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DEPARTMENT OF ENERGY, MINES AND RESOURCES

BULLETIN 240

LOWER ORDOVICIAN TRILOBITES FROM THE SUMMERFORD GROUP AT VIRGIN ARM, NEW WORLD ISLAND, NORTHEASTERN NEWFOUNDLAND

W. T. Dean

Ottawa
Canada
1973

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PREFACE

This report describes a group of trilobites from the Ordovician rocks of northeastern Newfoundland. The faunal assemblage has some unique features that have no exact counterpart elsewhere; however, there are sufficient affinities with other faunas of world-wide distribution to place the fauna, and hence the rocks containing the fossils, into the accepted Ordovician time scale.

It is by detailed studies of total faunas such as this that paleontologists are able to fill lacunae in the stratigraphic column and provide data for the calibration of the geological time scale so necessary for the precise dating and correlation of the rocks that make up the geological framework of Canada.

D. J. McLaren,
Director.

Ottawa, July 4, 1973

CONTENTS

ILLUSTRATIONS

LOWER ORDOVICIAN TRILOBITES FROM THE SUMMERFORD GROUP AT VIRGIN ARM, NEW WORLD ISLAND, NORTHEASTERN NEWFOUNDLAND

ABSTRACT

Ordovician trilobites from Unit B, the third oldest of six units into which the Summerford Group on New World Island, northeastern Newfoundland, has been subdivided, occur in a volcanic terrain and include *Geragnostus* sp., *Scotoharpes* sp., *Bergamia?* sp., *Paratretaspis terranovica* gen. et sp. nov., *Pseudosphaerexochus* (s. l.) sp., *Encrinuroides hornei* sp. nov., *Ischyrophyma* sp., odontopleurid gen. et sp. undetermined, *Metopolichas* cf. *M. verrucosus* (Eichwald), *Illaenus* (s. l.) sp. and *Annamitella? insulana* sp. nov. The assemblage does not have an exact counterpart elsewhere, but the bathyurid *Annamitella?* indicates affinities with Lower Ordovician faunas in Maine, North Wales, Argentina, Vietnam and southern U. S. S. R. The *Metopolichas* indicates Balto-Scandinavian affinities and suggests that the age of the fauna is highest Arenig or lowest Llanvirn Series, a conclusion generally supported by the remainder of the assemblage.

RÉSUMÉ

Les trilobites ordoviciens de l'unité B, la troisième plus ancienne des six unités selon lesquelles on a subdivisé le groupe de Summerford à New World Island, au nord-est de Terre-Neuve, se retrouvent en terrain volcanique et comprennent les espèces *Geragnostus*, *Scotoharpes*, *Bergamia?* le genre et espèce nouvelle *Paratretaspis terranovica*, l'espèce *Pseudosphaerexochus* (s. l.) la nouvelle espèce *Encrinuroides hornei*, l'espèce *Ischyrophyma*, des odontopleurinés de genre et d'espèce indéterminés, *Metopolichas* cf. *M. verrucosus* (Eichwald), l'espèce *Illaenus* (s. l.) et l'espèce nouvelle *Annamitella? insulana*. Cet assemblage n'a pas d'équivalent exact ailleurs, mais l'*Annamitella?* bathyuridé présente des ressemblances avec la faune de l'Ordovicien inférieur du Maine, du nord du pays de Galles, de l'Argentine, du Viet-Nam et du sud de l'U. R. S. S. Le *Metopolichas* présente des ressemblances baltico-scandinaves et incite à penser que la faune date de l'Arenig supérieur ou du Llanvirn inférieur, conclusion que confirme en général le reste de l'assemblage.

INTRODUCTION AND ACKNOWLEDGEMENTS

New World Island lies within the so-called Central Volcanic Mobile Belt, the second of the three structural units into which Newfoundland was divided by Williams (1964). The rocks composing the island are largely of Ordovician age, with the Cambrian and Silurian represented on only a minor scale. The area is traversed by a number of prominent faults which run east-northeast and subdivide New World Island into four distinct areas, each with its own distinctive rock succession or "sequence", using the terminology proposed by Kay (1967). General accounts of the geology of New World Island have been given by Williams (1963), who provided also a geological map of the region at a scale of one inch to one mile, and by Kay (1967), whilst a more detailed account and geological map of the western end of the island were published by Horne (1970).

The rocks with which the present paper is concerned form part of the Summerford Group, a name proposed by Horne and Helwig (1969, p. 393) for the lower portion of what Kay (1967, p. 588) earlier had termed the "Cobbs Arm sequence". They represent part of map-unit 4 employed by Williams (1963), a subdivision described by him as comprising "green pillow-lava and related pyroclastic rocks; minor sandstone, siltstone, argillite, limestone". The Summerford Group was stated by Horne (1970, p. 1770) to "apply to Ordovician volcanic rocks and sedimentary equivalents throughout the lateral extent of the Cobbs Arm sequence on New World Island" and to consist of "a mixed and heterogeneous assemblage of stratified volcanic and sedimentary rocks". Horne subdivided the Summerford Group into six mappable units, in ascending order as follows: Unit Z, lower volcanic unit; Unit A, arkosic unit; Unit B, middle volcanic unit; Unit C, Caradocian argillite unit; Unit D, upper volcanic unit; and Unit E, chaotic unit. Of these subdivisions Unit Z was said to be of probable Tremadoc age on the basis of contained nautiloids identified by R.H. Flower (in Kay, 1967, p. 588), though trilobites from the same locality proved less definitive and were held only to indicate an early Ordovician age (Whittington in Horne, 1970, p. 1771). Unit B was stated to have yielded "brachiopods of Llanvirn - Llandeilan age" in tuffs and limestones associated with volcanics at two localities. The black argillites of Unit C were described as comprising beds less than 30 metres thick containing graptolites of Elles and Wood's zones 12-13, i.e. the Clingani and Linearis zones of the Caradoc Series and probably basal Ashgill Series. Of the remaining units D did not yield fossils but E was found to contain both graptolites and brachiopods of Ashgill age.

The fossils described in the present account come from Unit B of the Summerford Group and were collected by Dr. G.S. Horne from a locality "along the east shore of Virgin Arm to the north of the Cobbs Arm fault" (Horne, 1970, p. 1773). The locality is indicated on Horne's map (1970, Fig. 3) by an "F" and lies by the east side of Virgin Arm embayment about 2750 metres east-northeast of the point where the main road from Gander meets the coast at Virgin Arm village (see Text-fig. 1). A large amount of poorly-preserved fossiliferous material was submitted to Dr. R.B. Neuman of the U.S. Geological Survey, Washington who, after etching it in dilute hydrochloric acid, kindly made the trilobites available to

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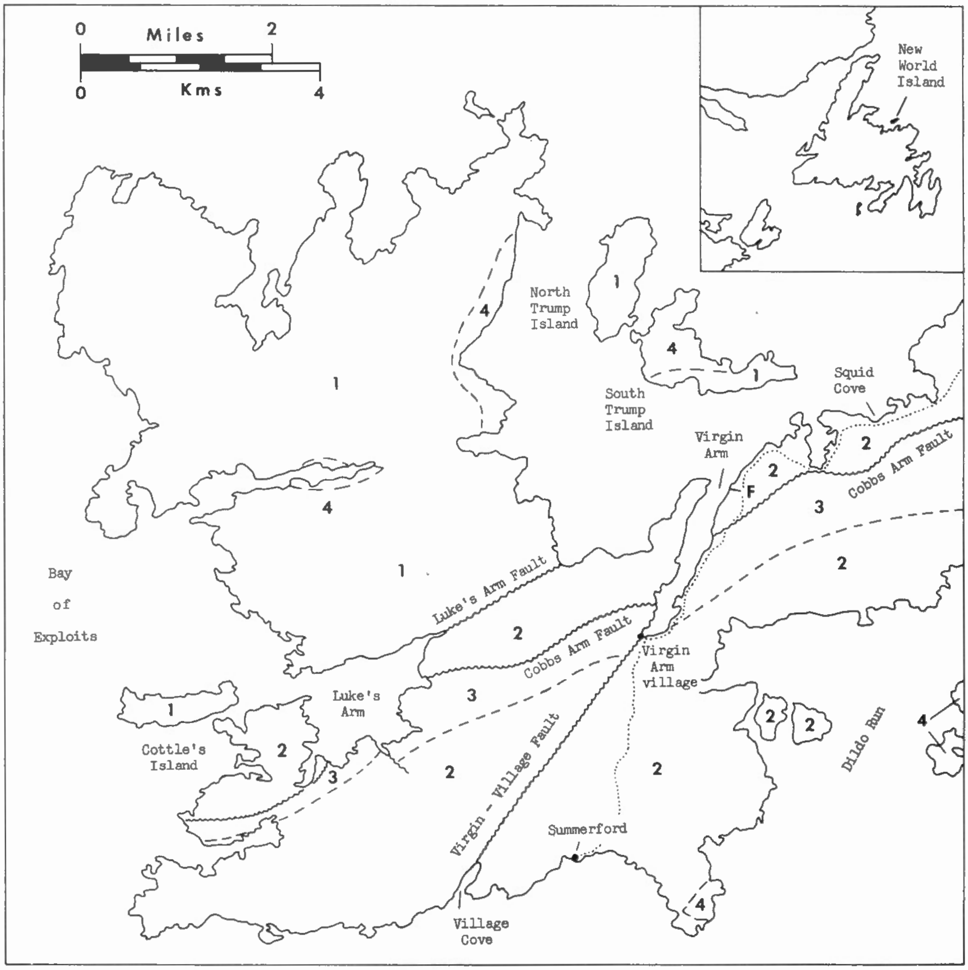

Text-figure 1. Western half of New World Island, with generalized geological boundaries after Williams (1963) and Horne (1970). Key as follows: 1, Lushs Bight Group (Ordovician); 2, Summerford Group (Ordovician); 3, Botwood Group (Silurian); 4, igneous intrusions. The letter F indicates the locality from which the trilobites described in this report were obtained. Dashed lines indicate geological boundaries, wavy lines denote faults, dotted line denotes road.

the writer and facilitated the transfer of the type and figured specimens to the collections of the Geological Survey of Canada in Ottawa. Most of the specimens are fragmentary and tectonically distorted, and as a result of their prolonged treatment with acid almost all are so fragile that in only a few cases has it proved possible to employ the usual techniques of latex casting. Consequently most are illustrated here as internal or external moulds, though a few are represented as casts made from plastic modelling compound and then baked to render them more permanent.

SYSTEMATIC DESCRIPTIONS

The terminology employed for the following descriptions follows for the most part that proposed in the Treatise on Intertebrate Paleontology (Harrington, Moore and Stubblefield in Moore, 1959, p. 0 117). That used in describing trinucleid trilobites follows Whittard (1955), who in turn based it on earlier work by Reed and Bancroft, but minor modifications suggested by Stäuble (1953) and Hughes (1971) are also incorporated.

Family AGNOSTIDAE M'Coy, 1849
Genus *Geragnostus* Howell, 1935

Type species. *Agnostus sidenbladhi* Linnarsson, 1869.

Geragnostus sp.
Plate 1, figures 1, 2, 4

Figured specimens. GSC 32723 (Pl. 1, figs. 1, 2), GSC 32724 (Pl. 1, fig. 4).

Description. An incomplete internal mould of the cranidium is much distorted but shows the characteristics of the genus. The glabella and occipital ring occupy together about four fifths of the median cranidial length, and traces remain of the left occipital lobe. The cephalic border is broadest (sag.) frontally and becomes narrower towards the genal angles which, as shown by the left side, are marked by a pair of short fixigenal spines formed by the lateral expansion of the posterior border.

A single fragment of pygidium (Pl. 1, fig. 4) shows the axis to be broad, about two fifths (est.) of the overall breadth and more than half the length, its outline tapering only gently towards the bluntly rounded tip. There are traces of two axial rings which together occupy over half the length of the axis; the second axial ring exhibits remains of a median tubercle. The portion of the border remaining shows it to be broad, convex, separated by a broad, shallow border furrow from the slightly narrower, confluent pleural fields.

Discussion. As far as may be judged the characters of the material from Virgin Arm agree essentially with those of the type species *G. sidenbladhi* (Linnarsson), redescribed from the upper Tremadoc Series of Sweden by Tjernvik (1956, p. 188, pl. 1, figs. 5, 6). This is particularly true of the cranidium but the Newfoundland pygidium, though fragmentary, clearly has the axis relatively larger and wider.

Identification of such poorly preserved material is unsatisfactory but the cranidium is not unlike that of *Geragnostus* sp. from the Shin Brook Formation of Maine figured by Whittington (in Neuman, 1964, p. E25, pl. 5, figs. 2-5, 7, 8); the pygidium of the American species has the axis slightly more tapered and the two axial rings occupy proportionately less of the length of the axis.

Family HARPIDAE Hawle and Corda, 1847
Genus *Scotoharpes* Lamont, 1948

Type species. *Scotoharpes domina* Lamont, 1948
Subjective synonyms. *Aristoharpes* Whittington, 1950; *Selenoharpes* Whittington, 1950.

Scotoharpes sp.
Plate 1, figures 3, 8, 11, 13

Figured specimens. GSC 32725 (Pl. 1, figs. 11, 13), GSC 32726, (Pl. 1, fig. 8), GSC 32727 (Pl. 1, fig. 3).

