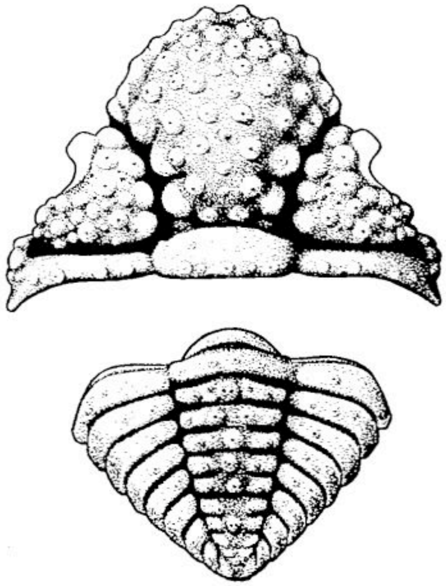
PALAEONTOGRAPHICA CANADIANA No. 14

Silurian encrinurine trilobites from the central Canadian Arctic



Jonathan M. Adrain
and
Gregory D. Edgecombe

1997

CANADIAN SOCIETY OF PETROLEUM GEOLOGISTS
GEOLOGICAL ASSOCIATION OF CANADA

TABLE OF CONTENTS

Silurian encrinurine trilobites from the central Canadian Arctic

JONATHAN M. ADRAIN[1]
and
GREGORY D. EDGECOMBE[2]

[1]Department of Palaeontology, The Natural History Museum, Cromwell Road, London SW7 5BD, United Kingdom
[2]Centre for Evolutionary Research, Australian Museum, 6 College Street, Sydney South, N.S.W. 2000, Australia

ABSTRACT

Carbonate debris flow deposits in the Cape Phillips Formation of the central Canadian Arctic Archipelago contain rich silicified shelly faunas, and preserve the most diverse and complete record of Wenlock trilobites known from anywhere in the world. This work describes the encrinurine trilobites of these faunas (28 species in total), along with a species from platform limestones of the upper Ludlow Douro Formation. Six stratigraphically successive trilobite faunas have been identified, four of which are named herein. The trilobites occur in strata interbedded with rich graptolitic mudrock/shale. As a result, their ages are known with precision. The generic makeup of the lower four faunas (mid-Sheinwoodian to lower Homerian) is similar. They are separated from the upper two faunas, which have a markedly different generic diversity, by a shelly fossil extinction event, nearly coincident with the well known pelagic (graptolitic) *Pristiograptus ludensis* event in the upper Homerian.

A comprehensive phylogenetic analysis of the *Struszia* genus group provides an explicit hypothesis of cladistic structure. The range of *Frammia* is extended into the Wenlock, and the genus is considered to be most closely related to *Struszia*. Successive outgroups to the *Struszia* plus *Frammia* clade are *Avalanchurus*, *Mackenziurus* plus *Fragiscutum*, and *Aegrotocatellus* plus *Balizoma*.

New species are *Avalanchurus simoni*, *A. garfunkeli*, *Frammia bachae*, *Mackenziurus ceejayi*, *M. deedeei*, *M. joeyi*, *M. johnnyi*, *Struszia* (s.l.) *epsteini*, *S.* (s.l.) *martini*, *S. onoae*, and *S.* (s.l.) *petebesti*. Species described from the Mackenzie Mountains and now recorded in the central Arctic include *S.* (s.l.) *dimitrovi*, *S.* (s.l.) *harrisoni* and "*S.*" *mccartneyi*.

RÉSUMÉ

Dans le centre de l'archipel arctique canadien, les dépôts carbonatés de coulée de débris associés à la Formation de Cape Phillips contiennent de riches faunes de coquilles silicifiées; on y observe des trilobites wenlockiens dont la diversité et la préservation sont sans égal dans le monde. Le présent article décrit les trilobites (Encrinurinae) des faunes coquillières en question (28 espèces au total), mais aussi une autre espèce observée dans des calcaires de plate-forme associés à la partie supérieure de la Formation de Douro (Ludlowien supérieur). Six faunes de trilobites, qui se superposent dans la stratigraphie, ont été identifiées et quatre d'entre elles sont nommées dans l'arcticle. Les trilobites sont fossilisés dans des lithologies interstratifiées au sein de shales et de mudstones aux graptolites abondants. Ainsi, il a été possible d'établir leur âge avec précision. Les genres observés dans les quatre faunes inférieures (s'échelonnant en âge du Sheinwoodien moyen à l'Homerien inférieur) sont presque les mêmes. Ces faunes sont séparées des deux faunes supérieures (caractérisées par une variété de genres tout à fait différente) par des roches où les fossiles l'apparition, à l'Homerien supérieur, d'un graptolite pélagique bien connu (*Pristiograptus ludensis*).

Une analyse phylogénétique approfondie du genre *Struszia* permet d'extension du genre *Frammia* va jusque dans le Wenlockien et le genre auquel il s'apparenterait le plus est *Struszia*. Les exogroupes successifs du clade *Struszia* plus *Frammia* sont *Avalanchurus*, *Mackenziurus* plus *Fragiscutum* et *Aegrotocatellus* plus *Balizoma*.

Les nouvelles espèces identifiées sont les suivantes : *Avalanchurus simoni*, *A. garfunkeli*, *Frammia bachae*, *Mackenziurus ceejayi*, *M. deedeei*, *M. joeyi*, *M. johnnyi*, *Struszia* (s.l.) *epsteini*, *S.* (s.l.) *martini*, *S. onoae* et *S.* (s.l.) *petebesti*. Les espèces d'abord décrites dans les monts Mackenzie mais qui sont maintenant signalées dans le centre de l'archipel arctique sont *S.* (s.l.) *dimitrovi*, *S.* (s.l.) *harrisoni* and "*S.*" *mccartneyi*.

ACKNOWLEDGMENTS

Fieldwork for this project was supported by grants from the Canadian Circumpolar Institute, joint grants from Natural Resources Canada (NRCan) and the Natural Sciences and Engineering Research Council of Canada (with Brian Chatterton, University of Alberta), logistical support from the Polar Continental Shelf Project (NRCan), and a grant-in-aid from the Paleontological Society. J.M.A. thanks Mike Caldwell and Al Lindoe for assistance in the field. Chatterton read an early version of the manuscript, and provided material collected by himself and the late David Perry. We thank Alan Lam for drawing the trilobites, Steve Westrop (Brock University) for making scan files for the production of several of the Text-figures, and Janet Waddington (Royal Ontario Museum) for curatorial assistance. Costs of technical preparation were met by NSERC operating grants to Chatterton and to Alf Lenz (University of Western Ontario). We are grateful to Lars Ramsköld (University of Uppsala) and Des Strusz (Australian Geological Survey Organisation) for reviews of the manuscript, and to Tim DeFreitas and Brian Norford (both of the Geological Survey of Canada) for additional comments and for permission to use stratigraphic and biostratigraphic information from unpublished work. This is FACPAC Contribution No. 5.

INTRODUCTION

Silurian rocks of the central Canadian Arctic are represented by several major facies. To the south and east, platform carbonates of the Allen Bay Formation, Cape Storm Formation, and Read Bay Group crop out. The lateral equivalent to the north and west are graptolitic basinal rocks including the Cape Phillips Formation. In the latter unit, along the line of facies change (Text-figs. 1A-C), several extremely diverse lower Wenlock to lower Ludlow silicified trilobite faunas have been recovered in stratigraphic sequence. The faunas occur in limestone debris flow deposits derived from the nearby shelf margin and interbedded with shales and shaly autochthonous limestones rich in graptolites. The result is the single most complete and well-resolved record of Wenlock trilobites in the world.

Silicified shelly faunas from the Cape Phillips Formation were first discovered by A.J. Boucot and R. Thorsteinsson, who collected a large sample from the south shore of Baillie-Hamilton Island in 1971. This collection formed the basis for publications on trilobites (Perry and Chatterton, 1977), gastropods (Rohr et al., 1981), brachiopods (Zhang, 1989), sponges (Rigby and Chatterton, 1989), and a monoplacophoran (Boucot, 1975). Additional collections were made during the late 1970s by B.D.E. Chatterton and D.G. Perry, and specimens from Cornwallis Island were described as *Acanthalomina thorsteinssoni arctica* Chatterton and Perry, 1979. The present work is based mainly on large new collections made by J.M.A. during the 1991 to 1993 field seasons, supplemented in some cases by the Chatterton and Perry collections. Description of the trilobites in these collections was begun by Adrain (1994, lichids), and subsequent works include Adrain and Edgecombe (1995, encrinurids; 1997, calymenids), Adrain and MacDonald (1996, phacopids), and Adrain and Ramsköld (1996, lichids; 1997, odontopleurids).

New collections have revealed at least five major stratigraphically separate trilobite faunas in the lower Wenlock to lower Ludlow interval of the Cape Phillips Formation, with few species in common, and with average diversity of about 25 to 30 trilobite species. There are, in addition, geographically separate contemporaneous faunas with some, but not all, species shared, and several smaller faunules interspersed through the sequence. In decreasing order of diversity, the trilobite faunas include proetids, lichids, odontopleurids, encrinurids, cheirurids, aulacopleurids, calymenids, styginids, brachymetopids, scharyiids, phacopids, and harpetids.

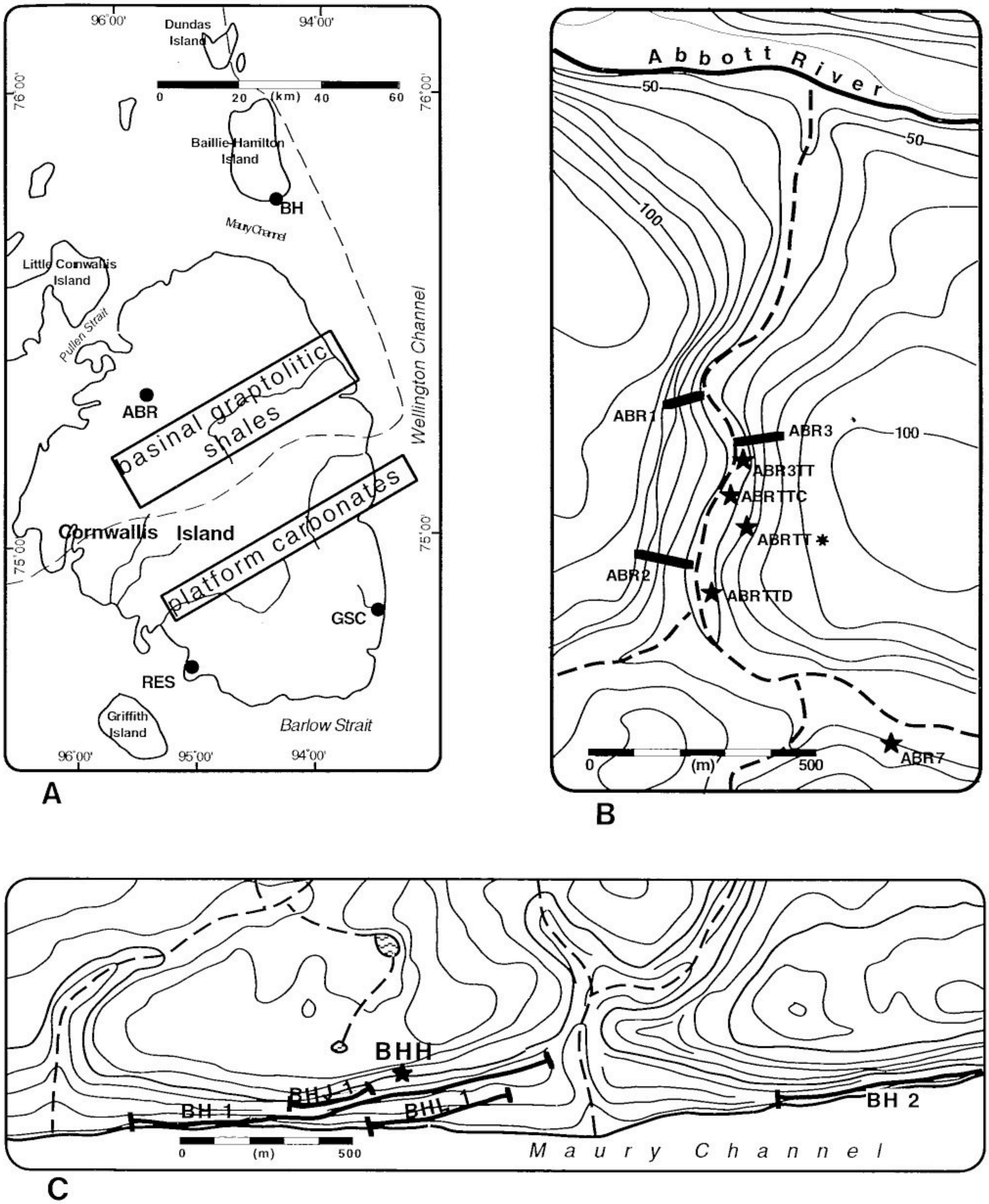
Extensive collections have also been made from platform limestones of the upper Ludlow Douro Formation on Somerset, Cornwallis, and Devon islands. Trilobites from the Douro Formation at Goodsir Creek on eastern Cornwallis Island, were described by Thomas and Narbonne (1979). Adrain and Edgecombe (1995) have given a history of study, and described species of *Balizoma* and the new encrinurid genera *Aegrotocatellus* and *Perirehaedulus* from the formation. A new species from Goodsir Creek, assigned to *Mackenziurus* Edgecombe and Chatterton, 1990, is described herein.

OCCURRENCE, ASSOCIATED FAUNA, AND PRESERVATION

Trilobites have two distinct types of occurrence in the Cape Phillips Formation. A few species have been found in situ, most belonging to genera known elsewhere to occur in disaerobic, deep water environments. These include: geographically widespread occurrence of the asaphid *Pseudogygites* Kobayashi, 1934, in the basal, Ashgill beds of the formation (Ludvigsen, 1979); undescribed occurrences of *Aulacopleura* Hawle and Corda, 1847, and *Raphiophorus* Angelin, 1854, in Telychian strata on Bathurst Island; the odontopleurid *Odontopleura arctica* Adrain and Chatterton, 1990, from the lower Ludlow of northwestern Cornwallis Island (the age of this species was originally reported as early Llandovery, but new collections made by A.C. Lenz at Abbott River in 1993 show it to be early Ludlow, *Lobograptus progenitor* Zone); and finally, in a small collection made by M.J. Melchin in 1992 from near Cape Manning on northeastern Cornwallis Island, species of *Aulacopleura* and an undetermined styginid from mid-Ludlow strata (*Saetograptus fritschi linearis* Zone). Other fossils occurring in situ in the deep-water shales of the Cape Phillips Formation include rich graptolites (Thorsteinsson, 1955, 1958; Lenz, 1978, 1990, 1993, 1994a; Lenz and Melchin, 1990, 1991; Melchin, 1987, 1989; Melchin and Lenz, 1986), along with conulariids, heterostracan fish, ostracods, small brachiopods, and rare phyllocarids and eurypterids.

A second type of occurrence includes all of the much more diverse faunas mentioned above. This is in the form of carbonate debris flow deposits, which are common in the lower Wenlock to lower Ludlow part of the Cape Phillips Formation in a geographic zone near to the line of facies change to platform carbonates of the Allen Bay Formation and Read Bay Group (Text-fig. 1A). These packstones and wackestones are typically richly bioclastic. In addition to the trilobites, brachiopods, gastropods, cephalopods, sponges, corals, bryozoans, ostracods, and machaeridians are very common, while rostroconchs, bivalves, and polyplacophorans are rare elements of the faunas. Three dimensional graptolites occur in some of the beds and radiolarians are nearly ubiquitous, although these also occur in thicker autochthonous limestone beds barren of silicified macrofossils (Goodbody, 1986).

The debris flow deposits range in thickness from several centimetres to over a metre, but the norm is 10-30 cm. Clasts are usually tightly packed and of chaotic orientation, although graded bedding can sometimes be observed. Larger allochthonous beds are often associated with syndepositional slumping of the underlying shales. Silicification of brachiopods is ubiquitous, but preservation of other groups is variable. Cephalopods are very rarely found silicified,



Text-fig. 1A. Map of main study area showing geographic position of localities (AB = Cape Phillips Formation, Abbott River sections ABR 1-2, talus boulders ABR TTD, ABR TT*; BH = Cape Phillips Formation, Baillie-Hamilton sections BH 1, BHL 1, and BH 2, locality BHH; GSC = Douro Formation, Goodsir Creek localities GSC 3, GSC 7, GSC 8). Dashed line represents the approximate line of facies change from platform carbonates to the east and southeast to basinal shales to the west and northwest. **B.** Detailed map of sections and collecting localities on a small, northerly-flowing tributary of the Abbott River ("AB" of 1A), northwestern Cornwallis Island. **C.** Detailed map of sections and collecting localities on the south shore of Baillie-Hamilton Island ("BH" of 1A).

while gastropods are usually coarsely silicified (although they can be locally very well preserved). In cases where particular groups are not silicified, the deposits will usually yield crack-out material. This is true, for example, of the trilobites in Ludlow debris flow deposits above the last good silicified fauna at horizon BH 2 42 on Baillie-Hamilton Island (see below).

Silicification of trilobites, where it occurs, is generally excellent. Surface sculpture is usually well preserved. Specimens have generally not suffered any distortion, but examination of the photographic plates will reveal that many are fragmentary. It is difficult to assess how much of this breakage has happened during acid preparation, when large, heavy clasts such as solitary corals are freed. It is certain, however, that a lot, if not all, of it is due to transport prior to deposition, as examination of weathered surfaces with silicified fossils in relief reveals a preponderance of broken specimens.

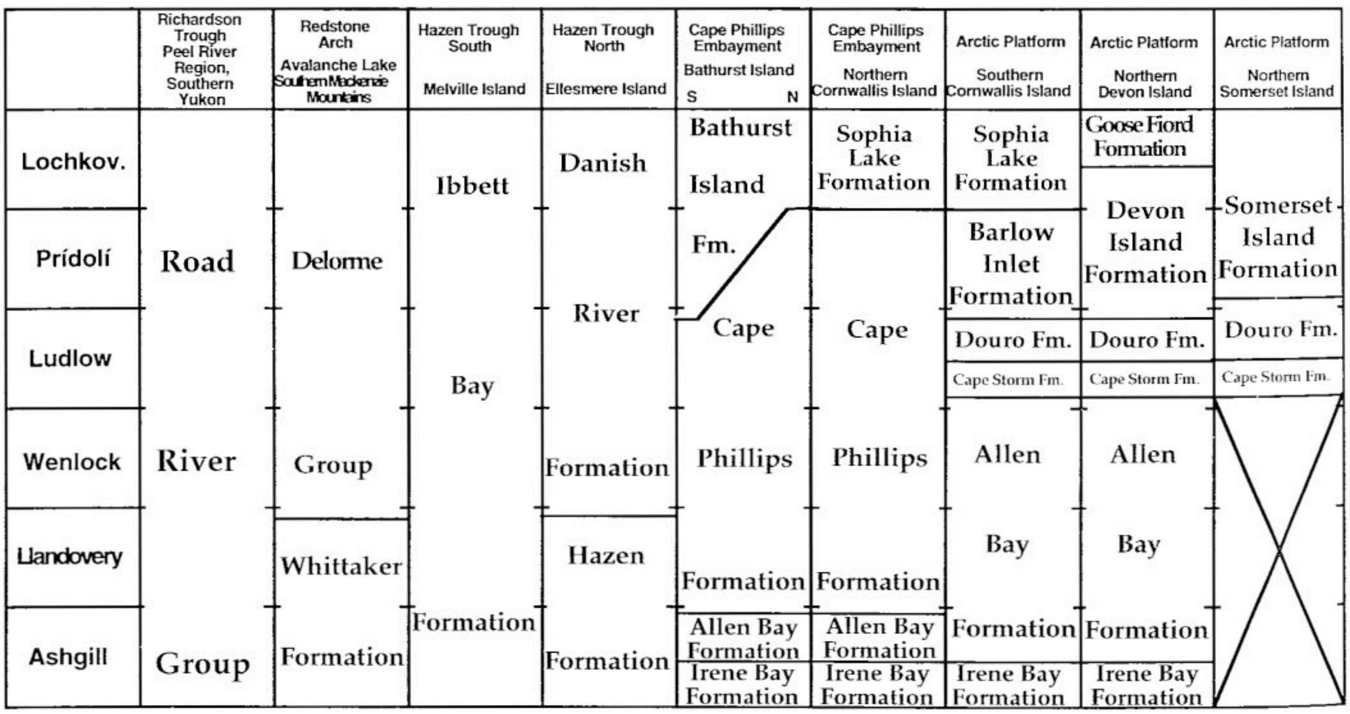
The weathered surface of the debris flows ranges in colour from medium brown to ochre to beige; fresh surfaces are almost always dark brown. Residues from acid digestion typically contain a high percentage of insoluble argillaceous material, and the silt content is sometimes so high that rocks will not break down in 10 percent hydrochloric acid. Silicified fossils from mid-Paleozoic deposits in other parts of the world are of a rather uniform aspect. They are typically found in black limestones, are medium to light gray in colour, and are extremely fragile. This style of silicification is displayed by all faunas of Ordovician to Devonian age that have yielded small silicified growth stages, including rocks of the Whittaker Formation and Delorme Group of the Mackenzie Mountains that are contemporaneous with, and share some species with, the Cape Phillips Formation.

The situation in the Cape Phillips Formation is very different. Silicified fossils are medium to light tan in colour and quite robust; it is possible to carefully handle larger specimens, a practice unthinkable for most silicified faunas. In addition, silicified faunas are often numerically biased toward smaller specimens. The opposite is true of the Cape Phillips faunas, which are biased toward large specimens. No protaspid specimens have been recovered, and only a very few large meraspids (e.g., transitory pygidia of *Borealarges* (s.l.) *calei* Adrain, 1994). In fact, in most beds there is a lower size limit to trilobite specimens that restricts the samples to holaspids (although smaller fossils belonging to other groups, such as ostracods, are often preserved). In addition, it is well established that silicification in other faunas often occurs in two layers, on the inner and outer surfaces of the original cuticle with a hollow space in between (e.g., Whittington and Evitt, 1954). This can sometimes be observed in Cape Phillips specimens (e.g., *Struszia* (s.l.) *harrisoni*, Pl. 18, fig. 8), but most specimens are solid, with the cuticle replaced by a single thick band of silica.

The process of silicification is in general not well understood, but it is apparent the situation in the Cape Phillips embayment is unlike that of other regions. The style of silicification, when it occurs, seems both geographically and stratigraphically uniform, as even Lower and Middle Devonian silicified faunas of the Sophia Lake and Blue Fiord formations are of similar preservational aspect.

LOCALITIES AND STRATIGRAPHY

The Cape Phillips Formation (Thorsteinsson, 1958) is a widely exposed unit comprised mainly of calcareous shale and argillaceous limestone, ranging in age from Ashgill to Přídolí or Lochkovian. The formation is developed across the Cape Phillips embayment (Melchin, 1989), and is a lateral equivalent of platform carbonates of the Allen Bay, Cape Storm, Douro, and Barlow Inlet formations to the east and southeast, and of deeper water sediments of the Hazen and Imina formations in the Hazen Trough to the north and northwest (Text-fig. 2). Three members are recognized. Member A is Ashgill to Telychian in age, B is Telychian, but restricted to the southwest part



Text-fig. 2. Comparison of uppermost Ordovician through lowest Devonian lithostratigraphic nomenclature across the northern Laurentian region.

of the outcrop area, and C is Telychian to Přídolí or Lochkovian. In situ faunas are found throughout the stratigraphic and geographic range, but allochthonous carbonate debris flow deposits are restricted to member C near to the southeastern line of facies change to platform carbonates (Text-fig. 1A).

The Cape Phillips Formation contains rich graptolite faunas throughout its stratigraphic range (Thorsteinsson, 1958). The graptolite zonation cited herein is that developed by Melchin (1987, Ashgill; 1989, Llandovery), Lenz and Melchin (1990, 1991, Wenlock), and Lenz (1990, Ludlow and Přídolí). A comparison of these zones with the standard British scheme, and with the informal sequence of trilobite faunas established herein, is given in Text-figure 3. Silicified trilobite collections have been obtained from two main localities: sections and frost-heave talus along the eastern part of the south shore of Baillie-Hamilton Island (Text-fig. 1C); and short sections and talus boulders along a small, northerly-flowing tributary of Abbott River, northwestern Cornwallis Island (Text-fig. 1B).

STRATIGRAPHIC SECTIONS

Measured sections at the two main localities, and their proposed correlation with coeval sections in the southwestern Northwest Territories, are shown in Text-figure 4.

		Cape Phillips Formation Trilobite Faunas	Arctic Islands Graptolite Zones	Standard Graptolite Zones
LUDLOW	Gorstian	Unstudied	*progenitor*	*scanicus*
		Unnamed Fauna 2		*nilssoni*
WENLOCK	Homerian	*Struszia harrisoni* Fauna	*ludensis**	*ludensis*
				praedeubeli-deubeli
		Mackenziurus deedeei Fauna		*parvus-nassa*
			lundgreni-testis	*lundgreni*
	Sheinwoodian	Unnamed Fauna 1	*perneri-opimus*	*rigidus-perneri*
		Struszia petebesti Fauna		
		Struszia dimitrovi Fauna	*instrenuus-kolobus*	
				riccartonensis-belophorus
		No Faunas	*centrifigus-insectus*	*centrifigus-murchisoni*

Text-fig. 3. Comparison of the Cape Phillips embayment Wenlock to lower Ludlow trilobite faunas and graptolite zonation (Lenz and Melchin, 1990, 1991; Lenz, 1990, 1992, 1995) with the standard zonal scheme (after Norford et al., in press). *Lenz (1995) has further subdivided the *ludensis* Zone of Lenz and Melchin (1991) into a tripartite scheme. How this new zonation relates to the Cape Phillips trilobite faunas cannot be determined without further fieldwork; hence it is omitted from this diagram.

SECTIONS BH 1, BHL 1, LOCALITY BHH

The sections on Baillie-Hamilton Island (Text-figs. 1C, 4A, 5) range from the lowest Wenlock *Cyrtograptus centrifigus-Cyrtograptus insectus* Zone (unmeasured Llandovery strata crop out along the shore to the west) through to the Lochkovian contact with the overlying Sophia Lake Formation near the southeast corner of the island. There is a minor fault and covered interval between sections BH 1 and BH 2, lying entirely within the lower Homerian *Cyrtograptus lundgreni-Monograptus testis* Zone. Section BH 1 was measured by Chatterton and Perry in 1976, and covers the part of the overall section lying beneath the faulted covered interval. While there are a few very prominent marker beds, it is difficult to replicate the original line of section. Much of the area is talus covered. Continuous outcrop can be found to about the original BH 1 164.5 m, but above this outcrop is very patchy and the uppermost 100 m or so is entirely talus-covered. Hence, new section designations were used during recollection in 1991-1993. Section BHL 1 probably lies to the south of the original line of section. BHL 1 0 m is a prominent flow without question equivalent to the original BH 1 110 m (362'; see Rohr et al., 1981). Locality BHH lies to the north of BH 1 and BHL 1, near the top of a hill along the coast. The rocks here are entirely covered by frost-heaved shale talus. Collections here are weathered limestone blocks lying frost-heaved approximately along strike (through visual estimate) with section BHL 1 92 m, with which they share most species. BHH-A and BHH-B are collections estimated to be about ten metres stratigraphically below BHH-C, but there is little variation in the faunal content of individual blocks from this locality. The well exposed lower part of the section contains abundant graptolites. Graptolites are rare in the covered higher part, but *Monograptus testis* Barrande has been collected from talus just beneath the faulted interval.

SECTION BH 2

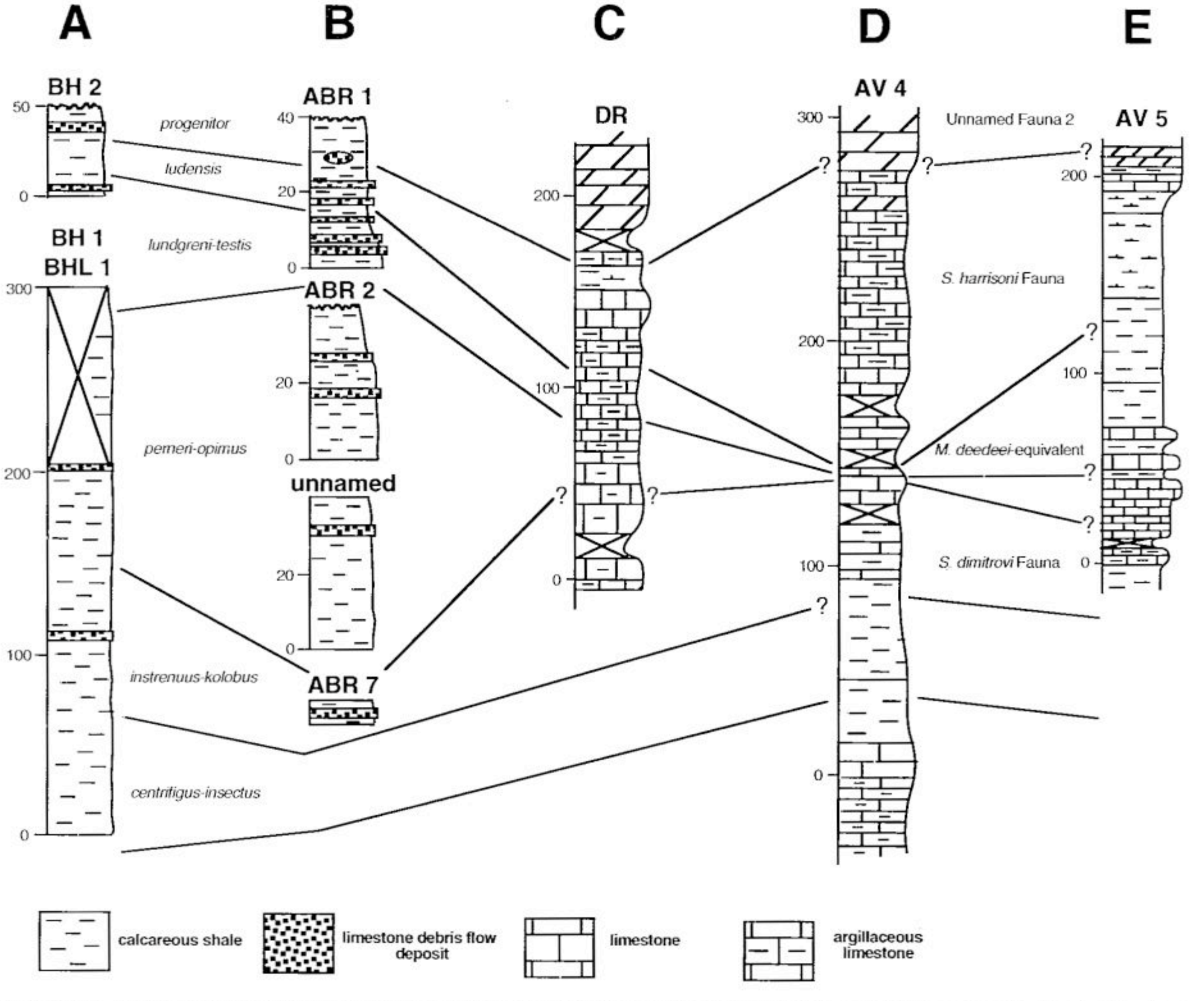
Section BH 2 begins with the first outcrop to the east of a stream running down the fault line separating BH 2 from BH 1. The section was originally measured by Chatterton and Perry in 1976, and extended upsection by Chatterton and J.M.A. in 1991. The section has limited areal extent along strike, but is very well exposed, and runs along a short cliff directly along the water's edge. *Monograptus testis* has been found in situ at BH 2 3 m and 6.5 m. There follows an interval almost barren of both diagnostic graptolites and shelly fossils, which must include the entirety of the *Pristiograptus ludensis* Zone and the Wenlock-Ludlow boundary. Both shelly fossil debris flows and graptolites resume just below BH 2 42 m, but where they reappear the graptolites already represent the lower Ludlow *Lobograptus progenitor* Zone.

ABBOTT RIVER SECTIONS

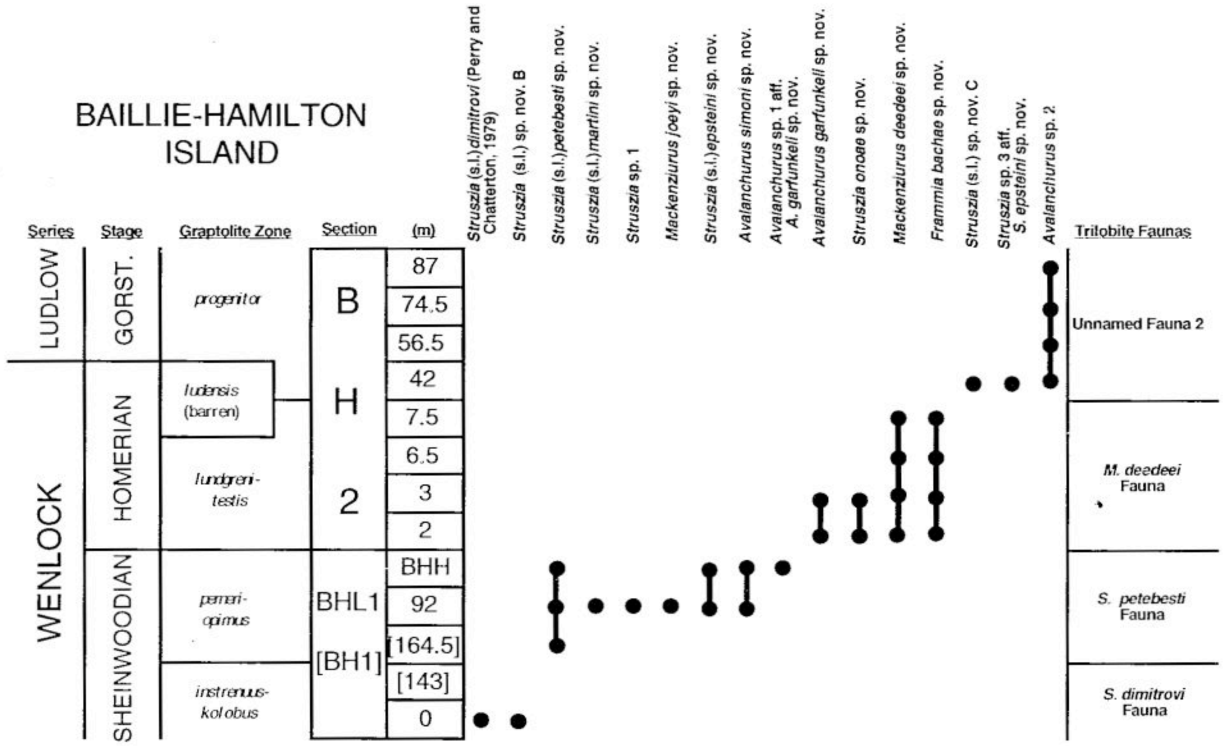
Exposures at a tributary of Abbott River on northwestern Cornwallis Island (Text-figs. 1B, 4B, 6) are in small (30-40 m high), steep cliffs along a sinuous creekbed. While exposure of a given short section can be excellent, there are covered intervals, and entire sections that are mostly talus cover. This is the case for section "CAR 1", measured by Perry and Chatterton (see Chatterton and Perry, 1979) and remeasured by J.M.A. as ABR 3. Rich collections from this section are all nodular talus. Also included are collections labeled "CAR 1 80'+" by Perry and Chatterton. While there is a good deal of well-preserved material (including the type material of *Acanthalomina thorsteinssoni arctica* Chatterton and Perry, 1979), it is now evident that stratigraphic mixing has occurred, and unfortunately the nodules were processed and the residues stored as a single lot. It is not possible to be certain of encrinurid associations and the material is not included in the present work. The base of this section contains prominent shale outcrop with graptolites of the *Cyrtograptus lundgreni-Monograptus testis* Zone. Limited but nearly continuous outcrop can be found in small melt-water streams until ABR 3 24 m, which is still *C. lundgreni-M. testis* Zone. Above this is a steep covered interval, most of which has talus of the *Pristiograptus ludensis* Zone. Outcrop at the top of the exposure, ABR 3 44 m, contains graptolites of the Ludlow *Lobograptus progenitor* Zone.

Rocks of the *Monograptus instrenuus-Cyrtograptus kolobus* Zone are present and well-exposed, and outcrop is more or less continuous down-section (upstream to the south). Shelly fossiliferous debris flow deposits are absent, except for a very thin bed discovered in 1994 and designated locality ABR 7 (Text-fig. 4B). Rich silicified shelly fossils were recovered from a large (50-60 kg) boulder associated with shale talus bearing graptolites of the *Cyrtograptus perneri-Monograptus opimus* Zone, designated ABR TTD (Text-fig. 6). The boulder was found in the creek bed beneath an entirely talus-covered slope from which, given its size and position, it was likely derived. It lies directly across from section ABR 2, but strike of the beds in that section indicate that ABR TTD was most probably derived from somewhat lower strata (very likely equivalent to the unnamed section shown in Text-fig. 4B). While the boulder contains many trilobite species found in section BHL 1 92 m and locality BHH on Baillie-Hamilton Island, its fauna occurs nowhere else at Abbott River, and the boulder may have been derived from entirely talus-covered strata.

