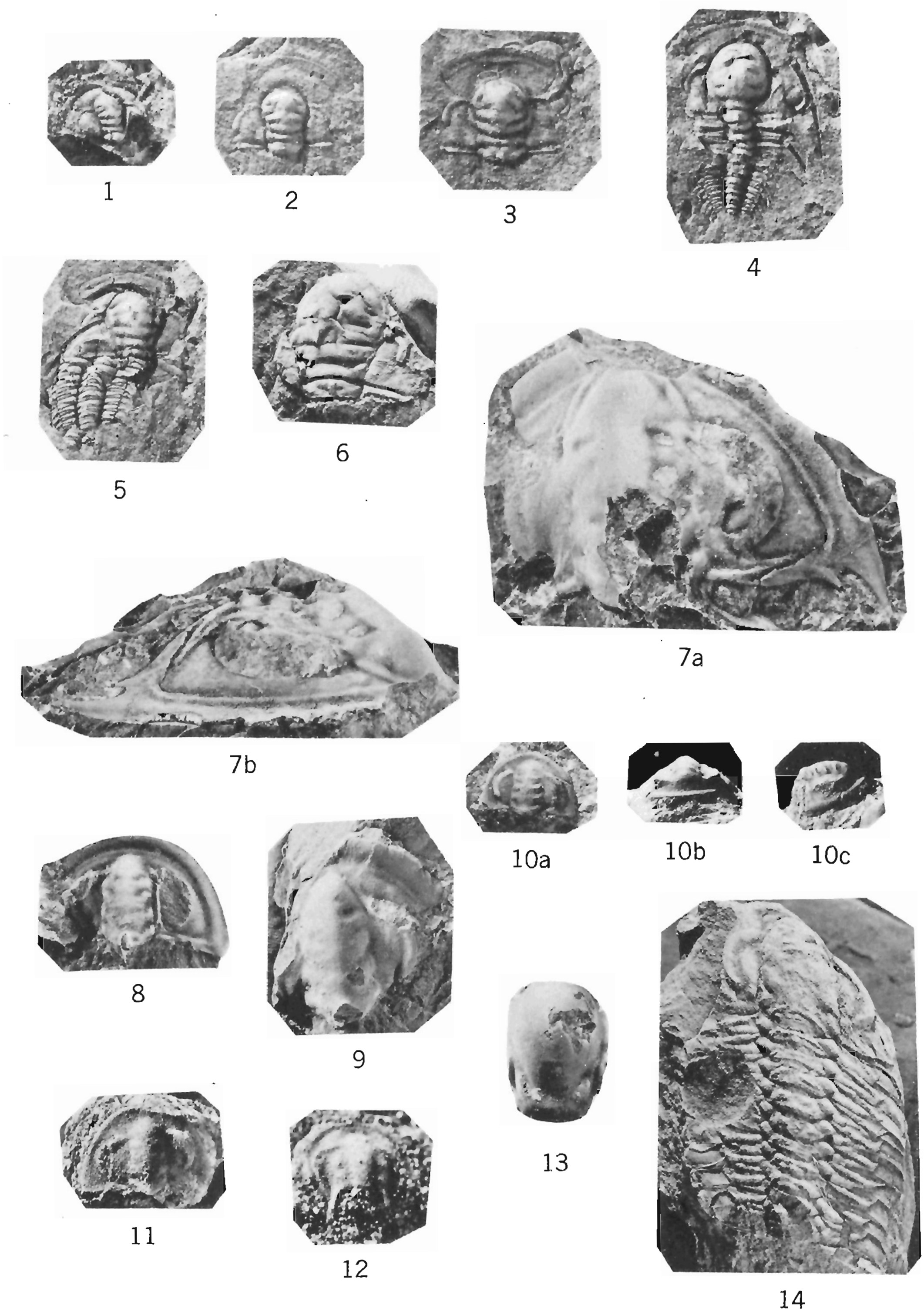
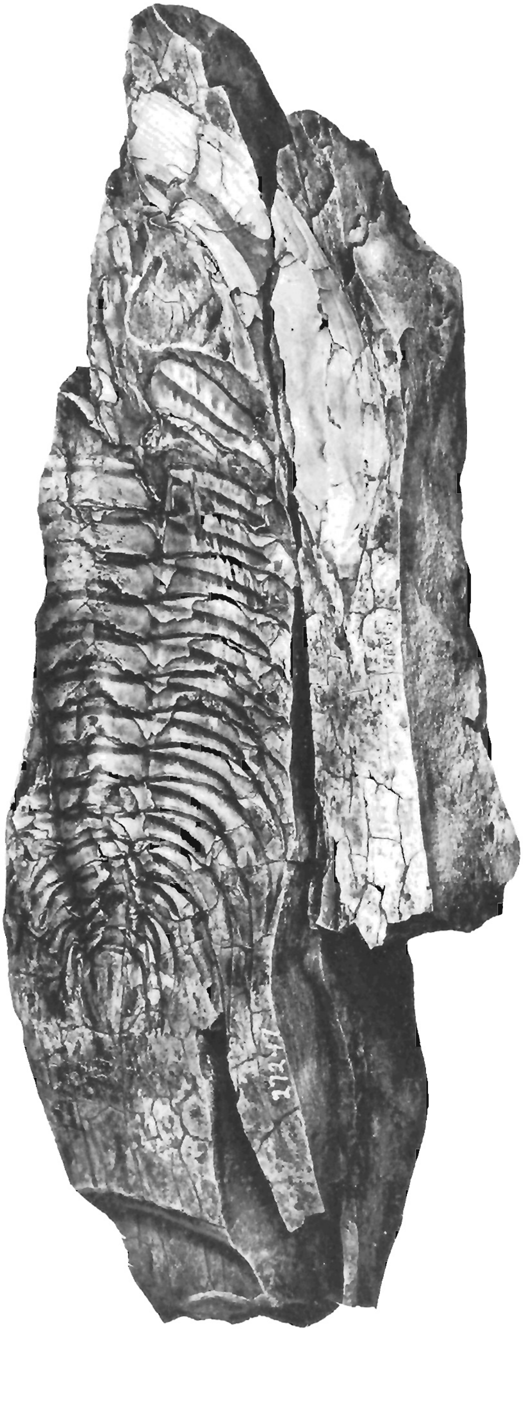


PLATE XXV

Paradoxides bennetti Salter (Page 117.)
Hypotype, GSC No. 13086, x½.

PLATE XXV



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