Description. Only three incomplete cranidia are available. The state of preservation is extremely fragile, so that the plastic casts used in illustration do not show all the detail seen on external moulds. The most complete, and smallest, specimen shows the outline in front of the posterior border to be almost semicircular, with the median length little more than half the maximum breadth. The glabella is roughly as broad as long with a single pair of small basal glabellar lobes equal to about one quarter of the median length, and the occipital ring carries a small median tubercle. The glabella stands much higher than the cheek lobes and its outline tapers gently to the broadly rounded frontal glabellar lobes. The glabella of the smallest specimen is relatively narrower posteriorly, a feature described also by Whittington (1965, p. 313) for *Selenoharpes singularis.* The axial furrows are narrow frontally but become markedly wider posteriorly to form depressed, triangular areas that contain a pair of low, indistinct alae immediately outside the basal glabellar lobes. The cheek lobes are strongly convex, their adaxial margins sharply defined and ridge-like anteriorly, becoming less so posterolaterally. The apex of each is marked by a conspicuous eye-tubercle from which a well-defined eye-ridge runs slightly forwards to the axial furrow, and a less distinct genal ridge runs back more strongly to end at the cephalic fringe. The preglabellar field is narrow (sag.) and shows traces of radiating genal caeca which become clearer on the cheek lobes and run across the surface of the fringe. The last-named is broad, slightly concave dorsally, has a prominent external rim, and show only traces of a smooth band on the dorsal lamella indicating the position of a girder which appears deep and narrow on the external mould and apparently meets the internal rim of the genal prolongations not far from the ends of the posterior border.

Dimensions (mm). (EM) = external mould.

	GSC 32725	GSC 32726
Max. breadth of cranidium	13.0 (EM)	———
Median length of cranidium	7.0 (EM)	———
Length of glabella	2.4 (EM)	4.4 (EM)
Basal breadth of glabella	2.0 (EM)	4.5 (EM)
Distance across eye-tubercles	3.3 (EM) est.	8.0 (EM)

Discussion. The type and other species of *Scotoharpes*, and the synonymy of the genus have recently been discussed by Norford (1973). The material from Virgin Arm shows most of the generic features enumerated by him but is too incomplete for specific identification and discussion is restricted to a few general comments.

Scotoharpes singularis (Whittington, 1965, p. 312, pls. 8, 9) from the Table Head Formation of western Newfoundland, though generally similar to the present form, has a relatively longer cranidium and a proportionately larger, longer glabella, a feature that appears even more conspicuously on small individuals, which have also a narrower fringe. *S. vitilis* (Whittington, 1963, p. 32, pl. 2, figs. 4-8; pl. 3), of similar age and from Lower Head, Newfoundland, has a broader fringe and more elongated cranidial outline than the species described here, but the glabella is of similar form and the occipital ring carries a median tubercle, a feature not seen in the type species. *S. excavatus* (Linnarsson, 1875) (see Whittington, 1950b, p. 303, pl. 1, figs. 1-3), from the *Megistaspis planilimbata* Zone (= Lower Arenig pars) of Sweden, was said to be one of the oldest known harpids. Genal caeca and alae are more strongly developed and the basal breadth of the glabella is greater than on the material from Virgin Arm but the general configuration is otherwise similar.

Family TRINUCLEIDAE Hawle and Corda, 1847
Subfamily TRINUCLEINAE Hawle and Corda, 1847
Genus *Bergamia* Whittard, 1955

Type species. *Bergamia rhodesi* Whittard, 1955

Bergamia? sp.
Plate 2, figures 3, 5, 7

Figured specimens. GSC 32740 (Pl. 2, fig. 7), GSC 32741 (Pl. 2, fig. 3), GSC 32742 (Pl. 2, fig. 5).

Description. Two trinucleid genera belonging to different subfamilies occur in the material from Virgin Arm. *Bergamia*? sp. is represented by only three fragments, the most complete of which (GSC 32740, Pl. 2, fig. 7) shows that the surface of the cheek lobe is reticulated, with a lateral eye tubercle, and that on the dorsal lamella at least most of the fringe pits, both E and I arcs, are located in well-developed radial sulci. The external mould of the ventral lamella of this specimen does not have the sagittal line clearly distinguishable but it is likely that the full half-fringe is present, with fourteen radial sulci located external to a strongly developed girder. E_1 extends from R1 - R14 and E_2 from R1 - R13, whilst an incipient E_3 arc is present from R6 - R11, a feature not usually seen in *Bergamia*. Also on the ventral lamella, the region internal to the girder is occupied posterolaterally by up to four I arcs; frontally the number is obscured by crushing but is unlikely to be more than two, and I_{1-2} converge adaxially at R4. I_1 extends from R1 - R14, but at R11 begins to diverge from a small subsidiary arc (not readily termed I_2) which extends thence to the fringe frame. The genal angle is not preserved on this specimen but is shown by a fragmentary external mould (GSC 32742, Pl. 2, fig. 5) which retains the impression of part of the posterolaterally directed librigenal spine together with the remains of five arcs, and five pits along the fringe frame.

GSC 32741 (Pl. 2, fig. 3) shows clearly the strong development of the girder, ornamented by fine, longitudinal terrace lines. Immediately in front of the glabella on this specimen only two arcs are visible and form twinned pits near the sagittal line; judging from the convergence of I_{1-2} noted above it is likely that the twinned pits represent arcs I_1 and I_3.

Discussion. The specimens are assigned to the Subfamily Trinucleinae, members of which have been described by Whittard (1955) and Hughes (1971). According to Hughes (1971, p. 119) the absence of eye tubercles and ridges is a characteristic of the subfamily, but in this instance the former are present on a trilobite that is otherwise a trinucleinid on the basis of the glabella and cephalic fringe. *Bergamia* sp. nov. from the highest beds of the Summerford Group elsewhere in New World Island (Dean, 1971, p. 5) also possesses lateral eye tubercles, whilst both eye tubercles and ridges are known from trinucleinids in the Oslo region of Norway. *Trinucleus* s. s. has only one E arc of pits, whilst *Bergamia* customarily has E_1 complete together with a variable development of E_2. The species from Virgin Arm is probably new but the available material is insufficient to decide whether the partial development of an E_3 arc merits generic discrimination.

Subfamily TRETASPIDINAE Whittington, 1941
Genus *Paratretaspis* nov.

Type species. *Paratretaspis terranovica* sp. nov.

Diagnosis. Cranidium with prominent pairs of lateral ocelli and eye ridges; alae and, probably, median ocellus weakly developed. Strong reticulate ornamentation on surface of glabella and cheek lobes. Occipital spine absent. Cephalic fringe broad with fringe pits, excluding those of outermost arc (E_2), showing conspicuous radial arrangement. Two E arcs discrete laterally, crowded together frontally, the pits of E_2 being smaller, more numerous and less regularly arranged than those of E_1. Concentric ridge on dorsal lamella between I_1 and I_2 separates cheek roll and brim. Up to four I arcs present frontally, the pits of I_{3-4} being twinned; radial sulci containing pits of I_{2-4} present frontally and anterolaterally, where up to six I arcs may be developed. Ventral fringe lamella has strongly developed girder and pits of I arcs are set in radial sulci.

Paratretaspis terranovica sp. nov.
Plate 1, figures 5-7, 9, 10, 12; Plate 2, figures 1, 2, 4, 6, 8-10

Diagnosis. As for genus.

Holotype. GSC 32736 (Pl. 2, figs. 2, 9).

Paratypes. GSC 32728 (Pl. 1, fig. 12), GSC 32729 (Pl. 2, figs. 4, 6), GSC 32731 (Pl. 2, fig. 8), GSC 32732 (Pl. 2, fig. 1), GSC 32733 (Pl. 1, fig. 9), GSC 32734 (Pl. 1, fig. 5), GSC 32735 (Pl. 1, fig. 10) GSC 32737 (Pl. 1, fig. 6), GSC 32738 (Pl. 1, fig. 7), GSC 32739 (Pl. 2, fig. 10).

Description. The bluntly-rounded cephalic outline is subsemicircular, with the genal angles set slightly behind a transverse line through the occipital ring. The cephalon is strongly convex both longitudinally and transversely, and the fringe is steeply declined both laterally as well as frontally where the fringe margin is gently arched transversely. The glabella is roughly pear-shaped in plan, broadly rounded frontally, expanding forwards from the occipital furrow so as to double its breadth in about two thirds its length. There is no clearly differentiated occiput such as is found in *Tretaspis*, but the glabellar furrows are of similar type, represented by two pairs of smooth, suboval depressions on the sides of the glabella and delimiting two pairs of small glabellar lobes. The glabellar surface is ornamented with a closely reticulate pattern of ridges which is coarsest at the apex and becomes finer towards the front of the glabella and the axial furrows. Only traces of a medium ocellus have been noted, but this part of the exoskeleton is not clearly preserved. The front half of the glabella is bounded by well-defined, deep, broad axial furrows which run as far as their intersection with the eye ridges. Behind the ridges the sides of the glabella become less steep and pass laterally into a pair of depressed, subtriangular areas which extend to the posterior border furrow. The adaxial portions of the subtriangular areas show a pair of faint, longitudinal swellings representing alae, the surface of which is closely reticulated, though that of the remainder of the areas carries an unusually open mesh pattern of thin ridges. An unusual feature here is the manner in which the reticulate ornamentation of the cheek lobe traverses the area customarily occupied by a smooth axial furrow to link with that of the glabella (see Pl. 1, fig. 5). Each of the quadrant-shaped cheek lobes carries a lateral ocellus sited well back posterolaterally, from which a low eye ridge runs slightly forwards adaxially to end at, and indent, the axial furrow. Both ocellus and ridge are obscured by a conspicuous reticulate pattern of ridges which is coarsest at the summit of the cheek lobe and becomes finer anterolaterally. The occipital ring is short (sag.), steeply inclined posteriorly, with no trace of an occipital spine. The posterior border furrow is broad (exsag.) and deep, parallel to the posterior border which is narrow (exsag.), transversely straight and horizontal except at its lateral extremities, where it flexes down slightly and passes into the fringe frame. The genal prolongations are small, running only slightly back from the narrow (exsag.) posterior border to the genal angles which are produced to form a pair of gently curved, slightly splayed librigenal spines.

The cephalic fringe is broad, its dorsal lamella comprising a moderately-declined, convex cheek roll bounded by a narrow, gently declined, concave brim. The fringe margin is marked by a narrow, smooth rim which appears thickest frontally, where it is slightly curled upwards. Fringe-pits are numerous and, except for those of arc E_2, give a striking overall impression of regular radial and concentric arrangement. A low concentric ridge between arcs I_1 and I_2 is only weakly developed frontally but becomes gradually more noticeable beyond about R4 and is well developed and broader anterolaterally and laterally, though whether it extends as far as the posterior margin of the fringe is not clear. The ridge marks the boundary between cheek roll and brim. Traces of other concentric ridges are seen anterolaterally, especially between I_2 and I_3, but appear less noticeable owing to the dominance of radial sulci on the cheek roll. There are two arcs of E pits. Those of E_1 are the larger and maintain an arrangement almost radially in-line with that exhibited by the I arcs. The exact number of pits in the principal arcs is difficult to assess, owing to the fragmentary nature of the material, but estimated pit-counts for half the fringe are as follows: - E_2 not seen in entirety but probably at least 40 small pits; E_1 20-24; I_1 20-23; I_2 20-23; I_3 20-23; I_4 no count available but developed at least from R6, whilst earlier radii may include twinned pits of

I_{3-4}; I_5 no count available, but arc developed from R8 and possibly a little earlier. The pits of E_1 are almost as large as those of I_{1-2} but the pits of E_2 are notably smaller. Although E_1 and E_2 are clearly distinguishable in the lateral and antero-lateral parts of the fringe, frontally they converge, become crowded together, and the concentric arrangement of the pits in E_2 is less orderly (see Pl. 1, fig. 10). E_2 may also be difficult to distinguish owing to its being partially overhung by the curled rim of the cephalon. Other pits which cannot readily be accommodated within the numbered arcs occur posterolaterally, internal to I_3, but are insufficiently well preserved for accurate counts.

The thorax is almost unrepresented in the present sample but fragmentary segments show nothing to distinguish them from other trinucleids. A small incomplete pygidium associated with part of an enrolled thorax and cephalon (Pl. 1, fig. 6) is the only one available. Of typical trinucleid form it is subtriangular in outline and very short with transversely-straight anterior margin. The low, gently tapered axis has three axial rings and a small terminal piece which merges with a low rim bordering the pleural regions. The latter show a pair of anterior half-ribs, one pair of ribs bounded by shallow, incised pleural furrows, and there is a suggestion of a second pair of ribs.

Dimensions (mm). (IM) = internal mould, (EM) = external mould

	GSC 32728	GSC 32729	GSC 32733	GSC 32736
Max. breadth of cranidium	6.5 (IM) est.	7.2 (IM) est.	7.5 (EM) est.	6.6 (IM) est.
Median length of cranidium	______	2.8 (IM) est.	3.0 (EM)	______
Length of glabella	______	______	2.3 (EM)	2.1 (IM)
Max. breadth of glabella	______	1.8 (IM) est.	1.7 (EM)	1.5 (IM)

Discussion. *Paratretaspis* shares with *Tretaspis* a number of important features considered here to indicate close affinities between the two genera. These include: strongly-developed reticulation of the surface of both glabella and cheek lobes; presence of lateral ocelli and eye ridges; absence of an occipital spine; frontal development of an upwardly curled rim that dies out laterally; clear division of the cephalic fringe into cheek roll and brim; the presence of concentric ridges between arcs on the cheek roll; strong development of radial sulci on the cheek roll (i.e. extending outwards to include I_2 but not I_1), particularly frontally; the equally strong development of radial sulci on the ventral lamella to include all I arcs.

Characters by which the two genera may be distinguished are as follows: all the fringe-pits of *Paratretaspis* are relatively smaller than is customary in *Tretaspis;* pits of arc E_2 in *Tretaspis* are not usually very different in size from those of adjacent arcs, whereas in *Paratretaspis* they are noticeably small and numerous, crowded together with no radial arrangement; on the dorsal fringe lamella of *Tretaspis* the well-marked radial arrangement includes both the E and the I arcs, but in *Paratretaspis* no such arrangement is seen; when reticulation of the cephalic surface is developed in *Tretaspis* it is generally confined to the higher portions of the glabella and cheek lobes, whereas in *Paratretaspis* it traverses the axial furrows and alar lobes.