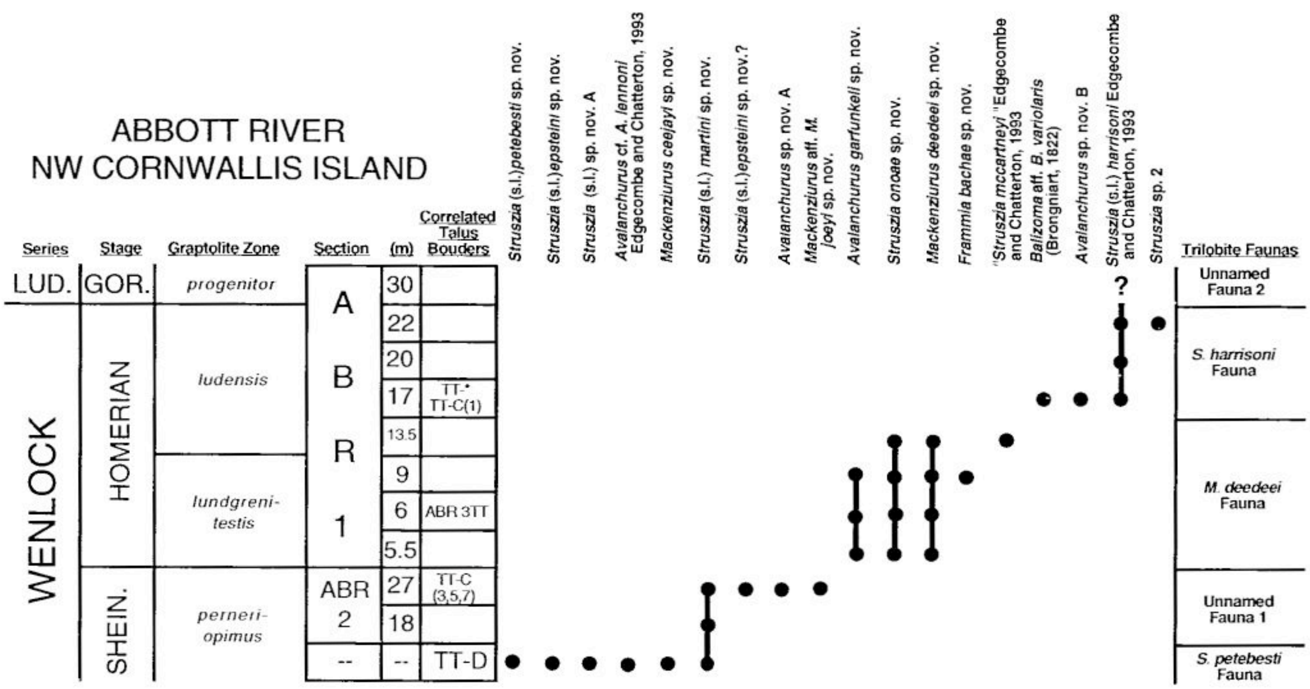
Section ABR 2 is contained entirely within the *C. perneri-M. opimus* Zone. Silicified shelly fossils occur at ABR 2 18 m and ABR 2 27 m. There is also abundant silicification in weathered and frost-heaved rocks a few metres higher at the top of the exposure, but these have not yielded trilobites.



Text-fig. 4. Approximate correlation between sections in the Cape Phillips embayment, central Canadian Arctic Archipelago, and other Canadian sections. Sections are not to uniform scale; thicknesses are in metres. Lines of correlation to Mackenzie Mountains sections are approximate, and are extrapolations based upon the series of trilobite faunas described herein, compared with the published descriptions of Mackenzie Mountains trilobites. **A.** Sections in the Cape Phillips embayment on southern Baillie-Hamilton Island. **B.** Sections in the Cape Phillips embayment near Abbott River, northwestern Cornwallis Island. **C.** Delorme Range section, Root basin, eastern Mackenzie Mountains. D, E. Sections Avalanche Lake 4 and 5, Selwyn basin or Redstone Arch, central Mackenzie Mountains (after Chatterton et al., 1990).



Text-fig. 5. Ranges of encrinurine species in Cape Phillips Formation strata on the south shore of Baillie-Hamilton Island.



Text-fig. 6. Ranges of encrinurine species in Cape Phillips Formation strata near Abbott River, northwestern Cornwallis Island.

Several water-worn talus boulders were collected from the creek bed at positions designated ABR TT* and ABR TTC (Text-fig. 1B; ABR TTA and TTB have also yielded a few less significant silicified trilobites). Unlike ABR TTD, which has associated graptolites, these collections have no independent biostratigraphic control. Their description might therefore be problematic, except that each block has been processed separately and found to contain a fauna identical with that from a given in situ horizon. As they can be related with confidence to well-controlled collections, and are a source of important well-preserved sclerites, their description is justified. Several of the boulders from ABR TTC (numbers 1, 2, 4, 6) and boulder ABR TT* correlate with horizon ABR 1 17 m, on the basis of the shared and unique occurrence of the encrinurid *Balizoma* aff. *B. variolaris* (Brongniart, 1822) (see Adrain and Edgecombe, 1995) and the odontopleurid *Meadowtownella* aff. *M. mendica* (Siveter, 1989). Boulders ABR TTC (numbers 3, 5, and 7) have a fauna identical with that from section ABR 2 18-27 m.

Talus boulder ABR 3TT is a large, spherical limestone nodule found at the base of section ABR 3. This section ranges from lower Homerian at base to Gorstian at top (see above), and again there is little independent biostratigraphic control available. The nodule contains a rich and well preserved trilobite fauna, however, which has most species shared with horizons ABR 1 5.5-13.5 m and BH 2 2-7.5 m. The boulder can therefore be asserted with confidence to have been derived from the *C. lundgreni-M. testis* Zone or the lower part of the *P. ludensis* Zone of section ABR 3, although a thorough search along strike yielded no further nodules.

Section ABR 1 is continuously exposed from its base to 23 m, and is thereafter partially covered. Graptolites of the *C. lundgreni-M. testis* Zone are abundant to ABR 1 10 m. Those of the *P. ludensis* Zone appear at ABR 1 12 m. ABR 1 23 m is definitely within the *P. ludensis* Zone, but the Wenlock-Ludlow boundary is positioned somewhere between this horizon and ABR 1 30 m, which is almost certainly within the *Lobograptus progenitor* Zone, as is much of the intervening shale talus. Silicified trilobites have been obtained from ABR 1 0.5, 5.5, 6, 9, 13.5, 17, 20, 22, and 30 m (the latter a single large nodule), and include some of the richest and most prolific horizons sampled. A thick debris flow deposit at ABR 1 34.5 m yielded abundant silicified brachiopods but no trilobites.

ABR 7 is a small exposure located upstream (and down-section) from the remainder of the horizons, and discovered only in the 1994 field season. A thin (approx 10 cm) debris flow deposit occurs in about 1 metre of shale exposed along the riverbank. Graptolite occurrences, while not conclusive, indicate the bed may be assigned to the *Monograptus instrenuus-Cyrtograptus kolobus* Zone. Preliminary trilobite sampling indicates the fauna is very similar to that of section BH 1 110 m, from the *M. instrenuus-C. kolobus* Zone of southern Baillie-Hamilton Island.

TRILOBITE FAUNAS

It may eventually be possible to propose a formal biostratigraphic scheme for the trilobites, calibrated against that for the graptolites, and applicable across northern Laurentia. For the present, with much systematic work remaining to be done, assemblages are described as faunas, named for some of the more common described species (Text-figs. 3, 5, 6). Discussion of the faunas is in ascending stratigraphic order.

STRUSZIA (S.L.) *DIMITROVI* FAUNA

Two rich and distinct faunas occur in section BH 1 (Text-fig. 5). The collections studied by Perry and Chatterton (1977) contain a mixture of sclerites from both faunas, and several of the sclerite associations in that work are now known to be incorrect (see Adrain, 1994, for a detailed discussion of the problem). The lowest fauna, named for the common encrinurid *Struszia* (s.l.) *dimitrovi* (Perry and Chatterton, 1979), is found in the mid-Sheinwoodian *Monograptus instrenuus-Cyrtograptus kolobus* Zone. First occurrence is at BH 1 106 m, but the most prolific bed is BH 1 110/BHL 1 0 m. The same fauna has its highest definite occurrence in a flow at BH 1 112 m. This fauna correlates well with section AV 4 126 m above base and its local equivalents in the Delorme Group, central Mackenzie Mountains (Chatterton and Perry, 1983, 1984; Chatterton et al., 1990). Several species are shared. Most are undescribed, but included are the faunal name-bearer, the aulacopleurid *Otarion huddyi* Adrain and Chatterton, 1994, the odontopleurid *Kettneraspis lenzi* (Chatterton and Perry, 1983) and the cheirurid *Sphaerexochus dimorphus* Perry and Chatterton, 1977 (see Chatterton and Perry, 1984). Hence the *S.* (s.l.) *dimitrovi* Fauna is time-equivalent to Faunal Assemblage j of Chatterton and Perry (1983). The *S.* (s.l.) *dimitrovi* Fauna has also been observed in the *M. instrenuus-C. kolobus* Zone of the Sheills Peninsula on northern Devon Island, of Baumann Fiord on Ellesmere Island, and of northern Dundas Island. It is also the only northern Canadian Wenlock fauna known with certainty to occur in Greenland, as Lane (1984) illustrated elements of it from the Offley Island and Hauge Bjerge formations on the north side of Kayser Bjerg, Hall Land, western North Greenland.

A debris flow deposit yielding silicified trilobites occurs at BH 1 143 m, also within the *M. instrenuus-C. kolobus* Zone. Unfortunately, the rocks are very argillaceous and it is difficult to obtain material. The horizon is significant, however, because the fauna may be in some ways distinct, and some of the material described by Perry and Chatterton (1977) was likely from this horizon. In particular, Perry and Chatterton (1977) described several pygidia which they assigned to their new *Sphaerexochus dimorphus*, and which bore long median spines on the axial rings. Also assigned were pygidia lacking these spines, and the species was considered dimorphic. At BH 1 110 m, however, only the non-spined variety has been recovered (with a very large sample size). This indicates that separate species are likely involved, an idea supported by the fact that there is almost no interspecific variation among cephala of all known Silurian species of *Sphaerexochus* worldwide (Thomas, 1981). Unfortunately, despite considerable effort and large new collections, none of the spine-bearing pygidia have since been recovered from BH 1. Since almost all obvious debris flows have been sampled, it seems likely that BH 1 143, from which trilobites are known to have been obtained but from which few new specimens were recovered, is the source of the spine-bearing specimens. The combined sample from the horizon is not large, but most species seem very similar to, and likely conspecific with, species occurring at BH 1 110 m. It is important to note that at AV 4 126 in the Mackenzie Mountains, both spined and non-spined pygidia definitely occur together (Chatterton and Perry, 1984).

STRUSZIA (S.L.) *PETEBESTI* FAUNA

The second major fauna at BH 1 occurs within the upper Sheinwoodian *Cyrtograptus perneri-Monograptus opimus* Zone, and is named for the common and ubiquitous encrinurid *Struszia* (s.l.)

petebesti n. sp. The fauna has been collected from talus boulders in the interval BH 1 192-209 m, in definite but patchy outcrop at BHL 1 81 and 92 m, and in frost-heaved talus at locality BHH. The *S.* (s.l.) *petebesti* Fauna at BH 1 is the most diverse Silurian trilobite fauna yet found, with nearly 60 species. The fauna has no equivalent in the Avalanche Lake sections of the Mackenzie Mountains. However, AV 4 126 m contains the *Struszia* (s.l.) *dimitrovi* Fauna, while AV 4 138 m correlates with the *Mackenziurus deedeei* Fauna (see below). This indicates an extremely narrow *C. perneri-M. opimus* Zone equivalent ("*firmus nahanniensis* beds" of Lenz, 1980) in the Avalanche Lake sections. In contrast, this interval in the Arctic contains two diverse and separate trilobite faunas (the *S.* (s.l.) *petebesti* Fauna and Unnamed Fauna 1, see below), and can occupy 70 or 80 m of section (Lenz and Melchin, 1991, fig. 2).

The *Struszia* (s.l.) *petebesti* Fauna occurs in talus boulder ABR TTD at Abbott River, northwestern Cornwallis Island (Text-fig. 6), although there are species unique to both the Baillie-Hamilton and Abbott River occurrences. The fauna has also been discovered in the *C. perneri-M. opimus* Zone of Cape Becher on Devon Island, and on northern Dundas Island.

UNNAMED FAUNA 1

This fauna is known from section ABR 2 18-27 m (*Cyrtograptus perneri-Monograptus opimus* Zone) and from several talus boulders in the creek bed at ABR TTC (numbers 3, 5, 7). No suitable name bearer has yet been formally described, and the common encrinurine, *Struszia* (s.l.) *martini*, ranges also through the underlying *S.* (s.l.) *petebesti* Fauna. The fauna has an almost identical generic makeup to the *S.* (s.l.) *petebesti* Fauna. While most well-represented genera have separate species in either fauna, *Struszia* (s.l.) *martini*, at least, ranges through both, and unlike other of the faunas recognized, there is some definite biostratigraphic overlap. Typically, congenerics from either fauna are very similar to one another, but can be distinguished by several sometimes subtle but pervasive characters. The two faunas occur in the same graptolite zone, although Unnamed Fauna 1 is almost certainly somewhat younger. The *S. petebesti* Fauna occurs in talus boulder ABR TTD, which was found across the creek from the base of ABR 2. It was very likely derived from talus-covered rocks on the east side of the creek. Visual projection of the strike of the ABR 2 beds indicates that the beds from which ABR TTD was derived are down-section from ABR 2. Given that ABR TTD is out of context, there is, of course, no way to be certain. Nevertheless, the idea that ABR TTD, and the *S.* (s.l.) *petebesti* Fauna, is older than ABR 2 and Unnamed Fauna 1 finds support in the morphology of the trilobites. In many putative trilobite evolutionary "lineages" from the northern Laurentian region, peramorphic evolutionary trends are correlated closely with stratigraphic sequence (Chatterton and Perry, 1983; Adrain and Chatterton, 1994). The causal basis for this is moot; Adrain and Chatterton (1994), using a series of species of *Otarion*, have pointed out that such trends should be cast as descendant phyletic lineages only when placed in global phylogenetic context (if at all). Nevertheless, the peramorphic trends, whatever their phylogenetic implications, exist and can be observed in several taxonomic groups and in several northern and Arctic Canadian sections. Work in progress has shown that several such trends (mainly in proetid genera) indicate that Unnamed Fauna 1 is probably younger than the *S.* (s.l.) *petebesti* Fauna, in agreement with the stratigraphic estimate.

While distinct and diverse, less material of unnamed fauna 1 has been recovered than any of the other major faunas. Trilobites are scarce at ABR 2 18 m, while the rocks at ABR 2 27 m have a high chert content and are difficult to break down. The richest collections come from the talus boulders at ABR TTC, but only three blocks containing the fauna have been found (only one of which, ABR TTC(3), is very large). Given the close similarity, and inferred phylogenetic affinity, of species from this fauna with their counterparts in the *S.* (s.l.) *petebesti* Fauna, the result is that the species from unnamed fauna 1 that are represented by a large number of specimens can generally be shown to be distinct, while species known from only a few sclerites are not always obviously distinct. This is probably due mainly to inadequate sample size, but it is possible that members of morphologically conservative groups, in which genetic change was less well expressed as phenotypic change or which simply had slower rates of evolution, may ultimately be shown not to vary between the faunas.

MACKENZIURUS DEEDEEI FAUNA

Elements of the *Mackenziurus deedeei* Fauna occur in debris flows at BH 2 2, 3, 6.5, and 7.5 m, at ABR 1 5.5-13.5 m, and in talus boulder ABR 3TT. Most of these horizons are definitely within the *Cyrtograptus lundgreni-Monograptus testis* Zone, but ABR 1 13.5 m is lower *Pristiograptus ludensis* Zone. All of the faunas to this point, including the *M. deedeei* Fauna, have a similar generic makeup. Between horizons ABR 1 13.5 m and ABR 1 17 m, both contained in the *P. ludensis* Zone, a profound turnover in the trilobite faunas occurs. Several clades become globally extinct, others disappear forever from the northern Laurentian record, and several clades either originate or appear in northern Laurentia for the first time at ABR 1 17 m. This indicates the occurrence of a major biotic event between ABR 1 13.5 m and ABR 1 17 m, with profound effects on the shelly benthos. It occurs just above the well-known *P. ludensis* event (situated in the interval ABR 1 10-12 m), a massive global extinction of pelagic graptolites (Koren, 1991; Lenz, 1994b). A Homerian shelly fossil event has not previously been reported, but this could well be due to the less well resolved Homerian shelly fossil record in areas other than the Cape Phillips embayment.

The *Mackenziurus deedeei* Fauna is coeval with that of section AV 5 58-60 m in the Delorme Group of the Mackenzie Mountains, and local equivalents. "*Struszia*" *mccartneyi* is shared, as are undescribed species of proetids, among others. Hence, the *M. deedeei* Fauna corresponds to trilobite assemblage x of Siveter and Chatterton (1996).

STRUSZIA (S.L.) *HARRISONI* FAUNA

As described above, the *Struszia* (s.l.) *harrisoni* Fauna has a very different generic makeup than any of the older faunas, which are all similar. Gone are all calymenids (which do not reappear in northern Laurentia), extinct worldwide are the acanthoparyphine *Hyrokybe* Lane, 1972, an undescribed proetid genus, and the odontopleurine genus *Edgecombeaspis* Adrain and Ramsköld, 1997. Disappearing from the Cape Phillips embayment (at least) are *Mackenziurus*, *Gerastos* Goldfuss, 1843, *Cyphoproetus* Kegel, 1928, *Interproetus* Šnajdr, 1977, and several other proetid genera. Appearing for the first time in the Cape Phillips embayment are *Balizoma*, *Coniproetus* Alberti, 1966, *Hedstroemia* Přibyl and Vaněk, 1978, and *Acanthalomina* Prantl and Přibyl, 1949 (*Coniproetus* and *Hedstroemia* are, however, known from older strata in the Mackenzie Mountains).

The *Struszia* (s.l.) *harrisoni* Fauna correlates with section AV 4 165-248.5 m in the Delorme Group of the Mackenzie Mountains, and local equivalents. Shared are the name-bearer along with the species *Otarion brauni* Perry and Chatterton, 1979 and *Sphaerexochus johnstoni* Chatterton and Perry, 1984, together with undescribed species of *Hedstroemia* and *Coniproetus*. The *S.* (s.l.) *harrisoni* Fauna therefore corresponds to Faunal Assemblage k of Chatterton and Perry (1983).

UNNAMED FAUNA 2

The last major fauna occurs in lowest Ludlow (*Lobograptus progenitor* Zone) rocks at sections ABR 1 30 m and BH 2 42-74.5 m. As with Unnamed Fauna 1, the Ludlow fauna is incompletely known, and no suitable name-bearer has yet been described (it is planned, however, to eventually name it for a common species of *Kettneraspis* Prantl and Přibyl, 1949). Trilobites are quite common at ABR 1 30 m, but the collection was a single large nodule which has been entirely processed. Silicified trilobites are exceedingly rare in the Ludlow section at BH 2. Nevertheless, enough is known to indicate the fauna is distinct from the *Struszia* (s.l.) *harrisoni* Fauna (e.g., the presence of *Struszia* sp. nov. B), although some species are possibly shared across the Wenlock-Ludlow boundary (*Acanthalomina arctica* Chatterton and Perry, 1979, definitely occurs in both faunas).

The unnamed Ludlow fauna correlates definitely with a single horizon of the Delorme Group in the Delorme Range, DR 182.9 m (Chatterton and Perry, 1983), based on the common occurrence of *Otarion beukeboomi* Adrain and Chatterton, 1994.

PALEOBIOGEOGRAPHIC AFFINITIES

At the generic level, the Wenlock faunas of northern Laurentia are most closely comparable to those of Baltica and Britain. With the exception of northern Laurentian endemics, most genera are shared between the three regions. The most significant difference, beyond the several northern Laurentian endemics, is the absence from northern Laurentia of staurocephalids, acastids, dalmanitids, and *Calymene* s.s., and the extreme rarity of phacopids (known from two upper Sheinwoodian species from the Cape Phillips embayment represented collectively by less than ten sclerites) and of *Encrinurus* s.s., both of which are common in Britain and Baltica.

Northern Laurentian Wenlock faunas have very little in common with those of southern Laurentia, indicating the Trans-Continental Arch was a significant barrier to migration and dispersal during Wenlock time.

At the specific level there are no direct links between northern Laurentia and other paleocontinents for most of the Wenlock. Thomas (1981) argued that *Sphaerexochus mirus* Beyrich, 1845, was widely distributed, considering it a senior synonym of the southern Laurentian *S. glaber* Holloway, 1980, and probably also of the northern Laurentian *S. dimorphus* Perry and Chatterton, 1977, along with other species. Ramsköld (1983), however, demonstrated that species of *Sphaerexochus* can usually be discriminated on the basis of pygidial morphology.

Likewise, Ramsköld (1986) considered *Struszia obtusa* (Angelin, 1851) to be widely distributed, and a senior synonym of *S. dimitrovi* (Perry and Chatterton, 1979), among others, but Edgecombe and Chatterton (1993) have since given several grounds for discrimination of the species group.

There is, however, a single possible species-level link between faunas from different paleocontinents in the *Pristiograptus ludensis* Zone. A fauna described by Siveter (1989) from southwest Ireland, while of radically different overall generic aspect, contains species of *Otarion*, *Meadowtownella*, and *Dicranopeltis* that are nearly indistinguishable from those occurring in the Cape Phillips embayment at section ABR 1 17 m. *Conoparia hollandi* Siveter, 1989, is a probable junior synonym of *Otarion brauni* Perry and Chatterton, 1979 (Adrain and Chatterton, 1994; 1996), while *Meadowtownella mendica* (Siveter, 1989) and *Dicranopeltis salteri*? (Fletcher, 1850) are known from undescribed and fragmentary occurrences at ABR 1 17 m. In addition, several sclerites from ABR 1 17 m and coeval talus boulders have been assigned with question by Adrain and Edgecombe (1995) to *Balizoma variolaris* (Brongniart, 1822) a species known elsewhere only from the *P. ludensis* Zone of the English Much Wenlock Limestone Formation and the lowest Ludlow of the Lower Elton Formation.

PHYLOGENETIC ANALYSIS OF THE *STRUSZIA* GENUS GROUP

Classification of the "*Encrinurus*" *variolaris* species group has been the subject of considerable work (Reed, 1928; Tripp et al., 1977; Strusz, 1980). Adrain and Edgecombe (1995) have given a brief history of the development of ideas, while Edgecombe (1994, fig. 1) has summarized the current phylogeny and classification, reflecting the many studies published in recent years.

Adrain and Edgecombe (1995) have outlined a hypothesis of relationship for the *variolaris* plexus, referring to work by Edgecombe and Ramsköld (1996). The latter have carried out parsimony analysis of the basal (mainly Llandovery) components of the plexus. Both of these studies have indicated the monophyly of a large post-Llandovery group encompassing the genera *Aegrotocatellus* Adrain and Edgecombe, 1995, *Avalanchurus* Edgecombe and Chatterton, 1993, *Balizoma* Holloway, 1980, *Fragiscutum* Whittington and Campbell, 1967, *Frammia* Holtedahl, 1914, *Mackenziurus* Edgecombe and Chatterton, 1990, and *Struszia* Edgecombe, Ramsköld, and Chatterton in Edgecombe and Chatterton, 1993. Edgecombe and Ramsköld (1996) have further determined that their new northwestern Canadian Telychian genus, *Billevittia*, is the probable sister group of this clade. We propose to refer to the clade, which includes much of the Upper Silurian diversity of the subfamily Encrinurinae, as the *Struszia* genus group. Given the significant new diversity described by Adrain and Edgecombe (1995), Edgecombe and Chatterton (1993), and herein, it is now possible to attempt a comprehensive parsimony analysis of the *Struszia* group.

TAXA

Ingroup taxa include all adequately known (i.e., information for at least cranidium, librigena, and pygidium) named species of all members of the genus group, along with a few less adequately known species which still appear interpretable. The choice of

Billevittia as outgroup follows the tree topology determined by Edgecombe and Ramsköld (1996). In that analysis, this genus was resolved as sister group to the species *Balizoma variolaris* and *Struszia* (s.l.) *dimitrovi*, included as representative of what is recognized here as the *Struszia* genus group.

CHARACTERS

Condition in *Billevittia* is indicated by the "0" coding (i.e., the outgroup has been given all 0 codings). The chosen outgroup had missing data for four of the characters selected; outgroup codings for these characters (21, 28, 30, 33) were achieved by reference to the next-most distant outgroup species indicated by the tree topology of Edgecombe and Ramsköld (1996).

Nearly all multistate (i.e., non-binary) characters were treated as unordered, as no plausible transformation series could be designated based on morphocline analysis (Mickevich and Weller, 1990) or ontogeny. An exception is character 24, in which the development of a tapered then tapered and waisted rhynchos represents progressive states in a morphocline and the character is accordingly treated as ordered. Illustrations of the characters employed are given in Text-figure 7.

Cranidium

1. *Condition of L1*: 0-very subdued, not always visible; 1-small, rounded swelling; 2-prominent, transverse swelling; 3-independently inflated, adaxially tuberculate lobe.
2. *Inflation of lateral glabellar lobes*: 0-strongly inflated; 1-very weakly inflated.
3. *Expression of III-2*: 0-independent tubercle, topologically distinct from L3; 1-partially or fully merged with swelling of L3.
4. *Expression of II-2*: 0-independent tubercle, topologically distinct from L2; 1-partially or fully merged with L2.
5. *Type of median occipital feature*: 0-single node; 1-paired occipital tubercles or spines.
6. *Shape of L0*: 0-short, subrhomboid, bowed forwards medially; 1-long (sag., exsag.), anterior margin transversely straight, subrectangular.
7. *Size of transverse tubercle row on posterior cranidial border and L0*: 0-subdued; 1-prominently expressed.
8. *Modal number of adaxial fixigenal tubercles*: 0-4; 1-5; 2-6; 3-3.
9. *Condition of posterior two adaxial fixigenal tubercles*: 0-independent tubercles; 1-partially or fully merged atop rounded fixigenal swelling.
10. *Intercalation of small adventitious tubercles among standard adaxial fixigenal tubercles in largest holaspides*: 0-absent; 1-present.
11. *Expression of anterior border tubercles (of holaspid)*: 0-moderately large tubercles; 1-extended into long spines.
12. *Genal angle/genal spine (of holaspid)*: 0-rounded; 1-long, robust spine; 2-small, thorn-like spine often present; 3-rounded, with lobate expansion of posterior border.
13. *Number of anterior fixigenal tubercles between eye and axial furrow*: 0-1; 1-2; 2-0.

Librigena

14. *Height of eye*: 0-not "stalked;" 1-very tall, "stalked."
15. *Eye size*: 0-moderately large; 1-small; 2-very large (note: coded on external views of librigenae or dorsal views of articulated cephala, where available).
16. *Number of transversely aligned tubercles at anterior edge of librigenal field*: 0-2; 1-1; 2-3.
17. *Adaxial portion of lateral border*: 0-non-lobate, with moderate-sized adaxial tubercles; 1-with very large lobate tubercles.
18. *Expression of outer row of lateral border tubercles*: 0-of moderate size; 1-strongly expressed.
19. *Depth of anterior furrow*: 0-deep; 1-shallow.
20. *Size of tubercle pairs at anteroventral margin of precranidial lobe*: 0-not large in holaspid; 1-retained as large, ventrally protruding tubercles in holaspid.

Rostral plate

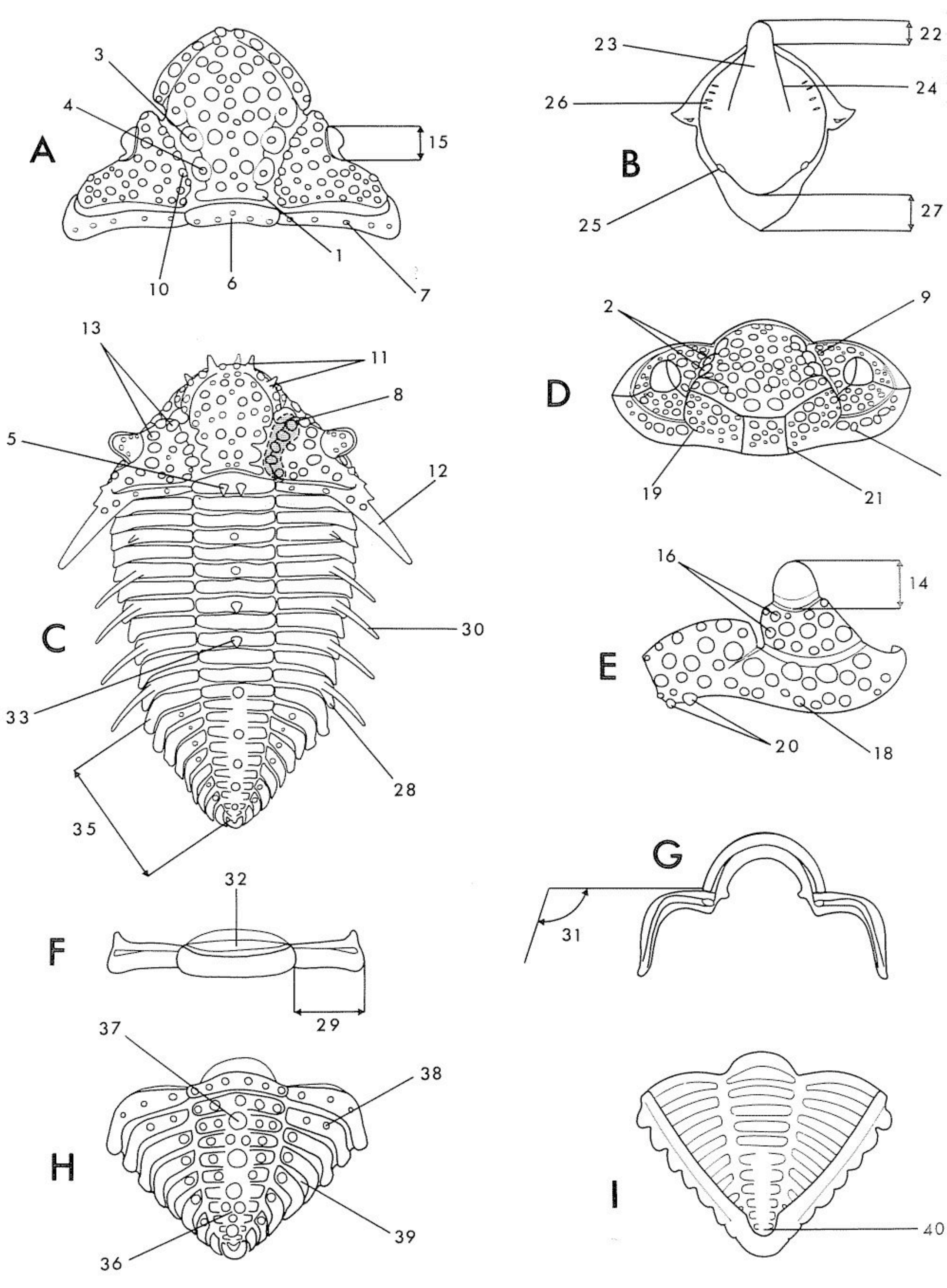
21. *Course of connective sutures*: 0-close together and subparallel, expanded ventrally around bulb, plate "keyhole" shaped; 1-ventrally divergent, but meeting or nearly meeting dorsally, plate wedge-shaped; 2-ventrally divergent, plate narrow but trapezoidal, typically with five tubercles on external surface; 3-ventrally divergent, plate nearly square; 4-ventrally convergent, plate nearly square to subrectangular.

Hypostome

22. *Length of rhynchos*: 0-not extending forward to anterior margin; 1-even with anterior margin; 2-extending forward past anterior margin.
23. *Inflation of rhynchos*: 0-very weakly inflated; 1-moderately inflated.
24. *Attitude of lateral margins of rhynchos*: 0-subparallel for at least posterior two-thirds; 1-evenly convergent forward, rhynchos tapered; 2-convergent forward, constricted behind anteriormost portion (rhynchos waisted).
25. *Expression of maculae*: 0-distinct; 1-indistinct.
26. *Expression of muscle impressions on middle body*: 0-not well impressed, at most scattered pits; 1-strong transverse striae developed on anterior half; 2-longitudinal rows of well-impressed pits flanking rhynchos.
27. *Length of posterior border*: 0-long, greater than 15 percent sagittal length of hypostome; 1-short, less than 15 percent length of hypostome.

Thorax

28. *Number of segments*: 0-11; 1-less than 11.
29. *Width of pleural lobe*: 0-moderate (axial lobe greater than 35 percent overall width); 1-wide (axial lobe less than 35 percent overall width).
30. *Presence of fulcral spines*: 0-reduced to tubercles or completely absent in holaspid; 1-strong tubercles or spines on segments 5, 7, 9, 11 in holaspid.


A
B
C
D
E
F
G
H
I
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
35
36
37
38
39
40

31. *Fulcral angle (transverse view)*: 0-about 135°; 1-about 100°.
32. *Expression of preannulus*: 0-serially variable, but generally weak to obscure; 1-always strongly expressed.
33. *Presence of sagittal tubercles on odd-numbered thoracic segments*: 0-absent in holaspid; 1-present in holaspid.

Pygidium

34. *R/P ratio*: 0-low (less than 1.4); 1-high (greater than 1.65).
35. *Modal number of pleural ribs*: $0\text{-}8^2$ or less; $1\text{-}9^2$ or more.
36. *Expression of sagittal band*: 0-present; 1-absent, rings continuous medially.
37. *Expression of sagittal tubercles*: 0-very large, bloated; 1-small or moderate in size; 2-completely effaced.
38. *Pleural tuberculation*: 0-moderate to strong; 1-very subdued to absent.
39. *Length of inter-rib furrows (exsag.)*: 0-short; 1-long.
40. *Depth of doublural notch*: 0-shallow, broad; 1-deep.

ANALYSIS

The data matrix employed is given in Table 1. The data were analyzed using *Billevittia*, coded 0 for all characters and designated the outgroup, with all characters except character 24 unordered, and with ACCTRAN optimization. Analyses were carried out using PAUP version 3.1.1 (Swofford, 1993) on an Apple Macintosh LC 475, and using Hennig86, version 1.5 (Farris, 1988) on a 486 DX2/66 MHz PC.

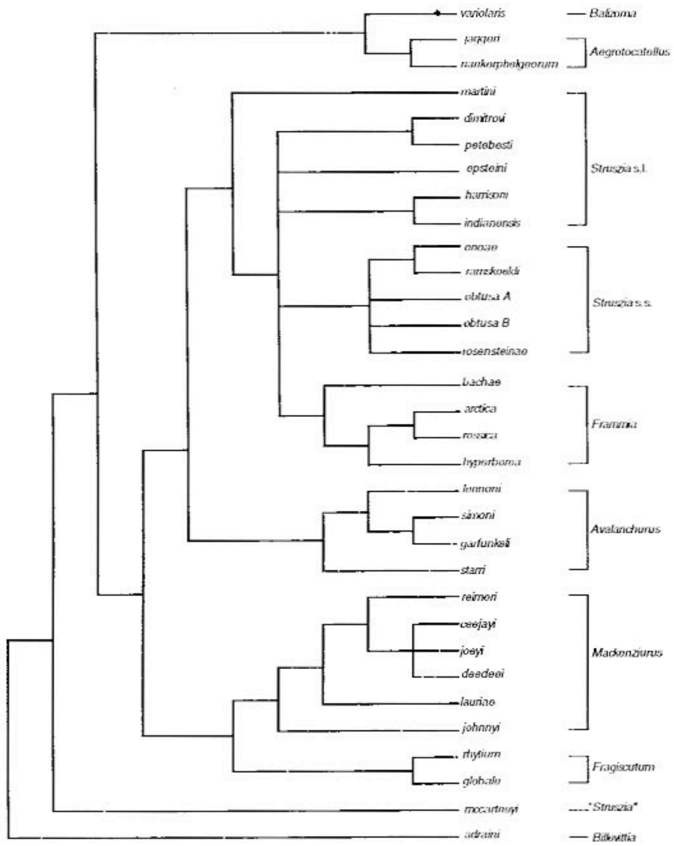
RESULTS

With the parameters described above, general heuristic search with PAUP, using TBR (tree bisection-reconnection) branch-swapping, yielded 36 trees of length 130 and consistency index of 0.431. As thorough attempts were made to find both shorter trees and additional trees of length 130, and since the result was independently confirmed by the Hennig86 program (using the mhennig* search algorithm combined with bb* extended branch swapping), we consider it likely that this is an optimal result. A strict consensus of the 36 trees is shown in Text-figure 8. One of the 36 trees, with character optimizations mapped on, is shown in Text-figure 9.

DISCUSSION

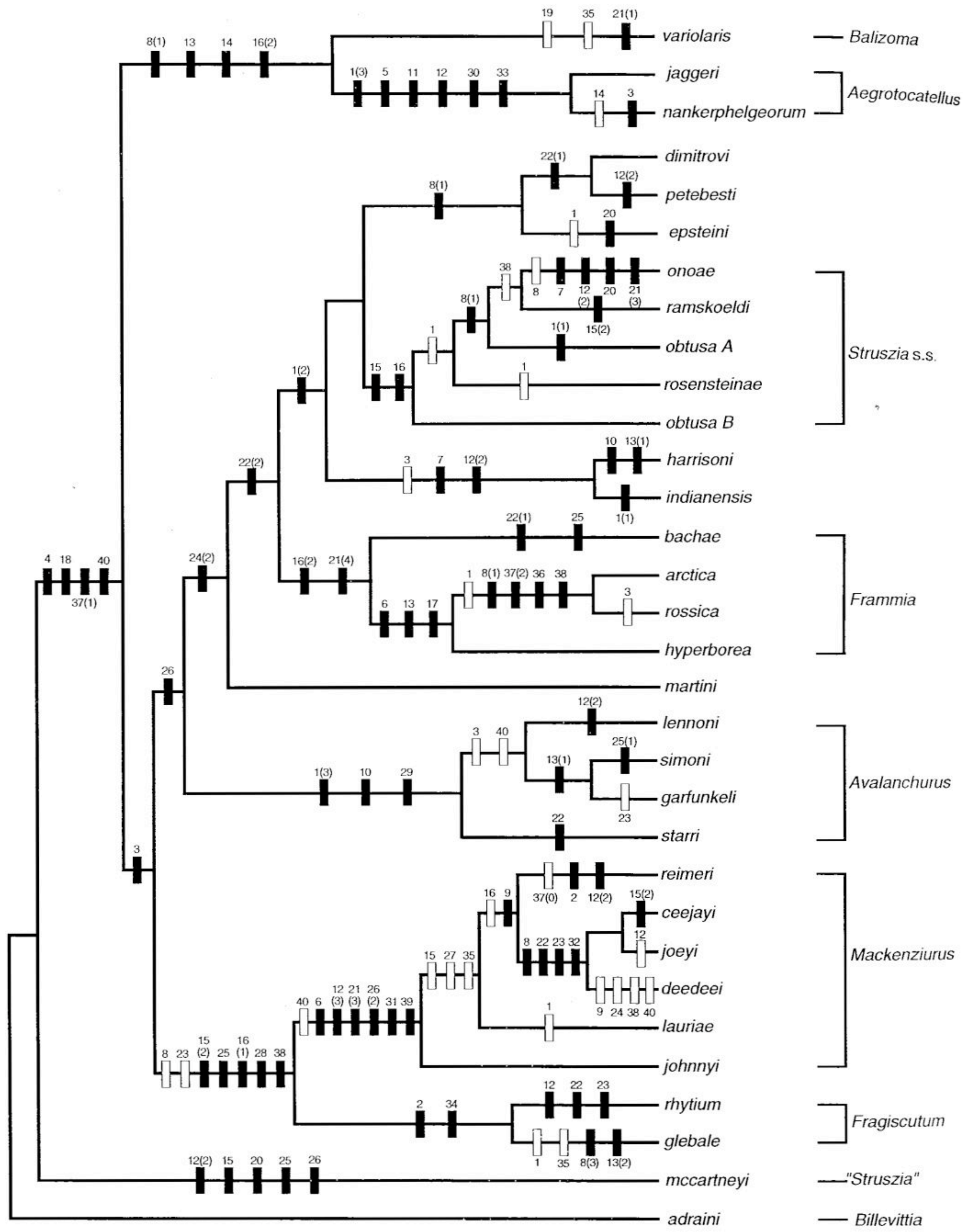
The number of minimal length trees obtained might appear large. Given the size of the analysis, however, it is a highly informative result, and reference to Text-figure 8 will confirm that there is a considerable amount of resolution in the cladogram, with much of the uncertainty at the intrageneric level. The analysis confirms what had previously been some less formal hypotheses of phylogeny, but also includes some novel results. The results are discussed in ascending order through the major nodes of the strict consensus cladogram (i.e., from most primitive to most derived). A simplified tree showing some of the most stable and compelling character support is shown in Text-figure 10.