The proliferation of pits reduced in size and located in arcs external to E_1, though unknown in *Tretaspis*, has been described in cryptolithinid genera such as *Salterolithus* and *Smeathenia* whilst its occurrence in the Tretaspidinae is demonstrated by *Decordinaspis bispinosa* Harper and Romano (1967) from the Caradoc Series of Ireland, a curious form in which the total number of arcs (including E_{1-3}) and pits is unusually large.

Although *Tretaspis* was particularly widespread and abundant in the Ashgill Series of Europe and Scandinavia, where species have proved of zonal value, the genus had a much longer vertical range and the earliest-known representatives have been described from the Porterfield Stage (about Llandeilo Series) of the southern Appalachians. *Paratretaspis* is the oldest described member of the Tretaspidinae and although its own origins are obscure, and its relationship to other early Ordovician trinucleids is not yet clear, the genus may provide a suitable ancestor for *Tretaspis*.

Family CHEIRURIDAE Hawle and Corda, 1847
Subfamily ECCOPTOCHILINAE Lane, 1971
Genus *Pseudosphaerexochus* Schmidt, 1881

Type species. *Sphaerexochus hemicranium* Kutorga, 1854.

Pseudosphaerexochus (s. l.) sp.
Plate 3, figures 1-3, 5, 6; Plate 4, figures 5, 7

Figured specimens. GSC 32750 (Pl. 3, figs. 1, 2), GSC 32751 (Pl. 3, figs. 3, 5), GSC 32752 (Pl. 3, fig. 6), GSC 32753 (Pl. 4, fig. 7), GSC 32754 (Pl. 4, fig. 5).

Description and Discussion. The cranidium is represented by only four fragmentary specimens, the largest of which (GSC 32750, Pl. 3, figs. 1, 2) shows part of the occipital ring plus an incomplete, strongly convex glabella with suboval outline and three pairs of lateral glabellar furrows, the 2p and 3p pairs forming only shallow, curved incisions even on the internal mould, the 1p pair broader, deep, curving backwards towards, but not attaining, the occipital furrow. This specimen appears not to have been appreciably distorted and the glabellar outline is slightly narrower than is customarily found in *Pseudosphaerexochus*, early Ordovician species of which are uncommon. Part of another cranidium (GSC 32752, Pl. 3, fig. 6) has its convexity distorted but again shows the incompletely circumscribed 1p glabellar lobes so characteristic of the genus, together with most of the occipital ring, which curves around the base of the 1p lobes. Both these specimens show the glabella to be a little narrower than that of *Pseudosphaerexochus (Pateraspis) pater* (Barrande, 1872), the type species of the subgenus and founded on material from the Šárka Beds, Llanvirn Series, of Bohemia (see Prantl and Přibyl, 1948, p. 30, 35, pl. 3, figs. 11, 12) where it ranges upwards into the Svatá Dobrotivá Beds of Llandeilo age. The 1p glabellar lobes of GSC 32750 are slightly smaller than those of *P. (P.) pater* and the frontal glabellar lobe is a little longer but otherwise the glabella is generally similar, though further comparison is not practicable. The 1p lobes of this Newfoundland specimen may better be compared with those of *P. (Pateraspis) inflatus* Poulsen (1965, p. 104, pl. 9, figs. 1-9) from the Arenig Series of Bornholm, but the latter species has the glabella more strongly arched and the frontal lobe is slightly shorter.

The smallest Newfoundland cranidium (GSC 32751, Pl. 3, figs. 3, 5), although slightly crushed, shows three pairs of almost equisized lateral glabellar lobes and the glabellar outline is expanded anteriorly, a feature found developed to an even greater degree in the Swedish species *Pseudosphaerexochus praecursor* Regnéll (1940, p. 12, pl. 1, figs. 6a-c). The latter, from the Planilimbata Limestone of Öland and of Lower Arenig age, has been referred to *P. (Pateraspis)* by Poulsen (1965, p. 105) and differs from the present species in having a more spherical glabella and proportionately shorter frontal glabellar lobe.

A single incomplete pygidium (GSC 32754, Pl. 4, fig. 5) has the axis broken and abraded but exhibits, nevertheless, the remains of three axial rings and a small, triangular terminal piece. The abaxial portions of the right halves of two pairs of thick ribs with traces of surface granulation are preserved, though not their lateral terminations, whilst the posterior margin appears deeply indented between the remains of a pair of broad, well-developed, third pleural spines. The general configuration suggests that the specimen belongs with the cranidia described above but no satisfactory comparison is possible.

Dimensions (mm). (IM) = internal mould; (EM) = external mould.

	GSC 32750	GSC 32751	GSC 32752
Median length of cranidium	______	2.2 est (IM)	______
Median length of glabella	4.2 est. (IM)	1.8 (IM)	______
Max. breadth of glabella	3.2 est. (IM)	2.0 (IM)	3.8 (IM)

Family ENCRINURIDAE Angelin, 1854
Genus *Encrinuroides* Reed, 1931

Type species. *Cybele sexcostata* Salter, 1848

Encrinuroides hornei sp. nov.
Plate 3, figures 4, 7, 8-13

Diagnosis. Proparian trilobite with glabellar outline expanded forwards, well rounded frontally and indented by median longitudinal furrow. Three unequal pairs of lateral glabellar lobes present, diminishing in size from 3p to 1p and delimited by deep, transversely-straight glabellar furrows. The portion of the preglabellar field behind the facial suture is narrow (sag.) medially, expands abaxially. Suggestion of short (tr.), transversely-straight rostral suture. Axial furrows deep; no evidence of anterior pits. Eyes probably stalk-like, bounded by wide furrows and located more than half-way from axial furrows to lateral margin and opposite 2p glabellar lobes. Surface of glabella and occipital ring ornamented with coarse tubercles; that of fixigenae with low tubercles and shallow pits. Pygidium has five pairs of ribs, the first three pairs ending in free points. Up to eight axial rings, followed by very small terminal piece; last four rings defined only laterally. Pygidial surface ornamented with small tubercles.

Holotype. GSC 32743 (Pl. 3, fig. 13).

Paratypes.. GSC 32744 (Pl. 3, fig. 12), GSC 32745 (Pl. 3, figs. 4, 7), GSC 32746 (Pl. 3, fig. 9), GSC 32747 (Pl. 3, fig. 8), GSC 32748 (Pl. 3, fig. 10), GSC 32749 (Pl. 3, fig. 11).

Description. The exoskeleton is known only from isolated cranidia and pygidia. The cranidium is only moderately convex both longitudinally and transversely, with a median length about half the maximum breadth, which it attains posteriorly. The glabella is relatively large, subclavate in outline with maximum breadth, measured across the frontal glabellar lobe, two fifths that of the cranidium. The frontal glabellar lobe is broadly rounded in plan, slightly more than twice as broad as long, and occupies about or a little more than two fifths of the median glabellar length; at the axial sagittal line it carries a longitudinal furrow which is deepest at its intersection with the preglabellar furrow but becomes shallower as it extends backwards to the centre of the frontal glabellar lobe. The term "longitudinal furrow" employed here follows the usage of Whittington (1950a, text-fig. 2) but the structure has also been termed "anterior medial furrow" by both Whittington (1950a, p. 538) and Henningsmoen (in Moore, 1959, p. 0 447). The remainder of the glabella is occupied by three well-defined unequal pairs of lateral glabellar lobes which diminish evenly in size from 3p to 1p; these are separated by transversely-straight pairs of lateral glabellar furrows, of which the 2p and 3p furrows end abaxially in apodemes. The 1p lateral lobes are very small, only about half the length (exsag.) of the 3p lobes, delimited by 1p lateral glabellar furrows which are narrow (exsag.) and deep, each extending across about one third of the glabellar breadth and linked by a shallow transglabellar furrow, the result being a poorly-defined basal glabellar segment. The 2p lateral furrows are of similar breadth (exsag.) and depth, joined by a still fainter transglabellar furrow. The 3p lateral furrows are shorter (tr.) than those of the other pairs, do not end in apodemes, and there is no more than a mere suggestion of a transglabellar furrow connecting them. The frontal glabellar lobe is separated by a well-defined preglabellar furrow from a convex, ridge-like structure that is interpreted, by analogy with other encrinurids, as the posterior portion of the preglabellar field. The latter runs parallel to the front of the glabella, ends in swollen extremities, and becomes slightly narrower medially where its otherwise smooth outline, formed by the facial suture, shows evidence of a short (tr.), transversely-straight rostral suture that is best seen on paratype GSC 32744. There is no sign of anterior pits in the axial furrows at the ends of the preglabellar furrow. The occipital furrow is transversely straight overall, shallowest medially and ends in a pair of conspicuous apodemes. The occipital ring is short (sag.) and straight for the most part, extends abaxially beyond the base of the glabella and curves forwards around the apodemes of the occipital furrow to form a pair of small occipital lobes, immediately behind which the posterior margin of the cephalon is indented to form a pair of articulating sockets. The axial furrows appear notably wide (tr.) on the internal mould, well rounded ventrally in cross-section. Their abaxial margins slope steeply to the fixigenae and the junction of the two structures is marked by a sharply-defined edge; the adaxial margins are overhung not only by the lateral glabellar lobes and posterolateral portions of the frontal glabellar lobe, but also by the swollen ends of the preglabellar field. The posterior border is narrow (exsag.) at the axial furrows, becoming broader at the genal angles which are produced abaxially backwards to form a pair of slim, fixigenal spines. The well-defined posterior border furrow is evenly broad (exsag.), transversely straight to within only a short distance of the lateral margin and then curves strongly forwards; the librigenae have not been found but the lateral border must have been fairly narrow. The eyes are set well apart, the distance between each eye and the axial furrow being approximately two thirds of the adjacent glabellar breadth, and opposite the 2p lateral glabellar lobes and furrows. The holotype shows the palpebral lobes to have been smooth and stalk-like, each separated from the fixigena by a broad, shallow furrow. The anterior branches of the facial suture converge strongly forwards to cut the axial furrows a short distance in front of the 3p glabellar furrows and then form a broad curve around the front of the cranidium, broken only by the short (tr.) rostral suture noted earlier. The posterior branches are short and curve backwards only a little before cutting the lateral margins.

The pygidium is moderately convex both longitudinally and transversely, wider than long, though the exact proportions are difficult to measure. The straight-sided axis stands higher than the pleural regions and is subtriangular in plan with frontal breadth about one third that of the pygidium. It comprises the articulating half-ring and up to eight axial rings which diminish in size posteriorly and are followed by a diminutive, narrow terminal piece. The first two axial rings are defined clearly by entire ring furrows but succeeding rings become progressively more indented at the sagittal line, and behind the fourth ring the axis carries a conspicuous median band which is smooth apart from occasional small tubercles similar in size to others that are arranged transversely along each axial ring. The anterolateral portion of each pleural region is smooth, slightly concave and flange-like showing no obvious development of a facet. Behind are five pairs of curved ribs, the first three of which are distinct and strongly developed, separated by deep, broad pleural furrows. The fourth ribs are subparallel and less distinct whilst those of the fifth pair are separated from the terminal piece of the axis by only a pair of shallow grooves. In plan the ribs of the first pair form gently sigmoidal curves and end in a pair of small, sharp free points set slightly above the lateral margin. The second and third pairs of ribs are progressively less curved with shorter free points, and the fourth pair form only small, node-like terminations. All the ribs, even those of the poorly-defined fifth pair, are higher and slightly swollen immediately outside the axial furrows; their surface is ornamented with tubercles and GSC 32749, an external mould, shows these to be of similar size to those of the axial rings, but arranged in two subparallel rows along each rib.

Dimensions (mm). IM = internal mould; EM = external mould.

	GSC 32743		GSC 32744		GSC 32745		GSC 32746	
Max. breadth of cranidium	5.4 est.	(IM)	5.0 est.	(IM)	6.4 est.	(EM)	———	
Median length of cranidium	2.8	(IM)	2.7	(IM)	———		———	
Median length of glabella	2.2 est.	(IM)	2.1	(IM)	———		———	
Max. breadth of glabella	2.1	(IM)	1.9	(IM)	2.4	(EM)	———	
Distance across palpebral lobes	4.0 est.	(IM)	3.5 est.	(IM)	5.0 est.	(EM)	———	
Median length of pygidium	———		———		———		1.8	(IM)
Max. breadth of pygidium (excluding free points)	———		———		———		2.6 est.	(IM)
Frontal breadth of axis	———		———		———		1.0	(IM)

Discussion. The type species *E. sexcostatus* (Salter) has been redescribed by Whittington (1950a, p. 535) from the Ashgill Series of both North and South Wales, where it occurs respectively in the Rhiwlas Limestone and Shoalshook Limestone. According to Whittington *Encrinuroides* may be distinguished from *Encrinurus* by the following features: presence of a preglabellar furrow and anterior medial furrow; the outline of the glabella; well-defined lateral glabellar lobes; the pygidium is broader than long. On the basis of these criteria the new species may best be assigned to *Encrinuroides,* and additional features resembling the type species include the direction and degree of development of the lateral glabellar furrows; the shape and size of the preglabellar field behind the facial suture (the remainder is not known); and the development of small fixigenal spines. To these may probably be added the possession of pedunculate eye lobes, though the evidence is incomplete. The cranidium of *E. hornei* differs from *E. sexcostatus* in that: the eyes are set slightly farther back; the glabella is more coarsely tuberculated; and the rostral plate was probably broader (tr.), assuming that the above interpretation of the rostral suture is correct. The pygidia of the two species are more distinct but both have a well-defined axis with several axial rings and a triangular terminal piece, the rings of the posterior part of the axis becoming obsolete at the sagittal line. The pygidium of *E. hornei* differs in having a larger, wider axis with fewer rings, as well as proportionately shorter (tr.), fewer ribs with generally longer free points set higher above the pygidial margin.