1. When Edgecombe and Chatterton (1993, p. 96) described their new *Struszia* (s.l.) *mccartneyi*, they recognized that the species was difficult to relate to congenerics in synapomorphic detail (hence the sensu lato designation). It now seems clear that the species is actually a highly plesiomorphic member of the *Struszia* group. Primitive features shared with the outgroup include the presence of large, independently inflated II-2 and



Text-fig. 8. Strict consensus of 36 cladograms of length 130, produced using heuristic search in PAUP 3.1.3 (Swofford, 1993) and confirmed using mhennig* and bb* in Hennig86 1.5 (Farris, 1988). Consistency index = 0.431. Retention index = 0.613.

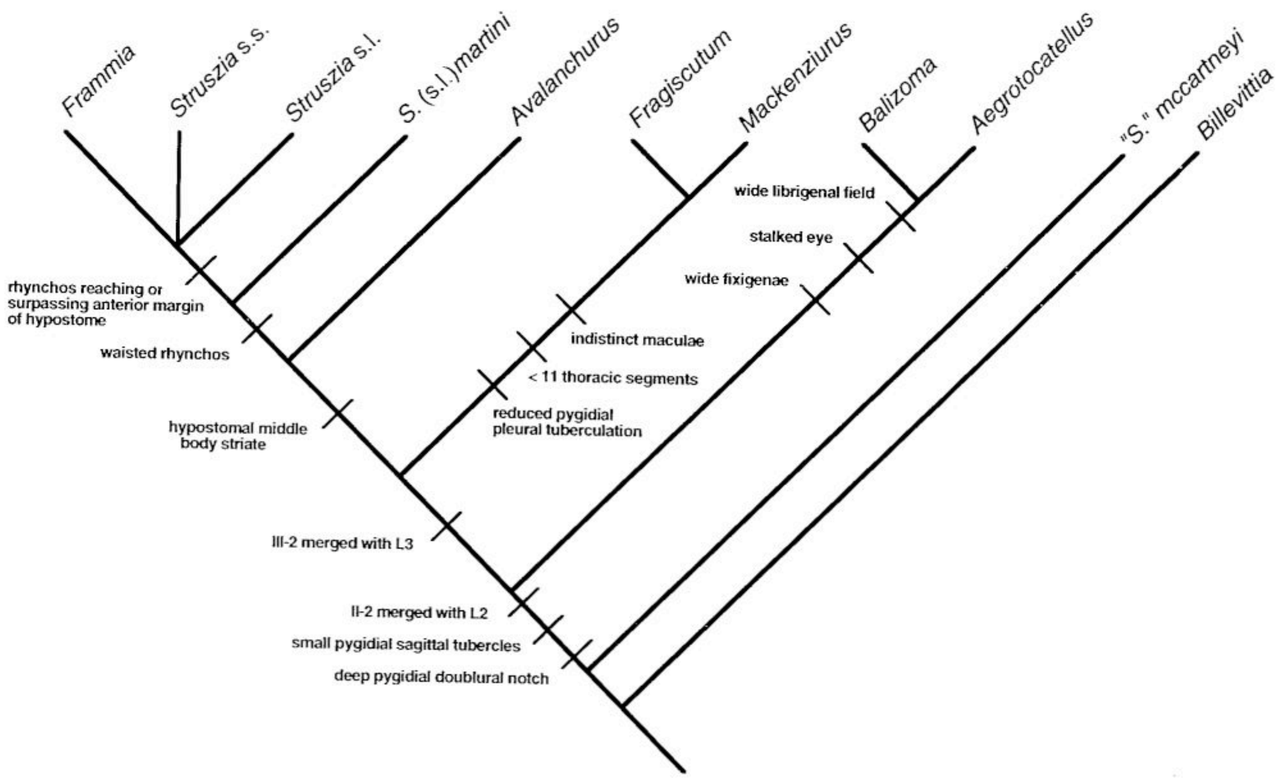
Text-fig. 7. Illustrations of the characters used in phylogenetic analysis, numbered as in text. **A.** Dorsal view of cranidium of *Avalanchurus lennoni* Edgecombe and Chatterton, 1993. **B.** Ventral view of hypostome of *Struszia* (s.l.) *epsteini* sp. nov. **C.** Dorsal view of dorsal exoskeleton of *Aegrotocatellus jaggeri* Adrain and Edgecombe, 1995. **D.** Anterior view of cephalon of *Mackenziurus deedeei* sp. nov. **E.** External view of librigena of *Struszia* (s.l.) *epsteini* sp. nov. **F, G.** Dorsal and anterior views of thoracic segment of *Mackenziurus deedeei* sp. nov. **H.** Dorsal view of pygidium of "*Struszia*" *mccartneyi* Edgecombe and Chatterton, 1993. **I.** Ventral view of pygidium of *Struszia* (s.l.) *harrisoni* Edgecombe and Chatterton, 1993.



Text-fig. 9. Optimized character distribution for one of the 36 most parsimonious trees. Black bars represent synapomorphies. White bars represent either reversals or characters with a potentially more general distribution. Note that zero length branches are depicted as resolved.

III-2, large, bloated, pygidial sagittal tubercles, and a shallow pygidial doublural notch. The remainder of the group is united almost universally by the merging of II-2 with L2. Hence, the classification of the species *mccartneyi* in *Struszia*, which is one of the most derived genera in the analysis, is likely artificial. Knowledge of the group is increasing rapidly, however, and it seems reasonable to defer strict assignment to a higher taxon pending more information. Hence, the species is referred to "*Struszia*," with the recognition that this is a temporary and expressly artificial classification of convenience.

2. Adrain and Edgecombe (1995) proposed *Aegrotocatellus*, indicating that it represents the sister-group of *Balizoma*, and that together this clade is sister to the rest of the *Struszia* group. With the exception of "*Struszia*" *mccartneyi*, discussed above, these ideas are all supported by the analysis.
3. Edgecombe and Chatterton (1990) erected *Mackenziurus*, and proposed a sister-group relationship with *Fragiscutum*. More diversity has since been added to *Mackenziurus*, but monophyly of the genera and their sister-group status is supported. Although there is information for only three species, the clade is likely characterized especially by reduction in thoracic segment number from the 11 that characterizes the entirety of the remainder of the subfamily to either 9 or 10. The *Mackenziurus* plus *Fragiscutum* clade is united with the remainder of the group to the exclusion of the *Aegrotocatellus* plus *Balizoma* clade.
4. Edgecombe and Chatterton (1993) proposed *Struszia*, with subgenera *Struszia* Edgecombe, Ramsköld and Chatterton, 1993, and *Avalanchurus* Edgecombe and Chatterton. Monophyly of the latter is supported, but classification of the concept of *Struszia* outlined in that work is complicated by the genus *Frammia*. *Avalanchurus*, given full generic status herein, is characterized particularly by the presence of extremely wide pleural lobes, and is sister to the clade including *Struszia* (*Struszia*) sensu Edgecombe and Chatterton (1993) and *Frammia*.
5. The entirety of the large *Struszia* plus *Frammia* clade is characterized by a specialized coaptative system involving a waisted hypostomal rhynchos and a deeply notched pygidial doublure. A relatively deep doublural notch is seen rarely outside this group, but the waisted rhynchos occurs elsewhere only in *Mackenziurus deedeei*. There is sufficient phylogenetic distance between *M. deedeei* and the *Struszia* plus *Frammia* clade, based on many compelling apomorphies, that the occurrence of a slightly waisted rhynchos in this is safely interpreted as a convergence. The clade is further characterized by a relatively long rhynchos, which in most taxa either reaches or extends beyond the anterior margin. An exception is *S.* (s.l.) *martini*. This species has a very short, but waisted, rhynchos, and is resolved as the sister species of the remainder of the clade. No matter how the *Struszia* plus *Frammia* problem is ultimately resolved, *S.* (s.l.) *martini* will likely continue to fall outside its structure. Hence a problem similar to that posed by "*S.*" *mccartneyi* (see above) arises: classification of the species *martini* in *Struszia* will likely render that genus paraphyletic.



Text-fig. 10. Simplified consensus cladogram showing character support for major clades.

The intrageneric structure of *Struszia* is in a state of flux, however, and as with "*S.*" *mccartneyi*, it does not seem advisable to erect a new generic taxon at this point.

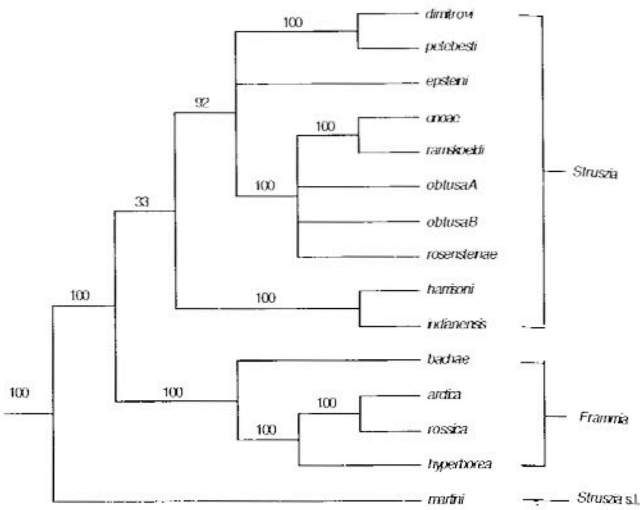
6. Edgecombe and Chatterton (1993, p. 86) noted that "the monophyly of *Struszia* is most seriously challenged by the origin of *Frammia*." Herein, analysis shows that *Frammia* (including the primitive *F. bachae* sp. nov.) does indeed render the monophyly of *Struszia* ambiguous. It is important to note, however, that the results of the analysis are not in conflict with a concept of *Struszia* including all species except *mccartneyi* and *martini*. A semistrict consensus cladogram (combinable components cladogram of Bremer, 1990) is shown in Text-figure 11. In essence, 12 of the 36 trees do recognize this nearly all-inclusive *Struszia* as monophyletic and sister to *Frammia*, although the nodal support is weak and no truly compelling (i.e., high consistency) apomorphies can be identified. The remaining 24 trees are not in conflict with this classification, but neither do they support it (parts of the *Struszia* clade and *Frammia* appear in a basal polytomy). It is evident, therefore, that the original concept of *Struszia* may yet prove to be monophyletic, but is at present not demonstrably so.

Two clades within the *Struszia* plus *Frammia* group are robustly supported. These are *Frammia* itself and a restricted subset of *Struszia* that includes the type species. It is possible to recognize the latter as *Struszia* (s.s.), or simply *Struszia* in the following systematic section. Relationships of the remainder of species assigned originally and herein to *Struszia* are problematic, although some structure is supported by some or all of the trees (Text-figure 11). These species are assigned for the present to *Struszia* (s.l.). As more information is compiled, they may be best classified in an expanded *Struszia*, or perhaps best accommodated in new generic taxa.

PALEOBIOGEOGRAPHIC IMPLICATIONS

One of the 36 most parsimonious cladograms, selected by maximal stratigraphic congruence via minimization of ghost lineages (Smith, 1994) is shown plotted against time in Text-figure 12. The majority of the diversity is northern Laurentian. More importantly, the earliest known representatives and the basal species of all major clades (with the exception of the southern Laurentian *Fragiscutum*, represented by only two species) are exclusively northern Laurentian. The group had originated by the mid-Sheinwoodian and radiated dramatically during the Wenlock, but only a few occurrences are known from outside northern Laurentia during the period. All are of late Wenlock age. One, *Balizoma variolaris*, is known from the Anglo-Welsh Basin, but likely appears in the Cape Phillips embayment at almost exactly the same time (Adrian and Edgecombe, 1995). The others are Ramsköld's (1986) report of two Wenlock pygidia assigned to the otherwise Ludlow *S. obtusa* Form B, and the species *Mackenziurus lauriae*.

Encrinurines have become perhaps the most thoroughly documented of Silurian trilobite groups. Hence, it seems very likely that the observed stratigraphic and geographic distribution of the *Struszia* genus group is real, and not due to varying amounts of study in different regions. The evolution of the group was the last major phylogenetic event in the history of the family. Following a northern Laurentian origin and Wenlock radiation, the *Struszia* group dispersed to southern Laurentia, Baltica, and Armorica during the Ludlow-Přídolí, prior to its extinction near the onset of the Devonian.



Text-fig. 11. Semistrict consensus (combinable components) of 36 most parsimonious cladograms, showing only the *Struszia* plus *Frammia* clade (topology of the remainder of the cladogram is identical to that of the strict consensus). This diagram demonstrates that while only 12 of the 36 cladograms provide explicit support for an all-inclusive monophyletic *Struszia* (i.e., including all species assigned to *Struszia* sensu lato herein, with the exception of *S.* (s.l.) *martini*), the remaining 24 trees are not in conflict with this resolution. Additionally, 33 of the 36 cladograms provide explicit, if weak, support for a concept of *Struszia* encompassing also the species *dimitrovi*, *epsteini*, and *petebesti*, while the remaining three cladograms are not in conflict with this resolution.

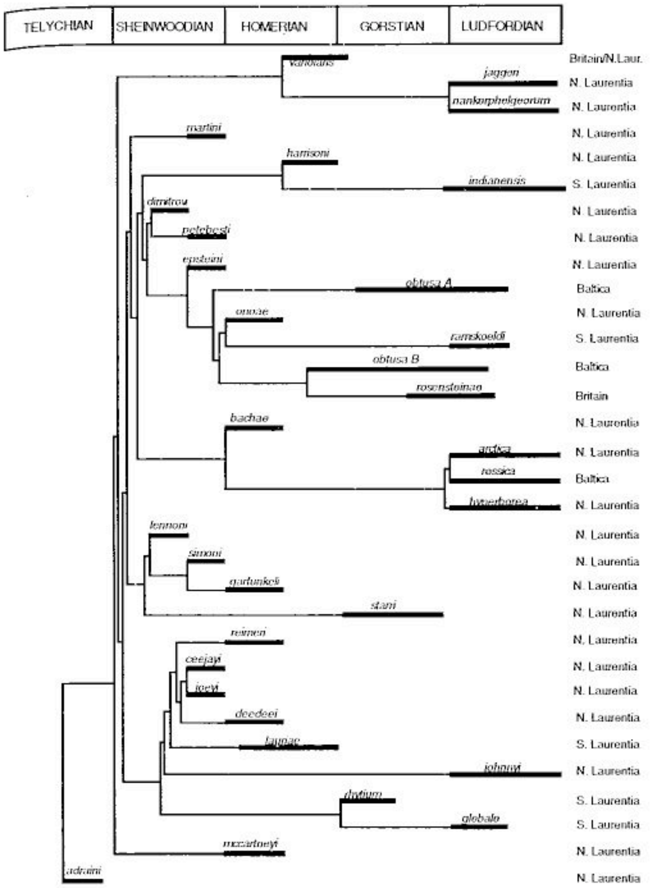
SYSTEMATIC PALEONTOLOGY

All figured specimens have been deposited in the collections of the Royal Ontario Museum, with specimen numbers prefixed ROM.

The arrangement of the plates follows the order of the systematic section, as much as possible. Plates 1-34 illustrate silicified specimens from the lower Wenlock to lower Ludlow of the Cape Phillips Formation. Plate 35 illustrates calcareous specimens from the upper Ludlow Douro Formation. All specimens were blackened with graphite paint, then whitened with ammonium chloride sublimate prior to photography. The photographs were made with 25 mm and 40 mm Zeiss Luminar micropaleontology lenses. Lighting was either with two flash units, directed usually at the anterior and posterior of the specimen, or with four photo-floods arranged at oblique vectors to the specimen.

Terminology follows the widely-circulated recommendations for the revised version of the *Treatise on Invertebate Paleontology* (H.B. Whittington and S.R.A. Kelley, unpublished). Morphological terminology for the encrinurine exoskeleton follows Edgecombe and Chatterton (1993, p. 77). Librigenal border tuberculation is described with reference to inner, median, and marginal tubercle rows of early ontogeny (Edgecombe and Chatterton, 1992, pp. 71-72). Measurement of glabellar length excludes L0 and S0. Width of the librigenal field is measured at the midlength of the eye, with width of the lateral border measured in direct continuation of this. Counts of pygidial axial rings include a terminal sagittal tubercle as evidence of a ring in the absence of a ring furrow.

New species are named after various contemporary minstrels and their spouses or associates.



Text-fig. 12. One of 36 maximally parsimonious cladograms mapped against timescale. This cladogram was selected from among the equally parsimonious trees through a criterion of maximum stratigraphic congruency via minimization of ghost lineages (Smith, 1994). Northern Laurentian species are shown in black; others are shown in gray stippling. Occurrence (and hence combined area cladogram) is given in right-hand column. Note that all pre-Homerian taxa, and both the oldest and most primitive presentatives of virtually all major clades, are northern Laurentian.

Family ENCRINURIDAE Angelin, 1854
Subfamily ENCRINURINAE Angelin, 1854

Genus *Struszia* Edgecombe, Ramsköld and Chatterton in Edgecombe and Chatterton, 1993

Type species. *Cryptonymus obtusus* Angelin, 1851, Hemse and Eke Beds, Ludlow (Gorstian), Gotland, Sweden.

Other species. *Struszia onoae* sp. nov., Wenlock (lower Homerian), Arctic Canada; *Balizoma ramskoeldi* Edgecombe, 1990, Ludlow (Ludfordian), Tennessee; *Encrinurus rosensteinae* Tripp, Temple and Gass, 1977, Ludlow (upper Gorstian-lower Ludfordian), Welsh Borderland.

Species assigned to Struszia (s.l.). *Encrinurus dimitrovi* Perry and Chatterton, 1979, Wenlock (mid-Sheinwoodian), northwestern Canada; *S.* (s.l.) *epsteini* sp. nov., Wenlock (upper Sheinwoodian), Arctic Canada; *Struszia* (*Struszia*) *harrisoni* Edgecombe and Chatterton, 1993, Wenlock (upper Homerian), northwestern Canada; *Encrinurus indianensis* Kindle and Breger, 1904, Ludlow-Přídolí, Indiana, U.S.A. (see Gass et al., 1992); *S.* (s.l.) *martini* sp. nov., Wenlock (upper Sheinwoodian), Arctic Canada; *S.* (s.l.) *petebesti* sp. nov., Wenlock (upper Sheinwoodian), Arctic Canada; *Cromus transiens* Barrande, 1852, Ludlow, Czech Republic (see Šnajdr, 1985).

Discussion. Edgecombe, Ramsköld and Chatterton (in Edgecombe and Chatterton, 1993) established *Struszia* with two subgenera, *S.* (*Struszia*) and *S.* (*Avalanchurus*). Given the hypotheses of relationship proposed herein, the taxa are treated in this work as separate genera. This follows from the resolution of *Struszia* as more closely related to *Frammia* than to *Avalanchurus* (i.e., a grouping that excludes *Frammia* is therefore paraphyletic). As discussed above, the concept of *Struszia* is restricted to a core group of species with narrow librigenal fields and generally small eyes. The remainder of species may or may not form a clade with the core group (see above) and are united for the present in *Struszia* (s.l.), pending further new discoveries and refinement of the phylogeny.

Struszia (s.l.) *dimitrovi* (Perry and Chatterton, 1979)
Pl. 1, figs. 1-25; Pl. 2, figs. 1-24

1977 *Encrinurus* (*Fragiscutum*) sp. Perry and Chatterton, p. 300, pl. 4, figs. 2-9? (*non* figs. 1?, 10?, 11-14, 25, 26 = *Struszia petebesti* sp. nov.).
1979 *Encrinurus dimitrovi* Perry and Chatterton, p. 589, pl. 73, figs. 1, 6, 10-15, 18, 29-31, pl. 74, figs. 1-14, 21-23.
1987 *Balizoma dimitrovi*; Edgecombe and Chatterton, partim, figs. 7b, e.
1992 *Balizoma* sp. or spp. Edgecombe and Chatterton, figs. 11.2-11.6.
1993 *Struszia* (*Struszia*) *dimitrovi*; Edgecombe and Chatterton, p. 87, pl. 8, figs. 1-4, 7-11, 14-16, 19-22, pl. 9, figs. 1-3, 6-22, 26, pl. 10, figs. 1-25, pl. 11, figs. 3-5, 7-10, 12-28.

Holotype. A cranidium (UA 2152) from locality 150 of Perry and Chatterton (1979), Delorme Group, Delorme Range, Northwest Territories.

Material. Assigned specimens ROM 50099-50127, from sections BH 1 106-110 m and BHL 1 0 m, Cape Phillips Formation, Wenlock (mid-Sheinwoodian, *M. instrenuus*-*C. kolobus* Zone), southern Baillie-Hamilton Island, central Canadian Arctic.

Discussion. The problem of the stratigraphically mixed samples studied by Perry and Chatterton has been discussed at length (see above; also Adrain, 1994, p. 1086). Revised assignments of their material in light of the present work are given in the synonymy above.

Perry and Chatterton (1979) and Ramsköld (1986) considered the Arctic material figured by Perry and Chatterton (1977) to be likely conspecific with *Struszia* (s.l.) *dimitrovi*. Edgecombe and Chatterton (1993, p. 93) reported that work then in progress indicated the Arctic material might represent a distinct new species. Full assessment herein, however, has revealed that while differences exist between the Baillie-Hamilton sample and the type material of *S.* (s.l.) *dimitrovi*, there are nevertheless no non-overlapping, discrete characters that might form the basis for specific discrimination. The Arctic material is therefore referred to *S.*(s.l.) *dimitrovi*, but discussion of the contrasts between the Arctic and Mackenzie Mountains samples follows.

The Baillie-Hamilton Island specimens differ from the Mackenzie Mountains material most prominently in the presence of a usually more depressed L1; often absent ii-0; vincular furrow that is straight in external view; hypostomal rhynchos extending anteriorly very slightly beyond hypostomal suture. Contrasts are as follows:

1. In many Mackenzie Mountains specimens, L1 is developed as a strong transverse ridge. It is a very small feature in most Arctic specimens (Pl. 1, figs. 1-3, 9-11, 14), but rare specimens (e.g., Pl. 1, fig. 16) do possess a strongly inflated L1 similar to that of the Mackenzie Mountains specimens.
2. Tubercle ii-0 is of ubiquitous occurrence in the Mackenzie Mountains sample. While it is absent from the majority of Arctic specimens (Pl. 1, figs. 1, 3, 9, 11), it is nevertheless strongly developed in some examples (Pl. 1, figs. 10, 16).
3. The preglabellar furrow is prominently expressed in all available Arctic material of *S.* (s.l.) *dimitrovi*, with a distinct break in slope between the glabella and anterior border. This agrees with its development in some Delorme Range material, but stands in contrast to most Avalanche Lake specimens, in which the furrow is shallower and the anterior border is more strongly downturned.
4. The number of adaxial fixigenal tubercles exhibits a different, but overlapping, range of variation between Mackenzie Mountains and Arctic specimens. The majority of cranidia from both areas have five tubercles. Some specimens of *S.* (s.l.) *dimitrovi* from the Delorme Range, however, have only four tubercles (Perry and Chatterton, 1979, pl. 74, fig. 30; Edgecombe and Chatterton, 1993, pl. 8, figs. 1, 3), while rare Arctic specimens have six.
5. The course of the vincular furrow in external view is always nearly straight in Arctic material (Pl. 1, figs. 20, 21, 23-25), but frequently with significant ventral convexity in Mackenzie Mountains specimens (Edgecombe and Chatterton, 1993, pl. 9, figs. 10, 20).
6. Many Arctic specimens (Pl. 2, figs. 3, 4) do not display the characteristic waisting of the hypostomal rhynchos that is seen in Mackenzie Mountains specimens and in other congenerics. The lateral margins of the rhynchos vary from straight (Pl. 2, fig. 3), to having a distinct flexure in their course (Pl. 2, fig. 9).
7. Relative width of the pygidium is slightly greater in Arctic specimens (length only 80 percent of width versus 85-95 percent in Mackenzie Mountains specimens).
8. Finally, the hypostomal rhynchos of Arctic material is slightly longer than that of Mackenzies specimens, as it extends anteriorly to very slightly project beyond the anteromedian margin.

Aside from this list of minor variations, the samples are otherwise identical. Most of the differences concern frequencies of occurrence, with morphological overlap between the samples. Definite evolutionary novelties cannot be recognized with confidence, and the samples, despite subtle differentiation, are hence considered conspecific.

Edgecombe and Chatterton (1993) compared *Struszia* (s.l.) *dimitrovi* with the congenerics then known. Phylogenetic analysis herein indicates that *S.* (s.l.) *dimitrovi* and *S.* (s.l.) *petebesti* sp. nov. are sister species (Text-fig. 8), and they are contrasted under discussion of the latter below.

Struszia (s.l.) *petebesti* sp. nov.

Pl. 3, figs. 1-23; Pl. 4, figs. 1-3, 4?, 5-8, 9?, 10-13, 14?, 15-25; Pl. 5, figs. 1-21; Text-fig. 13

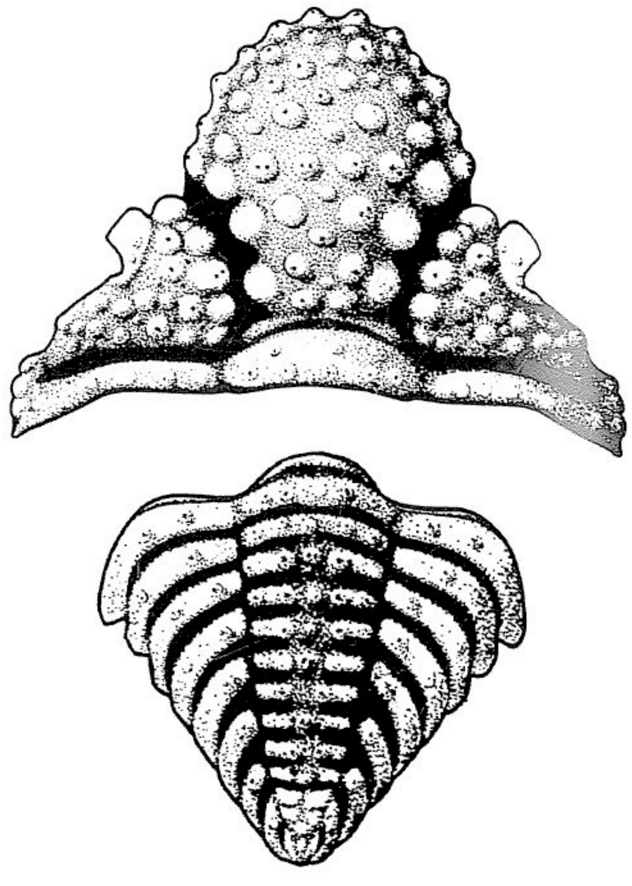
1977 *Encrinurus* (*Fragiscutum*) sp. Perry and Chatterton, p. 300, pl. 4, figs. 1?, 10?, 11-14, 15, 16 (*non* figs. 2-9? = *Struszia* (s.l.) *dimitrovi*).

Etymology. After Pete Best.

Types. Holotype cranidium ROM 50129 (Pl. 3, figs. 2, 5, 8, 11) from section BH 1 192 m; paratypes ROM 50128, 50131-50140, 50142, 50143, 50145-50151, 50153-50158, and questionably assigned specimen ROM 50141, from section BHL 1 92 m and locality BHH, Cape Phillips Formation, Wenlock (upper Sheinwoodian, *C. perneri-M. opimus* Zone), southern Baillie-Hamilton Island, central Canadian Arctic. Assigned specimens ROM 50130, 50144, 50152, from talus boulder ABR TTD, Cape Phillips Formation, Wenlock (upper Sheinwoodian, *C. perneri-M. opimus* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic.

Diagnosis. *Struszia* with anterior part of cranidium elongate, describing shallow inverted "V" in plan view, with correspondingly long librigenal precranidial lobe; ii-0 of uncommon occurrence; L1 inflated into transverse bar; usually five adaxial fixigenal tubercles; strong transverse tubercle row on posterior cranidial border and occipital ring; very small, thorn-like genal spine retained in largest holaspides; hypostomal rhynchos broad anteriorly, strongly waisted, extended to slightly behind to slightly in front of hypostomal suture; pygidium with 12-13 axial rings and usually 9^2 pleural ribs.

Description. Cranidial length 50-63 percent of width; axial furrow narrow to moderately wide, deep, concave outward between S1 and fossula; glabellar length (sag.) 105-119 percent of width across frontal lobe; width of L3 74-80 percent width of L4; width of L2 61-67 percent width of L4; glabella gently convex (sag.), raised above genal field and eye, of moderate, even transverse convexity; glabellar tuberculation includes pentagonal arrangement



Text-fig. 13. *Struszia* (s.l.) *petebesti* sp. nov. Reconstruction of cranidium and pygidium.

of II-1 larger than and abaxial to I-1, iii-0, with ii-0 usually absent; III-1 larger than II-1; III-2 usually small tubercle fused to swelling of lateral lobe; frontal lobe bearing moderate number of small to large tubercles; III-1, IV-1 largest glabellar tubercles; V-1 closely spaced; L2-L4 lateral lobes swollen, tuberculiform, larger than glabellar tubercles; S1 directed posteromedially; L1 short (exsag.), low ridge or swelling; L0 of even length across most of width, length (sag.) 24-31 percent width, gently bowed forward, with anterior margin nearly straight medially; transverse row of five to seven subdued tubercles near posterior edge of L0; apodemes in order of decreasing size S1, S2, S0, small S3; preglabellar furrow shallow (sag., exsag.); anterior cranidial border bearing 10 or 12 tubercles; PL of similar size to second and fourth tubercle pairs (counted abaxially) on anterior border; midlength (exsag.) of palpebral lobe opposite S2 or posterior part of L3; posterior edge of palpebral lobe opposite middle to posterior part of L2; two tubercles between midlength of eye and axial furrow; several strongly subdued palpebral tubercles; adaxial fixigenal row usually of five, sometimes six, tubercles, posterior two tubercles (opposite S0, S1) slightly smaller than others, second (opposite S3) sometimes developed as small lobiform swelling bearing small tubercle pair, first (opposite preglabellar furrow) largest, ovate in outline; CT1 slightly larger than other tubercles on fixigenal field; CT2 partly abaxial to CT1, with or without an intervening tubercle; posterior border furrow short (exsag.), moderately deep, transverse or gently flexed backward distal to fulcrum, abruptly shallowing at anterior flexure to facial suture; posterior border short (exsag.), weakly lengthening to fulcrum, with moderately strong, even lengthening distally; numerous small, relatively strong tubercles along posterior border, becoming more pronounced distally; cluster of three stronger tubercles on posterolateral border in front of genal angle; genal angle bearing tiny point set inward of posterolateral edge of cranidium.

Rostral suture narrow, straight; dorsal part of rostral plate inferred to be of similar width to that of *S.* (s.l.) *martini*.

Librigenal field usually about equal in length to precranidial lobe, minimum 85 percent length of precranidial lobe; field 80-100 percent width (tr.) of lateral border; tubercles on field arranged two deep anteriorly, two or three deep posteriorly, totalling 12-20 tubercles (including very small, weak tubercles); eye socle narrow, set off by sharp furrow ventrally; lateral border furrow narrow, shallow; four inner row tubercles on lateral border much larger than any on field, some ovate in outline, tubercles of median row considerably smaller; marginal row of small tubercles subdued but with many tubercles distinctly defined; coarse, dense granulation along lateral margin; anterior furrow very shallow; precranidial lobe covered with 14-18 tubercles of varied size; vincular furrow narrow, shallow, gently curved ventrally; doublure extending about 70 percent width to border furrow, gently and evenly tapering beneath precranidial lobe.

Hypostome subrhomboid, length about 115 percent of width across anterior wings; wing situated at about 42 percent length (sag.) of hypostome; anterolateral border very short (exsag.), margin gently convex outward, then bulging forward around rhynchos; anterior margin arched dorsally; middle body ovate, length (including rhynchos) 120-128 percent of width, gently convex (sag.) medially, gently arched transversely, sometimes slightly trilobate, with medial bulge; lateral margins of rhynchos approximately straight for much of length, with moderately strong posterior divergence, becoming indistinct opposite rear edge of anterior wing; anterior part of rhynchos approximately parallel-sided, rounded anteromedially, terminating slightly behind to slightly in front of hypostomal suture; width at posterior edge of rhynchos 52-61 percent width of middle body; several pronounced muscle impression striae on anterolateral region of middle body; granulate sculpture pervasive on middle body; macula moderately large, inflated, ovate; border furrow narrow, well impressed posterolaterally, shallow medially behind very short (sag.) posteromedian bulge on middle body; posterolateral margin weakly sinuous, flexed ventrally; posterior border 18 percent length (sag.) of hypostome; posteromedian margin pointed, with weak pair of angulations abaxially.

Axial ring about 36 percent width of thorax; ring of even length (sag., exsag.), posterior margin approximately transverse, abaxial edge flexed forward; ring moderately arched (tr.), inflated abaxially, raised well above pleura; articulating half ring 50-60 percent length (sag.) of axial ring, set off by short, moderately deep ring furrow; pleura gently sloping (tr.) to fulcrum, then declined at about 45 degrees distally; pleural furrow narrow, sharply impressed, with transverse course proximally, abruptly shallowing and effacing on articulating facet; anterior pleural band short (exsag.), set below posterior band; anterior flange flexed forward at distal end of articulating facet as small, pointed process; posterior band extended distally, terminating as short, blunt angulation; tuberculation lacking on known segments of thorax.

Pygidial length 81-88 percent of width; axis 37-40 percent of pygidial width anteriorly, composed of 12 or, more rarely, 13 rings, gently convex (sag.); anterior rings moderately arched (tr.), with subflattened median region on middle/posterior rings; axial furrow narrow, moderately deep anteriorly except for shallow impression against first ring, straight against anterior eight rings, then gently shallowing and converging more strongly, with light but distinct incision around axial terminus; usually four strong sagittal tubercles, first usually on third or fourth ring and then on alternating rings or each third ring; anterior rings aligned with two or three pairs of small, usually subdued tubercles and sagittal tubercle; ring furrows impressed abaxially as deep, transverse grooves, shallowing medially, very lightly impressed between medial part of posterior few rings; usually 9^2, occasionally 10^1, pleural ribs; four congruent segments; inter-rib furrows narrow, usually less than half length (exsag.) of rib, moderately deep proximally, narrowing between pleural tips; inter-rib furrows shallow between distal parts of posterior ribs; anterior pleurae moderately steeply turned down at fulcrum, posterior ribs more strongly curved down and back along entire width; narrow, sharply impressed pleural furrow with straight course on articulating facet of first rib, effaced well above outer edge of facet; several small, subdued pleural tubercles of varied size along each rib, with abaxialmost tubercle well defined, particularly on posterior ribs; anterior three or four ribs gently turned out distally, with blunt rounded to subquadrate tips; terminal rib pair (usually 9^2) gently curved outward, separate ribs weakly defined posteroventrally but not fused as loop; doublure gently lengthening backward, inner margin approximately straight for most of length; doublure moderately expanded in front of deep, U-shaped posteromedian embayment.

Basis of association. Within the *C. perneri-M. opimus* Zone there occur what are interpreted above as two stratigraphically successive trilobite faunas. Unlike most of the major faunas described herein, however, some species are known to range from the *Struszia* (s.l.) *petebesti* Fauna upwards to Unnamed Fauna 1 (see Text-fig. 6). These include *S. martini*, described below. Further, within the *S.* (s.l.) *petebesti* Fauna, there is variation in diversity between the sample from southern Baillie-Hamilton Island and that from the large talus boulder ABR TTD on northwestern Cornwallis Island. Within the *C. perneri-M. opimus* Zone in total three new named species of *Struszia* (s.l.) are proposed herein, while at least a further two occur and are reported in open nomenclature. Given this diversity, and the co-occurrence of several species at single horizons (see Text-figs. 5, 6), the basis of association of sclerites must be made explicit.

On southern Baillie-Hamilton Island, *Struszia* (s.l.) *petebesti*, *S.* (s.l.) *epsteini*, and *S.* (s.l.) *martini* occur together. At ABR TTD on northwestern Cornwallis Island, all three occur together with a fourth species, *Struszia* (s.l.) sp. nov. A. In the overlying Unnamed Fauna 1, at ABR 2 18-27 m, *S.* (s.l.) *martini* occurs along with *Struszia* (s.l.) *epsteini*? Sclerites have been assigned to particular species using the following criteria.

1. Frequency of occurrence. On southern Baillie-Hamilton Island, *Struszia* (s.l.) *petebesti* is very common. *Struszia* (s.l.) *epsteini* is present but not common, and *S.* (s.l.) *martini* is very rare (two sclerites). The approximate relative percentage frequency of occurrence is 80:19:1.

In talus boulder ABR TTD, from northwestern Cornwallis Island, *Struszia* (s.l.) *martini* is most common, *S.* (s.l.) *petebesti* is less common, *Struszia* (s.l.) sp. nov. A is about as common as *S.* (s.l.) *petebesti*, and *S.* (s.l.) *epsteini* is rare. Relative percentage frequency of occurrence is about 65:15:15:5.