Other species of *Encrinuroides* occur at various horizons in the Ordovician of the Girvan district, Scotland, where the faunas are of Appalachian type. *E. autochthon* Tripp (1962, p. 22, pl. 3, figs. 18-25), from the "Confinis" Flags and of Porterfield age, has a cranidium very like that of *E. hornei* but the glabella is relatively narrower and the glabellar furrows are slightly shorter (tr.), the basal glabellar segment is smaller; and the eyes are set farther forwards. The largest illustrated pygidium of *E. autochthon* is longer than required by the generic diagnosis and has seven or eight pairs of ribs, but immature pygidia, including the original of Tripp, 1962, pl. 3, fig. 25, were said to lack the full number of segments, to have the axis wide frontally, and to have the first four pairs of ribs ending in long, outturned, free points. All these last features are found in *E. hornei.*

Family DIMEROPYGIDAE Hupé, 1953
Genus *Ischyrophyma* Whittington, 1963

Type species. *Ischyrophyma tuberculata* Whittington, 1963

Ischyrophyma sp.
Plate 5, figures 2, 4

Figured specimen. GSC 32755.

Description and Discussion. A single poorly-preserved fragment of cranidium is the sole example of the genus in the present sample. The convexity of the front of the glabella has been exaggerated by crushing but the glabellar outline is seen to be well rounded anteriorly. The remaining left side of the glabella retains the 2p lateral glabellar lobe and part of the larger 1p lobe; the two are connected by a smooth and only slightly indented area corresponding to the abaxial portion of the 1p lateral furrow, the adaxial portion of which forms a deep, slot-like depression. The narrow fixigena shows evidence of the left palpebral lobe approximately opposite the 2p lateral glabellar lobe. The surface of fixigena and glabella, excluding furrows, has a prickly appearance and is covered with closely grouped tubercles of moderate size.

The type species of the genus, *Ischyrophyma tuberculata* Whittington (1963, p. 48, pl. 8, figs. 1-10) from the Table Head Formation of Lower Head, western Newfoundland, has a notably more tumid glabella than the present form, whilst the tuberculation of the exosketeton is much coarser and the 2p lateral lobes are less distinct. Similarly convex is *I. tumida* Whittington (1965, p. 339, pl. 19, figs. 6-12, 15) from the middle Table Head Formation, a species in which the glabellar outline is almost parallel-sided and the 1p lateral furrows are more divergent forwards. Specific identification is virtually impossible but a closer comparison may, perhaps, be made with *Ischyrophyma marmorea* Dean (1970, p. 4) from the Lushs Bight Group, and of Arenig age, in the area southwest of the western end of Notre Dame Bay, Newfoundland; the latter species, although possessing four pairs of lateral glabellar lobes, has apparently similar ornamentation whilst the size of the 2p lateral lobes, the elongation of the 1p lobes and the indentation of the 1p furrows are comparable.

Family ODONTOPLEURIDAE Burmeister, 1843
? Subfamily Apianurinae Whittington, 1956
Odontopleurid gen. et sp. undetermined
Plate 5, figures 1, 3

Figured specimen. GSC 32761.

Description. A fragment of the internal mould of a cranidium is the only odontopleurid found in the sample from Virgin Arm. The remains of the glabella show it to have been steeply declined anteriorly and moderately convex transversely; the posterior portion of the fronto-median lobe is only weakly defined laterally by broad, shallow, longitudinal furrows which separate it from the scarcely discernible 1p lateral glabellar lobes. The occipital furrow is broad (sag.) and shallow, gently concave forwards or almost straight. The large occipital ring is longest medially and there is no distinct subdivision into anterior and posterior bands; what is judged to be the posterior band at the extremities of the occipital ring is extended abaxially to form the posterior border.

The posterior margin of the occipital ring is produced upwards and abaxially backwards to form the bases of a pair of stout occipital spines. The anterior band has a conspicuous, though not particularly large, median tubercle sited a short distance behind the occipital furrow. The surface of the glabella, excluding furrows, is covered with closely grouped tubercles, a form of ornamentation virtually absent from the occipital ring, where only an occasional smaller tubercle is visible to either side of the median tubercle and on the basal portion of the occipital spines.

Discussion. In northeastern Maine an assemblage of trilobites from the Shin Brook Formation of suggested Whiterock age contains, *inter al.*, *Annamitella?* and an odontopleurid referred to "Miraspinid gen. undet." by Whittington (in Neuman, 1964, p. E32, pl. 7, figs. 13, 14, 16, 18). The latter trilobite, like the specimen from Virgin Arm, has a long occipital ring with a prominent pair of occipital spines and a median occipital spine. The last named is more prominent than that of the Newfoundland specimen, and the median glabellar lobe of the Maine material is almost parallel-sided, bounded by deep furrows, so it is unlikely that the two belong to the same subfamily. A better assignment may perhaps be made to the Subfamily Apianurinae, members of which exhibit a similar association of long occipital ring with a median spine or tubercle immediately in front of a pair of stout occipital spines. Definite generic assignment is not possible but some comparison may be made with *Apianurus* and *Calipernurus*, both described by Whittington (1956, p. 252, 271). Another apianurinid *Boedaspis*, described from the Lower Ordovician of Sweden by Whittington and Bohlin (1958, p. 38), has ornamentation of the glabella not unlike that of the present specimen, but the tubercles extend across the occipital ring and the occipital furrow is less well defined.

Family LICHIDAE Hawle and Corda, 1847
Genus *Metopolichas* Gürich, 1901

Type species. *Metopias hübneri* Eichwald, 1842.
Subjective synonym. *Macroterolichas* Phleger, 1937.

Metopolichas cf. *M. verrucosus* (Eichwald)
Plate 4, figures 1-4, 6, 8, 9

Metopias verrucosus Eichwald, 1842, p. 63, Pl. 3, figs. 23a, b.

Lichas verrucosus (Eichwald), Warburg, 1939, p. 17, Pl. 3, figs. 1-6. Includes comprehensive synonymy prior to 1939.

Metopolichas verrucosus verrucosus (Eichwald), Tripp, 1958, p. 575.

Metopolichas verrucosus (Eichwald), Tripp in Moore, p. 0 496, Fig. 392, 1c.

Figured specimens. GSC 32756 (Pl. 4, figs. 1, 4), GSC 32757 (Pl. 4, fig. 3), GSC 32758 (Pl. 4, figs. 2, 6), GSC 32759 (Pl. 4, fig. 9), GSC 32760 (Pl. 4, fig. 8).

Description and discussion. Warburg (1939, p. 17) has already described the species in considerable detail and it remains only to compare her relatively well-preserved Scandinavian specimens with the less than pristine material from Virgin Arm. The most complete Newfoundland cranidia (Pl. 4, figs. 1, 3, 4) are comparatively large members of the trilobite fauna, the larger specimen an internal mould having a basal glabellar breadth of 16. 3 mm. Both the figured cranidia have the front of the glabella bent strongly down and back, but the glabellar outline closely resembles that of Warburg's material and in particular the longitudinal furrows have similar hook-like posterior terminations, curving sharply around the posterior ends of the bicomposite glabellar lobes and then dying-out rapidly. Compared with Warburg's figured specimens the occipital furrow is transversely straight or very slightly convex forwards rather than straight or slightly concave, and the well-defined occipital lobes occupy a little less of the length (exsag.) of the occipital ring, though they are comparable with those of a Baltic specimen illustrated by Schmidt (1907, pl. 1, fig. 20). The palpebral lobes of the Newfoundland specimens are not preserved intact but their position is fairly clear and corresponds to that of the Swedish specimens.

The most nearly complete hypostoma (Pl. 4, figs. 2, 6) agrees in many respects with those illustrated by Warburg (1939, pl. 3, fig. 3) and Tripp (in Moore, 1959, Fig. 392, 1c) but has its anterior margin arched forwards more strongly; the median body is slightly more parallel-sided; whilst the small anterior wings and lateral extremities of the posterior wings are set a little farther back. Such differences might be accounted for by tectonic distortion. The front of the median notch in the posterior margin of this figured specimen is well rounded but that of another example (GSC 32784, not illustrated) has the front of the notch transversely straight. The posterior wings of both specimens show a well-developed ornamentation of anastomosing ridges subparallel to the margin.

Neither of the two most complete pygidia shows all features satisfactorily though one (Pl. 4, fig. 9), preserved as an external mould too fragile for casting, agrees in several respects with the limestone specimen referred questionably to the species by Warburg (1939, pl. 3, figs. 5, 6). It differs, however, in that the axis, although of comparable length, is broader posteriorly and that both the pleural and interpleural furrows are both straighter and much less strongly curved backwards. Such differences may have been exaggerated by crushing. This specimen is interpreted as having one well-defined axial ring in addition to the articulating half-ring whereas Warburg described also a second ring that was defined only laterally. The other figured pygidium (Pl. 4, fig. 8) shows only the external mould of part of the doublure, a structure not described for this species by Warburg, and the internal mould of a fragment of the left pleural field. The doublure is broadest (sag.) medially and the ventral surface is seen to have been ornamented with widely spaced, anastomosing terrace lines. The inner margin is indented and forms a raised flange below the presumed tip of the axis, whence it follows an undulating course anterolaterally, flexing inwards approximately opposite the posterior band of each pleura. Pleural spines are not preserved but the bases of three pairs are apparent on the doublure.

Family ILLAENIDAE Hawle and Corda, 1847
Genus *Illaenus* Dalman, 1827

Type species. *Entomostracites crassicauda* Wahlenberg, 1821.

Illaenus (s.l.) sp.
Plate 5, figures 5, 6, 8-10, 12

Figured specimens. GSC 32762 (Pl. 5, fig. 10), GSC 32763 (Pl. 5, fig. 12), GSC 32764 (Pl. 5, fig. 9), GSC 32765 (Pl. 5, fig. 8), GSC 32766 (Pl. 5, fig. 6), GSC 32767 (Pl. 5, fig. 5).

Description. The cranidial outline is well rounded frontally, the distance across the palpebral lobes being slightly more than the median length. The overall convexity is only moderate and may be the result of dorsal compression. An internal mould of the axial region is not defined frontally but carries traces of a shallow occipital furrow and short (sag.) occipital ring; it is bounded by axial furrows that run forwards about half the length of the cranidium, converging at first, then diverging gently and becoming shallower. The eyes are small, sited well back, and the short posterior branches of the facial suture are strongly divergent backwards. The external mould of the doublure of a single right librigena shows it to be notably wide at the bluntly-rounded genal angle, becoming a little narrower adaxially. The adaxial margin forms a small, dorsally-directed flange, immediately outside which are several widely spaced, subparallel terrace lines.

A few fragmentary pygidia are available, the most complete of which has a sub-semielliptical outline with median length only a little more than half the maximum breadth. A poorly defined, subtriangular axis occupies about half the projected overall length, whilst the pleural regions are flat proximally but strongly arched down distally. A pair of small facets is present anterolaterally. The doublure is conspicuous, widest (sag.) at the sagittal line where its ventral surface carries a low axial ridge that narrows posteriorly and dies out without attaining the margin. To either side of the axial ring, the ventral surface is ornamented with widely spaced, anastomosing terrace lines. The front of the doublure extends forwards at points in-line with the axial furrows to form a pair of conspicuous, obtuse points separated by a broad, rounded notch.

Dimensions (mm). (IM) = internal mould, (EM) = external mould.

	GSC 32762	GSC 32763	GSC 32764	GSC 32765	GSC 32766
Median length of cranidium	15.0 (IM)	____	____	____	____
Basal breadth of axial region	7.7 (IM)	____	____	____	____
Distance across palpebral lobes	18.2 (IM)	____	____	____	____
Max. breadth of pygidium	____	17.8 (IM)	24.5 (IM)	22.8 (IM) est.	7.6 (IM)
Median length of pygidium	____	____	11.2 (IM)	____	5.5 (IM)
Frontal breadth of axis	____	6.0 (IM)	8.0 (IM)	9.0 (IM)	2.4 (IM)

Discussion. Several *Illaenus* species have been described from the Lower Ordovician, Whiterock Stage, of western Newfoundland but none can be compared satisfactorily with the present material. The Virgin Arm specimens are considered also to be distinct from *Illaenus* (s.l.) sp. described by Whittington (in Neuman, 1964, p. E30, pl. 7, figs. 1-7) from the Shin Brook Formation of Maine. The cranidium of the latter form has the axial region more strongly tapered forwards, the fixigenae are narrower, and the pygidium is notably shorter.

A closer comparison may be made with certain Lower Ordovician species from Scandinavia. In a review of illaenid trilobites Jaanusson (1954, text-figs. 10A, E) illustrated pygidia with the median portion of the doublure margin indented and bifid for *Illaenus sarsi* Jaanusson and *Stenopareia avus* Holm. Other species of both genera were shown with the margin of the doublure forming either an unbroken curve or a single median projection. The doublure of *Stenopareia avus*, an Ashgill species, is narrower and the pygidial axis less distinct than that of the present material, which more resembles the pygidium of *I. sarsi*. The latter was founded by Jaanusson (1954, p. 575) on material from the Expansus Limestone ($B_{III\alpha}$) (= upper Arenig pars) of Sweden and later described by him in greater detail (1957, p. 114). His account suggests that the present cranidium differs from *I. sarsi* in having a narrower glabella and wider fixigenae, but only minor features distinguish the pygidia, those from Newfoundland apparently being slightly shorter with a less well-rounded outline. The pygidium of *Illaenus aduncus* from the "Raniceps" limestone (= lowest Llanvirn Series) of Öland illustrated by Jaanusson (1957, pl. 6, fig. 6) also may be compared with GSC 32763 (see Pl. 5, fig. 12); the Swedish species differs only in having the overall outline more rounded posterolaterally and the doublure slightly narrower anterolaterally. Differences in the cranidium are difficult to assess owing to the lower convexity (due to compression) of the Newfoundland material.

Family BATHYURIDAE Walcott, 1886
Genus *Annamitella* Mansuy, 1920

Type species. *Annamitella asiatica* Mansuy, 1920.

Annamitella? insulana sp. nov.
Plate 5, figures 7, 11; Plate 6, figures 1-9; Plate 7, figures 1-10

Diagnosis. Glabellar outline subparallel-sided frontally, widens posteriorly. Three unequal pairs of lateral glabellar lobes present. Eye-lobes large, convex, set well back opposite posterior half of glabella. Deep axial furrows end behind pair of large anterior pits. Front of glabella poorly defined; anterior border not distinctly developed. Pygidium sub-semicircular with large straight-sided axis and up to eight axial rings. Pleural regions show unfurrowed, convex border and up to six pairs of ribs. Surface of cranidium ornamented with coarse, closely-grouped tubercles; that of pygidium smooth or almost so.

Holotype. GSC 32778 (Pl. 6, figs. 4, 5, 9).

Paratypes. GSC 32730 (Pl. 7, figs. 5, 9), GSC 32768 (Pl. 6, figs. 6-8), GSC 32769 (Pl. 7, figs. 8, 10), GSC 32770 (Pl. 7, fig. 2), GSC 32771 (Pl. 6, fig. 1), GSC 32772 (Pl. 7, fig. 4), GSC 32773 (Pl. 5, fig. 7), GSC 32774 (Pl. 6, fig. 3), GSC 32775 (Pl. 6, fig. 2), GSC 32776 (Pl. 5, fig. 11), GSC 32777 (Pl. 7, fig. 1), GSC 32779 (Pl. 7, figs. 6, 7), GSC 32780 (Pl. 7, fig. 3).

Description. The exoskeleton is known only from isolated cranidia, librigenae and pygidia, most of which have been tectonically distorted to a greater or lesser degree. The largest cranidium attained an estimated length of up to 26 mm, and smaller specimens indicate that a number of changes took place during ontogeny. The largest specimens of glabella show the outline of the frontal two thirds almost parallel-sided, becoming wider posteriorly coincident with the development of large 1p lateral glabellar lobes. The latter are of subtriangular outline, defined by well-developed 1p lateral glabellar furrows which are slightly curved and run approximately half-way to the occipital furrow. Also seen clearly on large cranidia are curved 2p lateral furrows which are short (tr.) and deep on the internal mould and almost equally so on the external surface; they delimit subquadrate 2p lateral lobes with a length more than half that of the 1p lobes. 3p lateral lobes are present, less than half the length of the 2p lobes and bounded by short (tr.), straight 3p lateral furrows which are not always clearly visible. The occipital ring is of almost uniform length (sag.), transversely straight except near the axial furrows, where it curves forwards slightly and forms a pair of occipital lobes that are most clearly seen on the internal mould. The eye-lobes are large and long, semielliptical in plan extending from slightly in front of centre of the glabella to only a short distance in front of the posterior border furrow. Better-preserved examples (Pl. 7, figs. 2, 4) show the palpebral rims well developed, particularly at front and back where the palpebral furrows deepen and then die out. The adjacent surface of the fixigena declines gently to the centre of the palpebral lobe (Pl. 7, fig. 4), in which area the surface ornamentation becomes obsolete. The sides of the glabella are bounded by deep, narrow axial furrows which end frontally at a pair of large anterior pits (Pl. 6, figs. 1, 3). The glabella arches gently down anteriorly but is poorly defined frontally where there is no evidence of a preglabellar field and a thin, low rim is the only indication of an anterior border. The anterior halves of the fixigenae become progressively narrower (tr.) frontally where the anterior branches of the facial suture turn sharply inwards just in front of the anterior pits and meet frontally in a broad, unbroken curve. The posterior halves of the fixigenae are small; the posterior branches of the facial suture curve back from the eyes to cut the posterior border furrow approximately midway between the eyes and the lateral border, and then flex abaxially across the posterior border almost to the base of the librigenal spines. Immediately outside the axial furrows, the posterior border has a breadth (exsag.) only half that of the occipital ring but widens gradually to the genal angles, where it is separated from the lateral border by the longitudinal groove along each librigenal spine. The foregoing remarks apply particularly to large cranidia, but a small example (Pl. 5, fig. 7) differs in certain respects: the glabellar outline is less constricted in front of the 1p lateral lobes; the eye lobes are less convex abaxially in plan and are sited closer to the glabella; the palpebral furrows are conspicuously and more uniformly deep.

Librigenae are uncommon and generally resemble those of *Annamitella? borealis* described by Whittington (in Neuman, 1964, Fig. 4, pl. 6, figs. 7-11), though the distance from eye to lateral margin is proportionately greater, particularly anteriorly. The visual surface of the eyes is not preserved, but immediately below it is a fairly well-defined eye platform (Pl. 6, fig. 2). Particularly noticeable is the thickening and bevelling of the lateral border just in front of the posterior border furrow. The genal angle is produced backwards and slightly outwards to form a stout librigenal spine, the dorsal surface of which carries a shallow median groove extending from the junction of the lateral border furrow and posterior border furrow.

A typical large pygidium is sub-semcircular in outline and the front of the prominent, straight-sided axis occupies more than one third of the overall breadth. There are five well-developed, transversely-straight axial rings which together occupy slightly more than half the length of the axis and are followed by a further two or three less clearly defined rings. The axis ends in a conspicuous, smooth, relatively high terminal piece that stands high above the side lobes (see Pl. 6, fig. 4) and declines steeply to the tip of the pygidium. The pleural regions have a conspicuous, smooth, convex border (Pl. 6, figs. 5, 9; Pl. 7, fig. 7) which is clearly differentiated from the pleural fields by a shallow border furrow and coalesces anterolaterally with the well-defined anterior half-ribs. An external mould of the pygidial doublure (Pl. 7, figs. 5, 9) shows that it coincides with the limits of the border. The pleural fields are convex and stand well above the border; large specimens show a pair of conspicuous half-ribs and six or seven pairs of ribs of unequal length (tr.) but almost equal breadth (exsag.), separated by pleural furrows which are nearly straight, deepen abaxially before ending at the border furrow and become progressively more strongly directed backwards. A small pygidium figured as a latex cast (Pl. 7, fig. 3) is less well segmented than large specimens and shows evidence of only three poorly-defined axial rings together with four pairs of shallow pleural furrows which scarcely reach a pygidial border that is broadest posterolaterally.

Dimensions (mm). (IM) = internal mould, (EM) = external mould.

	GSC 32768	GSC 32769	GSC 32770	GSC 32774	GSC 32777	GSC 32778
Median length of glabella	23. 0(IM) est.	20. 5(EM) est.	7. 0(IM) est.	11. 5(IM) est.	———	———
Frontal breadth of glabella	15. 0(IM) est.	12. 0(EM)	5. 0(IM) est.	———	———	———
Basal breadth of glabella	16. 0(IM) est.	13. 7(EM)	5. 6(IM) est.	9. 8(IM)	———	———
Distance across palpebral lobes	28. 0(IM) est.	24. 0(EM) est.	10. 0(IM) est.	———	———	———
Max. breadth of pygidium	———	———	———	———	23. 5(EM) est.	35. 0(IM) est.
Median length of pygidium	———	———	———	———	15. 0(EM) est.	20. 5(IM) est.
Frontal breadth of axis	———	———	———	———	7. 5(EM)	13. 5(IM)

Discussion. In many respects the new species resembles *Annamitella? borealis* Whittington (in Neuman, 1964, p. E28) from the Shin Brook Formation of Maine and the two may be regarded as congeneric even though some uncertainty remains as to their true generic postion. *A? insulana* may be distinguished from the American species by the following features: the glabellar outline is widest basally and narrows slightly forwards, instead of being parallel-sided overall but slightly expanded frontally; a preglabellar furrow is not distinctly developed; there are three pairs of lateral glabellar furrows compared with two; as noted earlier, the librigenae are relatively broader; the surface is coarsely tuberculated instead of apparently smooth; the pygidium has more axial rings (seven or eight compared with four or five); the pleural fields are better segmented, with up to seven or eight pairs of pleural furrows (compared with five). Whittington (in Neuman, 1964, p. E29-20; in Neuman, 1972, p. 300) discussed the status of *Annamitella* and pointed out the overall resemblance to, if not generic identity with, corresponding trilobites (whether they be called *Bathyuriscops, Monella* or *Proetiella)* in such widely-spaced regions as Maine, Wales, Kazakhstan, Argentina, Vietnam and Australia where the age of a particular occurrence may fall within the range from Arenig to Llanvirn Series.

Annamitella asiatica Mansuy (1920, p. 14, pl. 2, figs. 7a-k), type species of the genus by monotypy, was founded on a number of small cranidia, whilst associated pygidia were assigned with some reservation to the same species. The type horizon was the "grès quartzeux de Dong-son" in southern Annam, Vietnam and associated trilobites included *Asaphopsis* and other asaphids together with supposed *Prosopiscus,* though the identity of this last, based on poor material and illustrations, may be considered uncertain. Mansuy's description and illustrations are still the only ones available for *A. asiatica* and from these it appears that the glabella of the Vietnamese species is more nearly parallel-sided than that of *A.? insulana,* whilst the pygidium has six or seven axial rings and six pleural ribs. According to Mansuy the pygidium of *A. asiatica* has no marginal border but this may be due to incomplete preservation; the species was said to have three pairs of lateral glabellar lobes, but only the 1p and 2p pairs are clearly visible.

The affinities of what later became the type species of *Bathyuriscops* were evidently appreciated by Weber (1948, p. 11, pl. 1, figs. 22-24) when he described it as *Annamitella? granulata,* from the Ordovician of Kazakhstan. *B. granulata* has since been refigured by Keller and Lisogor (1954, p. 76, pl. 1, figs. 1-7) and by Chugaeva (1958, p. 17, pl. 1, figs. 1-3), and differences between it and *A.? insulana* are most apparent in the case of the cephalon, where only two pairs of lateral glabellar lobes are present, those of the 1p pair being proportionately smaller, and the lateral glabellar furrows are conspicuously deep and wide (exsag.). The age of the Russian species was given as early Llandeilo Series by Chugaeva

(1958, Table 2) but more recently it has been shown as one of the characteristic trilobites of the Llanvirn Series in Kazakhstan by Nikitin et al. (1968, table) and by Nikitin (1972, Table 10).

The alleged proetid *Proetiella* Harrington and Leanza (1957, p. 139, Fig. 59, 3-7), founded on *Dalmanitina tellecheai* Rusconi, 1951 from the Upper Llanvirn of Argentina, is apparently congeneric with *Bathyuriscops* though whether both are synonymous with *Annamitella* remains to be proved. The pygidium of *P. tellecheai,* with seven axial rings and five or six pairs of ribs in addition to the anterior half-ribs, is very similar to that of *A.? insulana,* but the cranidium of the Argentinian species differs in having only two subequal pairs of glabellar lobes bounded by wide (exsag.), deep lateral glabellar furrows, whilst the glabellar outline narrows opposite the 2p lobes but expands markedly in front of them.

The resemblance of the North Wales trilobite *Monella perplexa* Bates (1968, p. 196, pl. 11, figs. 15-21) to *Annamitella? borealis* has been noted by Whittington (in Neuman, 1972, p. 300) and as far as comparison is possible the two are regarded here as being probably congeneric. *Annamitella? perplexa* comes from the Carmel Formation of Anglesey and according to Bates (1968, p. 134, 140) occurs mainly in the *Didymograptus extensus* Zone of the Arenig Series, though the genus was also recorded questionably (as *Monella?* sp.) from the succeeding Treiorwarth Formation, *D. hirundo* Zone. Figures of the cranidia of *A.? perplexa* suggest that the glabellar outline is more expanded frontally that of *A.? insulana* and the 1p glabellar lobes are slightly smaller. Satisfactory comparison of the pygidia is not yet possible but both species appear to have similar proportions with comparable numbers of axial rings and pleural ribs. *A.? perplexa* may eventually prove to offer the closest comparison with the Newfoundland species, but the available material is inadequate.

AGE AND AFFINITIES OF THE TRILOBITES

Perhaps the most noticeable aspect of the Virgin Arm trilobite fauna is the presence of the bathyurid *Annamitella?*, here the most abundant genus in the sample but recorded elsewhere in North America only from the Shin Brook Formation of Maine (Whittington in Neuman, 1964, p. E28). The Newfoundland species differs, however, in several respects from *Annamitella? borealis* Whittington (see earlier) whilst certain other factors suggest that the fauna from Virgin Arm is at least as old as, and possibly slightly older than, that from Maine. Whittington (in Neuman, 1964, p. E33), when discussing the age of the Shin Brook fauna, concluded that "certain elements strongly indicate correlation with rocks of the Whiterock Stage", that is to say with typically North American strata that are customarily equated, approximately at least, with the lower half of the Llanvirn Series, in terms of the Anglo-Welsh Ordovician. The significance of *Nileus, Illaenus* (s.l.) and *Raymondaspis* at Shin Brook was emphasized by Whittington, who pointed out that none had been found in strata older than Whiterock Stage in North America although all three were, in fact, known from older beds in the Balto-Scandinavian region. The associated brachiopods from the Shin Brook Formation were shown by Neuman (1964, p. E23) to be of probably Arenig or Llanvirn age and some were said to be of Baltic type.