Finally, at ABR 2 18-27 m, and correlated talus boulders, *Struszia* (s.l.) *martini* occurs almost by itself, with only a single hypostome assigned to *Struszia* (s.l.) *epsteini*? Here, frequency of occurrence of *S.* (s.l.) *martini* is effectively 100 percent.

2. Articulation. Several articulated cranidia and librigenae are known for *Struszia* (s.l.) *martini*, and one for *Struszia* (s.l.) sp. nov. A, allowing definite association of these sclerites.

Specimens were sorted into morphological classes by horizon, then associated using these criteria. There is considerable confidence in the resulting assignments, with the exception of the question of the proper hypostomes and pygidia to be assigned to *Struszia* (s.l.) sp. nov. A. Figured hypostomes (Pl. 8, figs. 9, 15, 17, 18) are not obviously distinguishable from those assigned with confidence to *Struszia* (s.l.) *petebesti* (Pl. 4, figs. 1-3), and could belong to either species (the *S.* (s.l.) *petebesti* hypostomes are assigned using frequency of occurrence at Baillie-Hamilton Island, from which *Struszia* (s.l.) sp. nov. A is unknown). Similarly, no pygidia that were obviously different from those definitely assigned to *S.* (s.l.) *petebesti* and *S.* (s.l.) *martini* were identified. It is conceivable, given the rarity of *Struszia* (s.l.) sp. nov. A, that simply none were recovered. It is also possible that the pygidium of this species overlaps in morphology with either of the similar co-occurring species. More material and, ideally, additional occurrences will be required to resolve this problem.

Discussion. *Struszia* (s.l.) *petebesti* is a distinctive species, with its anteriorly elongate glabella, and concomitant long librigenal precranidial lobe and elongate pygidium. It is most similar to the slightly older *S.* (s.l.) *dimitrovi*, and a sister-species relationship is indicated by parsimony analysis (Text-fig. 8). The species share a pattern of most commonly five adaxial fixigenal tubercles (character 8) and a hypostomal rhynchos with length usually about level with the hypostomal suture (character 22). Arctic material of *S.* (s.l.) *dimitrovi* is also similar to *S.* (s.l.) *petebesti* in the common absence of glabellar tubercle ii-0. In addition to the features noted above, *S.* (s.l.) *petebesti* may be distinguished from *S.* (s.l.) *dimitrovi* in its more strongly expressed posterior border and L0 transverse tubercle row; transverse versus subdued L1; relatively smaller, less subpolygonal librigenal tuberculation with greater space between tubercles; more flexed lateral librigenal margin, particularly beneath the precranidial lobe; more laterally concave pygidial lateral margins; and slightly deeper pygidial doublural notch.

Struszia (s.l.) *petebesti* can be distinguished from *S.* (s.l.) *epsteini*, with which it occurs, in its anteriorly more elongate cranidium; transverse versus small, teardrop-shaped or rounded L1; more strongly expressed transverse tubercle row on L0 and the posterior cranidial border; wider (tr.) posterolateral fixigena distal to the palpebral lobe; large L2, usually with distinct II-2 placed atop it, versus subdued, transversely subelliptical L2 with almost indistinguishable II-2; librigenal precranidial lobe with much weaker flexure, lacking the ventrally directed tubercles near the connective suture of *S.* (s.l.) *epsteini* (character 20); relatively broad hypostomal rhynchos anteriorly level with anterior margin, versus narrow, anteriorly elongate rhynchos; and much narrower pygidium with stronger posterior taper. The species are united, together with *S.* (s.l.) *dimitrovi*, in the typical possession of five adaxial fixigenal tubercles (a synapomorphy in some trees; see Text-fig. 9).

Struszia (s.l.) *petebesti* is distinguished from *S.* (s.l.) *martini*, with which it commonly co-occurs in talus boulder ABR TTD, in its more elongate cranidium; stronger transverse tubercle row on L0 and the cranidial posterior border; five versus commonly six adaxial fixigenal tubercles; rounded versus often blocky and subpolygonal adaxial and other fixigenal tubercles; librigenal precranidial lobe that is distinctly longer (exsag.) relative to its width (tr.), with much narrower connective suture; usually slightly longer hypostomal rhynchos; and longer, narrower pygidium with much more prominent concavity of the lateral margins and stronger posterior taper. The species are similar in their transverse L1 and hypostomes with nearly identical proportions.

Struszia (s.l.) *petebesti* is distinguished from the younger *S.* (s.l.) *harrisoni* in the possession of an anteriorly narrower, more elongate glabella; common absence versus universal occurrence of ii-0; II-2 merged with and set atop L2, versus often fully independent and adaxially placed; III-2 almost always merged with and set atop L3, versus universally retained as independent, adaxially set tubercles; typically five as opposed to six adaxial fixigenal tubercles; one as opposed to two anterior fixigenal tubercles; slightly less prominent transverse tubercle row on L0 and the posterior cranidial border; at most very short, thorn-like genal spines versus often quite long spines; more elongate, narrower librigenal precranidial lobe with narrower connective suture; less elongate (exsag.) librigenal field; relatively wider (tr.) librigenal lateral border; slightly shorter, anteriorly more narrow, hypostomal rhynchos; and narrower, more elongate pygidium, with 9^2 versus often 10^2 pleural ribs.

Struszia (s.l.) *petebesti* is the most common trilobite species in samples from BHL 1 92 m and BHH. It has a distinctive morphology that is generally consistent among the material assigned. The only exception is the hypostomal morphotype shown (Pl. 4, figs. 4, 9, 14). This type of hypostome has not been found at BHL 1 92 m, but several have been recovered from BHH, although they are not found as often as the type confidently assigned to the species (Pl. 4, figs. 1-3). This second morphotype differs from the more common form in its much shorter rhynchos and shorter posterior border. Also common in the BHH samples are hypostomes of *S.* (s.l.) *epsteini*, but these are so distinctive (Pl. 7, figs. 11-14) that there is no possibility of confusion. Hypostomes of the type shown herein (Pl. 4, fig. 4) are assigned with question to *S.* (s.l.) *petebesti*. The range of intraspecific variation thus implied, however, is greater than that observed in related species. Hence the hypostomes may belong to either another, very rare, new species, or possibly to *S.* (s.l.) *martini*, which occurs at BHL 1 92 m but which has not definitely been recovered from BHH. The hypostomes are similar to those of *S.* (s.l.) *martini* in their short rhynchos, but the rhynchos is smaller and the posterior border shorter than in most specimens assigned to that species. Despite a large sample size, no corresponding other sclerite types (e.g., librigenae, cranidia) that could be associated with these hypostomes were recovered. All other sclerite types in the BHH samples seem to match readily either *S.* (s.l.) *petebesti* or *S.* (s.l.) *epsteini*.

Struszia (s.l.) *epsteini* sp. nov.

Pl. 6, figs. 1-22; Pl. 7, figs. 1-23; Pl. 19, fig. 10?

Etymology. After Brian Epstein.

Types. Holotype hypostome ROM 50206 (Pl. 7, figs. 11, 15, 17, 20) from section BHL 1 92 m; paratypes ROM 50189, 50191, 50192, 50194-50209, 50211, from section BHL 1 92 m and locality BHH, Cape Phillips Formation, Wenlock (upper Sheinwoodian, *C. perneri-M. opimus* Zone), southern Baillie-Hamilton Island, central Canadian Arctic. Assigned specimens ROM 50190, 50193, 50210, 50212, from talus boulder ABR TTD, Cape Phillips Formation, Wenlock (upper Sheinwoodian, *C. perneri-M. opimus* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic. Questionably assigned specimen ROM 50337, from section ABR 2 27 m, Cape Phillips Formation, Wenlock (upper Sheinwoodian, high in *C. perneri-M. opimus* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic.

Diagnosis. Glabella short, anterior margin almost evenly arcuate in plan view; ii-0 absent; five adaxial fixigenal tubercles; L1 a subdued, rounded or teardrop-shaped node; L2 relatively small, transversely subelliptical, with nearly indistinguishable dorsal II-2; ventral margin of librigena strongly sinuous; two ventrally protruded tubercles on ventral margin of librigena near connective suture; hypostomal rhynchos exceptionally long, projecting far in front of hypostomal suture, in some specimens lacking obvious waisting; pygidium wide relative to length (sag.), low, with 10^1 or 10^2 pleural ribs, 12-14 axial rings, and narrow doublural notch.

Description. Cranidial length 56-64 percent of width (inferred from axis and either gena); axial furrow moderately wide, deep, concave outward between S1 and fossula; glabellar length (sag.) 108-117 percent of width across frontal lobe; width of L3 78-91 percent width of L4; width of L2 60-71 percent width of L4; glabella gently convex (sag.), raised above genal field and eye, of moderate transverse convexity; tuberculation includes I-1 (sometimes with tubercles of unequal size) or I-0, absence of ii-0, II-1 abaxial to I-1, iii-0; III-2 weakly defined on inner edge of swollen lateral lobe; frontal lobe bearing moderate number of tubercles with few very small tubercles; IV-1 and sometimes III-1 distinctly enlarged; L2 lateral lobe relatively subdued, ranging from tuberculiform swelling to small, irregular bulge; L4 considerably smaller than L3; S1 directed posteromedially, merged with S0; L1 short (exsag.), depressed, teardrop-shaped or subrounded; L0 of even length across most of width, length (sag.) 25 percent of width, anterior margin gently convex forward; weak transverse row of small tubercles near posterior edge of L0; preglabellar furrow shallow (sag., exsag.); anterior cranidial border bearing 12 tubercles, PL smaller than some others, fourth tubercle pair (counted abaxially) largest; weak cranidial anteromedian impression; midlength (exsag.) of palpebral lobe opposite anterior edge of S2 to posterior part of L3; posterior edge of palpebral lobe opposite middle of L2; two tubercles between midlength of eye and axial furrow; several subdued palpebral tubercles; adaxial fixigenal row of five rounded tubercles, anterior four of equal size, not larger than others on fixigenal field, posterior tubercle opposite S0 small; CT2 slightly enlarged relative to other small tubercles on fixigenal field, considerably smaller than CT1; one small tubercle between CT1 and CT2; posterior border furrow of moderate depth and length (exsag.), transverse, abruptly shallowing at anterior flexure to facial suture; posterior border short (exsag.), weakly lengthening to fulcrum, with moderately strong, even lengthening distally; several small, faint tubercles along rear half of posterior border; cluster of three or four stronger tubercles on posterolateral border in front of genal angle; genal angle bearing short spinule set inward of posterolateral edge of cranidium.

Rostral suture narrow, straight; dorsal part of rostral plate inferred to be of similar width to that of *S. martini*.

Librigenal field slightly shorter (exsag.) than precranidial lobe, about equal in width (tr.) to lateral border; tubercles on field arranged two deep anteriorly, two or three deep posteriorly, totalling 11-15 tubercles (including very small, weak tubercles); eye socle narrow, set off by moderately deep furrow ventrally, very faint furrow dorsally; lateral border furrow narrow, shallow; four inner row tubercles on lateral border moderately large, tubercles of median row considerably smaller; marginal row of small tubercles subdued but most distinctly defined; coarse, dense granulation along lateral margin; anterior furrow very shallow; precranidial lobe covered with 14-16 small and medium-sized tubercles; lateral margin relatively strongly curved ventrolaterally; prominent pair of marginal tubercles at anterolateral edge of librigena; vincular furrow narrow, shallow, curved ventrally.

Hypostome subrhomboid, length slightly less than 115 percent of width across anterior wings; wing situated at about 45 percent length (sag.) of hypostome; anterolateral border very short (exsag.), margin gently convex outward; anterior margin weakly arched dorsally; middle body subcircular, length (including rhynchos) 130-142 percent of width, gently convex (sag.) medially, gently arched transversely; rhynchos conical, extending well in advance of hypostomal suture, apparently projecting in front of rostral plate, lateral margins approximately straight, with moderately strong posterior divergence, becoming indistinct opposite rear edge of anterior wing; rhynchos rounded anteromedially; dorsal surface of anterior projection of rhynchos flat; width at posterior edge of rhynchos 50-60 percent width of middle body; relatively weak muscle impression striae on anterolateral region of middle body; granulate sculpture pervasive on middle body, especially dense on rhynchos; middle furrow faint; macula obscure; border furrow narrow, well impressed posterolaterally, shallow medially behind very short (sag.) posteromedian bulge on middle body; posterolateral margin gently sinuous, flexed ventrally, in part weakly concave outward; posterior border 16-18 percent length (sag.) of hypostome; posteromedian margin pointed, with weak pair of angulations slightly abaxially; doublure very narrow posterolaterally, lengthening medially as anteriorly-projecting "tongue".

Pygidial length 72-74 percent of width; axis 33-37 percent of pygidial width anteriorly, composed of 12-14 rings, very gently convex (sag.); anterior rings moderately arched (tr.), with subflattened median region on posterior rings; axial furrow narrow, moderately deep anteriorly except for shallow impression against first ring, weakly convex outward, shallowing behind eighth or ninth ring furrow, with light incision against axial terminus; four or, typically, five strong sagittal tubercles, first usually on fourth ring and then on alternating rings; anterior rings aligned with two or three pairs of small tubercles and sagittal tubercle; ring furrows impressed abaxially as deep, transverse grooves, shallowing medially, nearly obsolete between medial part of posterior few rings; 10^1-10^2 pleural ribs; four congruent segments; inter-rib furrows narrow, moderately deep proximally, with slight, even lengthening (exsag.) toward fulcrum, then narrowing distally, abruptly shallowing between pleural tips; inter-rib furrows very shallow between distal parts of posterior ribs; anterior pleurae moderately steeply turned down at fulcrum, posterior ribs more strongly curved down and back along entire width; narrow, sharply impressed pleural furrow with straight course on articulating facet of first rib, effaced above outer edge of facet; small, subdued pleural tubercles along each rib, relatively numerous on anterior ribs; anterior three or four ribs with bluntly pointed tips turned out and back; terminal rib pair (9^2 or 10^2) gently curved outward but not fused posteroventrally; doublure gently lengthening backward, densely granulate, inner margin approximately straight, with fairly deep, parabolic posteromedian embayment.

Discussion. The basis for assignment of sclerites to various species cooccurring in the *C. perneri-M. opimus* Zone was discussed under *Struszia* (s.l.) *petebesti* above.

Struszia (s.l.) *epsteini* has several features which immediately distinguish it from most other potential congenerics. Most obvious is the extremely long, anteriorly protuberant, hypostomal rhynchos. The pygidium is also significantly wider anteriorly than in any other *Struszia*. The ventrally directed tubercle pairs on the librigenal precranidial lobe do occur elsewhere (e.g., in *Struszia onoae* sp. nov., see below), but are very rare. Finally, L2 is much reduced and subelliptical in *S.* (s.l.) *epsteini* as compared with congenerics.

Struszia (s.l.) *epsteini* is highly autapomorphic, and has no obvious close comparison among described species. Parsimony analysis (Text-fig. 8) groups it with *S.* (s.l.) *dimitrovi* and *S.* (s.l.) *petebesti* in most of the shortest cladograms, mainly on the basis of a shared pattern of five adaxial fixigenal tubercles. This is likely accurate in the current state of knowledge, but conjecture about the precise origins and close relationships of *S.* (s.l.) *epsteini* must await discovery of relevant new species. Detailed comparisons with other currently assigned members of *Struszia* (s.l.) would consist mainly of reiteration of the autapomorphies of the species, and are thus not given.

While the function of the extended hypostomal rhynchos (if any) is difficult to assess, it seems possible that some of the unusual features of *Struszia* (s.l.) *epsteini* are part of a character system associated with the rhynchos. Encrinurines typically employ a sphaeroidal full-enrollment pattern, with the pygidial and cephalic doublures flush and the pygidial margins accommodated in librigenal vincular furrows (e.g., *Balizoma variolaris*, see Thomas, 1981, pl. 18, figs. 2a-d). The anterior end of the swollen rhynchos, when present, is accommodated in a posterior notch in the pygidial doublure, but lies posterior to the cephalic doublure (i.e., the bottom of the rostral plate). In *S. epsteini*, however, the rhynchos must have extended forward beneath the rostral plate, and likely protruded slightly anteriorly from the cephalon. If this is so, during full enrollment flush contact between the anterior part of the cephalon and the posterior part of the pygidium is no longer possible, and a means of maintaining a gap to accommodate the rhynchos is required. This was evidently accomplished through the retention in the holaspid of two pairs of prominent tubercles alongside the connective suture on the ventral aspect of the precranidial lobe. These features may have propped the cephalon and pygidium apart, allowing space for the anterior protrusion of the rhynchos. The strongly flexed precranidial lobes may be a response to foreshortening of the librigena required to create space for the width of the rhynchos during enrollment. The precranidial tubercles are general juvenile encrinurine features (see Edgecombe and Chatterton, 1992, figs. 11.2-11.5). Their development in holaspid *S. epsteini* could therefore be interpreted as a paedomorphic retention.

Similar anterior extension of the rhynchos in encrinurines is seen only in some species of *Wallacia* Lamont, 1978 (see Ramsköld and Edgecombe, 1994). In species such as *W. jaanussoni* Ramsköld and Edgecombe, however, the extended rhynchos was evidently accommodated with the pygidial doublure, as it is not visible in full enrollment (Ramsköld and Edgecombe, 1994, p. 102). The mucronate pygidium of such species is posteriorly elongate, and the anterior sagittal edge of the doublure is visible in front of the cephalon in a fully enrolled specimen of *W. jaanussoni* (Ramsköld and Edgecombe, 1994, fig. 5D). This is in contrast to the situation in *Struszia* (s.l.) *epsteini*, which by all indications employed typical and nearly exact sphaeroidal enrollment.

A single hypostome from ABR 2 27 m (Pl. 19, fig. 10) shows obvious similarity to *Struszia* (s.l.) *epsteini*. The rhynchos is narrower, more parallel-sided anteriorly, and longer than in almost all examples of *S.* (s.l.) *epsteini* (Pl. 7). The posterior border is also longer. As explained above (see discussion of Unnamed Fauna 1), while species known from only a few sclerites are difficult to distinguish from their counterparts in the *S.* (s.l.) *petebesti* Fauna, those known from adequate material often prove to be subtly, but pervasively distinct, although *S* (s.l.) *martini* is definitely well-represented in both faunas. Hence, it is at least possible that some of the contrasts noted above represent species differentia, and the specimen is assigned with question.

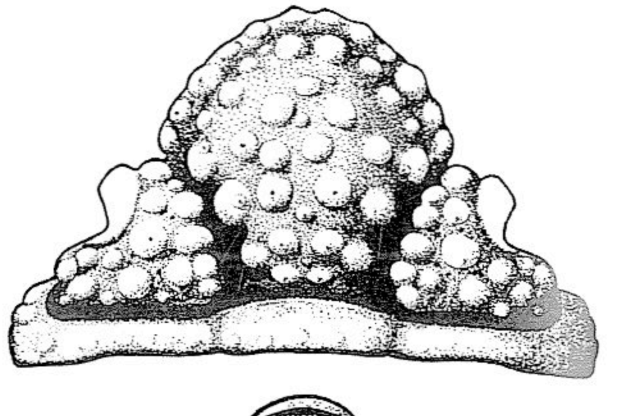
Struszia (s.l.) *martini* sp. nov.
Pl. 8, figs. 19, 20; Pl. 9, figs. 1-26; Pl. 10, figs. 1-19; Pl. 11, figs. 1-21; Pl. 12, figs. 1-17, 19-21; Text-fig. 14

Etymology. After George Martin.

Types. Holotype cranidium ROM 50214 (Pl. 11, figs. 2, 3, 5), from talus boulder ABR TTC(3); paratypes ROM 50215-50217, 50219, 50220, 50222, 50225, 50227-50231, 50233, from talus boulders ABR TTC(3), ABR TTC(5), and ABR TTC(7), Cape Phillips Formation, Wenlock (upper Sheinwoodian, high in *C. perneri-M. opimus* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic. Assigned specimens ROM 50213, 50218, 50221, 50223, 50224, 50226, from section ABR 2 18-27 m, Cape Phillips Formation, Wenlock (upper Sheinwoodian, high in *C. perneri-M. opimus* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic. Assigned specimens ROM 50159-50161, 50163-50175, 5017, from talus boulder ABR TTD, Cape Phillips Formation, Wenlock (upper Sheinwoodian, low in *C. perneri-M. opimus* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic. Assigned specimens ROM 50162, 50176, from section BHL 1 92 m, Cape Phillips Formation, Wenlock (upper Sheinwoodian, *Cyrtograptus perneri-Monograptus opimus* Zone), southern Baillie-Hamilton Island, central Canadian Arctic.

Diagnosis. Five or usually six adaxial fixigenal tubercles; L1 short, low ridge or small, teardrop-shaped to tuberculiform swelling; ii-0 variably present; rhynchos prominently waisted, not reaching anterior margin of hypostome; pygidium vaulted, lateral margins slightly convex outward, not tapering prominently posteriorly, usually 9 pleural ribs.

Description. Cranidial length 53-63 percent of width; axial furrow moderately wide, deep, concave outward; glabellar length (sag.) 100-110 percent of width across frontal lobe; width of L3 76-79 percent width of L4; width of L2 58-63 percent width of L4; glabella gently convex (sag.), raised above genal field and eye, of moderate, even transverse convexity; glabellar tuberculation usually includes posterior pentagonal arrangement of II-1 abaxial to I-1, iii-0, with ii-0 frequently absent; I-0 occasionally present; III-2 small, strongly subdued tubercle fused to swelling of lateral lobe; frontal lobe bearing mostly moderate-sized and coarse tubercles, including prominent IV-1, 2 and V-1, 2; L2-L4 lateral lobes swollen, tuberculiform, distinctly larger than glabellar tubercles; S1 directed posteromedially, usually merged with S0 sagittally; L1 either short (exsag.), low ridge or teardrop-shaped swelling; L0 gently lengthening medially, length (sag.) 26-31 percent width, anterior margin gently bowed forward; transverse row of up to seven small, subdued but distinct tubercles near posterior edge of L0; preglabellar furrow shallow (sag., exsag.); anterior cranidial border bearing 10 or 12 tubercles; PL not enlarged relative to other anterior border tubercles; midlength (exsag.) of palpebral lobe opposite posterior part of L3; posterior edge of palpebral lobe opposite middle of L2; two tubercles between midlength of eye and axial furrow, one anterior tubercle against facial suture; palpebral tubercles weak; adaxial fixigenal row of five or six tubercles, posterior two tubercles (opposite S0, S1) smaller than others; adaxial fixigenal region opposite S3 with single tubercle or developed as small lobiform swelling bearing tiny anterior tubercle and larger posterior tubercle; CT1 of about equal size to coarsest



Text-fig. 14. *Struszia* (s.l.) *martini* sp. nov. Reconstruction of cranidium and pygidium.

adaxial tubercles; CT2 largely abaxial to CT1, with or without an intervening tubercle; posterior border furrow short (exsag.), deep, transverse proximally, may be weakly flexed backward distal to fulcrum, abruptly shallowing at anterior flexure to facial suture; posterior border short (exsag.), weakly lengthening to fulcrum, with moderately strong, even lengthening distally; numerous small tubercles along posterior border, very weak to subdued but distinct proximally, becoming more pronounced distally; cluster of stronger tubercles on posterolateral border in front of genal angle; genal angle bearing tiny point set inward of posterolateral edge of cranidium.

Rostral plate subtrapezoidal; rostral suture straight, moderately wide; connective sutures diverge weakly to anterior furrow, well below mid-height of rostral plate, then run approximately parallel to hypostomal suture; rostral plate bearing five tubercles, including moderately coarse pair at mid-height.

Librigenal field 88-107 percent length (exsag.) of precranidial lobe, usually about equal in width (tr.) to lateral border; tubercles on field arranged two deep anteriorly, two or three deep posteriorly, totalling 11-14 (including very small, weak tubercles); eye socle narrow, set off by sharp furrow ventrally, very faint furrow dorsally; lateral border furrow narrow, shallow; inner row tubercles on lateral border much larger than any on field, tubercles of median row much smaller; marginal row of small tubercles subdued but with most tubercles distinctly defined amidst coarse, dense granulation along lateral margin; anterior furrow very shallow; precranidial lobe covered with 13-20 tubercles of varied size; vincular furrow narrow, shallow, gently curved ventrally; doublure extending nearly 70 percent width to border furrow, gently and evenly tapering beneath precranidial lobe.

Hypostome subrhomboid, length 105-112 percent of width across anterior wings; wing situated at 40-45 percent length (sag.) of hypostome; anterolateral border short (exsag.), margin gently convex outward, weakly bulged forward around rhynchos; anterior margin weakly arched dorsally; middle body ovate, length 113-120 percent of width, flattened medially along much of length (sag.), gently arched transversely; rhynchos extending to anterior border furrow, never reaching hypostomal suture, lateral margins of posterior two-thirds of rhynchos approximately straight and with moderately strong divergence backwards, becoming indistinct opposite rear edge of anterior wing; width at posterior edge of rhynchos about 60 percent width of middle body; rhynchos usually strongly waisted, anterior part thimble-shaped or slightly bulging, rounded anteromedially; approximately transverse muscle impression striae on anterolateral region of middle body, usually well impressed, sometimes shallow; granulate sculpture pervasive on middle body; macula well defined ovate swelling; border furrow narrow, well impressed posterolaterally, shallow medially; lateral margin directed straight back for a short length (exsag.) behind wing, then abruptly flexed inward; posterolateral margin nearly straight or gently sinuous, flexed ventrally; course of margin interrupted at posterolateral angulation, then running straight in and back to sharp posteromedian angulation; posterior border about 18 percent length (sag.) of hypostome.

Pygidial length 78-84 percent of width; axis 36-40 percent of pygidial width anteriorly, composed of 11 or 12 rings, gently convex (sag.); anterior rings gently to moderately arched (tr.), with somewhat flattened median region on middle/posterior rings; axial furrow narrow, moderately deep anteriorly except for shallow impression against first ring, straight against anterior seven rings, then gently and evenly shallowing and converging more strongly, with light incision around axial terminus; four or five strong sagittal tubercles, first usually on third or fourth ring and then on alternating rings or each third ring, tubercles usually present on rings 6, 8, and 10; anterior rings aligned with two or three pairs of small, subdued tubercles and sagittal tubercle; posterior rings bear single small tubercle pair; ring furrows impressed abaxially as deep, transverse grooves, abruptly shallowed medially, lightly impressed between medial part of rings at midlength of axis; usually 9^2 pleural ribs; four congruent segments; inter-rib furrows narrow, deep across most of width, narrowing and shallowing between pleural tips, very shallow between distal parts of posterior ribs; anterior pleurae moderately steeply turned down at fulcrum, posterior ribs more strongly curved down along entire width; pleural furrow on articulating facet of first rib narrow, sharply impressed, straight, effaced well above outer edge of facet; several small, subdued pleural tubercles along each rib, with farthest abaxial tubercle most strongly defined, particularly on posterior ribs; anterior two or three ribs weakly turned out distally, with blunt tips, turned back slightly more strongly than proximal part of rib; terminal rib pair (usually 9^2) gently curved outward, with weak, separate tips or fused posteroventrally as loop; doublure narrow, gently and evenly lengthening backward, inner margin approximately straight for most of length; doublure with gentle but distinct expansion in front of moderately to strongly deepened, rounded posteromedian embayment.

Discussion. *Struszia* (s.l.) *martini*, despite its late Sheinwoodian age, is resolved (Text-fig. 8) as the most primitive known member of the *Struszia* plus *Frammia* clade. At present, no very close relatives are evident. The species was compared with *S*. (s.l.) *petebesti* above. Contrasts with other possibly relevant members of the group follow.

Struszia (s.l.) *martini* differs from Arctic material of the older *S*. (s.l.) *dimitrovi* in its more strongly expressed L1; typically six versus five adaxial fixigenal tubercles; more flexed librigenal lateral margin beneath the precranidial lobe; usually smaller librigenal tubercles; and shorter, narrower hypostomal rhynchos. Pygidia of the species are very similar, but those of *S*. (s.l.) *dimitrovi* are more laterally concave posteriorly.

Struszia (s.l.) *martini* is similar to *S*. (s.l.) *harrisoni* Edgecombe and Chatterton, 1993, in the typical possession of six adaxial fixigenal tubercles, but differs in the occurrence of many fewer glabellar tubercles; usually smaller L1; II-2 and III-2 merged with L2 and L3, respectively, versus retained with independent inflation; one versus often two fixigenal tubercles between the anterior edge of the palpebral lobe and the axial furrow; exceedingly small versus often large genal spine in holaspides; weak versus strong expression of the transverse tubercle row on L0 and the posterior cranidial border; shorter librigenal field; shorter hypostomal rhynchos; and a pygidium with 9^2 versus usually 10^2 pairs of pleural ribs.

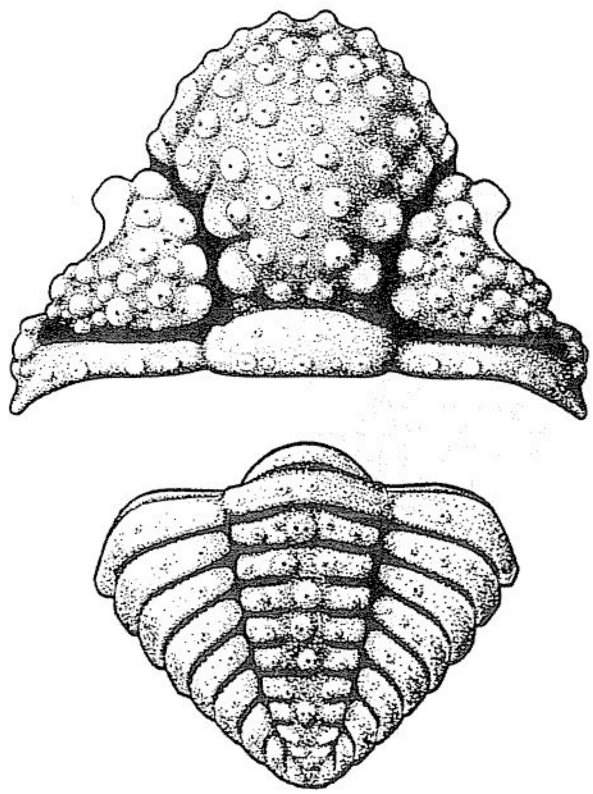
Struszia (s.l.) *martini* is the only species proven thus far to range from the *S*. (s.l.) *petebesti* Fauna into the overlying Unnamed Fauna 1. Other poorly-known candidates exist (see discussion of *S*. (s.l.) *epsteini* above), but most closely-related congenerics for which adequate material is available are specifically distinct between the two faunas. The only difference of any seeming significance between the lower (*S. petebesti* Fauna) and upper (Unnamed Fauna 1) samples of *S*. (s.l.) *martini* is that lower material (Pl. 9, figs. 3, 11, 14) often shows the second of six adaxial fixigenal tubercles (counted from the front) as a minute spot, while upper material (Pl. 11, figs. 1, 4) has the corresponding tubercle nearly as large as the others. An intermediate between these conditions occurs in the same specimen, however. The cranidium (Pl. 11, fig. 2) shows the minute tubercle on the left fixigena (similar to lower forms), while the right fixigena displays six almost equally large tubercles (similar to other upper forms). Hence, this difference can safely be interpreted as minor, perhaps anagenetic, intraspecific variation.

A single pygidium (Pl. 12, figs. 18, 22) from section ABR 2 27 m is obviously distinct from the co-ocurring *Struszia martini* in its more steeply inclined pleurae, laterally convex pygidial lateral margins, shorter (exsag.) more tuberculate pleural ribs, and posteriorly broader axis. It differs also from the rare co-occurring *Mackenziurus* aff. *M. joeyi* sp. nov. (e.g., 9^2 versus 8^2 pleural ribs that are much shorter (exsag.)), and likely represents an extemely rare new species of *Struszia*.

Struszia onoae sp. nov.
Pl. 13, figs. 1-25; Pl. 14, figs. 1-16; Pl. 15, figs. 1-27;
Text-fig. 15

Etymology. After Yoko Ono.

Types. Holotype cranidium ROM 50234 (Pl. 13, figs. 1, 2, 5, 6); paratypes ROM 50235-50260, 50262, from talus boulder ABR 3TT, Cape Phillips Formation, Wenlock (lower Homerian, probably *C. lundgreni-M. testis* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic. Assigned specimens ROM 50261, 50263, 50265, 50267, 50268, from section ABR 1 5.5-13.5 m,



Text-fig. 15. *Struzia onoae* sp. nov. Reconstruction of cranidium and pygidium.

Cape Phillips Formation, Wenlock (lower Homerian, *C. lundgreni-M. testis* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic. Assigned specimens ROM 50264, 50266, from section BH 2 2-3 m, Cape Phillips Formation, Wenlock (lower Homerian, *C. lundgreni-M. testis* Zone), southern Baillie-Hamilton Island, central Canadian Arctic.

Diagnosis. Universally four robust adaxial fixigenal tubercles; ii-0 always present; strong transverse tubercle row on L0 and posterior cranidial border; L1 very short, low; short genal spine retained in large holaspides; connective suture with considerable transverse extent and rostral plate relatively wide; librigena with two prominent tubercles on anteroventral margin beneath precranidial lobe near connective suture; eyes small; librigenal field narrow anteriorly, with either two nearly fused or one field tubercle; hypostome with broad rhynchos extending anteriorly slightly past anterior margin, and "birdsfoot" pattern of middle body striae; pygidium broad; pleural ribs with only faint transverse tubercle rows; inter-rib furrows short (exsag.); lateral pygidial margins distinctly arcuate and laterally convex in ventral view; large, inflated pygidial sagittal tubercles; 10 or more usually 11 axial rings; 9^2-10^2 pleural ribs.

Description. Cranidial length slightly less than 60 percent of width; axial furrow narrow, deep, concave outward between S1 and fossula; glabellar length (sag.) 102-107 percent of width across frontal lobe; width of L3 75-80 percent width of L4; width of L2 60-65 percent width of L4; glabella gently convex (sag.), raised above genal field and eye, of moderately strong transverse convexity; tuberculation includes I-1, small ii-0, II-1 abaxial to I-1, iii-1 or few irregular tubercles, relatively small III-1, (2); frontal lobe bearing many small to moderate sized tubercles; III-1, IV-1 largest glabellar tubercles; IV-1, V-1 only slightly enlarged; L2-L4 lateral lobes swollen, tuberculiform, considerably large than glabellar tubercles; S1 directed posteromedially, merged with S0; L1 very short (exsag.), low, teardrop-shaped ridge; L0 of even length across most of width, length (sag.) 22-30 percent of width, anterior margin usually faintly concave forward medially; transverse row of four to seven (usually five) relatively strong tubercles near posterior edge of L0; preglabellar furrow shallow (sag., exsag.); anterior cranidial border bearing 12 tubercles, PL sometimes larger than others; midlength (exsag.) of palpebral lobe opposite middle to posterior part of L3; posterior edge of palpebral lobe opposite anterior part of L2; two tubercles between midlength of eye and axial furrow; palpebral tubercles indistinct; adaxial fixigenal row of four equal-sized (moderately large) tubercles; CT1 usually smaller than adaxial fixigenal tubercles; CT2, CT3 slightly to moderately enlarged relative to other small tubercles on fixigenal field; one small tubercle between CT1 and CT2; posterior border furrow short (exsag.), moderately deep, transverse, abruptly shallowing at anterior flexure to facial suture; posterior border short (exsag.), weakly lengthening to fulcrum, with moderately strong, even lengthening distally; four or five small, well-defined tubercles along rear half of posterior border; cluster of four tubercles on posterolateral border in front of genal angle; genal angle bearing short spine with gentle lateral deflection, set inward of posterolateral edge of cranidium.

Width (tr.) across rostral suture about 65 percent height of connective suture (rostral plate inferred to be subtrapezoidal); rostral suture straight, moderately wide; connective sutures diverge weakly to anterior furrow, well below mid-height of rostral plate, gently converge to hypostomal suture.

Librigenal field slightly shorter than or of equal length to precranidial lobe, 85-100 percent width of lateral border; tubercles on field arranged one deep anteriorly (tubercle often bicomposite), totalling 12-13 tubercles (including very small, weak tubercles); eye socle narrow, set off by moderately deep furrow ventrally, faint furrow dorsally; lateral border furrow narrow, moderately deep; four inner row tubercles on lateral border moderately large; some tubercles of median row as large as inner row tubercles but usually distinctly smaller; marginal row of small tubercles subdued but most at least weakly discernible; coarse, dense granulation along lateral margin; anterior furrow very shallow; precranidial lobe covered with 15-19 small and medium-sized tubercles; prominent marginal tubercle at anteroventral corner of librigena; vincular furrow narrow, shallow, gently curved ventrally.

Anterolateral border of hypostome very short (exsag.), margin gently convex outward; middle body ovoid, longer than wide, gently convex (sag.) medially, gently arched transversely; rhynchos extending to hypostomal suture, rounded anteromedially, with short (exsag.), subparallel-sided anterior portion, then with lateral margins approximately straight, moderately strongly diverging backwards, becoming indistinct opposite wing process; width at posterior edge of rhynchos 55-60 percent width of middle body; shallow to sharply incised muscle impression striae on anterolateral region of middle body, typically a few narrow (tr.) grooves radiating inwards; granulate sculpture pervasive on middle body; middle furrow very shallow; macula weak.

Axial ring slightly less than 40 percent width of thorax; height of segment 31-33 percent of width; ring of about even length across most of width, posterior margin faintly bowed forwards medially, abaxial edge flexed forward and weakly swollen; relatively long (sag.), lenticular preannulus between ring and sharply incised ring furrow in some segments; ring gently to moderatgely arched (tr.), raised well above pleura, bearing transverse row of five to seven subdued (distinct to faint) tubercles behind midlength; articulating half ring 60-65 percent length (sag.) of axial ring (including preannulus where present); pleura moderately turned down at fulcrum; fulcrum set closer to axial furrow on segments inferred to represent posterior part of thorax, with stronger posterior deflection of distal part of rib; few small, weak tubercles aligned across rib; pleural furrow narrow, sharply impressed, with approximately transverse course proximally, usually faintly concave forward, gently concave forward on articulating facet, effaced well above distal edge of articulating facet; anterior pleural band short (exsag.), set well below posterior band; axial articulating process small, ovoid; anterior flange flexed forward across distal part of articulating facet as pointed process; posterior band extended distally, terminating as short, blunt angulation; vincular furrow lightly impressed along posterior margin of rib.

Pygidial length 72-80 percent of width; axis 38-41 percent of pygidial width anteriorly, composed of 10 or (usually) 11 rings, gently convex (sag.), moderately arched transversely; axial furrow narrow, moderately deep against anterior seven or eight rings, weakly convex outward, shallowing behind about eighth ring furrow, with light incision against axial terminus; three to five strong sagittal tubercles, first on any of rings two to four, most commonly three, then on alternating rings or with one pair on successive rings; anterior rings aligned with one or two pairs of small tubercles, with relatively strong adaxial pair in those lacking sagittal tubercle; one tubercle pair on most of succeeding rings; ring furrows impressed abaxially as deep, transverse grooves, shallowing medially, nearly obsolete between medial part of posterior few rings; 9^2-10^2 pleural ribs; five or six congruent segments; inter-rib furrows narrow, moderately deep, abruptly shallowing and narrowing between tips of third or fourth and succeeding ribs, very shallow between distal parts of posterior few ribs; anterior pleurae gently sloping down to fulcrum, then rather steeply declined and more sharply turned back, with pleural profile (tr.) moderately convex; posterior ribs more strongly curved down along entire width; narrow, sharply impressed pleural furrow with straight course on articulating facet of first rib, abruptly effaced above outer edge of facet; small, subdued pleural tubercles along each rib, two on posterior few pleurae aligned along pygidium, up to five on anterior ribs; anterior two or three ribs with bluntly pointed, weakly turned-out tips; posterior pleurae more strongly squared-off; terminal rib pair (9^2 or 10^2) merged posteroventrally, rarely with intervening unpaired rib (10^1); doublure narrow, gently lengthening backward, densely granulate, inner margin weakly concave, with shallow, rounded posteromedian embayment.

Basis of association. In the combined occurrence of the *Mackenziurus deedeei* Fauna, the associations made herein indicate the presence of five encrinurines, including two species of *Struszia*. Association of sclerites of the species *Avalanchurus garfunkeli* sp. nov. and *Mackenziurus deedeei* sp. nov. is not at issue, since there are no co-occurring congenerics with which they could be confused. The species of *Struszia* and *Frammia* are also very different from one another, but the basis of association must be outlined.

Sclerites are associated using several criteria. First is frequency of occurrence. *Struszia onoae* is exceedingly common in ABR 3TT, while *Frammia bachae* sp. nov. is rare and "*S.*" *mccartneyi* Edgecombe and Chatterton, 1993, is very rare. Conversely, *Frammia bachae* is common at BH 2 2-7.5, while *S. onoae* is very rare, and "*S.*" *mccartneyi* has not been found. Finally, *S. onoae* is quite common at ABR 1 5.5-13.5 m, while the other two species are rare. The disparity in frequency of occurrence at any one locality would yield a confident association; taken together, little doubt remains.

The species can also be discriminated by reference to other localities. "*Struszia*" *mccartneyi* can be compared with material from its type locality in the Mackenzie Mountains, and the material of this species thus segregated, further strengthening the association based upon frequency of occurrence.

Finally, an articulated cranidium and librigena is known for *Struszia onoae*, confirming this assignment.

Discussion. In its relatively small eye and anteriorly narrow librigenal field, *Struszia onoae* is a typical member of the *Struszia* s.s. group. It resembles *S. obtusa* forms A and B of Ramsköld (1986) and *S. rosensteinae* Tripp, Temple and Gass, 1977, in its subdued pygidial pleural tuberculation. Unique autapomorphies of the species include the retention in the holaspid of a ventrally protruding tubercle pair beneath the anterior part of the precranidial lobe (character 20; convergent with *S.* (s.l.) *epsteini*), the possession of only four adaxial fixigenal tubercles, and the "birdsfoot" pattern of hypostomal middle body striae.

Struszia onoae is the oldest known member of *Struszia* (s.s.), almost the only Wenlock species (the only other is Ramsköld's (1986, p. 562) reported but unfigured occurrence of two pygidia assigned to the otherwise Ludlow *S. obtusa* Form B in the Wenlock Mulde Beds, Gotland, Sweden), and the only northern Laurentian species. While it shows definite reduction of the anterior librigenal field to one tubercle, this tubercle occasionally shows vestiges of derivation from a transversely aligned pair of tubercles, the primitive condition (Pl. 15, figs. 1, 17), and the field remains wider anteriorly than in any other member of the *Struszia* s.s. group. In these respects, *S. onoae* may demonstrate a relatively primitive, transitional morphology, in keeping with its relative age.

Parsimony analysis resolves *Struszia onoae* as sister to *S. ramskoeldi* (Edgecombe, 1990), from the Brownsport Formation of Tennessee. The available sample of the latter is not well preserved, but the species share a pattern of very large and uneven pygidial sagittal tubercles (character 37). This morphology is very rare within the group, and thus presents a compelling synapomorphy. The species also share an atypically low number of pygidial axial rings (9-10 in *S. ramskoeldi*; 10-11 in *S. onoae*). *Struszia onoae* differs from *S. ramskoeldi* in the possession of four, versus five, adaxial fixigenal tubercles; smaller eyes; an apparently relatively wider rostral plate; much more subdued pygidial pleural tuberculation; and the absence of the knob-like posterodorsal extension of the fused posteriormost pygidial rib pair. The latter feature is interpreted as an autapomorphy of *S. ramskoeldi*, although a similar morphology is developed in some specimens of *S obtusa* Form B of Ramsköld (1986, pl. 49, fig. 9b).

"*Struszia*" *mccartneyi* Edgecombe and Chatterton, 1993
Pl. 21, figs. 16, 17, 21; Pl. 22, figs. 17-20

1993 *Struszia* (s.l.) *mccartneyi* Edgecombe and Chatterton, p. 94, pl. 15, figs. 1-11, pl. 16, figs. 1-9, pl. 17, figs. 1-22.

Holotype. Cephalon, UA 8845 (Edgecombe and Chatterton, 1993, pl. 15, figs. 1-3), Delorme Group, section AV 5 58-60 m, Mackenzie Mountains, Northwest Territories.

Material. Assigned specimens ROM 50674, 50288, and 50290, from talus boulder ABR 3TT (Homerian; probably *C. lundgreni-M. testis* Zone) and ROM 50289, from section ABR 1 13.5 m (Homerian; *P. ludensis* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic.

Discussion. A few sclerites cannot be assigned to either of the co-occurring *Struszia onoae* or *Frammia bachae*. The cranidia are distinguished by the prominent development of III-2, which is set adaxially and independent of L3. The single assigned librigena has a librigenal field of conventional width, but retains a prominent abaxial lateral border tubercle row (this feature is displayed to some degree by librigenae assigned to *Frammia bachae*, but is more prominent in this specimen, which also lacks their wide field). These features are typical of "*S.*" *mccartneyi*, from which the available material cannot be differentiated.

Struszia (s.l.) *harrisoni* Edgecombe and Chatterton, 1993
Pl. 16, figs. 1-25; Pl. 17, figs. 1-28; Pl. 18, figs. 1-16

1979 *Encrinurus dimitrovi* Perry and Chatterton, partim, p. 589, pl. 72, figs. 1-3, pl. 73, figs. 2-5, 7, 8, 16, 17, pl. 74, figs. 18-20.
1993 *Struszia* (*Struszia*) *harrisoni* Edgecombe and Chatterton, p. 93, pl. 8, figs. 5, 6, 12, 13, 17, 18, pl. 9, figs. 23-25, pl. 12, figs. 1-26, pl. 13, figs. 1-29, pl. 14, figs. 1-18.

Holotype. Pygidium, UA 8735 (Edgecombe and Chatterton, 1993, pl. 13, figs. 24, 25), Delorme Group, section AV 4 248.5 m, Mackenzie Mountains, Northwest Territories.

Material. Assigned specimens ROM 50291-50328, from section ABR 1 22 m, Cape Phillips Formation, Wenlock (Homerian; *P. ludensis* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic.

Discussion. A large and well preserved sample of *Struszia* (s.l.) *harrisoni* from the Cape Phillips Formation does not deviate significantly from the range of variation observed in the type area near Avalanche Lake in the Mackenzie Mountains and in a third occurrence in the Delorme Range. The Cape Phillips specimens possess the following features diagnostic of the species: relatively elongate glabella; L2-L4 with reduced lateral inflation; consistent strong expression of L1; typically six adaxial fixigenal tubercles; relatively strong tubercles across L0 and the posterior cephalic border and thoracic segments; elongate librigenal field; and usual presence of 10^2 pygidial pleural ribs.

The following discussion considers variation within and between samples of *Struszia* (s.l.) *harrisoni* from the Cape Phillips Formation and the Delorme Group. II-2 is relatively adaxially positioned and strongly differentiated from the swelling of the L2 lateral lobe in many Cape Phillips specimens (Pl. 16, figs. 1, 4, 10). It is usually merged with the lateral lobe in specimens from the Mackenzie Mountains, a condition also observed in some Cape Phillips specimens (Pl. 16, figs. 8, 16, 21). No Arctic specimen shows the strong projection of a genal spine that is often developed in typical *S.* (s.l.) *harrisoni* (e.g., Edgecombe and Chatterton, 1993, pl. 14, fig. 1). However, this character is variable in *S.* (s.l.) *harrisoni*, and some Arctic specimens possess a thorn-like genal spine (Pl. 16, fig. 5) that exceeds the spine in many Delorme Range and Avalanche Lake specimens. Most large Cape Phillips cranidia have relatively suppressed adaxial fixigenal tubercles. One or more of these tubercles may be developed as weak lobes against the axial furrow, sometimes with tiny intercalated tubercles (Pl. 16, fig. 1), a morphology also observed in *Avalanchurus* (Pl. 23, fig. 3, Pl. 25, fig. 13). This modification of the adaxial fixigenal tubercle row (primitively composed of five subequal sized, inflated tubercles) is observed in some Mackenzie Mountains *S.* (s.l.) *harrisoni*, but is less common. Possibly the most significant difference is the form of the hypostomal posterior border. Large holaspid hypostomes from the Cape Phillips Formation (Pl. 17, figs. 1, 3) have a longer border than is typical of Mackenzie Mountains material (e.g., Edgecombe and Chatterton, 1993, pl. 14, figs. 3, 7, 10), and the margin often retains the three short spines that are well developed in juvenile stages of the genus.

Struszia (s.l.) *harrisoni* was compared with *S.* (s.l.) *petebesti* and *S.* (s.l.) *martini* under discussion of those species above. A relationship to the Ludlow-Přídolí *Struszia* (s.l.) *indianensis* (Kindle and Breger, 1904) is indicated by the shared thorn-like genal spine, abundance of glabellar tubercles, III-2 independent of the inflation of L3, relatively strong expression of tubercles across the cephalic border and pygidium, and relatively large number of pygidial pleural ribs (usually 10^2-11^2). *Struszia* (s.l.) *harrisoni* is most obviously distinguished from *S.* (s.l.) *indianensis* by its more elevated L1 and wider, less convex (sag.) pygidium.

Struszia (s.l.) sp. nov. A
Pl. 8, figs. 1-8, 9?, 10-12, 13-18?

Material. Assigned specimens ROM 50178-50186, from talus boulder ABR TTD, Cape Phillips Formation, Wenlock (upper Sheinwoodian, low in *C. perneri-M. opimus* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic.

Discussion. Several cranidia and librigenae from talus boulder ABR TTD have a very distinctive morphology and almost certainly represent a new species, distinct from the co-occurring *Struszia* (s.l.) *martini*, *S.* (s.l.) *petebesti*, and *S.* (s.l.) *epsteini*. The basis for association of sclerites is strong, and was outlined under discussion of *S.* (s.l.) *petebesti*, above. Features not shared with any of the co-occurring species include very large, closely spaced, and blocky tubercles on the entirety of the external surface, width of rostral suture equal to the height of the connective suture (Pl. 8, fig. 8), and the presence of unusually large, coarse tubercles (matching those on the librigenal lateral border) on the cranidial posterior border near the posterior section of the facial suture (Pl. 8, figs. 5, 7). A similar rostral plate shape is seen in *Mackenziurus*, but the connective sutures in *Struszia* sp. nov. A are slightly convergent near their ventral extent. All *Struszia* for which information is available are either nearly subparallel or slightly convergent in this area. Problems of association of hypostomes and pygidia were discussed under *S.* (s.l.) *petebesti*.

Struszia (s.l.) sp. nov. B
Pl. 19, figs. 1-3, 6

Material. Illustrated specimens ROM 50329, 50330, from sections BH 1 110 m and BHL 1 0 m, Cape Phillips Formation, Wenlock (Sheinwoodian; *M. instrenuus-C. kolobus* Zone), southern Baillie-Hamilton Island, central Canadian Arctic.

Discussion. A single cephalon and one isolated librigena show many differences from the co-occurring *Struszia* (s.l.) *dimitrovi*, and almost certainly represent a separate species. Differences include relatively smaller glabellar tubercles; development of L1 as a transverse bar versus usually suppressed; and a much narrower librigenal field, with a single tubercle anteriorly. The ventral course of the connective sutures features a marked divergence, and lacks a lower subparallel course seen in *S.* (s.l.) *dimitrovi* (Edgecombe and Chatterton, 1993, pl. 10, fig. 3, 5, 12, 15, 19).

Struszia (s.l.) sp. nov. C
Pl. 19, figs. 4, 5, 7-9, 11-13, 17

Material. Illustrated specimens ROM 50331-50336, from section BH 2 42 m, Cape Phillips Formation, Ludlow (Gorstian; *L. progenitor* Zone), southern Baillie-Hamilton Island, central Canadian Arctic.

Discussion. Ludlow specimens from BH 2 42 m definitely represent two or more new species of *Struszia*, but the available material is insufficient for formal naming. Particularly distinctive of the specimens grouped here as *Struszia* (s.l.) sp. nov. C are the narrow pygidial pleurae with very prominent transverse tubercle rows and the librigenae with prominent retention of the abaxial lateral border tubercle row. In the latter feature, there is obvious similarity to the Homerian "*S.*" *mccartneyi*. The pygidia, however, closely resemble those of *Struszia* n. sp. A of Edgecombe and Chatterton (1993, pl. 16, figs. 11-19), although the tubercle rows are even more pronounced in the younger Arctic material. The bases for association of sclerites at AV 5 58-60 m, the type stratum of "*S.*" *mccartneyi*, are frequency of occurrence and morphological congruence (i.e., fit of cephala and pygidia in enrollment), and are strong. This might indicate that the librigena and pygidia grouped here actually represent different species.

Struszia? sp. nov. D
Pl. 20, figs. 1-24

Material. Illustrated specimens ROM 50342-50353, from section HI 1 69.5-70 m, Cape Phillips Formation, latest Wenlock or early Ludlow, Hoved Island, north-central Canadian Arctic.

Discussion. A small sample from Hoved Island (75°30'N, 84°50'W), collected by B.D.E. Chatterton in 1977, is of uncertain age, as diagnostic graptolites were not recovered. The trilobites are of low diversity (six species). Present, however, are species of *Acanthalomina* and *Tetinia*. These indicate that the fauna is either of latest Wenlock (*P. ludensis* Zone) or early Ludlow age, based on comparison with faunas elsewhere in the Cape Phillips embayment.

The collection includes material belonging to a single new encrinurine species. Most of the material is juvenile, and formal naming is deferred until more can be collected. The species is assigned to *Struszia* based on the seemingly short, lozenge-shaped L0 and the relatively shallow pygidial inter-rib furrows. There is a small possibility, however, that the species might belong to *Mackenziurus*. The primary evidence for this is the very broad and shallow doublural notch borne by the largest pygidium (Pl. 20, fig. 6), a feature unusual for *Struszia* but common in *Mackenziurus*. The available hypostomes are too small to be diagnostic, and the rostral suture is not preserved on any of the available cranidia. However, a small, incomplete cranidium with an articulated librigena (Pl. 20, figs. 11, 15-17) reveals that the rostral plate gently widens ventrally and is apparently relatively narrow dorsally (as such, more similar to *Struszia* than to *Mackenziurus*).

The most distinctive features of the species are the presence of six adaxial fixigenal tubercles, a narrow librigenal field (sometimes with a single anterior tubercle) and large eye, and 10^1 or 10^2 pygidial pleural ribs.

Struszia? sp. 1
Pl. 8, fig. 21

Material. Assigned specimen ROM 50188, from section BHL 1 92 m, Cape Phillips Formation, Wenlock (upper Sheinwoodian, *C. perneri-M. opimus* Zone), southern Baillie-Hamilton Island, central Canadian Arctic.

Discussion. A single cranidium from BHL 1 92 m is obviously different from those assigned to any of the co-occurring encrinurines (*Struszia* (s.l.) *petebesti*, *S.* (s.l.) *epsteini*, *S.* (s.l.) *martini*, *Mackenziurus joeyi*, *Avalanchurus simoni* sp. nov.). Distinctive features include the strong transverse expansion of the anterior part of the glabella, the very small lateral glabellar lobes, and the presence of four independent adaxial fixigenal tubercles. The latter is seen also in the co-occurring *M. joeyi*, but the posterior two tubercles in that species are typically grouped or merged on an adaxial evagination of the fixigena. Reduced lateral glabellar lobes are seen in some species of *Mackenziurus* and *Fragiscutum*. The cranidium assigned to *Struszia*? sp. 1 lacks the elongate L0 of members of *Mackenziurus*. Its affinities are obscure, and it likely represents a very rare new taxon.

Struszia sp. 2
Pl. 19, fig. 18

Material. Assigned specimen ROM 50339, from section ABR 1 22 m, Cape Phillips Formation, Wenlock (upper Homerian, *P. ludensis* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic.

Discussion. A single cranidium from ABR 1 22 m differs from co-occurring specimens of *Struszia* (s.l.) *harrisoni* in its coarser (almost conical), sparser glabellar and fixigenal tuberculation, long (sag.) occipital ring, five versus typically six strong, rounded adaxial fixigenal tubercles, and absence versus almost universal presence of ii-0. While apparently not conspecific with *S.* (s.l.) *harrisoni*, the affinities of the specimen are obscure. No other sclerites that might belong with it were recovered, in contrast with the dozens of sclerites assignable to *S.* (s.l.) *harrisoni*.

Struszia sp. 3 aff. *S.* (s.l.) *epsteini* sp. nov.
Pl. 19, figs. 19-21

Material. Illustrated specimens ROM 50340, 50341, from section BH 2 42 m, Cape Phillips Formation, Ludlow (Gorstian; *L. progenitor* Zone), southern Baillie-Hamilton Island, central Canadian Arctic.

Discussion. In addition to sclerites grouped above as *Struszia* (s.l.) sp. nov. C, two sclerites occurring at BH 2 42 m are obviously distinct. In general proportions, they are both most similar to *S.* (s.l.) *epsteini*. The pygidium is wide and quite low. The librigena displays the strong curvature of the lateral margin and precranidial lobe seen so prominently in *S.* (s.l.) *epsteini*. It lacks, however, the strongly retained anteroventral tubercles present in that species. As mentioned above, the material grouped as *Struszia* (s.l.) sp. nov. C may actually represent two species. While individual sclerites of a given type can be segregated, it is obvious that much more material would be required for confident associations to be made.

Genus *Frammia* Holtedahl, 1914

Type species. *Encrinurus arcticus* Salter, 1852, from the Douro Formation, upper Ludlow, eastern Cornwallis Island, central Canadian Arctic. See discussion in Tripp, Temple and Gass (1977, p. 864).

Other species. *Frammia bachae* sp. nov., Cape Phillips Formation, Wenlock (lower Homerian), Arctic Canada; *Encrinurus hyperboreus* Thomas *in* Thomas and Narbonne (1979), Douro Formation, upper Ludlow, Arctic Canada; *E.* (*Frammia*) *rossicus* Maksimova, 1970, Ludlow, Vaygatch Island, Arctic Russia.

Diagnosis. Rostral plate broad; rostral suture in shape of shallow "V"; connective sutures slightly ventrally convergent; primitively six adaxial fixigenal tubercles; librigenal field anteriorly broad, with at least three tubercles aligned along edge.

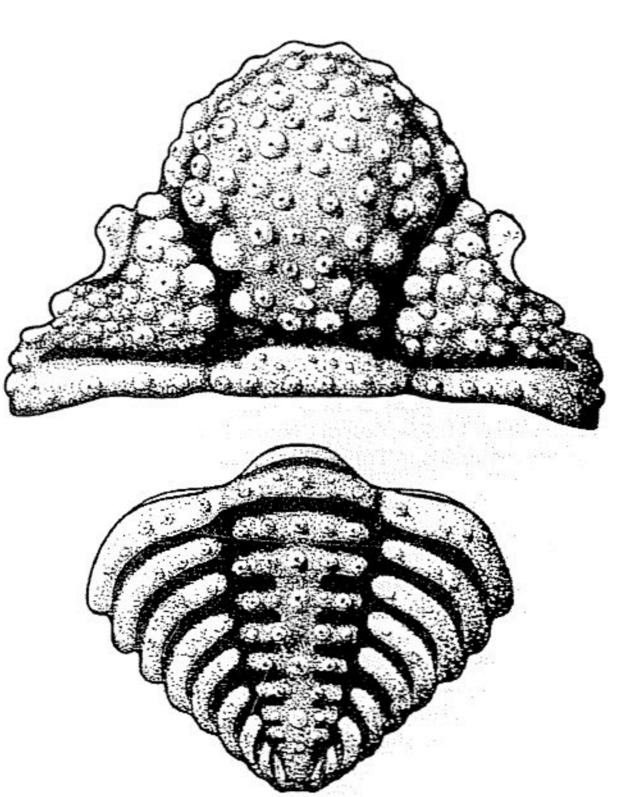
Discussion. *Frammia* is in general not a well known taxon. Large new collections of the type and other species have been made, and a full revision is in progress. A preliminary assessment is given here, based in part on knowledge of new material and made necessary by the discovery of what is evidently the oldest, most primitive member of the genus. Upper Ludlow representatives (*F. arctica*, *F. rossica*), are highly autapomorphic, but *F. bachae* sp. nov., from the lower Homerian, shares what seem to be two key characters with the more derived forms. These are the basis for the above diagnosis, which does not include autapomorphies of the type species. The shape of the rostral suture on the anterior of the cranidium is associated with the transverse *Frammia* rostral plate. Both are unique to the genus. While the rostral plate of *F. bachae* has not been found, the cranidium shows a broad, "V"-shaped rostral suture (Pl. 21, figs. 4, 5) identical to that observed in *F. arctica* (Tripp, Temple and Gass, 1977, pl. 115, fig. 16; also much unpublished material collected by J.M.A.), but unknown in other encrinurine genera. In addition, within the *Struszia* genus group, the presence of an anterior librigenal field three tubercles in width (Pl. 22, figs. 5-7) is seen outside *Frammia* only in the *Aegrotocatellus* plus *Balizoma* clade, with which there is little question of close phylogenetic connection.

Hence, despite its strong similarity (in what, relative to *Frammia*, are plesiomorphic features) to members of the *Struszia* (s.l.) group, the species *bachae* is most informatively classified with *Frammia*. This discovery is significant, as it extends the range of a highly modified, difficult to interpret taxon, along with a strong clue to its origins among more typical encrinurines.

Frammia bachae sp. nov.
Pl. 21, figs. 1-15, 18-20; Pl. 22, figs. 1-16; Text-fig. 16

Etymology. After Barbara Bach.

Types. Holotype cranidium ROM 50269 (Pl. 21, figs. 1, 4, 7, 11), from section BH 2 3 m; paratypes ROM 50270-50274, 50279-50284, 50286, 50287, from section BH 2 2-7.5 m, Cape Phillips Formation, Wenlock (lower Homerian, *C. lundgreni-M. testis* Zone),



Text-fig. 16. *Frammia bachae* sp. nov. Reconstruction of cranidium and pygidium.

southern Baillie-Hamilton Island, central Canadian Arctic. Assigned specimen ROM 50285, from section ABR 1 9 m, and ROM 50275-50278, from talus boulder ABR 3TT, Cape Phillips Formation, Wenlock (lower Homerian, *C. lundgreni-M. testis* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic.

Diagnosis. L1 depressed but retained as a very small abaxial tubercle; posterior glabellar tubercle pentagon anteroposteriorly retracted, ii-0 present but usually laterally displaced; six adaxial fixigenal tubercles; glabella broad anteriorly; hypostomal rhynchos narrow but distinctly waisted, produced anteriorly to just short of anterior margin; hypostomal middle body striae not prominent; eye small; librigenal field wide anteriorly, sometimes with three transversely aligned tubercles; strong sutural ridge along posterior section of facial suture on librigena; pygidium with 9^2 pleural ribs.

Description. Cranidial length about 55 percent of width; axial furrow narrow, deep; glabella slightly longer (sag.) than width across frontal lobe, gently convex (sag.), raised well above genal field and eye, moderately arched transversely; width of L3 about 75 percent of width across L4; width of L2 about 60 percent width of L4; II-1 markedly abaxial to I-1, usually situated near inner edge of L2 lateral lobe; ii-0 represented in a few specimens by nearly exsagittally aligned tubercle pair, slightly displaced laterally; III-1 also with strong abaxial displacement in some specimens; III-2 usually merged with tuberculiform swelling of L3; swelling of L2 slightly to considerably less than L3; L4 lateral lobe large but less strongly inflated than L3, bearing one or two tubercles; L3 and frontal lobe bearing relatively numerous small and moderate sized tubercles; S1 directed posteromedially, merged with S0 medially, isolating L1 as small, low tuberculiform swelling; S1 and S2 apodemes prominent, S0 small, S3 very small, positioned adaxial to other apodemes; L0 of about even length across most of width, length (sag.) 25-30 percent of width, abruptly shortened distally, anterior margin approximately straight, transverse medially; transverse row of small tubercles across posterior part of L0 relatively prominent; preglabellar furrow shallow (sag., exsag.), without anteromedian depression; anterior cranidial border bearing 12 tubercles; midlength (exsag.) of palpebral lobe opposite middle of L3; posterior edge of palpebral lobe opposite anterior part of L2; palpebral tubercles strongly subdued; two tubercles between midlength of eye and axial furrow, one anteriorly along facial suture; adaxial fixigenal row of six tubercles, second tubercle (opposite L4) smallest, others of similar, moderate size; CT1 positioned adjacent to palpebral furrow or separated by a small tubercle; CT2, CT3 smaller than CT1 but slightly to distinctly larger than other (mostly small) dense tubercles on fixigenal field; posterior border furrow short (exsag.), deep, approximately transverse, abruptly effacing at anterior flexure to facial suture; posterior border short, very gently lengthening to fulcrum, aligned with five to seven small, subdued to faint tubercles; cluster of tubercles on posterolateral border pronounced in some specimens; genal angle bearing small point set inward of posterolateral edge of cranidium.

Rostral suture (on cranidium) describing very shallow "V", with median angulation; dorsal part of rostral plate inferred to be moderately wide.

Librigenal field ranging from slightly shorter to slightly longer than precranidial lobe, slightly narrower (tr.) than lateral border; tubercles on field arranged three deep anteriorly and posteriorly, totalling 13-18; eye socle narrow; lateral border furrow narrow, moderately deep along most of length, abruptly shallowing posteriorly, very shallow near facial suture; four inner row tubercles on lateral border moderately large, decreasing in size posteriorly, second (from front) partly overhanging border furrow; three interspersed tubercles of median row slightly smaller; small tubercles of marginal row completely defined in some specimens; anterior furrow shallow; precranidial lobe covered with 17-19 small and medium sized tubercles; marginal tubercle at anteroventral edge of librigena subdued; vincular furrow narrow, shallow, gently curved ventrally or with nearly straight component.

Hypostomal anterolateral margin gently convex outward in ventral view, with weak bulge medially around rhynchos; anterior margin arched dorsally, weakly curved ventrally in front of rhynchos; middle body subcircular, length 108 percent of width, moderately convex (sag., tr.); rhynchos with distinct to pronounced waisting, anterior region usually narrow, parallel-sided, with margins abruptly flaring to moderate divergence backwards; shallow depression with subdued sculpture bounding most of rhynchos; width across posterior edge of rhynchos 50-55 percent width of middle body; rhynchos rounded anteromedially, terminating very slightly behind anterior margin; muscle impression striae on anterolateral region of middle body shallow or obscure; macula small but relatively strong.

Height of thoracic segment 36 percent of width; axial ring 36 percent width of thorax; short (sag.), lenticular preannulus sharply set off by preannular furrow; raised part of ring shortened medially behind preannulus; ring gently flexed forward distally, gently arched (tr.); ring furrow narrow, deep; pleura gently sloping outward proximally, moderately steeply turned down distal to fulcrum; tuberculation lacking on known thoracic segments.

Pygidial length 70-76 percent of width; axis 35 percent of pygidial width anteriorly, composed of 11-12 rings, moderately convex (sag.); axial furrow narrow, deep, nearly straight against anterior six to eight rings then converging more strongly backward, with very light impression against axial terminus; four or five strong, moderately large sagittal tubercles, first on ring two or four and then usually on alternating rings; anterior rings aligned with one to three pairs of small slightly subdued tubercles and sagittal tubercle; all ring furrows but first shallowing medially, with narrow sagittal band; 9^2 pleural ribs; five congruent segments; inter-rib furrows moderately wide, deep, abruptly shallowing between distal parts of posterior three rib pairs; anterior ribs gently declined outwards proximal to fulcrum, then moderately steeply turned down and more sharply flexed back distal to fulcrum; posterior ribs strongly curved down and back along entire width; numerous small, subdued tubercles aligned across ribs, adaxial tubercle strongest on posterior few rib pairs; anterior few rib pairs with rounded, very weakly turned out tips; terminal rib pair (9^2) faintly curved outward in posteroventral course, terminae of ribs nearly merged; doublure relatively broad, becoming broader posteriorly, with dense granular sculpture and deep, subpolygonal posterior embayment.

Discussion. *Frammia bachae* sp. nov. is distinguished from the co-occurring *Struszia onoae* in the presence of six, versus four, adaxial fixigenal tubercles; broader anterior part of glabella; slightly wider, "V"-shaped rostral suture; smaller, shorter hypostomal rhynchos; reduced versus prominent and birdsfoot-shaped hypostomal middle body striae; absence of well developed ventral tubercles beneath the precranidial lobe; wider librigenal field; shorter (exsag.), more tuberculate pygidial pleural ribs; and 9^2 versus 10^1 or 10^2 pygidial pleural ribs.

Frammia bachae is distinguished from *F. hyperborea* in its smaller, less subpolygonal cephalic tubercles; smaller abaxial tubercle on L1; narrower interocular fixigena; more anteriorly set eye; less dense librigenal field tuberculation; smaller inner row of librigenal lateral border tubercles; and 9^2 versus 10^2 pygidial pleural ribs. It should be noted that of the material assigned to *F. hyperborea* by Thomas *in* Thomas and Narbonne (1979), the articulated specimens (his pl. 3, figs. a and d), are both almost certainly referable to *F. arctica*, which re-collection has shown occurs in great abundance immediately above the beds containing *F. hyperborea*. Articulated specimens of *F. hyperborea* are extremely rare, while those of *F. arctica* are large and extremely common. Beyond knowledge of the locality, that the specimens belong to *F. arctica* is confirmed by the morphology of the librigenal lateral border, visible in both. The lateral border of *F. hyperborea* (the example figured by Thomas, *ibid.*, pl. 3, fig. e, is thus far the only one illustrated, but many more have since been collected) is relatively narrow and strongly tuberculate. That of *F. arctica* is broad, adaxially lobate, but otherwise almost smooth, matching those seen in the articulated specimens of Thomas's pl. 3, figs. a and d. In addition, one of the pygidia figured by Thomas (*ibid.*, pl. 3, fig. p) has very prominent sagittal tubercles and tapering, laterally concave lateral margins. It likely belongs to the common, co-occurring *Aegrotocatellus jaggeri* Adrain and Edgecombe, 1995 (as does the cranidium illustrated by Thomas (*ibid.*, pl. 4, figs. g, h, j, m, n) as encrinurid gen. et sp. indet.; see Adrain and Edgecombe, 1995).

Genus *Avalanchurus* Edgecombe and Chatterton, 1993

Type species. *Struszia* (*Avalanchurus*) *lennoni* Edgecombe and Chatterton, 1993, from the Delorme Group, Wenlock (mid-Sheinwoodian, questionably ranging to lower Homerian), Avalanche Lake, Northwest Territories, Canada.

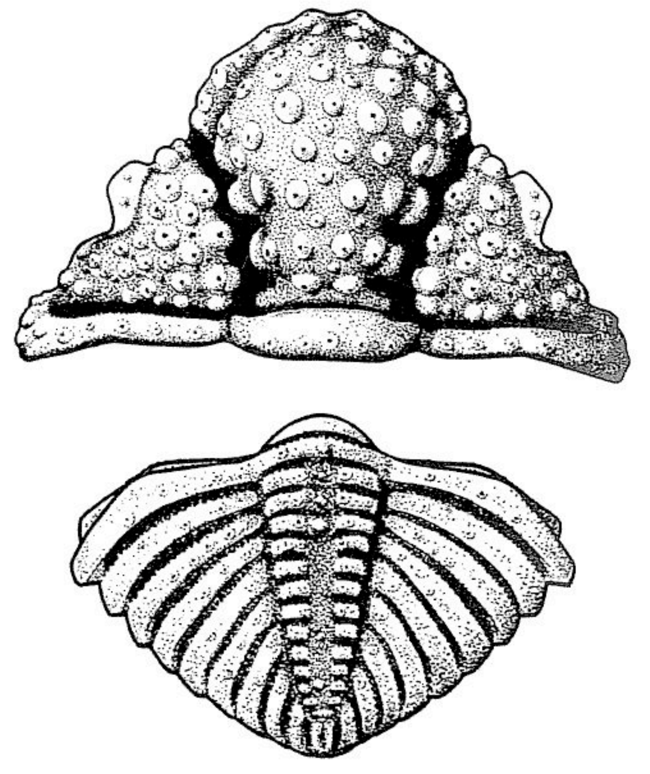
Other species. *Balizoma dakon* Šnajdr, 1983, Ludlow, Czech Republic; *Avalanchurus garfunkeli* sp. nov., Wenlock (lower Homerian), Arctic Canada; *A. simoni* sp. nov., Wenlock (upper Sheinwoodian), Arctic Canada; *Struszia* (*Avalanchurus*) *starri* Edgecombe and Chatterton, 1993, Ludlow?, northwestern Canada.

Discussion. Reasons for considering *Struszia* and *Avalanchurus* as separate at the generic level were given under discussion of *Struszia* above. While at least five new species (two of which are formally named) are reported below, the generic concept of *Avalanchurus* arrived at through treatment of the new material and phylogenetic analysis is essentially identical to that of Edgecombe and Chatterton (1993). Hence, no new diagnosis is given.

Avalanchurus simoni sp. nov.
Pl. 23, figs. 1-23; Pl. 24, figs. 1-10, 12; Text-fig. 17

Etymology. After Paul Simon.

Types. Holotype cranidium ROM 50355 (Pl. 23, figs. 2, 5, 6); paratypes ROM 50354, 50356-50373, from locality BHH and sections BH 1 195-209 m and BHL 1 92 m, Cape Phillips Formation, Wenlock (Sheinwoodian, *C. perneri-M. opimus* Zone), southern Baillie-Hamilton Island, central Canadian Arctic.



Text-fig. 17. *Avalanchurus simoni* sp. nov. Reconstruction of cranidium and pygidium.

Diagnosis. Anterior margin of cranidium well rounded; III-2 relatively coarse; two more or less distinct fixigenal tubercles between anterior edge of palpebral lobe and axial furrow; lateral margins of rhynchos slightly subdued; distal part of anterior few pleurae only moderately declined outward, terminating as blunt points; 10^1-10^2 pleural ribs and 12-15 axial rings; 4-5 relatively subdued sagittal tubercles; prominent sagittal band.

Description. Description is limited to characters of diagnostic or potentially diagnostic difference from the similar *Avalanchurus lennoni* (see Edgecombe and Chatterton, 1993, for a full description of *A. lennoni*).

Glabella widening forward with approximately straight tangent to abaxial edges of L2-L4 (concave outward in *A. lennoni*); II-2 varying from coarse tubercle as large as II-1, strongly differentiated from swelling of L2 lateral lobe, to very small tubercle weakly defined on adaxial part of lateral lobe; III-2 sometimes larger than III-1; preglabellar furrow describing semicircular arc in dorsal orientation, less parabolic than in *A. lennoni*; tubercles on anterior cranidial border relatively coarse; midlength (exsag.) of palpebral lobe opposite S2 to middle of L3.

Largest hypostome with blunt rhynchos, lateral margins weakly diverging backward.

Pygidial length 62-63 percent of width; 15 distinct axial rings in largest specimen, only four small, subdued sagittal tubercles including very weak sagittal tubercle on first ring; additional paired tubercles aligned on anterior rings very small, faintly developed; ring furrows very shallow or effaced medially behind sixth and succeeding rings; sagittal band shallow but relatively wide; pleurae weakly convex (tr.); numerous small tubercles very faintly developed across width of ribs; posteromedian embayment in doublure rounded, very shallow.

Discussion. *Avalanchurus simoni* sp. nov. is a relatively rare component of the *Struszia petebesti* Fauna, most common in talus blocks at locality BHH. While similar to *A. lennoni*, particularly in cephalic features, it is immediately distinguished by a more subdued hypostomal rhynchos with much weaker furrows, and a wider, less vaulted pygidium with typically 10^1 or 10^2 versus typically 9^2 pleural ribs. *Avalanchurus simoni* appears to share derived features with the younger *A. garfunkeli* to the exclusion of *A. lennoni*, as reflected in Text-figures 8 and 9. Most prominent is the shared possession of two versus one anterior fixigenal tubercles. While some specimens of *A. lennoni* show a composite tubercle in this position (Edgecombe and Chatterton, 1993, pl. 18, figs. 10, 16), most cranidia of *A. simoni* and *A. garfunkeli* have a broader anterior extent of the fixigena, with two more or less independent tubercles. *Avalanchurus simoni* is further similar to *A. garfunkeli* in its more subdued rhynchos, with shallower lateral furrows posteriorly, and lower, wider pygidium.