Geragnostus is of little or no significance in the Virgin Arm fauna, not merely because the species is undeterminable but also because the genus is cosmopolitan and has an extended vertical range from Upper Cambrian to highest

Ordovician. Although members of the Trinucleidae are commonly of great stratigraphic value, in this instance their contribution is unusually small. The less common of the two forms represented, although referred questionably to *Bergamia*, a genus known from Arenig to Caradoc Series, has part of an extra E arc (in this case E_3) represented anterolaterally, a criterion frequently regarded as worthy of generic discrimination in other trinucleids, for example *Bergamia* has one more E arc than *Trinucleus* s. s., *Costonia* one more than *Marrolithus*, and *Bettonia* apparently one more than *Cryptolithus*. *Pseudosphaerexochus* is an inconclusive age indicator as the genus occurs in Scandinavia as early as Arenig Series and is particularly well represented in later Ordovician strata. Likewise *Encrinuroides* was previously known only from middle and upper Ordovician strata, and the new record is its earliest known occurrence. *Metopolichas* is of considerable interest here as the oldest species assigned to it have been reported from the "Asaphus Limestone" of the Balto-Scandinavian region (Warburg, 1939; Tripp, 1958), and *M. verrucosus* was recorded from Stages $B_{III\,\beta}$ and $B_{III\,\gamma}$, i. e. lowest Llanvirn, by Lamansky (1905, p. 70, 170). Both *Metopolichas* and *Illaenus* are unknown below the Upper Arenig Series in Scandinavia and the Baltic region. No stratigraphic information may be derived from the fragmentary odontopleurid but the incomplete specimen of *Ischyrophyma* indicates a genus which, although best known from its type species in the Whiterock Stage of western Newfoundland, occurs also in the Arenig Series of both Sweden and the Central Volcanic Belt of central Newfoundland. The latter occurrence, at South Catcher Pond, southwest of King's Point (Dean, 1970) is associated with conodonts which Dr. Stig Bergström kindly informs me (pers. comm. 1972) are of Lower Arenig age and Swedish type. The bathyurid *Annamitella?* may be congeneric with a number of widely-distributed forms that range in age from Lower Arenig to Llanvirn Series.

To summarize, the affinities of the Virgin Arm trilobites are insufficiently close to any single described fauna to give conclusive evidence of age, and the Index of Faunal Resemblance (see Whittington, 1968, p. 118) is relatively low (no more than 50, and less if doubtful genera were better documented) even for the Shin Brook Formation of Maine, which also contains *Annamitella?*, *Geragnostus* and *Illaenus*. The fauna cannot be older than Arenig Series or younger than Whiterock Stage (= Lower Llanvirn Series approx.) whilst the lichid and illaenid rule out a Lower Arenig age. The facies of the Shin Brook Formation is broadly similar to that of the Virgin Arm rocks and its age was postulated by Whittington (in Neuman, 1964, p. E33) as probably Whiterock because of the presence of *Ampyx*, *Nileus* and *Raymondaspis*. Their absence from the Newfoundland fauna, although negative evidence, could perhaps be regarded as supporting an Upper Arenig or pre-Whiterock age, but on the other hand the evidence of the *Metopolichas* favours a very early Llanvirn age (see above).

Neuman (1972), in discussing Lower Ordovician brachiopod faunas from the so-called Magog Belt of predominantly volcanic rocks in Maine, New Brunswick and central Newfoundland, suggested that around volcanic islands the ocean floor occupied by such faunas provided important centres of evolution previously unknown or not understood, and a source of many faunal stocks which then migrated to continental margin areas where, though better documented, their origin was not clear. One of the localities upon which Neuman's interesting hypothesis was based is that from which the present trilobites were obtained. *Paratretaspis* and *Encrinuroides* here are the earliest-known members of their respective subfamilies and it is possible that, as suggested by Neuman's hypothesis, they have evolved in the vicinity of volcanic island arcs and then migrated periodically to platform regions. On the other hand *Illaenus*, *Ischyrophyma*, *Metopolichas* and *Pseudosphaerexochus* are known from similar or older horizons in Scandinavia and their presence in central Newfoundland could be accounted for by migration in the reverse direction. Of the remaining trilobites, *Geragnostus* is cosmopolitan whilst *Annamitella*? is widespread and occurs in both older and younger rocks. The trilobite evidence for the hypothesis must therefore be considered inconclusive.

It is now possible to attempt a slightly more detailed biostratigraphic correlation of the lithostratigraphic subdivisions established previously for the Ordovician rocks of the Cobbs Arm Sequence in New World Island, though much detailed work remains to be done and it is not always possible to reconcile satisfactorily the geological boundaries of the two maps so far published.

Williams' (1963) account gave the following rock sequence (in descending order):

Map-unit 8.	Interbedded greywacke, siltstone and argillite, minor pebble conglomerate beds.		Silurian and possibly Ordovician
Map-unit 7.	Black slate and siliceous argillite, etc.		Ordovician
Map-unit 6.	Crystalline limestone, minor limy shale.		Ordovician
Map-unit 5.	Grey sandstone, siltstone and argillite.		Ordovician
Map-unit 4.	Green pillow-lava and related pyroclastic rocks; minor sandstone, siltstone, etc.		Ordovician
Map-unit 3.	Interbedded grey quartzite and argillite.	Lushs Bight Group	Ordovician
Map-unit 2.	Grey to red chert, argillite and quartzite with minor acidic volcanics.	Lushs Bight Group	Ordovician
Map-unit 1.	Altered green lava and pyroclastic rocks with diorite, quartzite, etc.	Lushs Bight Group	Ordovician

A fossil locality west of Village Cove, on the southwest coast of New World Island, was shown by Williams as occurring in rocks of map-unit 4. Cephalopods there have since been stated by Flower (in Kay, 1967, p. 588) to indicate a Gasconadian age (i. e. highest Canadian Series); trilobites from the same locality, though less definitive, suggested an early Ordovician age (Whittington in Horne, 1970, p. 1771). The trilobites described in the present paper suggest that in the Virgin Arm area the age of Williams' map-unit 4 ranges upwards at least into the Upper Arenig and probably the lowest Llanvirn Series.

No fossils were reported from Williams' map-unit 5, but at Squid Cove, less than two miles northeast of the present fossil locality, trilobites of Llandeilo age and mixed Appalachian-Scottish-Scandinavian affinities have been described from the highest part of map-unit 6 (Dean, 1971). The fossiliferous sandy limestones of Squid Cove are succeeded by black argillites, map-unit 7 of Williams, in which graptolites were found indicating an age near the boundary between the *Climacograptus peltifer* Zone and the *C. wilsoni* Zone (= Zones 10 and 11 in the numerical convention used by Elles and Wood) of the Caradoc Series (Toghill in Dean, 1971, p. 32). No evidence of the *Nemagraptus gracilis* Zone (= Zone 9) has yet been found at Squid Cove, but investigation of the junction of map-units 6 and 7 there is difficult.

The lithostratigraphic succession within Cobbs Arm Sequence, and its biostratigraphic correlation, as given by Horne (1970) shows some differences from that provided by Williams. Horne's table of strata, in descending order, is as follows:

Unit E.	Chaotic unit. Fossils include Ashgill graptolites in dark argillites near the top; Ashgill brachiopods in a mudflow conglomerate; and Ashgill graptolites in a 3-metre bed of argillite at the base.	Summerford Group
Unit D.	Upper volcanic unit. Lithology like unit B and in some areas the two are continuous. In most areas is underlain by beds with "Zone 12" graptolites.	
Unit C.	Caradocian argillite unit. Less than 30 metres of black, siliceous argillites with graptolites of "Zones 12-13".	
Unit B.	Middle volcanic unit. Mostly volcanic rocks, but some siltstones, calcilutites and calcarenites.	
Unit A.	Arkosic unit. Greywackes, argillites, etc. No fossils.	
Unit Z.	Lower volcanic unit. Pillow lavas, agglomerates, etc. with local lenses of limestone.	

Williams' map-unit 4 contains the Gasconadian cephalopod locality noted already west of Village Cove, and therefore corresponds, at least approximately, to Horne's Unit Z. Beyond this point two interpretations are possible: 1. We can interpret Horne's Unit B as ranging in age from Upper Arenig or early Llanvirn (based on the Virgin Arm trilobites) to Llandeilo (by analogy with Squid Cove), overlain by Caradoc argillites, and underlain by Unit A of uncertain age which separates it from Unit Z (of Gasconadian age = Tremadoc pars); 2. Williams' map-unit 4 ranges in age from Gasconadian to Upper Arenig or early Llanvirn and is followed in turn by unfossiliferous map-unit 5 and then map-unit 6, at least the higher part of which is of Llandeilo age (at Squid Cove), succeeded by Caradoc argillites.

Map-unit 7, a conspicuous group of black argillites, may presumably by equated with unit C, said by Horne (1970, p. 1772) to be "one of the keys in understanding stratigraphic complexities within the Summerford Group", but evidence for the age of this subdivision is incomplete. Toghill's determinations drew attention also to the lithological and faunal resemblance of the Squid Cove samples to strata (part of the Hartfell Shales) in the Southern Uplands of Scotland. Elsewhere Horne (1970, p. 1772) recorded graptolites indicative of Zone 11 above lavas of Units B and C in the northwestern part of Farmer's Island, off the southwest coast of New World Island, as well as graptolites of Zones 12 and 13 from strata between Units A and D to the west of Village Cove. It is not yet known whether all these graptolite zones occur within a single sequence, and whether there is a disconformity at the base of Unit C [= map-unit 7]. If one wished to make further comparison with the British Isles then one might be tempted to draw an analogy with parts of North Wales where the Snowdon Volcanic Group is succeeded disconformably by black shales and argillites, locally phosphatic at the base. The latter are known variously as the Nod Glas or Pen-y-garnedd Shales and contain graptolites indicating Zones 12 and, possibly, 13.

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PLATES 1 to 7

Specimen numbers refer to the type collection in the Geological Survey of Canada, Ottawa. All the material is from a single locality in Unit B, middle volcanic unit, of the Summerford Group situated by the east side of Virgin Arm embayment, and approximately 2750 metres east-northeast of the point where the main road from Gander meets the coast at the village of Virgin Arm, New World Island. Specimens whitened with ammonium chloride before being photographed. Photographs by the writer.

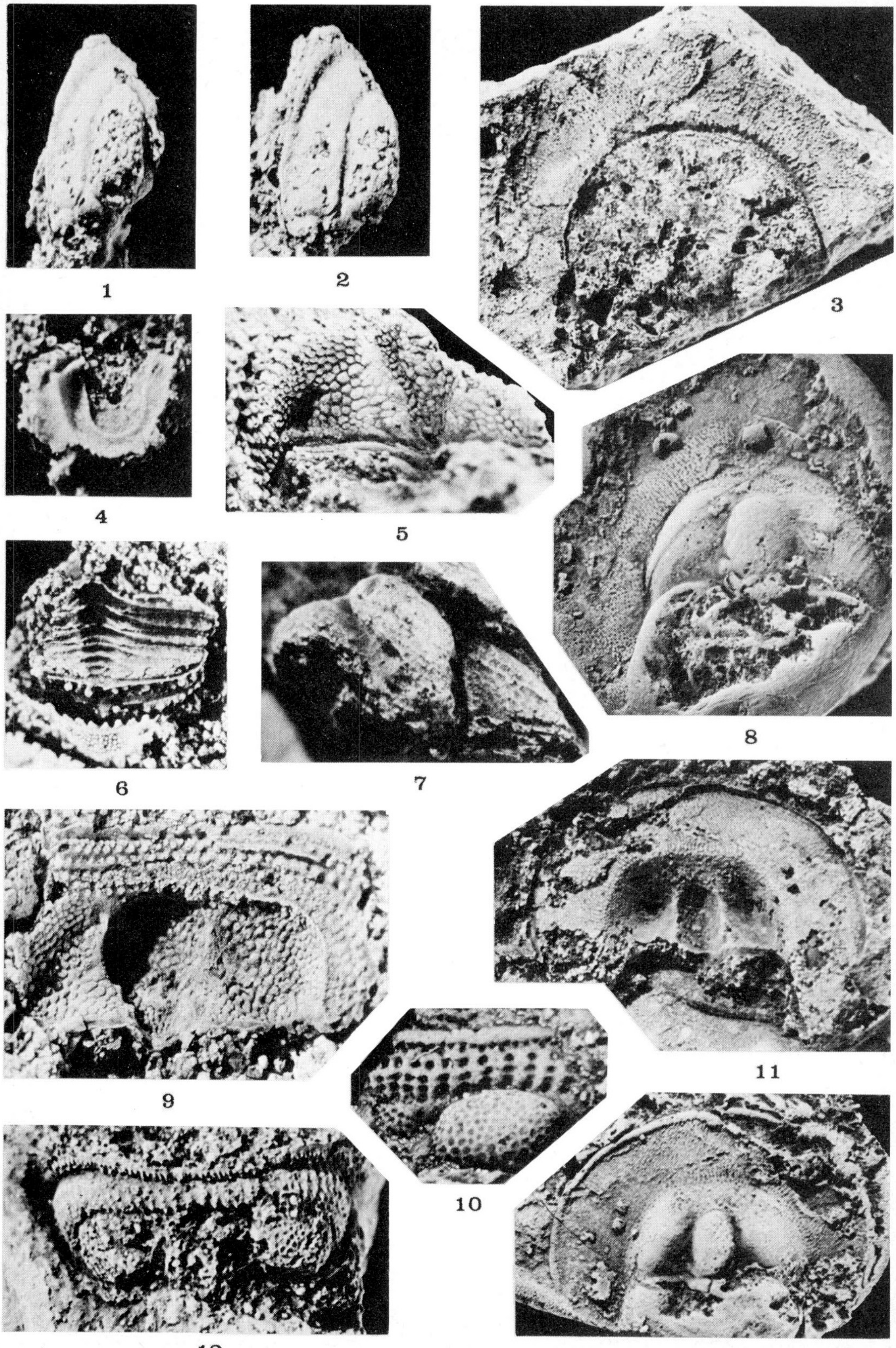
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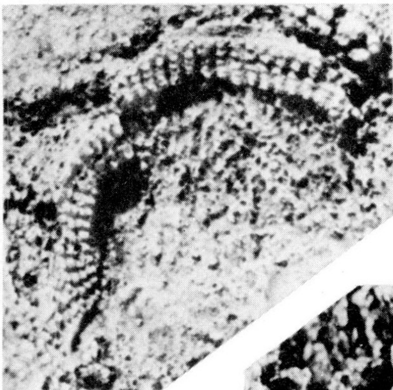
PLATE 1

	Geragnostus sp.	Page 3
Figures 1, 2.	Plan and oblique left lateral views of incomplete cranidium. GSC 32723. x 10. 5	
Figure 4.	Fragmentary pygidium viewed internally. GSC 32724. x 10.	
	Scotoharpes sp.	Page 4
Figure 3.	External mould of part of cranidium. GSC 32727. x 3.	
Figure 8.	Plastic cast of incomplete cranidium. GSC 32726. x 3.	
Figures 11, 13.	External mould and plastic cast of cranidium. GSC 32725. x 4.	
	Paratretaspis terranovica gen. et sp. nov.	Page 6
Figure 5.	Fragment of external mould of cranidium. Paratype. GSC 32734. x 10.	
Figure 6.	Interior of small pygidium and part of three attached thoracic segments. Paratype. GSC 32737. x 10.	
Figure 7.	Fragment of cranidium showing reticulate ornamentation. Paratype. GSC 32738. x 10.	
Figure 9.	Incomplete external mould of cranidium. Paratype. GSC 32733. x 10.	
Figure 10.	Plastic cast of anterior portion of cephalic fringe. Paratype. GSC 32735. x 12.	
Figure 12.	External mould of lower lamella of cephalic fringe. Paratype. GSC 32728. x 8.	