Avalanchurus simoni differs from the younger *Avalanchurus* sp. nov. A in its less subquadrate lateral glabellar lobes, smaller hypostomal rhynchos that does not extend to anterior margin, and slightly smaller, somewhat less tuberculate librigenal precranidial lobe. *Avalanchurus simoni* differs from the coeval *A.* cf. *A. lennoni*, which occurs with the *Struszia petebesti* Fauna at Abbott River, in its smaller librigenal field tubercles, less tuberculate precranidial lobe, and particularly in its narrower, more subdued, hypostomal rhynchos and obscure middle body striae (the middle body muscle impressions of *A. simoni* are developed as many clustered pits rather than transverse striae; Pl. 23, fig. 16). The species differs from the much younger *Avalanchurus* sp. nov. B in its less abaxially tuberculate L1, relatively smaller, less tuberculate librigenal field, relatively broader librigenal lateral border, and shallower librigenal anterior furrow.

Avalanchurus garfunkeli sp. nov.
Pl. 25, figs. 1-21

Etymology. After Art Garfunkel.

Types. Holotype cranidium ROM 50392 (Pl. 25, figs. 1-3, 6) and paratype librigena ROM 50396, from section ABR 1 9 m, Cape Phillips Formation, Wenlock (Homerian; *C. lundgreni-M. testis* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic. Assigned specimens ROM 50393-50395, 50397-50404 from section BH 2 2-3 m, Cape Phillips Formation, Wenlock (Homerian; *C. lundgreni-M. testis* Zone), southern Baillie-Hamilton Island, central Canadian Arctic.

Diagnosis. Lateral glabellar lobes extremely inflated and subquadrate; L1 with full, independent inflation; adaxial fixigenal tubercles subdued, transversely stretched; fixigena very broad; eye set far forward, with midlength (exsag.) of palpebral lobe opposite anterior part of L3; large librigena elongate, narrow, with relatively short precranidial lobe and reduced tuberculate sculpture; hypostome with subdued, very weakly divergent rhynchos; pygidium very low and wide.

Description. Cephalic axial furrow narrow, deep, concave outward; glabella apparently longer (sag.) than width across frontal lobe; glabellar tubercles relatively small, subdued; II-1 aligned (exsag.) with I-1; II-2 subdued tubercle on adaxial part of lateral lobe; L2-L3 large, rounded swellings, L4 slightly less inflated and subquadrate; L1 prominent, with rounded tuberculiform swelling distally; S1 apodeme large, S2 and S0 considerably smaller, S3 apodeme very small; S0 short (sag.), moderately deep; L0 lengthening medially, with anterior margin bowed forward; occipital tubercles obscure; anterior cranidial border furrow shallow (exsag.); posterior edge of palpebral lobe opposite anterior part of L2; few palpebral tubercles subdued but clearly defined; about eight small adaxial fixigenal tubercles, lacking significant projection over axial furrow, several tubercles transversely widened, some by merging of two adjacent tubercles; large area of fixigenal field densely covered with abundant small tubercles; two tubercles between eye and axial furrow anteriorly; posterior cranidial border furrow short (exsag.), deep, faintly convex forward, with slight posterior inflection distally; posterior border short (exsag.) proximally, less than one third length (exsag.) of fixigenal field behind eye, with tuberculation very faintly defined.

Librigenal field 170-185 percent length (exsag.) of precranidial lobe in large specimens; narrowest (tr.) part of field slightly wider than lateral border or up to 150 percent width of border; tubercles on field abundant but subdued, arranged two deep anteriorly, at least three deep posteriorly; eye socle narrow; lateral border furrow narrow, moderately deep; lateral border tuberculation weak, more subdued than that on field and precranidial lobe, inner row tubercles discernible but faint; marginal tubercles undefined amidst strong, dense granulation; anterior furrow nearly obsolete; precranidial lobe densely covered with many very small to medium sized tubercles; doublure beneath lateral border extending about 70 percent of width to border furrow; vincular furrow narrow, very shallow.

Hypostome subrhomboid; maximum width across wing situated at about 32 percent length (sag.) of hypostome; anterolateral margin nearly straight or faintly convex outward, then gently flaring out to large anterior wing, rounded medially; anterior margin weakly arched (tr.) dorsally, faintly concave above front of rhynchos; wing about half total dorsoventral height of hypostome; middle body ovate, length about 125 percent of width, of moderate, even convexity (sag., tr.); rhynchos weakly, evenly tapering forwards, lateral margins defined by shallow or very shallow furrows that deepen abruptly well anterior to midlength (exsag.); width at posterior edge of rhynchos about 50 percent width of middle body; rhynchos strongly rounded anteromedially, bulging over anterior border furrow but terminating behind hypostomal suture; series of shallow, transverse muscle impression striae paralleling margin of rhynchos on lateral part of middle body; maculae small, weakly inflated; posterior border furrow very shallow medially; lateral margin running straight back for a short distance behind wing, then abruptly flexed inward; posterolateral margin faintly sinuous, concave outward then convex outward; posterior border 23 percent length (sag.) of hypostome; margin rounded posteromedially, with weak trace of posterolateral angulation.

Pygidial length 55-60 percent of width; axis slightly less than 30 percent of pygidial width anteriorly, composed of about 14 rings, weakly convex (sag.); axial furrow narrow, moderately deep, straight against first ten rings, abruptly shallowing at twelfth ring furrow, weakly impressed against axial terminus; four or five relatively small sagittal tubercles, first on ring three or four, on alternating rings in posterior half of axis; row of smaller, more subdued tubercles across anterior rings, single subdued tubercle pair on posterior rings; anterior two ring furrows strongly impressed medially, thereafter with narrow sagittal band; at least 9^2 pleural ribs, possibly small tenth rib(s); four or five congruent segments; inter-rib furrows moderately wide, deep; rib gently lengthening (exsag.) distally; anterior ribs moderately turned back proximally, more sharply flexed posteriorly near rounded tips, only faintly turned out; numerous very small, weak tubercles aligned across pleurae; doublure narrow, faintly lengthening backward, densely granulate, inner margin gently concave, apparently lacking posteromedian embayment.

Discussion. Large holaspid specimens of *Avalanchurus garfunkeli* sp. nov. differ considerably from other members of the genus. With its low convexity, extremely wide pleural lobes, and broad fixigenae with forwardly placed eyes, the species serves to emphasize the homoplasy between *Avalanchurus* and *Cromus* Barrande, 1852 (see discussion in Edgecombe and Chatterton, 1993, p. 100). An additional seemingly plesiomorphic feature is the parallel-sided hypostomal rhynchos. Nevertheless, *A. garfunkeli* bears many obvious and diagnostic advanced features, indicating that its apparent plesiomorphies are very likely either convergences or reversals, most of which could be associated with its extreme broadening and lowering of the exoskeleton. Among the derived features indicating membership in the *Struszia* genus group, and not *Cromus*, are the presence of prominent adaxial fixigenal tubercles, L1 with much reduced length (exsag.), and all lateral glabellar lobes with significant independent inflation.

Avalanchurus garfunkeli is distinguished from all congenerics in a suite of characters associated with its extremely broad exoskeleton (length of librigenal field, width of fixigena, width of pygidium, etc.), in its forwardly set eye, and in its almost parallel-sided hypostomal rhynchos. All are autapomorphic, although, as noted above under discussion of *A. simoni*, some features associated with broadening, but not as completely developed, are possibly shared with that species.

Avalanchurus sp. nov. A
Pl. 24, figs. 11, 13-16

Material. Illustrated specimens ROM 50376 and 50377 from section ABR 2 27 m and ROM 50374 and 50375 from talus boulder ABR TTC(3), both Cape Phillips Formation, Wenlock (Sheinwoodian; *C. perneri-M. opimus* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic.

Discussion. A few sclerites recovered from Unnamed Fauna 1 evidently represent a distinct species of *Avalanchurus*. The most unusual aspect of the species is the shape of the hypostomal rhynchos, which extends anteriorly past the anterior margin. This feature has not been observed in any other species of *Avalanchurus*, and some question must therefore be raised about the strength of the association. The hypostome is assigned to *Avalanchurus* on the basis of its low convexity and otherwise low, broad rhynchos. It is obviously different from either of the co-occurring species of *Struszia* (compare the hypostomes of *S*. (s.l.) *martini*, Pl. 12, figs. 1-7 and *S*. (s.l.) *epsteini*?, Pl. 19, fig. 10). The only other encrinurine occurring is a very rare species of *Mackenziurus* (see below), to which the hypostome in question is very unlikely to belong (compare the typical *Mackenziurus* hypostomes described below). Hence, in the absence of evidence to the contrary, the sclerite must be treated (with caution) as *Avalanchurus*. In addition to the differences in the hypostome, *Avalanchurus* sp. nov. A is distinguished by the near-subquadrate form of its lateral glabellar lobes, in which it most closely resembles the Ludlow *Avalanchurus* sp. 2 described below.

Avalanchurus sp. nov. B
Pl. 26, figs. 13-15, 17, 18

Material. Illustrated specimens ROM 50388-50390, from section ABR 1 17 m, Cape Phillips Formation, Wenlock (Homerian; *P. ludensis* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic.

Discussion. *Avalanchurus* sp. nov. B was compared with *A. simoni* above. It more closely resembles *Avalanchurus* sp. nov. A and *A*. cf. *A. lennoni* in the coarser and more densely crowded librigenal tuberculation. The librigenal field is wider than in any other member of *Avalanchurus*, and the anterior furrow is relatively deep.

Avalanchurus cf. *A. lennoni* Edgecombe and Chatterton, 1993
Pl. 26, figs. 1-12, 16

Material. Illustrated specimens ROM 50379-50387, from talus boulder ABR TTD, Cape Phillips Formation, Wenlock (Sheinwoodian; associated with shale talus containing graptolites of the *C. perneri-M. opimus* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic.

Discussion. *Avalanchurus* cf. *A. lennoni* was compared with *A. simoni* above. In its broad and well defined hypostomal rhynchos and prominent middle body striae it most closely resembles *A. lennoni* Edgecombe and Chatterton, 1993, but appears to differ from that species in its generally larger librigenal tuberces, particularly the inner lateral border row. More material would be required to adequately assess the degree of relationship.

Avalanchurus sp. 1 aff. *A. garfunkeli* sp. nov.
Pl. 24, fig. 17

Material. Illustrated specimen ROM 50378, from locality BHH-C, Cape Phillips Formation, Wenlock (Sheinwoodian; *C. perneri-M. opimus* Zone), southern Baillie-Hamilton Island, central Canadian Arctic.

Discussion. A single librigena recovered from locality BHH differs from the cooccurring *Avalanchurus simoni* in its relatively longer field and much shorter precranidial lobe (the precranidial lobe is not broken; the anterior end is definitely the connective suture). In these features it bears obvious similarity to the Homerian *A. garfunkeli* (cf. Pl. 24, fig. 18 with Pl. 25, fig. 13).

Avalanchurus sp. 2
Pl. 26, fig. 19

Material. Cranidium ROM 50391, from section BH 2 42 m, Cape Phillips Formation, Ludlow (Gorstian; *L. progenitor* Zone), southern Baillie-Hamilton Island, central Canadian Arctic.

Discussion. A single large, fragmentary cranidium probably represents a new species of *Avalanchurus*. It is distinguished by the subquadrate form of the lateral glabellar lobes (in which it most resembles *Avalanchurus* sp. nov. A), the low number of large glabellar tubercles, and particularly by the inflated, subquadrate appearance of the adaxial fixigenal tubercles.

Genus *Mackenziurus* Edgecombe and Chatterton, 1990

Type species. *Mackenziurus reimeri* Edgecombe and Chatterton, 1990, Delorme Group, Wenlock (lower Homerian; correlated on basis of trilobites with *C. lundgreni-M. testis* Zone of Cape Phillips embayment), near Avalanche Lake, central Mackenzie Mountains, Northwest Territories, Canada.

Other species. *Mackenziurus ceejayi* sp. nov., Wenlock (upper Sheinwoodian), Arctic Canada; *M. deedeei* sp. nov., Wenlock (lower Homerian), Arctic Canada; *M. joeyi* sp. nov., Wenlock (upper Sheinwoodian), Arctic Canada; *M. johnnyi* sp. nov., late Ludlow, Arctic Canada; *M. lauriae* Gass, Edgecombe, Ramsköld, Mikulic and Watkins, 1992, late Wenlock, Wisconsin, Illinois, U.S.A.

Diagnosis. Glabella broad anteriorly and typically densely tuberculate; posterior two adaxial fixigenal tubercles sometimes partially merged atop subconical swelling of fixigena; L0 long (sag., exsag.), subrectangular; rostral plate square; librigena with marginal row of border tubercles often effaced; hypostome nearly round in ventral view, with very short posterior border; muscle impressions forming two pairs of linear pits on hypostomal middle body, one following lateral margin of generally subdued rhynchos, the second set abaxially near the lateral border furrow; thoracic segments robust, with strongly developed preannulus, fulcral angle approximately 100 degrees; pygidium with 7^2-9^2 pairs of pleural ribs; ribs square in section, inter-rib furrows long and deep; doublural notch usually shallow to obscure.

Discussion. When erected, the only species of *Mackenziurus* known were the type and two unnamed forms from the United States. One of these, from the Wenlock of Arkansas (Holloway, 1980, pl. 12, figs. 22-25; Gass et al., 1992, fig. 1.20), is known only from pygidia. The second was formalized as *Mackenziurus lauriae* Gass, Edgecombe, Ramsköld, Mikulic and Watkins, 1992. *Mackenziurus lauriae* is coded in this work with emphasis on the internal mold of a complete enrolled specimen (Gass et al., 1992, figs. 5.4-5.7) that possesses states of the ventral cephalic sutures and rostral plate diagnostic of *Mackenziurus*. The taxonomic composition of this species, originally including material from numerous localities in Wisconsin and Illinois, is, however, suspect, and two species are very likely represented. The holotype cephalon (Gass et al., figs. 5.1-5.3) differs from the enrolled specimen in its considerably smaller glabellar tubercles and apparently narrower rostral plate. Although one of the librigenae is rotated in the holotype, the course of the rostral suture on the cranidium indicates that it is narrower than in the enrolled *Mackenziurus*, and the rostral plate may be trapezoidal as in *Struszia* and *Fragiscutum*. Support for the assignment of the holotype cephalon to *Mackenziurus* is thus weakened, although all of the encrinurine pygidia at the type locality are referable to *Mackenziurus*.

The discovery of new Arctic species indicates that the type species, *Mackenziurus reimeri*, has many autapomorphic features. While its cranidial dimensions (e.g., sagittal length versus width across palpebral lobes, etc.) are not unusual, the disposition of cranidial features is. Essentially the area associated with L1-L4 has been greatly reduced. The lobes are small and set relatively far back, and the basal part of the glabella is small and narrow. Concomitantly, the adaxial fixigenal tubercles are "retracted," in some cases represented by only two large, posteriorly set tubercles. Compensating for this posterior retraction of L1-L4 is an unusually long anterolateral part of the glabella, extending as an oblique, almost smooth line from a tiny L4 to the anterolateral corner of the glabella (Edgecombe and Chatterton, 1990, figs. 6.2, 6.8, 6.11). This is matched on the fixigena by an elongate, obliquely displaced adaxial portion devoid of major tubercles. This modification is possibly foreshadowed in both new species *M. joeyi* and *M. ceejayi*. Both of these species usually display four adaxial fixigenal tubercles, in contrast to the five (or even six) seen in taxa such as the new species *M. deedeei* and *M. johnnyi* (see below). This could be interpreted as reduction toward the two or three seen in *M. reimeri*, but in addition these two species often show the posterior two tubercles partially merged and set atop a subconical extrusion of the cheek. This is likely an indication of evolution towards the extreme situation seen in the largest *M. reimeri* cranidia (e.g., Edgecombe and Chatterton, 1990, figs. 5, 7.1).

Mackenziurus joeyi sp. nov.
Pl. 27, figs. 1-19, 20-23?; Pl. 28, figs. 1-22

Etymology. After Joey Ramone.

Types. Holotype cranidium ROM 50405 (Pl. 27, figs. 1, 4, 7, 8); paratypes ROM 50406-50425 from section BHL 1 92 m, Cape Phillips Formation, Wenlock (upper Sheinwoodian, *C. perneri*-*M. opimus* Zone), southern Baillie-Hamilton Island, central Canadian Arctic.

Diagnosis. Cranidium with usually four adaxial fixigenal tubercles; when five present, second and third (from front) invariably merged; posterior two adaxial fixigenal tubercles often set on subconical evagination of fixigena; genal angle of large holaspides retains very small, thorn-like genal spine; librigenal tubercles relatively small and rounded; librigenal lateral border narrowed (tr.) posteriorly; pygidium with 8^2 pleural ribs and 9-10 axial rings.

Description. Cranidial length about 55 percent of width; axial furrow narrow, deep, weakly concave outward between S1 and fossula; glabellar length (sag.) 100-110 percent of width across frontal lobe; width of L3 74-79 percent width of L4; width of L2 59-65 percent width of L4; glabella gently convex (sag.), raised well above genal field and eye, of moderate, even transverse convexity; I-1 small; ii-0 usually present; tuberculation in row II variable, either with II-1 larger than I-1 and positioned abaxial to I-1 or similar size to I-1, with irregular insertion of one or two adventitious tubercles; posterior pentagonal tubercle arrangement (with iii-0) sometimes developed; frontal lobe bearing abundant small and moderate-sized tubercles; tuberculiform swellings on L2 and L3 lateral lobes usually larger than other glabellar tubercles, that on L3 usually bearing small, fused tubercle adaxially; L4 bearing smaller tuberculiform swelling than L3; L1 depressed abaxial swelling, obsolete medially; L0 of even length across most of width, length (sag.) 26-29 percent width, anterior margin usually faintly concave forwards across most of width, occasionally faintly convex forwards; shallow furrow impressed anterolaterally on L0, running posteromedially then curving inwards and effacing, defining weak anterior and posterior bands; anterior band slightly depressed; occipital tubercles nearly indistinct in largest specimens; apodemes in order of decreasing size S1, S2, S0, very small S3; preglabellar furrow shallow (sag., exsag.); anterior cranidial border bearing 11-14 tubercles (11 due to asymmetry; anteromedian tubercle absent), most commonly 12; midlength (exsag.) of palpebral lobe opposite S2 to posterior part of L3; posterior edge of palpebral lobe opposite posterior half of L2; two tubercles between midlength of eye and axial furrow; palpebral tubercles faint; adaxial fixigenal row of four or five tubercles; paired small tubercles closely spaced on weak lobe-like projections of fixigena opposite L2 and S3; anterior tubercle of adaxial fixigenal row opposite preglabellar furrow relatively large, sometimes transversely elliptical; CT2 slightly abaxial to larger CT1, with one usually tiny intervening tubercle; posterior border furrow short (exsag.), moderately deep, transverse, abruptly shallowing at anterior flexure to facial suture; posterior border short (exsag.), weakly lengthening to fulcrum, then more strongly lengthened distally; tuberculation indistinct along most of posterior border, with a few subdued tubercles posterolaterally near genal spine; genal angle bearing tiny, blunt spinule set inward of posterolateral edge of cranidium.

Height of connective suture slightly greater than width (tr.) across rostral suture (rostral plate inferred to be slightly longer than wide); rostral suture straight; connective sutures diverge weakly to anterior furrow, well below mid-height of rostral plate, then run approximately parallel to hypostomal suture.

Librigenal field 100-113 percent length (exsag.) of precranidial lobe, 80-124 percent width (tr.) of lateral border; tubercles on field arranged two deep anteriorly, two or three deep posteriorly, totalling 12-14 tubercles (including very small subdued tubercles); eye socle moderately wide; lateral border furrow narrow, shallow; inner row tubercles on lateral border moderately large, interspersed median row tubercles considerably smaller; marginal row of small tubercles subdued, with coarse, dense granulation along lateral margin; anterior furrow very shallow; precranidial lobe densely covered with 15-19 small and medium-size tubercles; doublure extending well inward and upward beneath lateral border; vincular furrow narrow, shallow, faintly curved ventrally.

Axial ring about 40 percent width of thorax; height of segment 48 percent of width; ring of about even length (sag., exsag.), posterior margin weakly bowed forward medially, abaxial edge flexed forward; ring moderately arched (tr.), raised well above pleura; pleura relatively abruptly turned down at fulcrum; height of steep distal part of pleura greater than width (tr.) of proximal part; pleural furrow narrow, sharply impressed, with transverse course proximally; anterior pleural band short (exsag.), set well below posterior band; posterior band extended distally, terminating as short, blunt angulation; vincular furrow moderately impressed along posterior margin of rib distal to fulcrum; tuberculation lacking on thorax except for subdued sagittal tubercle on some segments.

Pygidial length 73-77 percent of width; axis about 40 percent of pygidial width anteriorly, very gently convex (sag.); 9-10 axial rings; axial furrow narrow, moderately deep, and approximately straight against anterior 6-7 rings, slightly more strongly convergent and shallow posteriorly; sagittal tubercles relatively subdued, present on third or fourth ring and then usually on alternating rings, typically present on four rings; anterior rings aligned with small paired tubercles; ring furrows impressed abaxially as deep, transverse grooves, shallowing medially, very weak between medial part of posterior few rings; 8^2 pleural ribs; five congruent segments; inter-rib furrows narrow, moderately deep proximally, gently lengthening (exsag.) toward flucrum, then shallowing distally; inter-rib furrows very shallow between distal parts of posterior ribs; anterior pleurae very steeply turned down at fulcrum, posterior ribs more strongly curved down and back along entire width; pleural tubercles subdued, few weakly defined along each rib; terminal rib pair (8^2) faintly to gently curved, fused posteroventrally, effacing above ventral margin of pygidium; doublure gently lengthening backward, inner margin weakly convex outward, with shallow, rounded posteromedian embayment.

Discussion. *Mackenziurus joeyi* sp. nov. is common at BHL 1 92 m, but very rare at locality BHH. Association of exoskeletal parts at these localities was discussed above under *Struszia* (s.l.) *petebesti*. Sclerites of *M. joeyi* are so distinctive that there is no question whatsoever of misassociation. The only exception is the hypostome. Reference to the similar species *M. ceejayi* sp. nov. and other congenerics reveals the expected hypostomal form: a very short posterior border and a slender, tapering rhynchos, with longitudinal series of middle body pits. No hypostomes definitely matching this morphotype were recovered from BHL 1 92 m. The only possible candidate is that illustrated in Pl. 27, figs. 20-23. This specimen does show a relatively small rhynchos and short posterior border. It possesses middle body striae, however, and a waisted rhynchos. The former feature is diagnostic of the clade encompassing *Avalanchurus*, *Struszia*, and *Frammia*, and is approached in *Mackenziurus* only by the widened pits of *M. johnnyi* sp. nov. The latter feature does occur in *M. deedeei* sp. nov. (see below), but is otherwise restricted to the *Struszia*/*Frammia* clade. Hence, is possible that this specimen is a shorter than normal example of *Struszia* (s.l.) *petebesti*, although the differences in longitudinal proportions are large (cf. Pl. 4, figs. 1-3 (note discussion under *S.* (s.l.) *petebesti* of Pl. 4, fig. 4) with Pl. 27, fig. 20).

Mackenziurus joeyi differs from *M. reimeri* in its more prominently expressed adaxial fixigenal tubercles; broader and more tuberculate basal area of the glabella; shorter (exsag.) anterolateral portion of the glabella; more posteriorly set eyes; shorter genal spine; prominent versus nearly effaced librigenal lateral border tubercles; posteriorly narrow librigenal lateral border; more elongate pygidium with much smaller sagittal tubercles; 8^2 versus sometimes 7^2 or 8^1 pygidial pleural ribs; typically 9-10 versus 8-9 pygidial axial rings; and shallow versus absent pygidial doublural notch.

Mackenziurus joeyi differs from the coeval *M. ceejayi* in the presence of less bloated and subpolygonal cephalic tubercles; a small genal spine versus a rounded, broadened, and lobate genal angle; a relatively shorter (exsag.) eye; more widely spaced librigenal field tubercles; much smaller inner row of librigenal lateral border tubercles; and a more posteriorly narrowed librigenal lateral border. The species resemble each other in the usual presence of four adaxial fixigenal tubercles with the posterior two placed on a subconical extrusion of the fixigena, and in their nearly identical pygidia.

Mackenziurus joeyi differs from *M. deedeei* in its slightly less inflated lateral glabellar lobes; small genal spine versus lobate genal angle; larger eye; smaller inner row of librigenal lateral border tubercles; less effaced outer row of librigenal lateral border tubercles; narrower posterior part of librigenal lateral border; less curved lateral librigenal margin; a shallower thoracic preannular furrow and an axial ring that is less strongly raised above the articulating half ring; and less prominent pygidial pleural tubercles.

Mackenziurus joeyi differs from *M. johnnyi* in its less inflated lateral glabellar lobes; much smaller L1; usually four versus five or six adaxial fixigenal tubercles; greater anterior width of the fixigena between the eye and axial furrow; genal spine versus lobate, rounded angle; relatively smaller eye; broader librigenal field; and narrower pygidium with usually 8^2 versus 9^2 pleural ribs.

Mackenziurus ceejayi sp. nov.
Pl. 29, figs. 1-22; Pl. 30, figs. 1-22

Etymology. After C.J. Ramone.

Types. Holotype cranidium ROM 50427 (Pl. 29, figs. 2, 5, 8); paratypes ROM 50426, 50428-50447, from talus boulder ABR TTD, Cape Phillips Formation, Wenlock (upper Sheinwoodian, low in *C. perneri-M. opimus* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic.

Diagnosis. Glabella broad anteriorly; most cephalic tubercles large, bloated, and subpolygonal; lateral glabellar lobes strongly inflated; usually four large adaxial fixigenal tubercles with posterior two often merged atop swelling of fixigena; posterolateral part of fixigena (distal to palpebral lobe) wide (tr.); genal angle rounded, expanded, and lobate; hypostomal posterior border very short; rhynchos narrow and with strong forward taper; eye large; librigenal field tubercles closely spaced; inner row of librigenal lateral border tubercles moderately large; pygidium with usually 8^2 pleural ribs and shallow doublural notch.

Discussion. *Mackenziurus ceejayi* sp. nov. is so similar to *M. joeyi* that an extended written description is not considered warranted. Points of distinction are given in the comparison under discussion of *M. joeyi* above. *Mackenziurus ceejayi* occurs with no other encrinurines with which it could be confused. Most exoskeletal parts are known and their association is not at issue.

Mackenziurus ceejayi differs from *M. deedeei* in its usually larger, more bloated and subpolygonal cephalic tubercles; four as opposed to typically five adaxial fixigenal tubercles; anteriorly broader glabella; larger eye; slightly smaller inner row of librigenal lateral border tubercles; less curved librigenal lateral margin; anteriorly narrower, unwaisted hypostomal rhynchos; and much shallower pygidial doublural notch.

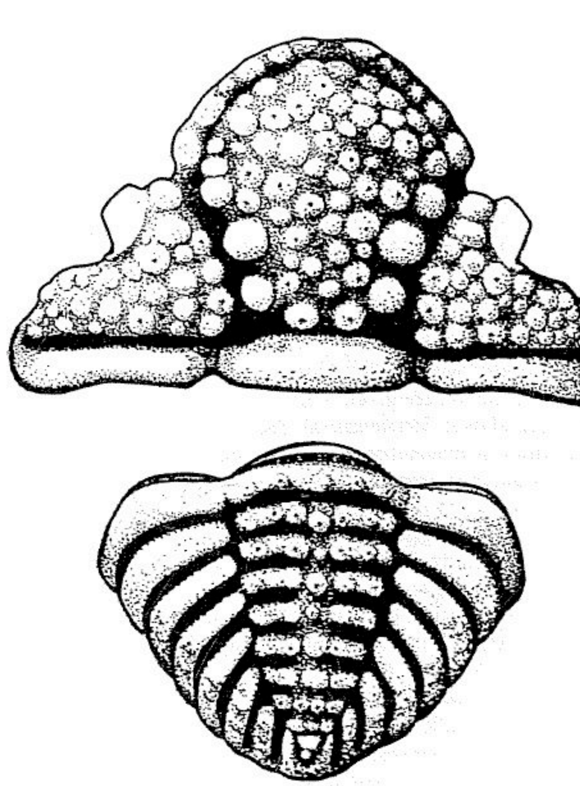
Mackenziurus ceejayi differs from *M. johnnyi* in its larger, more subpolygonal cephalic tubercles; smaller L1; four versus five or six adaxial fixigenal tubercles, with the posterior two on an adaxial projection; broader interocular fixigena; wider librigenal field; anteriorly narrower hypostomal rhynchos; shorter hypostomal posterior border; and pygidium with 8^2 versus 9^2 pleural ribs. The species are similar in their strongly inflated lateral glabellar lobes, lobate genal angles, large eyes, and relatively straight librigenal lateral margins.

Mackenziurus deedeei sp. nov.
Pl. 31, figs. 1-26; Pl. 32, figs. 1-24; Pl. 33, figs. 1-22,
Pl. 34, figs. 1-11, 12-23?, 25?, 26?; Text-fig. 18

Etymology. After DeeDee Ramone.

Types. Holotype cranidium and left librigena ROM 50448 (Pl. 31, figs. 1, 2, 5), from section ABR 1 6 m; paratypes ROM 50449-50461, from section ABR 1 5.5-13.5 m, Cape Phillips Formation, Wenlock (Homerian, *C. lundgreni-M. testis* Zone to *P. ludensis* Zone), near Abbott River, northwest Cornwallis Island, central Canadian Arctic. Assigned specimens ROM 50462, 50464-50487, 50650-50653, and questionably assigned specimen ROM 50463, from section BH 2 2-6.5 m, Cape Phillips Formation, Wenlock (lower Homerian, *C. lundgreni-M. testis* Zone), southern Baillie-Hamilton Island, central Canadian Arctic. Questionably assigned specimens ROM 50654-50659, from talus boulder ABR 3TT, Cape Phillips Formation, Wenlock (Homerian, probably *C. lundgreni-M. testis* Zone), near Abbott River, northwest Cornwallis Island, central Canadian Arctic.

Diagnosis. Lateral glabellar lobes strongly inflated; usually five adaxial fixigenal tubercles; inner row of librigenal lateral border tubercles very large, almost lobate; librigenal lateral margin sinuous; eye small; rhynchos extending to or past anterior margin of hypostome, slightly waisted; axial lobe of thorax very large relative to pleural lobes in transverse view; thoracic preannular furrow deeper than ring furrow, posterior band of axial ring raised strongly above preannulus; pygidium with usually 8^2 pleural ribs and deep doublural notch.



Text-figure 18. *Mackenziurus deedeei* sp. nov. Reconstruction of cranidium and pygidium.

Description. Cranidial length 52-58 percent of width; axial furrow moderately wide, deep, weakly concave outward between S1 and fossula; glabella slightly longer (sag.) than width across frontal lobe; width of L3 75-80 percent width of L4; width of L2 61-64 percent width of L4; glabella gently convex (sag.), raised well above genal field and eye, of moderate, even transverse convexity; I-1 ubiquitous; small ii-0 more commonly present than absent; tuberculation in row II variable, II-1 larger or smaller than I-1, usually positioned abaxial to I-1 (occasionally strongly so), sometimes aligned, or with asymmetrical inclusion of an adventitious tubercle; posterior pentagonal tubercle arrangement (with iii-0) often developed, or made asymmetrical by adventitious tubercle in row iii; frontal lobe tuberculation variable, usually bearing abundant small and moderate-sized tubercles with III-1, IV-1, and V-1 sometimes showing insignificant enlargement, rarely with relatively few coarse tubercles; tuberculiform swellings on L2 and L3 lateral lobes usually considerably larger than other glabellar tubercles; III-2 usually strongly incorporated into inflation of lateral lobe, occasionally forming distinct swelling at abaxial edge of lateral lobe; L4 with less inflated lateral lobe than L3, often bearing small anterior tubercle and larger posterior tubercle; L1 depressed teardrop-shaped swelling, obsolete medially, S1 merged with S0; L0 of even length across most of width, length (sag.) 25-29 percent width, abruptly shortened near distal edge, anterior margin nearly straight or weakly convex forwards across most of width; L0 strongly, evenly arched (tr.); occipital tubercles at most faintly defined transverse row just in front of posterior margin; preglabellar furrow shallow (sag., exsag.); cranidial anteromedian depression absent; anterior cranidial border usually bearing 12 tubercles, rarely 14; PL frequently largest of anterior border tubercles; midlength (exsag.) of palpebral lobe opposite anterior to posterior edge of L3; posterior edge of palpebral lobe opposite S2 to middle of L2; two tubercles between midlength of eye and axial furrow, one tubercle anteriorly along facial suture; palpebral tubercles weak or obscure; adaxial fixigenal row usually of five tubercles, occasional four or six, not significantly larger than some others on fixigenal field; tubercles opposite S1 and S2 usually distinctly larger than that opposite S3, anterior tubercle sometimes largest; CT2 often aligned with (if not set adaxial to) larger CT1, with one small intervening tubercle; posterior border furrow short (exsag.), moderately deep, approximately transverse, abruptly shallowing at anterior flexure to facial suture; posterior border short (exsag.), very weakly lengthening to fulcrum, then rather strongly lengthened distally; tuberculation indistinct along most of posterior border, with a few very subdued tubercles posterolaterally near genal angle; genal angle rounded, with no trace of spine.

Height of connective suture approximately equal to width (tr.) across rostral suture (rostral plate inferred to be nearly square); rostral suture straight; connective sutures running approximately straight to about mid-height of rostral plate, then weakly diverging to hypostomal suture.

Librigenal field usually about 110 percent length (exsag.) of precranidial lobe but sometimes slightly longer, about 60-90 percent width (tr.) of lateral border; tubercles on field arranged two deep anteriorly, two or three deep posteriorly, totalling 11-14; eye socle narrow; lateral border furrow narrow, moderately deep; inner row tubercles on lateral border large, with significant expansion into lateral border furrow, anterior tubercle elliptical; median row tubercles considerably smaller, typically teardrop shaped with narrow end interspersed between inner row tubercles; marginal row of small tubercles subdued, with discrete tubercles poorly defined amidst coarse, dense granulation along lateral margin; anterior furrow very shallow, mostly obscure; precranidial lobe densely covered with 14-19 small and medium-sized tubercles; doublure beneath lateral border extending at least 60 percent width to border furrow; vincular furrow narrow, shallow, with gentle, even ventral curvature.

Hypostome subrhomboid, length 85 to about 95 percent of width across anterior wings; wing situated at 42-49 percent length (sag.) of hypostome, with substantial lateral projection; wing process strong; anterolateral border short (exsag.), margin gently convex outward, sometimes weakly bulged forward around rhynchos; anterolateral margin gently flexed dorsally; middle body subcircular, length (including rhynchos) 111-117 percent of width, of gentle, even convexity (sag.), gently arched across most of width (tr.), with stronger slope towards lateral edge; rhynchos usually extending to hypostomal suture, sometimes projecting slightly in advance of suture; lateral margins of posterior two-thirds of rhynchos approximately straight and with moderately strong divergence backwards; width at posterior edge of rhynchos 55-64 percent width of middle body; rhynchos usually waisted, with parallel-sided anterior part, but sometimes evenly tapering, rounded anteromedially; linear series of numerous shallow muscle impression pits defining abaxial edge of rhynchos, another line of narrow, transverse pits on anterolateral part of middle body, gently diverging from course of lateral border furrow backwards; granulate sculpture pervasive on middle body; middle furrow sometimes defined as short depression but usually obscure; macula indistinct; border furrow narrow, well impressed posterolaterally, shallowing medially; lateral margin gently curved inward for a short length (exsag.) behind wing, then flexed more strongly inward; posterolateral margin approximately straight, flexed ventrally; posteromedian margin rounded, lacking spines, with weak posterolateral angulation occasionally present; posterior border 11-16 percent length (sag.) of hypostome.

Height of thoracic segment about 55 percent of width (as inferred from half specimens); axial ring nearly 50 percent width of thorax; ring (excluding preannulus) of about even length across width, anterior and posterior margins approximately straight medially, abaxial edge gently flexed forward; ring strongly arched (tr.), nearly semicircular, raised strongly above pleura; prominent, lenticular preannulus about as long (sag.) as articulating half ring; ring furrow sharply impressed but considerably shorter and shallower than preannular furrow; articulating half ring set at same height as preannulus, well below remainder of ring; pleura abruptly turned down nearly vertically at fulcrum, gently flexed backward distal to fulcrum; pleural furrow narrow, sharply impressed, with approximately straight course, not curving on articulating facet; anterior pleural band considerably shorter (exsag.) than posterior band proximally, set well below posterior band except at fulcrum, where it lies only slightly lower; axial articulating process small; anterior flange flexed forward across distal part of articulating facet as pointed process; tuberculation absent on known thoracic segments.

Pygidial length 71-82 percent of width; axis 40-45 percent of pygidial width anteriorly, gently convex (sag.); usually 9 (occasionally 10) axial rings; axial furrow narrow, moderately deep, weakly convex outward against anterior 6-7 rings, more strongly convergent and shallow posteriorly, but distinctly impressed around axial terminus; moderately large sagittal tubercles on three or four rings, first usually on second or third ring and then usually on alternating rings; anterior rings aligned with two or three pairs of small tubercles and usually sagittal tubercle; ring furrows impressed abaxially as deep, transverse grooves, shallowing medially, very weak between medial part of posterior few rings; usually 8^2 pleural ribs (rarely 8^1); five or six congruent segments; inter-rib furrows relatively wide, moderately deep, very slightly lengthening (exsag.) toward fulcrum, very shallow between distal parts of posterior ribs; anterior pleurae steeply curved down at fulcrum, distal part of rib curved back slightly more strongly than proximal part; posterior ribs strongly curved down along entire width; pleural tubercles subdued, few weak but distinct along each rib, most prominent proximally on posterior few ribs; terminal rib pair (usually 8^2) faintly curved or running nearly straight back, fused posteroventrally or with weak definition of separate ribs; doublure narrow, weakly lengthening backwards, inner margin gently convex outward, with slightly stronger widening just in front of moderately deep, rounded posteromedian embayment.

Discussion. *Mackenziurus deedeei* sp. nov. was compared with *M. joeyi* and *M. ceejayi* under discussion of those species above. *Mackenziurus deedeei* is very common at BH 2 2-6.5 m and ABR 1 5.5-13.5 m. The basis for association of encrinurine sclerites in this interval was discussed under *Struszia onoae* above. There is little chance of confusion of sclerites belonging to *M. deedeei* with any of the co-ocurring species (*S. onoae*, *Frammia bachae*, *Avalanchurus garfunkeli*, "*S.*" *mccartneyi*). A single cranidium (Pl. 32, figs. 2, 5) from BH 2 2 m is unusual in its possession of a fewer number of very large, subconical glabellar tubercles. Its subrectangular L0 and broad rostral suture leave little doubt that this specimen belongs to *Mackenziurus*, but it may represent a very rare second species in these strata. No other sclerites that could be associated with it were found, and it is assigned with question to *M. deedeei*. A sample from talus boulder ABR 3TT (Pl. 34, figs. 12-23, 25, 26) is very similar to *M. deedeei*. Many other species are known to be definitely shared between the BH 2 and ABR 1 intervals, and ABR 3TT (including *S. onoae* and "*S.*" *mccartneyi*). Some differences do exist in the sample at hand. While the librigenae are virtually identical with those of *M. deedeei*, the single fragmentary cranidium shows only a few, large tubercles on the abaxial part of the fixigena. The single thoracic segment recovered shows a relatively smaller axial lobe with a weaker preannular furrow. The extreme incision of the preannular furrow (to exceed the depth of the ring furrow) is unique to *M. deedeei*. Finally, the pygidia, while they have a deep doublural notch like those of *M. deedeei*, seem to show stronger pleural tuberculation. With more cranidial material available, it might be possible to demonstrate that this sample represents a distinct species. If so, however, it remains very similar to, and most closely related to, *M. deedeei*. In the present state of knowledge, the material is assigned with question to that species.

Mackenziurus deedeei differs from *M. reimeri* in its more inflated lateral glabellar lobes; broader, larger posterior glabella area; usually five versus two or three main adaxial fixigenal tubercles; more anteriorly set L2-L4; more posteriorly set eye; rounded genal angle versus small genal spine; strongly tuberculate versus effaced librigenal lateral border; large, elongate, and waisted versus ill-defined hypostomal rhynchos; thoracic axis with strongly defined versus obscure preannulus; and deep versus absent pygidial doublural notch.

Mackenziurus deedeei differs from *M. johnnyi* in its smaller L1; broader interocular fixigena; smaller eye; broader librigenal field; larger inner row of librigenal lateral border tubercles; sinuous versus nearly straight librigenal lateral margin; anteriorly narrower, more elongate, and waisted hypostomal rhynchos; shorter hypostomal posterior border; and narrower pygidium with 8^2 versus 9^2 pleural ribs and more prominent sagittal tubercles.

Mackenziurus johnnyi sp. nov.
Pl. 35, figs. 1-29

1979 *Encrinurus* aff. *hyperboreus* Thomas *in* Thomas and Narbonne, p. 10, pl. 3, figs. j, l, m (*non* figs. o, s = *Frammia* sp. nov.).

Etymology. After Johnny Ramone.

Types. Holotype cranidium ROM 50662 (Pl. 35, figs. 1, 4-6); paratypes ROM 50663-50672, from localities GSC 3 and GSC 8 (see Adrain and Edgecombe, 1995), Douro Formation, late Ludlow, near Goodsir Creek, eastern Cornwallis Island, central Canadian Arctic.

Diagnosis. Anteromedian margin of cranidium only weakly convex in dorsal view in largest holaspides, anterior border very short (sag.); frontal glabellar lobe bearing abundant small and moderate sized tubercles; L1 bearing small round tubercle abaxially; eye positioned immediately adjacent to axial furrow, intervening anterior fixigenal tubercle very small or absent; five or six adaxial fixigenal tubercles; palpebral tubercles distinct; librigenal field very narrow (tr.) anteriorly, tubercles only one row deep; eye large; hypostomal rhynchos wide (tr.), posterior border long; pygidium with 9^2 (or with small 10^2) pleural ribs, subdued axial and pleural tuberculation.

Description. Cranidial length (sag.) slightly more than 50 percent of width; axial furrow narrow to moderately wide, deep, gently concave outward between S1 and fossula; glabellar length about 110-115 percent width across L4; width across L3 about 75 percent width of L4; glabella gently convex in sagittal profile, raised well above genae, of moderate, even transverse convexity; L2-L3 bearing distinct small to moderately coarse tubercle on adaxial part of lateral lobe; L2-L3 well rounded, L4 less strongly inflated abaxially; L1 with small, rounded tubercle abaxially; II-1 not significantly displaced outward (tr.) from I-1; ii-0 small, occasionally absent; L3-L4 densely covered with abundant small and moderate sized tubercles, symmetry indistinct; S0 short (sag., exsag.), moderately deep, gently and evenly convex forward; length (sag.) of L0 slightly more than 20 percent of width, slightly shortened abaxially, gently bowed forward medially, of low convexity and weakly sloping forward in sagittal profile; L0 moderately arched transversely, slightly less steeply declined outward adjacent to axial furrow, tubercles weakly defined; cephalic tubercles covered with fine granulation; preglabellar furrow shallow (sag., exsag.); 12 tubercles on anterior cranidial border, coarser abaxially; cranidial anteromedian depression narrow, shallow; midlength of palpebral lobe opposite L3; five or six adaxial fixigenal tubercles set against, and only weakly overhanging, axial furrow, most not coarser than other fixigenal field tubercles; adaxial tubercle opposite S3 with tendency to be enlarged, ovate, with faint definition of two fused tubercles; anterior tubercle against facial suture very small or absent in large specimens; palpebral furrow narrow, sharply impressed; posterior cranidial border furrow short (exsag.), moderately deep, with approximately straight transverse course in undistorted specimens, shallowing at anterior flexure to facial suture; posterior border relatively short (exsag.) and gently declined outward (tr.) proximally, with even lengthening (exsag.) distal to fulcrum, moderately declined; posterior border bearing row of distinct, subdued tubercles toward posterior edge of border in small specimens; numerous small, faint border tubercles in large holaspides; genal spine represented by very small, adaxially displaced point in immature specimens; genal angle rounded in largest specimens.

Rostral suture (anteromedian margin of cranidium) relatively broad, straight, transverse in some individuals

Librigenal field strongly narrowing forward, bearing 13-14 tubercles; eye socle narrow (tr.), set off by shallow furrow dorsally, deep furrow ventrally; lateral border furrow deep, narrow; lateral border bearing five large, low, subovate tubercles against border furrow; outer (submarginal) row of tubercles more subdued, of moderate size; ventrolateral margin of border nearly straight; anterior furrow moderately impressed posterodorsally, shallowing anteroventrally; precranidial lobe 80 percent length (exsag.) of librigenal field, densely covered with small and moderate sized tubercles; connective suture (librigenal margin) approximately straight.

Hypostome subrhomboid, length 100 percent of width; maximum width across anterior wing at 45 percent of length; anterior border short medially; anterolateral margin gently convex outward; lateral border turned down as narrow (tr.) ridge; border furrow deep, widened anterolaterally against edge of rhynchos; middle body subcircular in outline, gently convex in sagittal profile, weakly arched across most of width (tr.), steeply declined laterally, coarsely granulate; rhynchos extending to anterior border furrow, rounded anteromedially; lateral margins of rhynchos nearly straight, moderately divergent backward, maximum width 55 percent width of middle body; narrow (tr.) series of muscle impression striae of moderate depth on anterolateral region of middle body; maculae large, ovate, weakly raised; posterior border 20 percent length (sag.) of hypostome; posterolateral margin approximately straight.

Pygidial length 65-72 percent of width; axis 34-38 percent of pygidial width anteriorly, of gentle, even convexity (sag.), raised well above pleurae, 9-10 distinct rings; axial furrow narrow, moderately deep, straight to about sixth ring furrow, then slightly more strongly convergent backwards, weakly incised against terminal region; anterior ring gently, evenly convex (tr.), rings progressively flatter in transverse profile posteriorly; axial and pleural tuberculation weakly defined in largest holaspides, smaller holaspides with a few moderately large, low sagittal tubercles, smaller adaxially paired tubercles on some alternating rings; anterior rings bearing transverse row of two or three pairs of subdued tubercles in smaller specimens; ring furrows impressed abaxially as deep, transverse grooves that narrow (tr.) progressively in posterior segments, shallowing medially, lightly incised between posterior rings; usually 9^2 pleural ribs, small 10^2 occasionally developed; articulating facet lengthening (exsag.) abaxially on anterior rib; anterior pleura gently convex and sloping down (tr.) to fulcrum, steeply declined distal to fulcrum; distal part of anterior ribs sharply flexed backward; posterior ribs with less abrupt break in slope posteriorly; a few strongly subdued tubercles along pleural ribs; inter-rib furrows of moderate width and depth, narrowing between pleural tips, sixth to eighth inter-rib furrows with shallow impression to margin; ribs 8^2 or 9^2 merged ventrally as "loop"; anterior four pleural tips gently turned out, with straight, subquadrate ventrolateral margin; dorsal surface of axial rings and pleural ribs covered with moderately dense, fine granulation; posteromedian embayment in margin of doublure relatively broad, shallow, rounded.

Discussion. Thomas (*in* Thomas and Narbonne, 1979, p. 10) considered several disarticulated encrinurine sclerites from locality GSC 3 to represent a single species, based upon their mutual occurrence. New collections show that two species are in fact represented. The large-eyed cranidium and librigena (Thomas, *ibid*., pl. 3, figs. j, l, m) belong with the newly discovered pygidial morph illustrated herein, and are assigned to *Mackenziurus johnnyi* sp. nov. The pygidium illustrated by Thomas (*ibid*., pl. 3, figs. o, s) belongs to an undescribed species of *Frammia*, more material of which has also been collected. Other newly discovered encrinurines occurring at locality GSC 3 include species of *Aegrotocatellus* Adrain and Edgecombe, 1995, and *Balizoma* Holloway, 1980 (see Adrain and Edgecombe, 1995, for both).

Mackenziurus johnnyi sp. nov. was compared with *M. joeyi*, *M. ceejayi*, and *M. deedeei* under discussions of those species above. It differs from *M. reimeri* in its larger L1; posteriorly broader glabella; anteriorly positioned L2-L4; five or six versus two or three adaxial fixigenal tubercles; posteriorly narrower fixigena; much larger palpebral lobe; lobate, rounded genal angle versus short genal spine; narrower librigenal field; tuberculate versus effaced librigenal lateral border; well defined versus obscure hypostomal rhynchos; longer hypostomal posterior border; and broader pygidium with much smaller sagittal tubercles and 9^2 versus 7^2-8^2 pleural ribs.

Mackenziurus aff. *M. joeyi* sp. nov.
Pl. 34 figs. 24, 27-29

Material. Illustrated specimens ROM 50660 from section ABR 2 27 m and ROM 50661 from talus boulder ABR TTC(3), Cape Phillips Formation Wenlock (upper Sheinwoodian; *C. perneri-M. opimus* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic.

Discussion. Two *Mackenziurus* sclerites from unnamed fauna 1 most closely resemble the slightly older *M. joeyi*. The fragmentary librigena is nearly indistinguishable from those assigned to *M. joeyi*, but the pygidium differs in the presence of 8^1 versus 8^2 pleural ribs. More material would be required for meaningful comparison.

Indeterminate encrinurine
Pl. 19, figs. 14-16

Material. Illustrated specimen ROM 50338, from talus boulder ABR TTC(1), Cape Phillips Formation, Wenlock (probably *P. ludensis* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic.

Discussion. A partial cranidium of late Homerian age is referable to the *variolaris* plexus but is not readily assigned to any taxon of the *Struszia* genus group. It differs most obviously from all post-Llandovery species of the group in the morphology of its second adaxial fixigenal tubercle, that positioned opposite L3. This is the sole tubercle between the palpebral lobe and axial furrow and is of strong transversely elliptical outline. This shape of the second adaxial fixigenal tubercle is possessed by most Llandovery species of the *variolaris* plexus, but no other Wenlock or Ludlow species. Also shared with some Llandovery species is a pronounced coarsening of the anterior border tubercles abaxially (such that PL is much larger than more medial tubercles).

REFERENCES

ADRAIN, J.M. 1994. The lichid trilobite *Borealarges* n. gen., with species from the Silurian of Arctic Canada. Journal of Paleontology, 68, pp. 1081-1099.

------ and CHATTERTON, B.D.E. 1990. *Odontopleura* (Trilobita; Silurian), and a method of constrained congruency analysis. Journal of Paleontology, 64, pp. 600-614.

------ and ------. 1994. The aulacopleurid trilobite *Otarion*, with new species from the Silurian of northwestern Canada. Journal of Paleontology, 68, pp. 305-323.

------ and ------. 1996. The otarionine trilobite *Cyphaspis*, with new species from the Silurian of northwestern Canada. Journal of Paleontology, 70, pp. 100-110.

------ and EDGECOMBE, G.D. 1995. *Balizoma* and the new genera *Aegrotocatellus* and *Perirehaedulus*: encrinurid trilobites from the Douro Formation (Ludlow) of Arctic Canada. Journal of Paleontology, 69, pp. 736-752.

------ and ------. 1997. Silurian (Wenlock) calymenid trilobites from the Cape Phillips Formation, central Canadian Arctic. Journal of Paleontology, 71.

------ and MACDONALD, E.W. 1996. Phacopid trilobites from the Silurian of Arctic Canada. Journal of Paleontology, 70, pp. 1091-1094.

------ and RAMSKÖLD, L. 1996. The lichid trilobite *Radiolichas* in the Silurian of Arctic Canada and Gotland, Sweden. Geological Magazine, 133, pp. 147-158.

------ and ------. 1997. Silurian Odontopleurinae (Trilobita) from the Cape Phillips Formation, Arctic Canada. Journal of Paleontology, 71, pp. 237-261.

ALBERTI, G.K.B. 1966. Über einige neue Trilobiten aus dem Silurium und Devon, besonders von Marokko. Senckenbergiana lethaea, 47, pp. 111-121.

ANGELIN, N.P. 1851. Palaeontologica Svecicae. I: Iconographia crustaceorum formationis transitionis. Holmiae. Fascicule 1, pp. 1-24.

------. 1854. Palaeontologia Scandinavica. I: Crustacea formationis transitionis. Academiae Regiae Scientarium Suecanae, Holmiae, pp. 21-92.

BARRANDE, J. 1852. Systême Silurien du centre de la Bohême. 1ér partie. Recherches paléontologiques, vol. 1. Prague and Paris.

BEYRICH, E. 1845. Ueber einige böhmische Trilobiten. Berlin, 47 pp.

BOUCOT, A.J. 1975. *Tryblidium thorsteinssoni*: first North American occurrence of the Silurian monoplacophoran genus. Geological Survey of Canada Bulletin, 235, pp. 1-3.

BREMER, K. 1990. Combinable components consensus. Cladistics, 6, pp. 369-372.

BRONGNIART, A. 1822. Des corps organisés fossiles nommes Trilobites. *In* Brongniart, A. and Desmarest, A.G. Histoire Naturelle des Crustacés Fossiles. F. G. Leverault, Paris and Strasbourg, pp. 1-65.

CHATTERTON, B.D.E. and PERRY, D.G. 1979. Wenlock trilobites and brachiopods from the Mackenzie Mountains, north-western Canada. Palaeontology, 22, pp. 569-607.

------ and ------. 1983. Silicified Silurian odontopleurid trilobites from the Mackenzie Mountains. Palaeontographica Canadiana, 1. 127 pp.

------ and ------. 1984. Silurian cheirurid trilobites from the Mackenzie Mountains northwestern Canada. Palaeontographica Abt. A, 184, pp. 1-78.

------, EDGECOMBE, G.D., and TUFFNELL, P.A. 1990. Extinction and migration in Silurian trilobites and conodonts of northwestern Canada. Journal of the Geological Society of London, 147, pp. 703-715.

EDGECOMBE, G.D. 1990. Encrinurine trilobites from the Silurian Brownsport Formation of Tennessee. Journal of Paleontology, 64, pp. 961-967.

------. 1994. New Lower Silurian (Llandovery) encrinurine trilobites from the Mackenzie Mountains, Canada. Journal of Paleontology, 68, pp. 824-837.

------ and CHATTERTON, B.D.E. 1987. Heterochrony in the Silurian radiation of encrinurine trilobites. Lethaia, 20, pp. 337-351.

------ and ------. 1990. *Mackenziurus*, a new genus of the Silurian "*Encrinurus*" *variolaris* plexus (Trilobita). American Museum Novitates, 2968, pp. 1-22.

------and ------. 1992. Early Silurian (Llandovery) encrinurine trilobites from the Mackenzie Mountains, Canada. Journal of Paleontology, 66, pp. 52-74.

------ and ------. 1993. Silurian (Wenlock-Ludlow) encrinurine trilobites from the Mackenzie Mountains, Canada, and related species. Palaeontographica Abt. A, 229, pp. 75-112.

------ and RAMSKÖLD, L. 1996. The "*Encrinurus*" *variolaris* plexus (Trilobita, Silurian): relationships of Llandovery species. Geobios, 29, pp. 209-233.

FARRIS, J.S. 1988. Hennig86. Version 1.5. Program with documentation. Port Jefferson Station, New York.

FLETCHER, T.W. 1850. Observations on Dudley Trilobites. Part I. Quarterly Journal of the Geological Society of London, 6, pp. 235-239.

GASS, K.C., EDGECOMBE G.D., RAMSKÖLD, L., MIKULIC, D.G., and WATKINS, R. 1992. Silurian Encrinurinae (Trilobita) from the central United States. Journal of Paleontology, 66, pp. 75-89.

GOLDFUSS, A. 1843. Systematische Übersicht der Trilobiten und Beschreibung einiger neue Arten derselben. Neues Jahrbuch für Mineralogie, Geognosie, Geologie, und Petrefaktenkunde, pp. 537-567. [for 1843]

GOODBODY, Q.H. 1986. Wenlock Palaeoscenidiidae and Entactiniidae (Radiolaria) from the Cape Phillips Formation of the Canadian Arctic Archipelago. Micropaleontology, 32, pp. 129-157.

HAWLE, I. and CORDA. A.J.C. 1847. Prodrom einer Monographie der böhmischen Trilobiten. Prague. 176 pp.

HOLLOWAY, D.J. 1980. Middle Silurian trilobites from Arkansas and Oklahoma, U.S.A. Palaeontographica Abt. A, 170, pp. 1-85.

HOLTEDAHL, O. 1914. On the fossil faunas from Per Schei's Series B in South western Ellesmereland. Report on the 2nd Norwegian Expedition in the 'Fram' 1898-1902, 32, pp. 1-48.

KEGEL, W. 1928. Über oberrsilurische Trilobiten aus dem Harz und dem Rheinischen Schiefergebirge. Jahrbuch der Preussischen Geologischen Landesanstalt, 48, pp. 616-647. [for 1927]

KINDLE, E.M. and BREGER, C.L. 1904. The stratigraphy and paleontology of the Niagara of northern Indiana. Indiana Department of Geology and Natural Resources, Annual Report 28, pp. 428-486. [for 1903]

KOBAYASHI, T. 1934. The Cambro-Ordovician formations and faunas of South Chosen. Palaeontology. Part I. Middle Ordovician faunas. Journal of the Faculty of Science, Imperial University of Tokyo, Section 2, 3, pp. 329-519.

KOREN, T. 1991. The *lundgreni* extinction event in central Asia and its bearing on graptolite biochronology within the Homerian. Proceedings of the Estonian Academy of Science, Geology, 40, pp. 74-78.

LAMONT, A. 1978. Pentlandian miscellany: Mollusca, Trilobita, etc. Scottish Journal of Science, 1, pp. 245-302.

LANE, P.D. 1972. New trilobites from the Silurian of north-east Greenland, with a note on trilobite faunas in pure limestones. Palaeontology, 15, pp. 336-364.

------. 1984. Silurian trilobites from Hall Land and Nyeboe Land, western North Greenland. Rapports Grønlands Geologiske Undersøgelse, 121, pp. 53-75.

LENZ, A.C. 1978. Llandoverian and Wenlockian *Cyrtograptus*, and some other Wenlockian graptolites from northern and Arctic Canada. Geobios, 11, pp. 623-653.

------. 1980. Wenlockian graptolite reference section, Clearwater Creek, Nahanni National Park, Northwest Territories. Canadian Journal of Earth Sciences, 17, pp. 1075-1086.

------. 1990. Ludlow and Pridoli (Upper Silurian) graptolite biostratigraphy of the central Arctic Islands: a preliminary report. Canadian Journal of Earth Sciences, 27, pp. 1074-1083.

------. 1992. Some late Wenlock and Ludlow monograptid graptolites, Cornwallis Island, Arctic Canada. Canadian Journal of Earth Sciences, 29, pp. 200-207.

------. 1993. Late Wenlock-Ludlow (Silurian) graptolite extinction, evolution, and biostratigraphy: perspectives from Arctic Canada. Canadian Journal of Earth Sciences, 30, pp. 491-498.

------. 1994a. Uppermost Wenlock and lower Ludlow plectograptine graptolites, Arctic Islands, Canada: new isolated material. Journal of Paleontology, 68, pp. 851-860.

------. 1994b. Extinction and opportunistic evolution among late Wenlock graptolites. Lethaia, 27, pp. 111-117.

------. 1995. Upper Homerian (Wenlock, Silurian) graptolites and graptolite biostratigraphy, Arctic Archipelago, Canada. Canadian Journal of Earth Sciences, 32, pp. 1378-1392.

------ and MELCHIN, M.J. 1990. Wenlock graptolite biostratigraphy of the Cape Phillips Formation, Canadian Arctic Islands. Canadian Journal of Earth Sciences, 27, pp. 1-13.

------ and ------. 1991. Wenlock (Silurian) graptolites, Cape Phillips Formation, Canadian Arctic Islands. Transactions of the Royal Society of Edinburgh: Earth Sciences, 82, pp. 211-237.

LUDVIGSEN, R. 1979. The Ordovician trilobite *Pseudogygites* Kobayashi in eastern and Arctic North America. Royal Ontario Museum Life Sciences Contributions, 120. 41 pp.

MAKSIMOVA, Z.A. 1970. Siluriyskie trilobity ostrova Vaygach. *In* Cherkosova, S. V. (ed.). Stratigrafiya y fauna siluriyskikh otlozheniy Vaygacha (sbornik statey). Nauch issled geol Arktiki, St. Petersburg, pp. 195-209.

MELCHIN, M.J. 1987. Upper Ordovician graptolites from the Cape Phillips Formation, Canadian Arctic Islands. Bulletin of the Geological Society of Denmark, 35, pp. 191-202.

------. 1989. Llandovery graptolite biostratigraphy and paleobiogeography, Cape Phillips Formation, Canadian Arctic Islands. Canadian Journal of Earth Sciences, 26, pp. 1726-1746.

------ and LENZ, A.C. 1986. Uncompressed specimens of *Monograptus turriculatus* (Barrande, 1850) from Cornwallis Island, Arctic Canada. Canadian Journal of Earth Sciences, 23, pp. 579-582.

MICKEVICH, M.F. and WELLER, S.J. 1990. Evolutionary character analysis: tracing character change on a cladogram. Cladistics, 6, pp. 137-170.

NORFORD, B. S., and 39 others. In press. Correlation chart and biostratigraphy of the Silurian rocks of Canada. International Union of Geological Sciences Publication.

PERRY, D.G. and CHATTERTON, B.D.E. 1977. Silurian (Wenlockian) trilobites from Baillie-Hamilton Island, Canadian Arctic Archipelago. Canadian Journal of Earth Sciences, 14, pp. 285-317.

------ and ------. 1979. Wenlock trilobites and brachiopods from the Mackenzie Mountains north-western Canada. Palaeontology, 22, pp. 569-607.

PRANTL, F., and PŘIBYL, A. 1949 A study of the Superfamily Odontopleuracea nov. superfam. (Trilobites). Rozpravy Ústředniho Ústavu Geologického, 12, pp. 1-221.

PŘIBYL, A., and VANEK, J. 1978. Studie zu einigen neuen Trilobiten der Proetidae-Familie. Acta Universitates Carolinae, Geology, 1, pp. 163-182.

RAMSKÖLD, L. 1983. Silurian cheirurid trilobites from Gotland. Palaeontology, 26, pp. 175-210.

------. 1986. Silurian encrinurid trilobites from Gotland and Dalarna, Sweden. Palaeontology, 29, pp. 527-575.

------ and EDGECOMBE, G.D. 1994. Revision of the Silurian encrinurine trilobite *Wallacia* Lamont, 1978, with species from Gotland and Canada. Paläontologische Zeitschrift, 68, pp. 89-115.

REED, F.R.C. 1928. Notes on the Family Encrinuridae. Geological Magazine, 65, pp. 51-77.

RICKARDS, R.B. 1976. The sequence of Silurian graptolite zones in the British Isles. Geological Journal, 11, pp. 153-188.
RIGBY, J.K. and CHATTERTON, B.D.E. 1989. Middle Silurian Ludlovian and Wenlockian sponges from Baillie-Hamilton and Cornwallis Islands, Arctic Canada. Geological Survey of Canada Bulletin, 391. 69 pp.
ROHR, D.M., BOUCOT, A.J., and PERRY, D.G. 1981. Silurian (Wenlockian) gastropods from Baillie-Hamilton Island, Canadian Arctic. Journal of Paleontology, 55, pp. 331-339.
SALTER, J.W. 1852. Geology. *In* Sutherland, P.C. (ed.). Journal of a voyage in Baffin's Bay and Barrow Straits, in the years 1850-1851, 2. London, pp. 217-233.
SIVETER, D.J. 1989. Silurian trilobites from the Annascaul Inlier, Dingle Peninsula, Ireland. Palaeontology, 32, pp. 109-161.
------ and CHATTERTON, B.D.E. 1996. Silicified calymenid trilobites from the Mackenzie Mountains, northwest Canada. Palaeontographica Abt. A, 239, pp. 1-42.
SMITH, A.B. 1994. Systematics and the fossil record: documenting evolutionary patterns. Blackwell Scientific Publications, Oxford. 223 pp.
ŠNAJDR, M. 1977. New genera of Proetidae from the Barrandian, Bohemia. Vestník Ústředního Ústavu Geologického, 52, pp. 293-298.
------. 1983. New Silurian trilobites from Bohemia. Vestník Ústredního Ústavu Geologického, 57, pp. 175-178.
------. 1985. Bohemian repesentatives of the subfamily Encrinurinae (Trilobita). Sborník Geologickych Ved, Palaeontology, 27, pp. 9-46.
STRUSZ, D.L. 1980. The Encrinuridae and related trilobite families, with a description of Silurian species from southeastern Australia. Palaeontographica Abt. A, 168, pp. 1-68.
SWOFFORD, D.L. 1993. PAUP: Phylogenetic Analysis Using Parsimony Version 3.1.1. Program distributed by the Illinois Natural History Survey, Champaign.
THOMAS, A.T. 1981. British Wenlock trilobites. Part 2. Palaeontographical Society Monograph, 559, pp. 57-99.
------ and NARBONNE, G.M. 1979. Silurian trilobites from arctic Canada. Geological Magazine, 116, pp. 1-19.
THORSTEINSSON, R. 1955. The mode of cladial generation in *Cyrtograptus*. Geological Magazine, 92, pp. 37-49.
------. 1958. Cornwallis and Little Cornwallis Islands, District of Franklin, Northwest Territories. Geological Survey of Canada Memoir, 294. 134 pp.
TRIPP, R.P., TEMPLE, J.T., and GASS, K.C. 1977. The Silurian trilobite *Encrinurus variolaris* and allied species, with notes on *Frammia*. Palaeontology, 20, pp. 847-867.
WHITTINGTON, H.B. and EVITT, W.R. 1954. Silicified Middle Ordovician trilobites. Geological Society of America Memoir, 59. 137 pp.
------ and CAMPBELL, K.S.W. 1967. Silicified Silurian trilobites from Maine. Bulletin of the Museum of Comparative Zoology, Harvard University, 135, pp. 447-483.
ZHANG, N. 1989. Wenlock (Silurian) brachiopods of the Cape Phillips Formation, Baillie Hamilton Island, Arctic Canada. Palaeontographica Abt. A, part 1, 206, pp. 49-97, part 2, 206, pp. 99-135, part 3, 207, pp. 1-48.

TABLE 1. Data matrix for analysis of the *Struszia* genus group. Missing data indicated by a question mark.

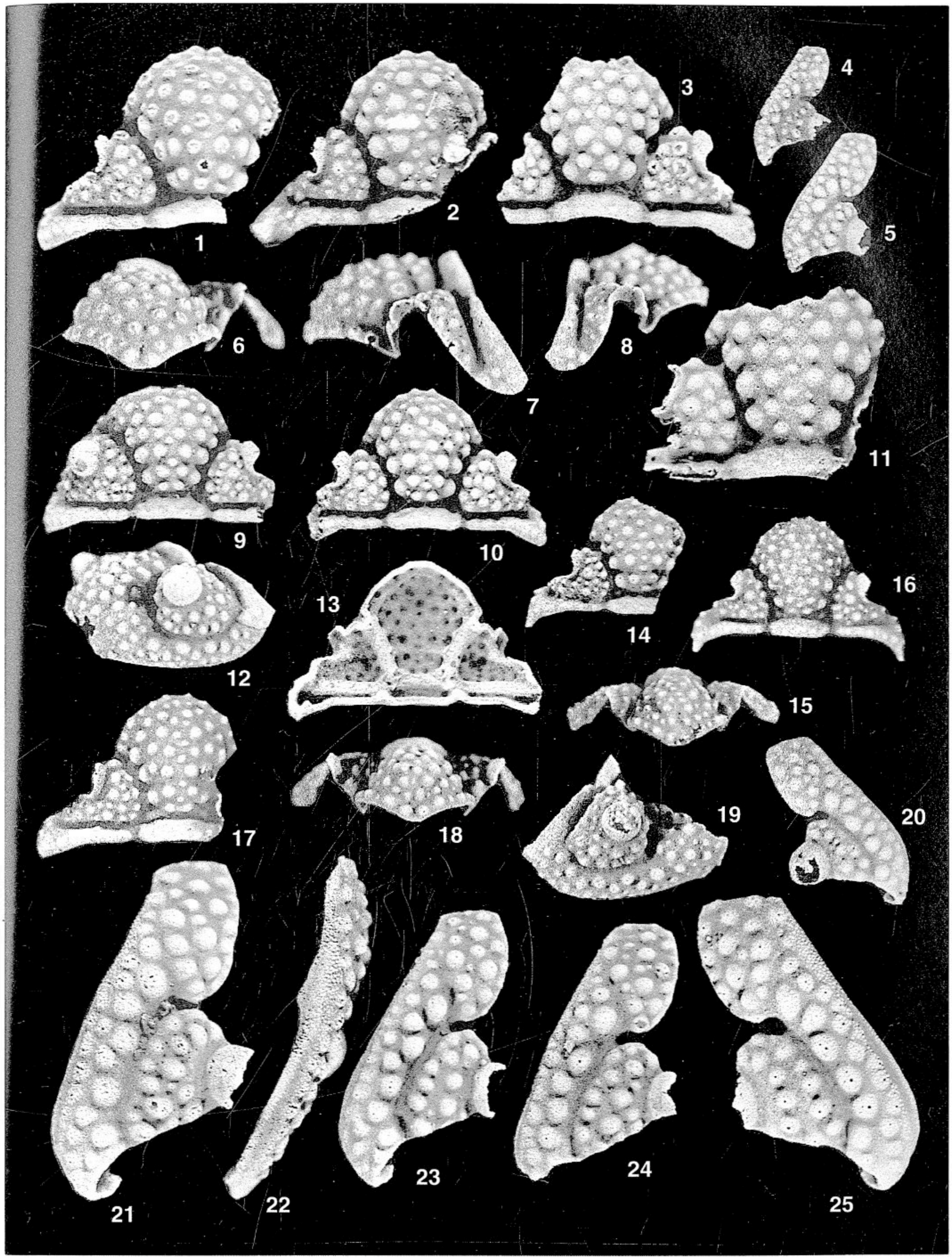
Taxon	1111111111222222222233333333334 1234567890123456789012345678901234567890
adraini	0000000000000000000000000000000000000000
arctica	0011010100001002111042120100000000112101
bachae	1011000200000002011 0?11211??000000101001
ceejayi	1011010110030020011 0?111121?001100001110
deedeei	1011010100030000011031121 21?001100001011
dimitrovi	2011000100000000011021120 10?000000101001
epsteini	0011000100000000011 1?212010?0?0?00101001
garfunkeli	30?1?002010?10000110?001010?1?0?00101000
glebale	0111?003000020210110200110010000 01001101
harrisoni	2001001201021000011022120 10?000000101001
hyperborea	1011010200001002111042120100000000101001
indianensis	100100120002000001102212?1??0?0?00101001
jaggeri	3001100100111102011020110000010010101001
joeyi	1011010110000000011 03???????001100001110
johnnyi	30110101010300210110?001120?0?1?00101010
lauriae	0011??000?0?00010?103??????1001?0000111?
lennoni	30010002010000000110?01101001000 00101000
martini	10110002000000000110201 2010?000000101001
mccartneyi	1000000200020010001120111 10?000000100000
nankerphelgeorum	?0111001001110020110???????001001010100?
obtusa A	1011000100000011011022120100000000101001
obtusa B	201100020000001101102??????0000000101001
onoae	001100100002001101113212?1??000000100001
petebesti	2011000100020000011021120 10?000000101001
ramskoeldi	0011??0100000210?102??????0000?0010000?
reimeri	1111010010020000011030011 21?001000000110
rhytium	1111000000020021011021111001000001101101
rosensteinae	001100020000001101102012010000 0?00101001
rossica	0001010100 0?1??2111?????????0???0011210?
simoni	30010002010010000110?011110?100000101000
starri	30110002010000000110?111010?1?0?00101001
variolaris	1001000100021112010010110000000000001001

PLATE 1

Figs. 1-25. *Struszia* (s.l.) *dimitrovi* (Perry and Chatterton, 1979)

Section BH 1 110 m (except where noted otherwise), Cape Phillips Formation, Wenlock (Sheinwoodian; *M. instrenuus-C. kolobus* Zone), southern Baillie-Hamilton Island, central Canadian Arctic. Magnifications are x10 except where noted.

1, 6, 7. Cranidium ROM 50099, dorsal, anterior, and left lateral views, x7.5.
2. Cranidium ROM 50100, dorsal view, x7.5 (BH 1 106 m).
3. Cranidium ROM 50101, dorsal view.
4. Left librigena ROM 50102, external view.
5. Left librigena ROM 50103, external view.
8, 10, 13, 17. Cranidium ROM 50104, right lateral, dorsal, ventral, and anterior views.
9, 12. Cranidium with left librigena ROM 50105, dorsal and oblique anterolateral views (BHL 1 0 m).
11. Cranidium ROM 50106, dorsal view.
14. Cranidium ROM 50107, dorsal view.
15, 18. Cranidium ROM 50108, anterior and dorsal views.
16. Cranidium ROM 50109, dorsal view.
19. Cranidial fragment and right librigena ROM 50110(BH 1 109 m).
20. Right librigena ROM 50111, external view.
21, 22. Left librigena ROM 50112, external and ventrolateral views, x7.5.
23. Left librigena ROM 50113, external view.
24. Left librigena ROM 50114, external view, x7.5.
25. Right librigena ROM 50115, external view.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

SILU

PLATE 2

Figs. 1-24. *Struszia* (s.l.) *dimitrovi* (Perry and Chatterton, 1979)

Section BH 1 110 m (except where noted otherwise), Cape Phillips Formation, Wenlock (Sheinwoodian; *M. instrenuus-C. kolobus* Zone), southern Baillie-Hamilton Island, central Canadian Arctic. Magnifications are x10 except where noted.

1, 2. Right librigena ROM 50116, internal and external views.
3, 8. Hypostome ROM 50117, ventral and dorsal views, x10 and x7.5 (BHL 1 0 m).
4. Hypostome ROM 50118, ventral view (BH 1 109 m).
5, 6. Thoracic segment ROM 50119, anterior and dorsal views.
7, 14, 16, 21. Pygidium ROM 50120, posterior, dorsal, left lateral, and ventral views, x7.5.
9, 11, 12. Hypostome ROM 50121, ventral, left lateral, and anterior views.
10. Pygidium ROM 50122, dorsal view.
13. Pygidium ROM 50123, dorsal view.
15, 17, 22. Pygidium ROM 50124, posterior, left lateral, and dorsal views, x7.5.
18. Pygidium ROM 50125, dorsal view.
19, 20, 23. Pygidium ROM 50126, dorsal, posterior, and left lateral views.
24. Pygidium ROM 50127, dorsal view.

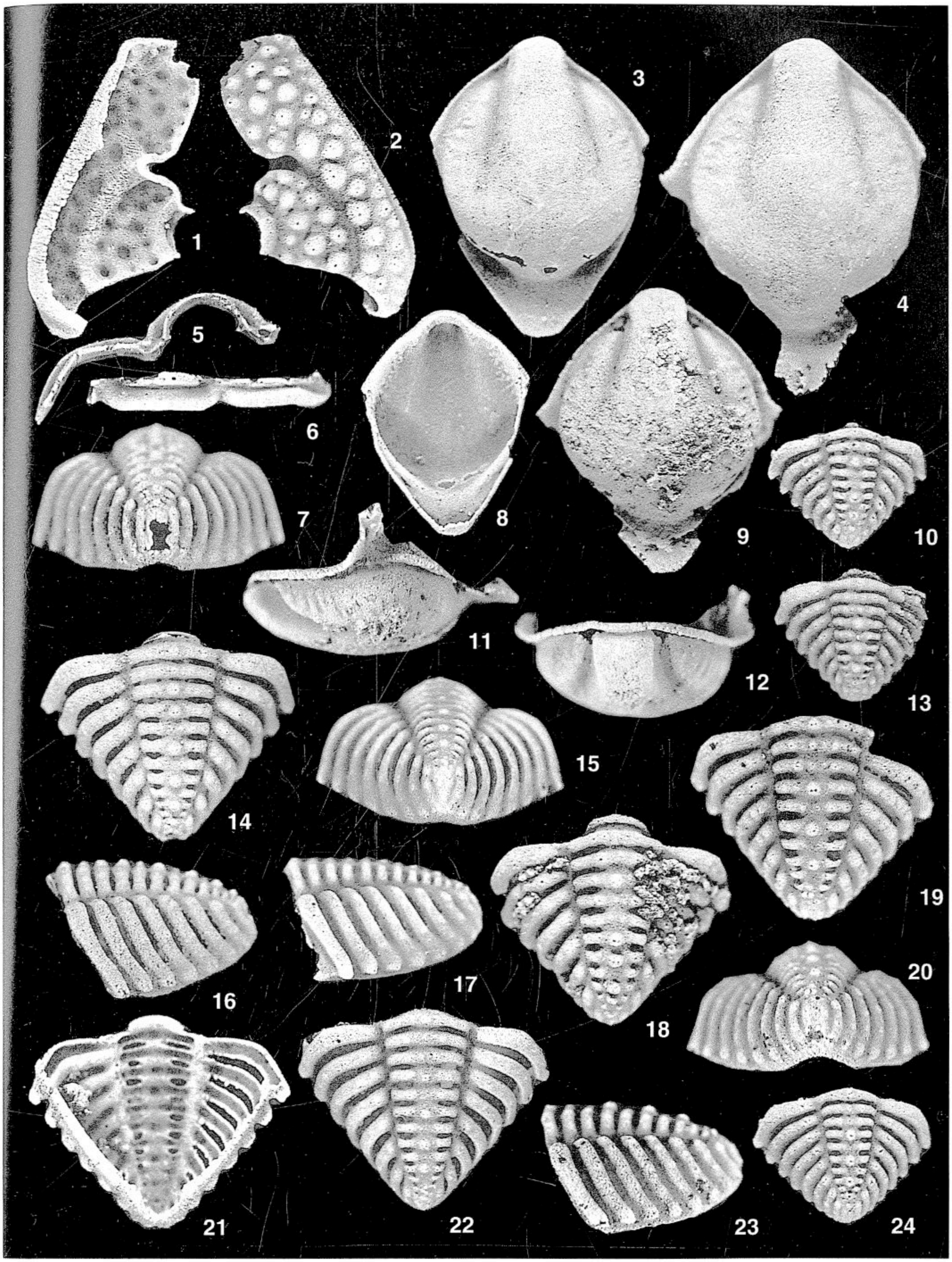

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

PLATE 3

Figs. 1-23. *Struszia* (s.l.) *petebesti* sp. nov.