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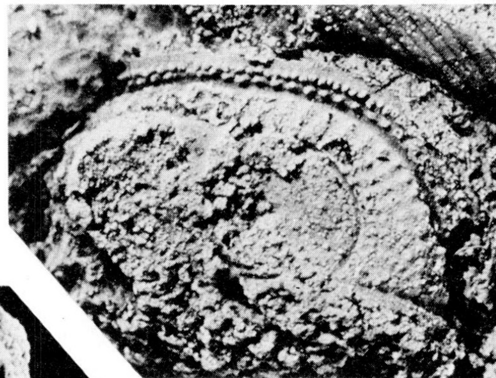

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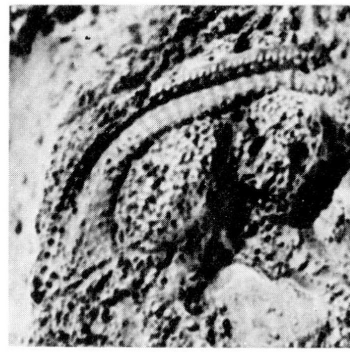

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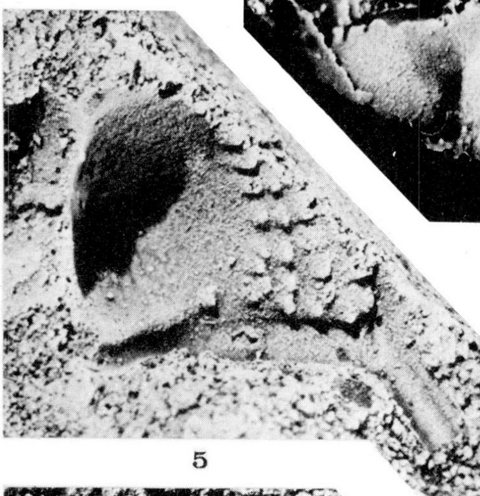

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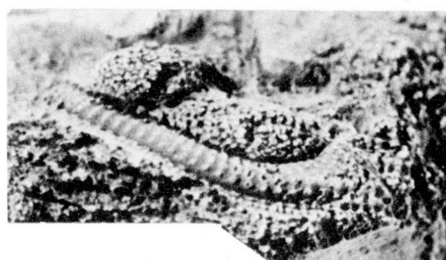

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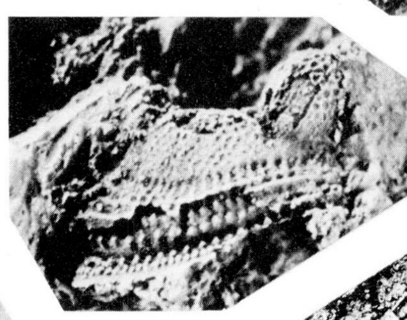

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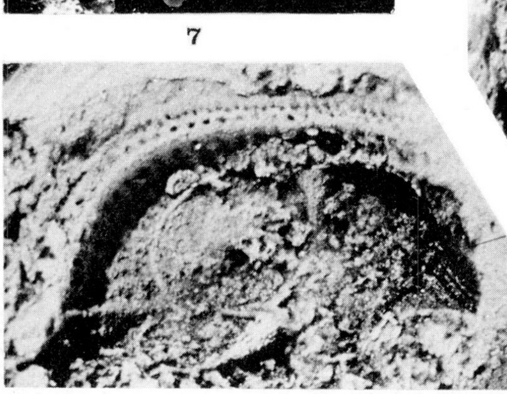

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PLATE 2

Paratretaspis terranovica gen. et sp. nov. — Page 6

Figure 1. External mould of dorsal lamella of incomplete cephalic fringe. Paratype. GSC 32732. x 8.

Figures 2, 9 External mould of ventral fringe surface, and plastic cast of same specimen. Holotype. GSC 32736. x 10.

Figures 4, 6. Plan and left lateral views of external mould of incomplete ventral fringe lamella. Paratype. GSC 32729. x 8.

Figure 8. Anterior view of fragmentary cranidium with part of dorsal fringe lamella broken away. Note concentric ridges or "lists" on dorsal surface of fringe, and girder on ventral surface. Paratype. GSC 32731, x 10.

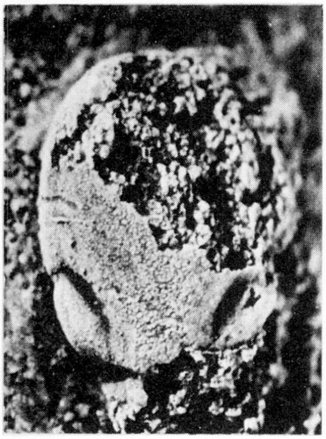
Figure 10. External mould of left half of fringe showing two E arcs and librigenal spine. Paratype. GSC 32739. x 10.

Bergamia? sp. — Page 5

Figure 3. Fragment of front of cephalon showing fringe pits and girder of ventral lamella. GSC 32741. x 10.

Figure 5. External mould of fragmentary fringe showing pit arrangement at and near left genal angle. GSC 32742. x 8.

Figure 7. Latex cast of fragment of cranidium. Note fringe pits set in well-defined sulci, and traces of reticulation on cheek-lobe. GSC 32740. x 8.



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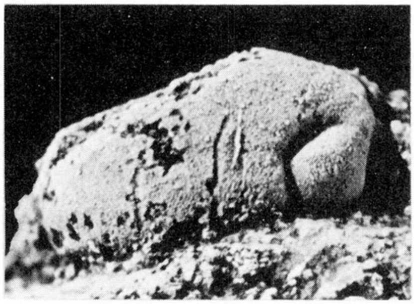

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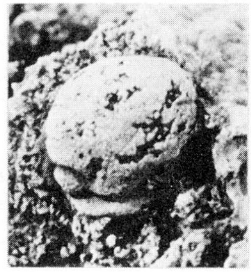

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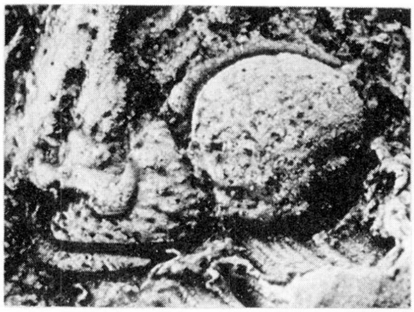

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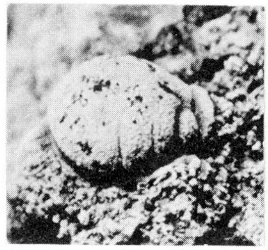

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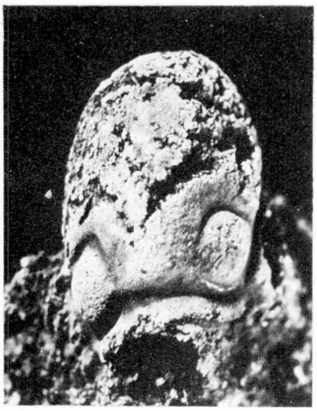

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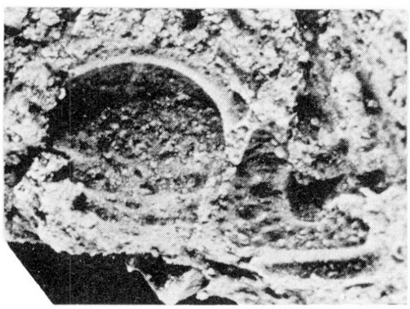

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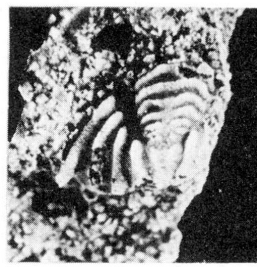

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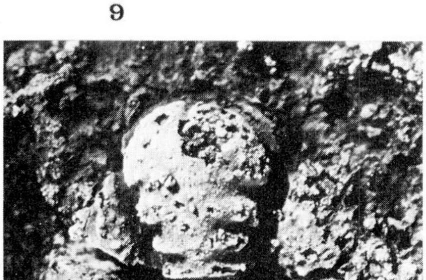

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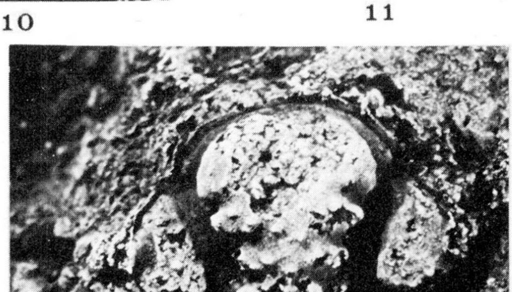

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PLATE 3

	Pseudosphaerexochus (s. l.) sp.	Page 9
Figures 1, 2.	Plan and left lateral views of glabella. Note three pairs of glabellar furrows. GSC 32750. x 10.	
Figures 3, 5.	Plan and oblique left lateral views of incomplete, small cranidium with tumid frontal glabellar lobe. GSC 32751. x 10.	
Figure 6.	Plan view of incomplete, distorted cranidium. GSC 32752. x 7.	
	Encrinuroides hornei sp. nov.	Page 10
Figures 4, 7.	Plastic cast and external mould of incomplete cranidium. Paratype. GSC 32745. x 10.	
Figure 8.	Internal mould of small pygidium. Paratype. GSC 32747. x 12.	
Figure 9.	Internal mould of pygidium. Paratype. GSC 32746. x 10.	
Figure 10.	Internal mould of incomplete, slightly distorted pygidium. Paratype. GSC 32748. x 10	
Figure 11.	External mould of incomplete pygidium. Paratype GSC 32749. x 10.	
Figure 12.	Internal mould of incomplete cranidium. Paratype. GSC 32744. x 10.	
Figure 13.	Internal mould of large, almost complete cranidium showing small, left fixigenal spine. Holotype. GSC 32743. x 10.	

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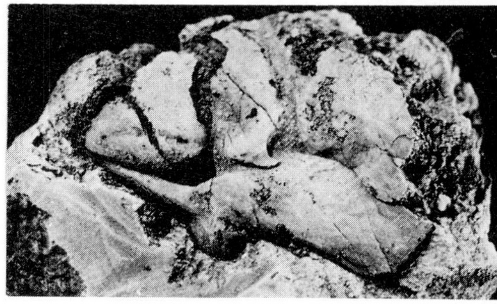

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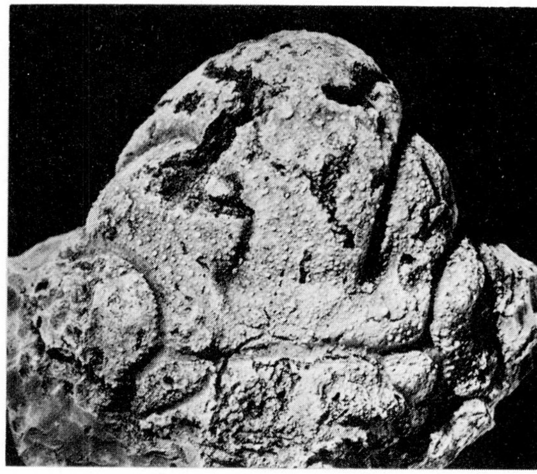

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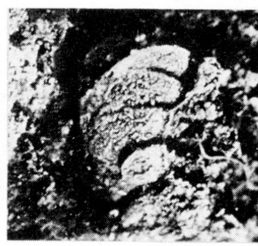

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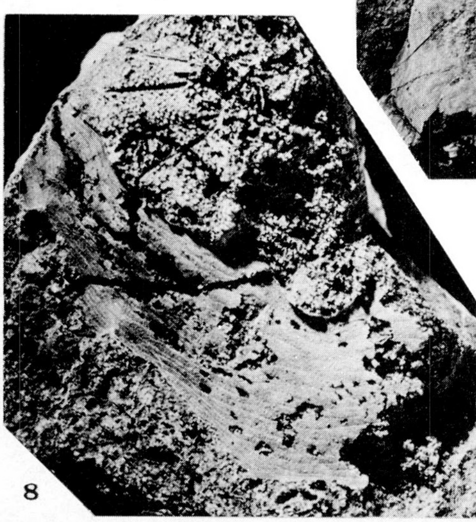

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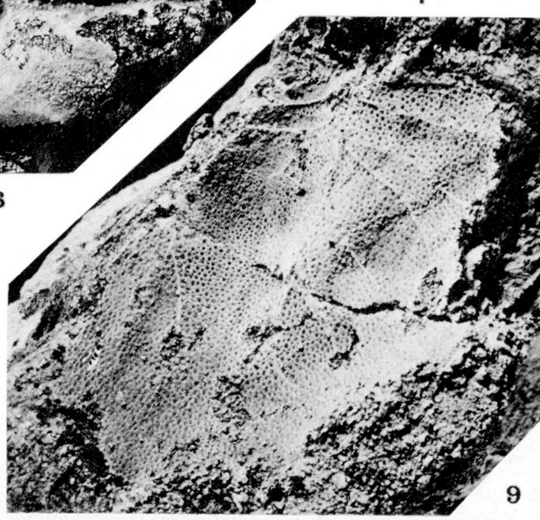

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PLATE 4

	Metopolichas cf. *M. verrucosus* (Eichwald)	Page 15
Figures 1, 4.	Oblique right lateral and plan views of internal mould of incomplete cranidium. GSC 32756. x 2.	
Figures 2, 6.	Oblique left lateral and plan views of incomplete large hypostoma. GSC 32758. x 2.	
Figure 3.	Internal mould of cranidium. GSC 32757. x 2.	
Figure 8.	External mould of doublure of incomplete, large pygidium. GSC 32760. x 3.	
Figure 9.	External mould of large, almost complete pygidium. GSC 32759. x 3.	
	Pseudosphaerexochus (s.l.) sp.	Page 9
Figure 5.	Portion of distorted internal mould of incomplete pygidium. GSC 32754. x 10.	
Figure 7.	Fragment of internal mould of small cranidium. GSC 32753. x 10.	

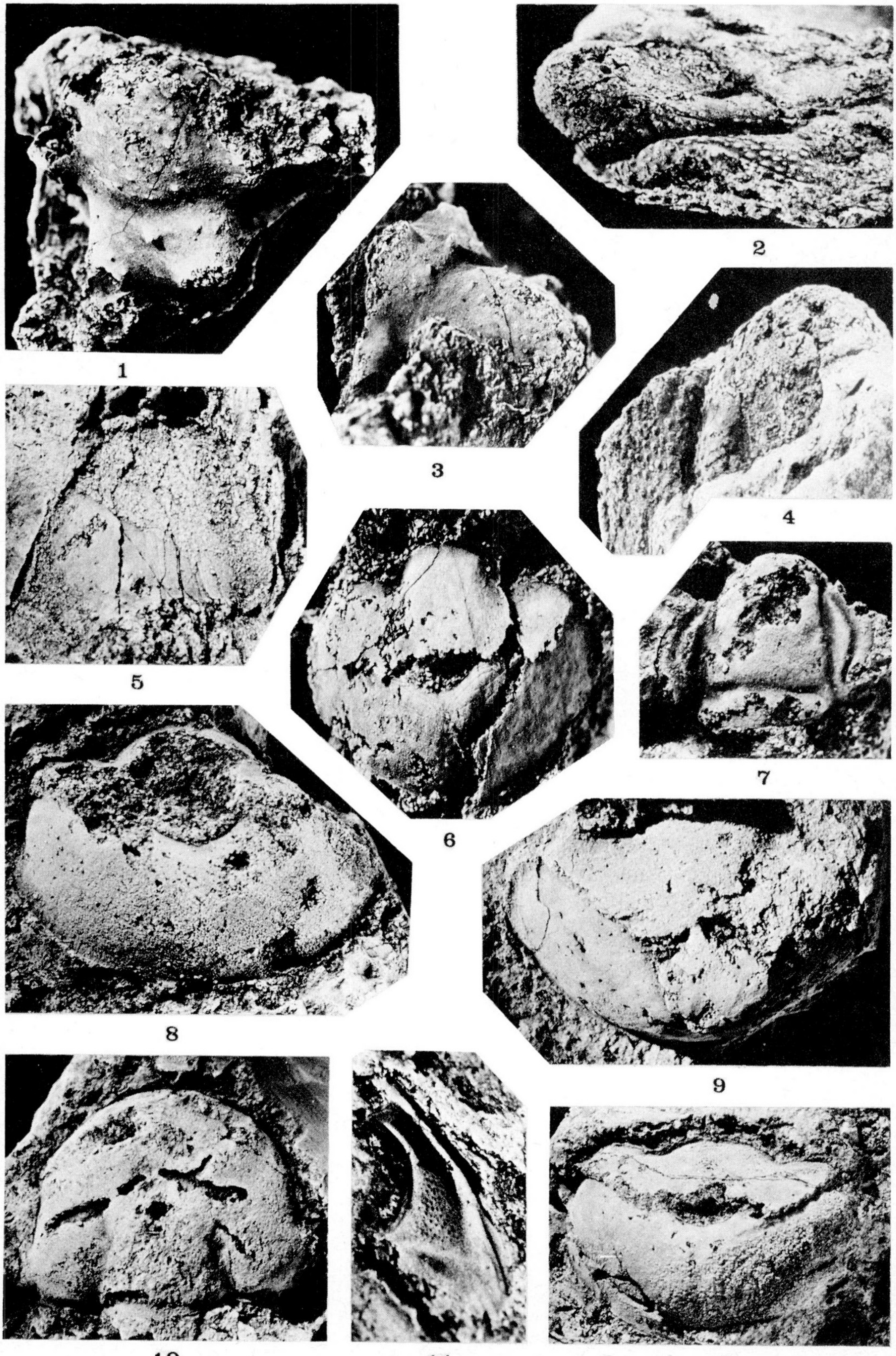
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PLATE 5

	Odontopleurid gen. et sp. undetermined	Page 14
Figures 1, 3.	Plan and right anterolateral views of cephalic fragment with paired occipital spines and median tubercle. GSC 32761. x 4.	
	Ischyrophyma sp.	Page 13
Figures 2, 4	Oblique left lateral and plan views of fragmentary internal mould of cranidium. GSC 32755. x 8.	
	Illaenus (s.l.) sp.	Page 16
Figure 5.	Fragment of external mould of ventral surface of cephalic doublure. GSC 32767. x 3.	
Figure 6.	Pygidium with part of exoskeleton removed to expose doublure. GSC 32766. x 6.	
Figure 8.	Incomplete pygidium with external mould of doublure. GSC 32765. x 2.5.	
Figure 9.	Almost complete pygidium with part of doublure exposed. GSC 32764. x 2.5	
Figure 10.	Internal mould of cranidium. GSC 32762. x 2.5.	
Figure 12.	Pygidium showing external mould of part of doublure. GSC 32763. x 2.5.	
	Annamitella? insulana sp. nov.	Page 18
Figure 7.	Internal mould of small, incomplete cranidium. Paratype. GSC 32773. x 5.	
Figure 11.	External mould of left librigena. Paratype. GSC 32776. x 6.	

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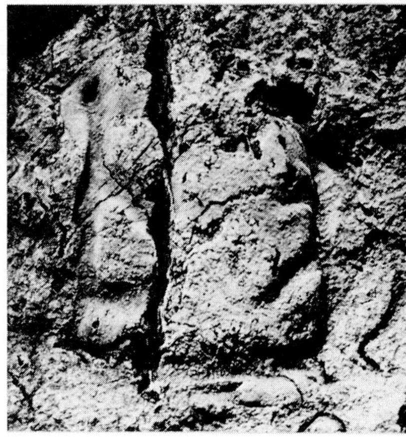

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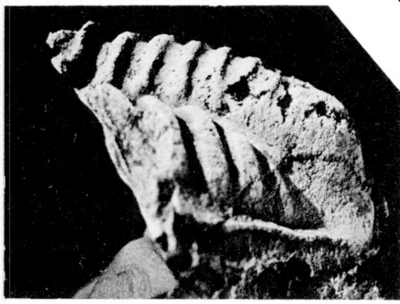

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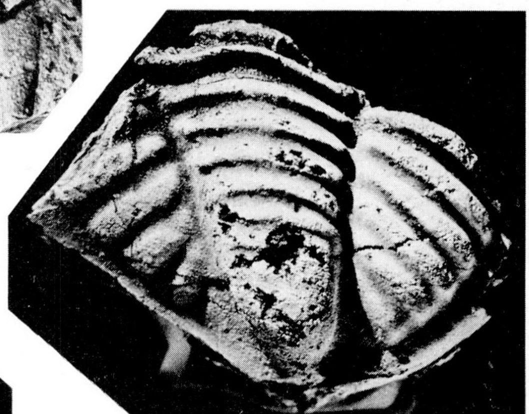

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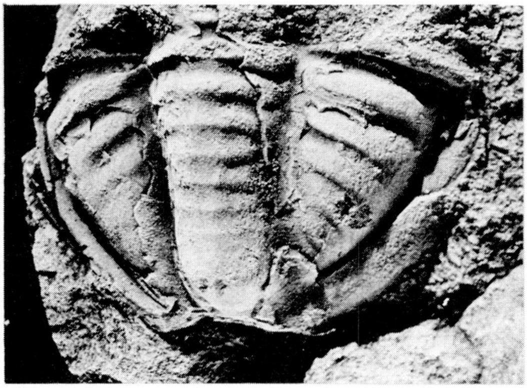
PLATE 6

Annamitella? insulana sp. nov. Page 18

Figure 1.	Internal mould of frontal portion of cranidium. Paratype. GSC 32771. x 3.5.
Figure 2.	Internal mould of right librigena, with external mould of librigenal spine. Paratype. GSC 32775 x 2.
Figure 3.	Internal mould of damaged glabella showing large left anterior pit and three pairs of glabellar furrows. Paratype. GSC 32774. x 3.
Figures 4, 5, 9.	Left lateral, plan and posterior views of internal mould of large, slightly distorted pygidium. Holotype. GSC 32778. x 2.
Figures 6-8.	Oblique right anterolateral, anterior and plan views of internal mould of large, distorted pygidium. Paratype. GSC 32768. x 2.



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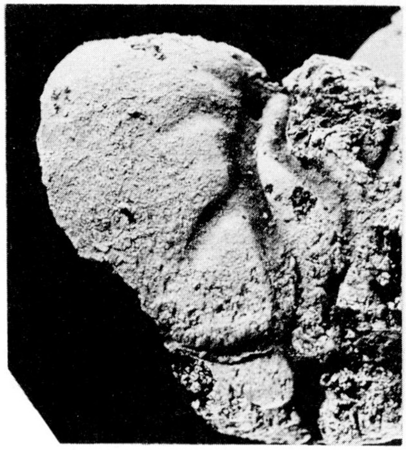

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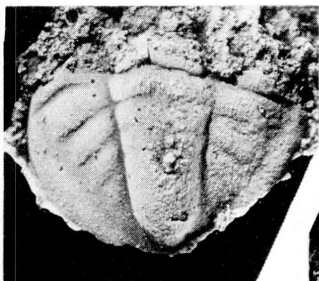

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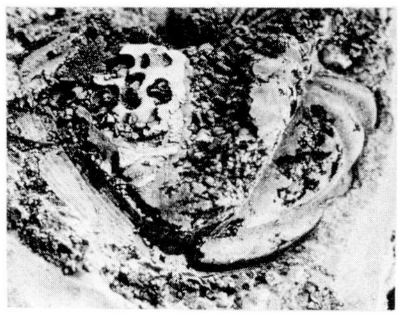

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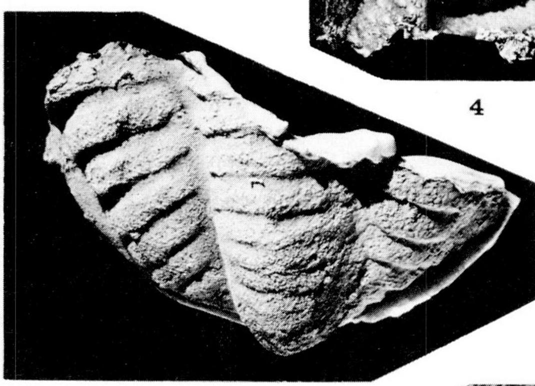

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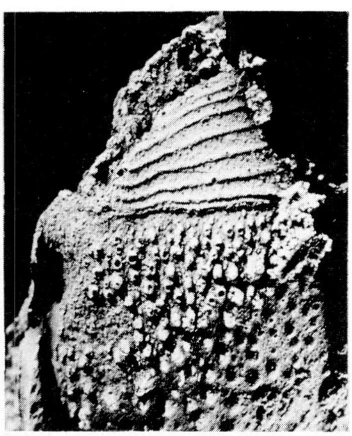

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PLATE 7

Annamitella? insulana sp. nov. Page 18

Figure 1.	Large, partially exfoliated pygidium. Paratype. GSC 32777. x 2.5.
Figure 2.	Internal mould of fragmentary cranidium showing three pairs of glabellar furrows. Paratype. GSC 32770. x 6.
Figure 3.	Latex cast of small pygidium. Paratype. GSC 32780. x 5.
Figure 4.	Latex cast of right palpebral lobe and part of glabella. Note ornamentation of coarse tubercles. Paratype. GSC 32772. x 4.
Figures 5, 9.	Damaged internal mould of pygidium photographed in slightly different positions to show lateral border and doublure. Paratype. GSC 32730. x 3.
Figures 6, 7.	Plan and left posterolateral views of latex cast of large, incomplete, slightly distorted pygidium. Paratype. GSC 32779. x 1.5.
Figures 8, 10.	10 = latex cast of large cranidium, x 2. 8 = front of same specimen enlarged (x5) to show coarse tubercles on glabella and terrace lines on rostral plate, Paratype. GSC 32769.

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Geological Survey of Canada

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