Locality BHH, sections BH 1 192 m and BHL 1 92 m, and talus boulder ABR TTD, Cape Phillips Formation, Wenlock (Sheinwoodian; *C. perneri-M. opimus* Zone), southern Baillie-Hamilton Island and northwestern Cornwallis Island, central Canadian Arctic.

1, 4, 7. Cranidium ROM 50128, dorsal, anterior, and left lateral views, x5 (BHH-A).
2, 5, 8, 11. Holotype cranidium ROM 50129, dorsal, anterior, left lateral, and ventral views, x5 (BH 1 192 m).
3, 6, 9. Cranidium ROM 50130, dorsal, anterior, and left lateral views, x6 (ABR TTD).
10, 12. Cranidium ROM 50131, dorsal and anterior views, x7.5 (BHL 1 92 m).
13, 16. Cranidium ROM 50132, dorsal and anterior views, x10 (BHH-A).
14, 17. Cranidium ROM 50133, dorsal and ventral views, x7.5 (BHH-B).
15, 18. Cranidium ROM 50134, dorsal and anterior views, x10 (BHL 1 92 m).
19. Cranidium ROM 50135, dorsal view, x10 (BHL 1 92 m).
20-22. Cranidium ROM 50136, anterior, left lateral, and dorsal views, x10 (BHL 1 92 m).
23. Cranidium ROM 50137, dorsal view, x5 (BHL 1 92 m).

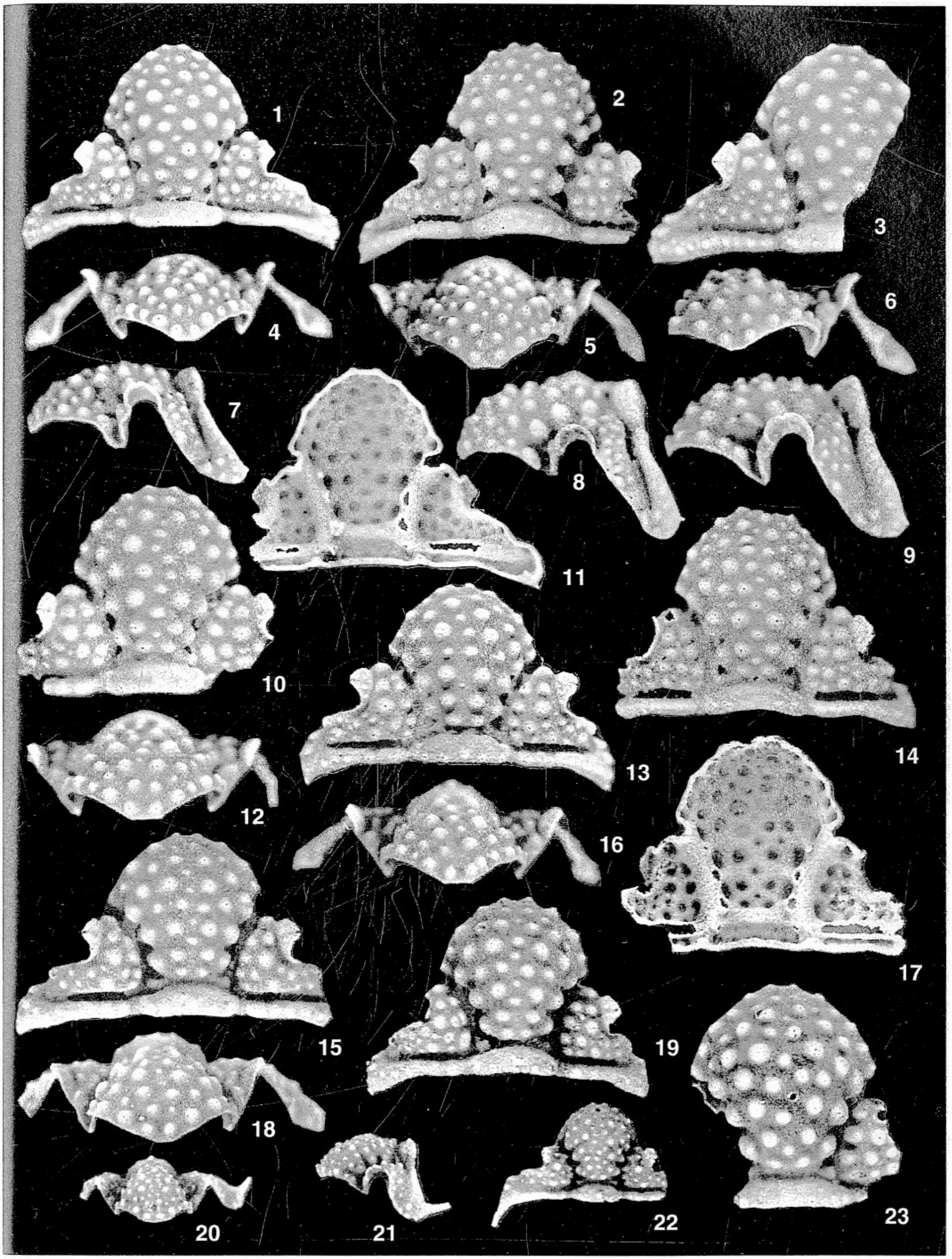

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23

PLATE 4

Figs. 1-25. *Struszia* (s.l.) *petebesti* sp. nov.

Locality BHH, section BHL 1 92 m, and talus boulder ABR TTD, Cape Phillips Formation, Wenlock (Sheinwoodian; *C. perneri-M. opimus* Zone), southern Baillie-Hamilton Island and northwestern Cornwallis Island, central Canadian Arctic.

1, 5, 6. Hypostome ROM 50138, ventral, anterior, and left lateral views, x7.5 (BHH-A).
2, 7, 8. Hypostome ROM 50139, ventral, left lateral, and anterior views, x7.5 (BHL 1 92 m).
3. Hypostome ROM 50140, ventral view, x7.5 (BHL 1 92 m).
4, 9, 14. Hypostome ROM 50141, ventral, anterior, and dorsal views, x10 (BHH-C); tentatively assigned to species.
10-12. Left librigena and cranidial fragment ROM 50142, external, ventrolateral, and dorsal views, x7.5 (BHL 1 92 m).
13. Right librigena ROM 50143, external view, x10 (BHL 1 92 m).
15, 16. Right librigena ROM 50144, internal and external views, x7.5 (ABR TTD).
17, 18. Right librigena ROM 50145, internal and external views, x7.5 and x10 (BHL 1 92 m).
19. Left librigena ROM 50146, external view, x7.5 (BHH-C).
20, 21. Thoracic segment ROM 50147, dorsal and posterior views, x6 (BHL 1 92 m).
22. Right librigena ROM 50148, external view, x10 (BHL 1 92 m).
23, 25. Thoracic segment ROM 50149, right lateral and dorsal views, x5 (BHL 1 92 m).
24. Left librigena ROM 50150, external view, x10 (BHL 1 92 m).

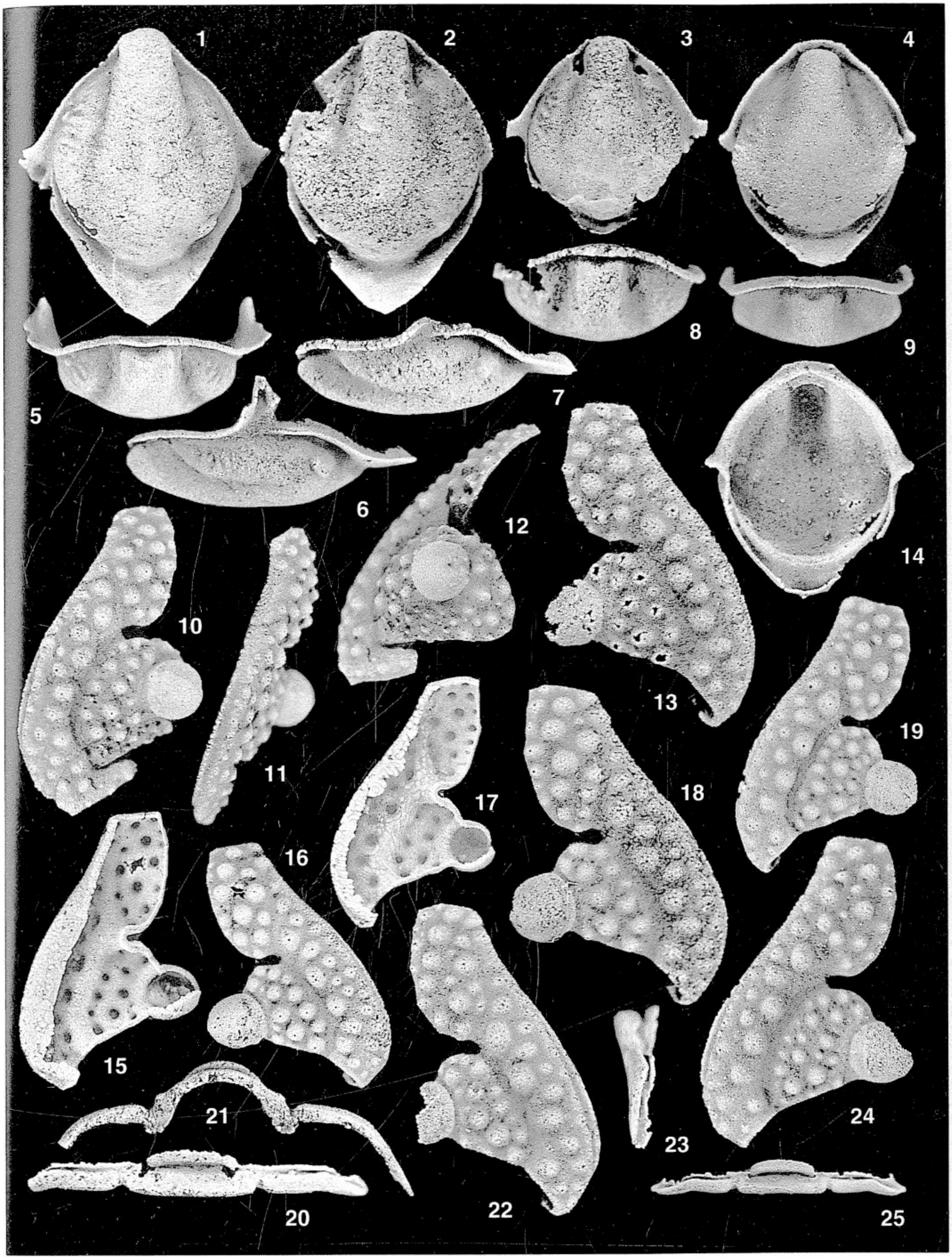

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

PLATE 5

Figs. 1-21. *Struszia* (s.l.) *petebesti* sp. nov.

Locality BHH, section BHL 1 92 m, and talus boulder ABR TTD, Cape Phillips Formation, Wenlock (Sheinwoodian; *C. perneri-M. opimus* Zone), southern Baillie-Hamilton Island and northwestern Cornwallis Island, central Canadian Arctic.

1, 2, 3, 5. Pygidium ROM 50151, dorsal, left lateral, posterior, and ventral views, x6 except fig. 5, x5 (BHL 1 92 m).
4, 8, 11. Pygidium ROM 50152, dorsal, left lateral, and posterior views, x5 (ABR TTD).
6, 7, 10. Pygidium ROM 50153, right lateral, dorsal, and posterior views, x7.5 (BHL 1 92 m).
9, 12, 13. Pygidium ROM 50154, dorsal, left lateral, and posterior views, x6 (BHH-C).
14, 15. Pygidium ROM 50155, posterior and dorsal views, x6 (BHL 1 92 m).
16, 18. Pygidium ROM 50156, dorsal and posterior views, x7.5 (BHH-A).
17, 19. Pygidium ROM 50157, dorsal and posterior views, x7.5 (BHL 1 92).
20, 21. Pygidium ROM 50158, posterior and dorsal views, x10 (BHL 1 92 m).

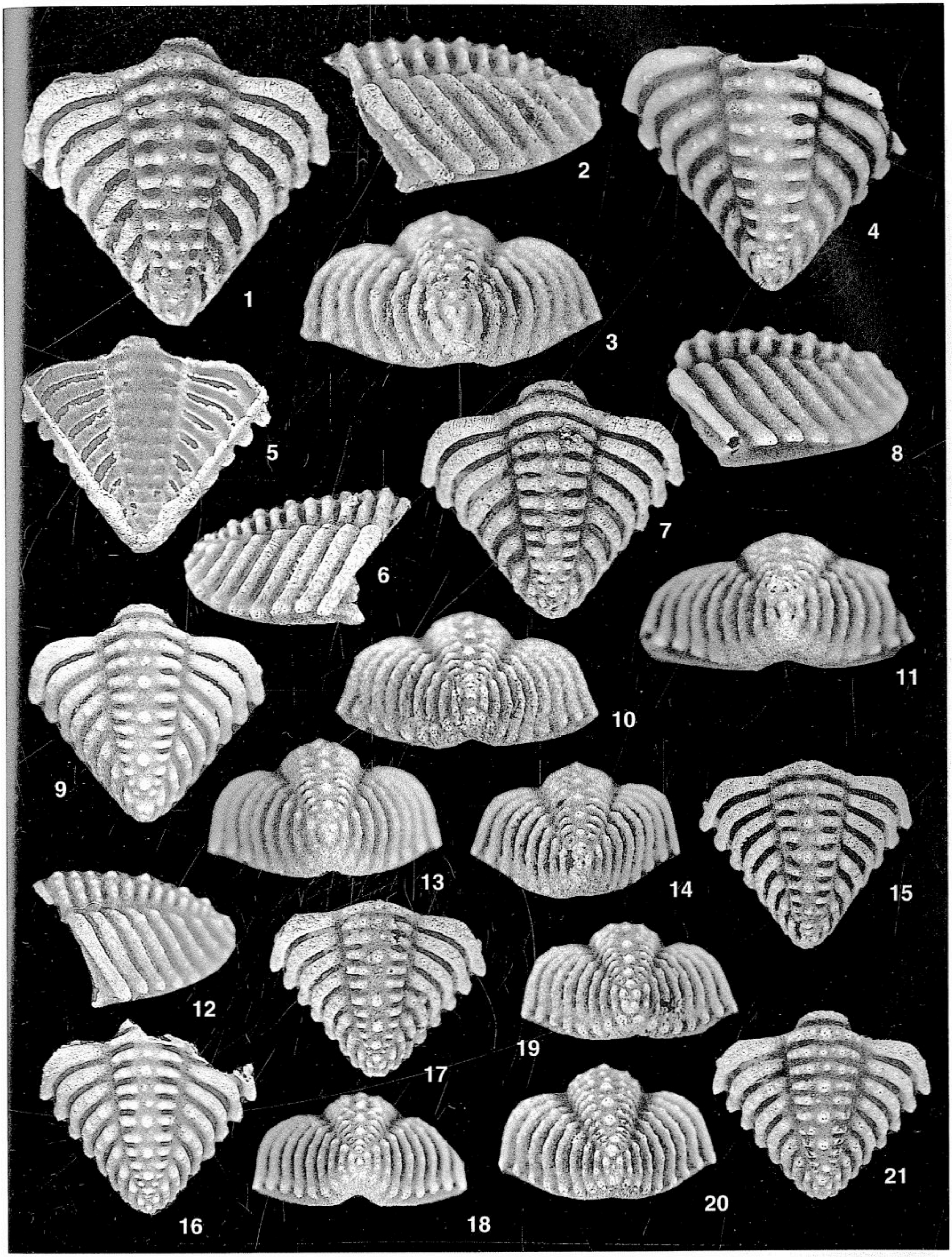

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21

PLATE 6

Figs. 1-22. *Struszia* (s.l.) *epsteini* sp. nov.

Locality BHH, section BHL 1 92 m, and talus boulder ABR TTD, Cape Phillips Formation, Wenlock (Sheinwoodian; *C. perneri-M. opimus* Zone), southern Baillie-Hamilton Island and northwestern Cornwallis Island, central Canadian Arctic.

1, 2. Cranidium ROM 50189, dorsal and ventral views, x7.5 (BHL 1 92 m).
3, 4. Cranidium ROM 50190, dorsal and anterior views, x7.5 (ABR TTD).
5, 9. Cranidium ROM 50191, dorsal and anterior views, x7.5 (BHL 1 92 m).
6, 10. Cranidium ROM 50192, dorsal and right lateral views, x7.5 (BHL 1 92 m).
7, 8, 12, 15. Pygidium ROM 50193, dorsal, left lateral, posterior, and ventral views, x7.5 except fig. 15, x10 (ABR TTD).
11. Pygidium ROM 50194, dorsal view, x10 (BHL 1 92 m).
13. Pygidium ROM 50195, dorsal view, x7.5 (BHL 1 92 m).
14, 17. Pygidium ROM 50196, dorsal and posterior views, x7.5 (BHL 1 92 m).
16, 20, 21. Pygidium ROM 50197, left lateral, posterior, and dorsal views, x5 (BHL 1 92 m).
18, 19, 22. Pygidium ROM 50198, posterior, left lateral, and dorsal views, x7.5 (BHL 1 92 m).

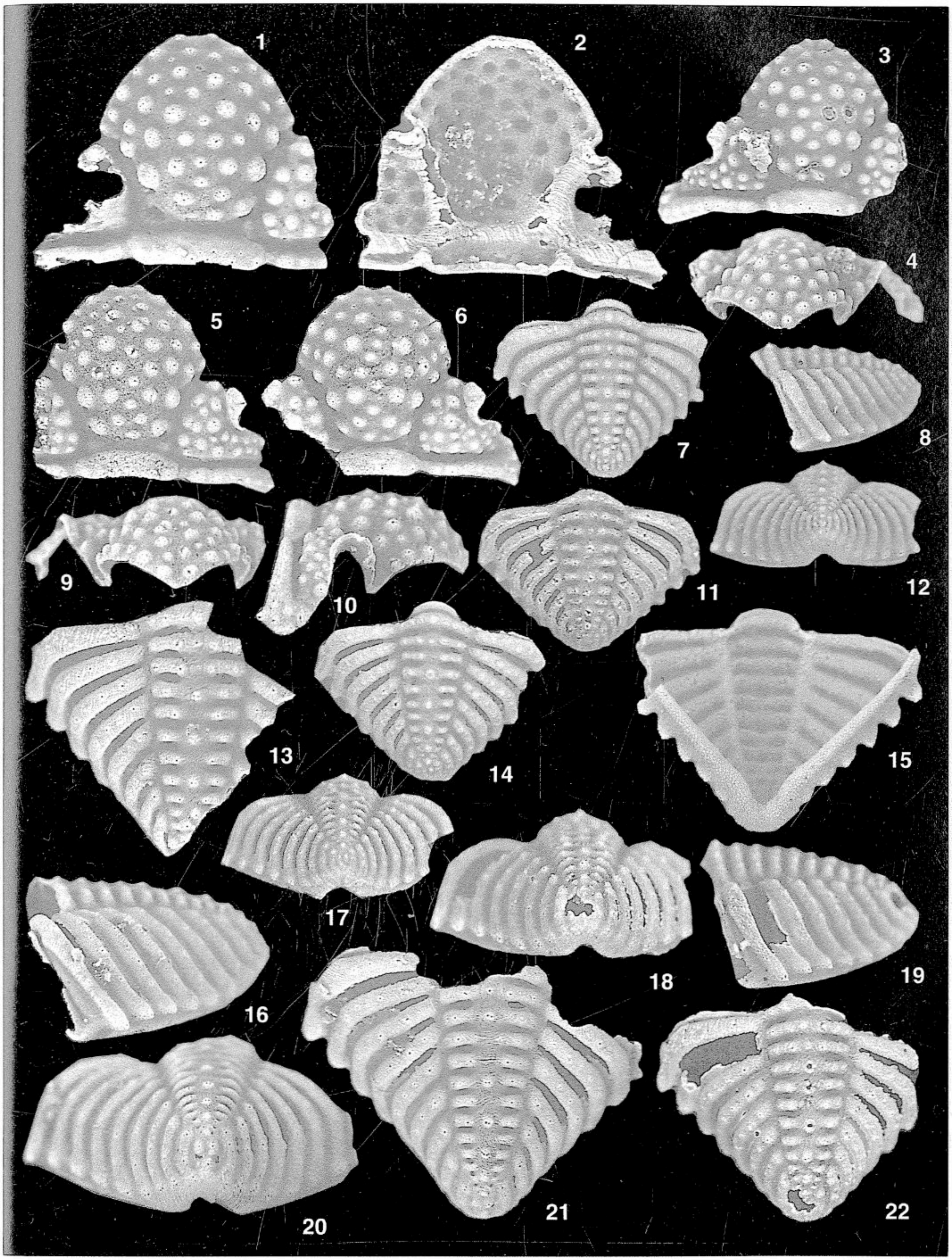

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

PLATE 7

Figs. 1-23. *Struszia* (s.l.) *epsteini* sp. nov.

Locality BHH, section BHL 1 92 m, and talus boulder ABR TTD, Cape Phillips Formation, Wenlock (Sheinwoodian; *C. perneri*-*M. opimus* Zone), southern Baillie-Hamilton Island and northwestern Cornwallis Island, central Canadian Arctic. Magnifications x10 except where noted.

1. Right librigena ROM 50199, external view, x7.5 (BHH-A).
2. Right librigena ROM 50200, external view (BHH-C).
3, 4, 10. Right librigena and cranidial fragment ROM 50201, external, ventrolateral, and internal views (BHH-C).
5. Left librigena ROM 50202, external view (BHH-C).
6, 7. Left librigena ROM 50203, external and ventrolateral views (BHH-C).
8. Left librigena ROM 50204, external view (BHH-C).
9. Right librigena ROM 50205, external view (BHL 1 92 m).
11, 15, 17, 20. Holotype hypostome ROM 50206, ventral, anterior, right lateral, and posterior views, x7.5 (BHL 1 92 m).
12. Hypostome ROM 50207, ventral view (BHH-C).
13, 18. Hypostome ROM 50208, ventral and dorsal views, x7.5 (BHL 1 92 m).
14, 16, 19. Hypostome ROM 50209, ventral, left lateral, and anterior views, x7.5 (BHH-C).
21. Hypostome ROM 50210, ventral view, x7.5 (ABR TTD).
22. Hypostome ROM 50211, ventral view (BHL 1 92 m).
23. Hypostome ROM 50212, ventral view (ABR TTD).

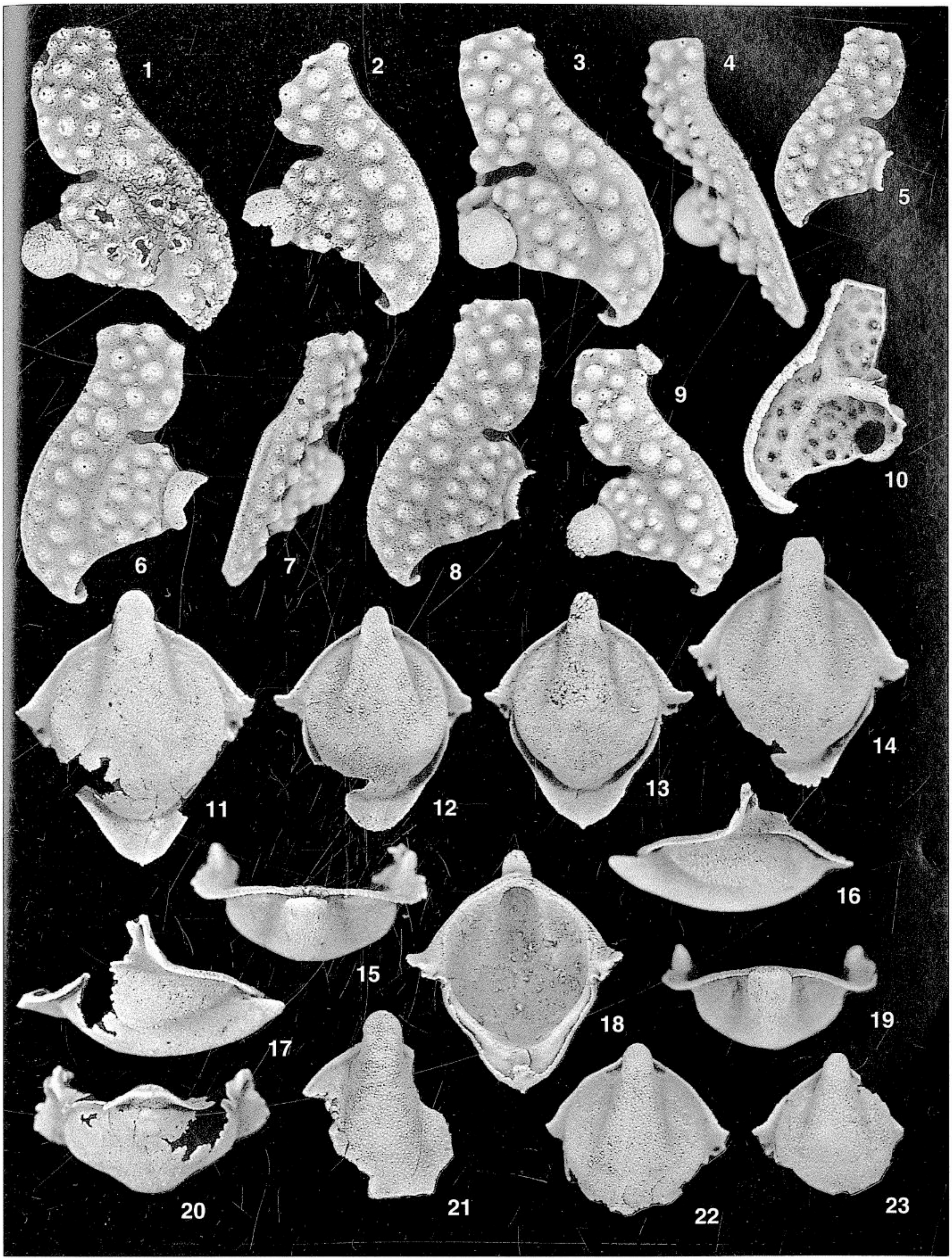

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23

PLATE 8

Figs. 1-8, 9?, 10-12, 13-18? *Struszia* (s.l.) sp. nov. A

Talus boulder ABR TTD, Cape Phillips Formation, Wenlock (Sheinwoodian; *C.perneri-M.opimus* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic.

1, 2, 4, 5, 8. Cranidium and right librigena ROM 50178, dorsal, ventral, oblique, right lateral, and anterior views, x10.
3, 6, 7. Cranidium, ROM 50179, dorsal, anterior, and right lateral views, x7.5.
9, 13, 14. Hypostome ROM 50180, ventral, right lateral, and anterior views, x7.5.
10. Right librigena ROM 50181, external view, x7.5.
11. Right librigena ROM 50182, external view, x10.
12. Left librigena ROM 50183, external view, x10.
15. Hypostome ROM 50184, ventral view, x10.
16, 17. Hypostome ROM 50185, right lateral and ventral view, x10.
18. Hypostome ROM 50186, ventral view, x10.

Figs. 19, 20. *Struszia* (s.l.) *martini* sp. nov.

Talus boulder ABR TTD, Cape Phillips Formation, Wenlock (Sheinwoodian; *C.perneri-M.opimus* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic. Right librigena and rostral plate ROM 50187, oblique and external views, x10.

Fig. 21. *Struszia*? sp. 1

Section BHL 1 92 m, Cape Phillips Formation, Wenlock (Sheinwoodian; *C. perneri-M. opimus* Zone), southern Baillie-Hamilton Island, central Canadian Arctic. Cranidium ROM 50188, dorsal view, x7.5.

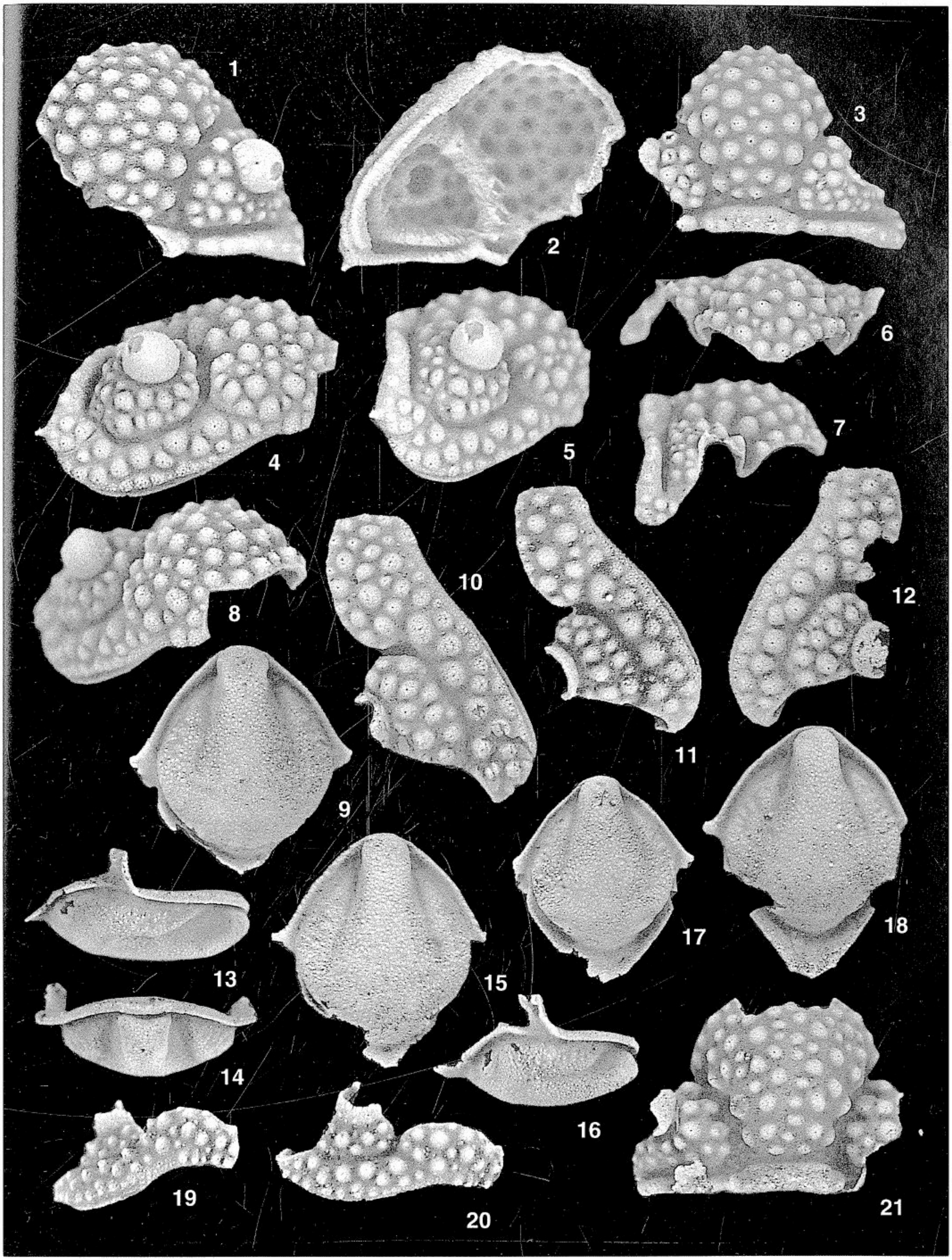

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21

PLATE 9

Figs. 1-26. *Struszia* (s.l.) *martini* sp. nov.

Section BHL 1 92 m and talus boulder ABR TTD, Cape Phillips Formation, Wenlock (Sheinwoodian; *C. perneri-M. opimus* Zone), southern Baillie-Hamilton Island and northwestern Cornwallis Island, central Canadian Arctic.

1, 2, 4, 5. Cephalon ROM 50159, dorsal, oblique, anterior, and left lateral views, x6 except fig. 1, x7.5 (ABR TTD).

3, 6, 10. Cranidium ROM 50160, dorsal, ventral, and left lateral views, x7.5 (ABR TTD).

7, 8, 12. Cranidium and left librigena ROM 50161, oblique, left lateral, and dorsal views, x6 (ABR TTD).

9, 14. Cranidium ROM 50162, right lateral and dorsal views, x7.5 (BHL 1 92 m).

11, 15. Cranidium ROM 50163, dorsal and left lateral views, x7.5 (ABR TTD).

13, 16, 17. Cephalon lacking right librigena ROM 50164, dorsal, oblique, and anterior views, x10 (ABR TTD).

18, 22, 23. Hypostome ROM 50165, right lateral, ventral, and dorsal views, x7.5 (ABR TTD).

19, 20, 24, 25. Hypostome ROM 50166, posterior, anterior, ventral, and right lateral views, x7.5 (ABR TTD).

21, 26. Cranidium ROM 50167, dorsal and left lateral views, x7.5 (ABR TTD).

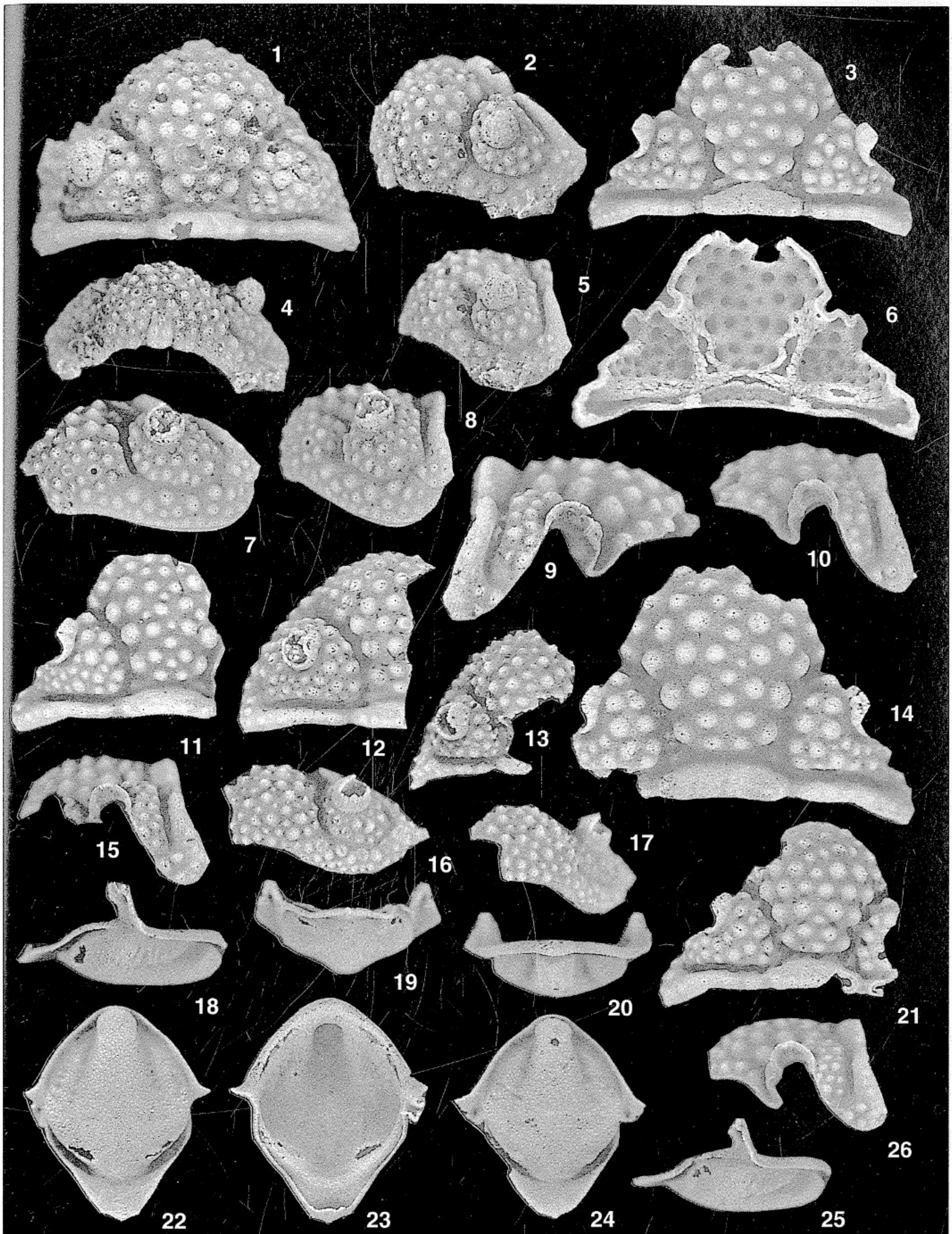

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26

PLATE 10

Figs. 1-19. *Struszia* (s.l.) *martini* sp. nov.

Section BHL 1 92 m and talus boulder ABR TTD, Cape Phillips Formation, Wenlock (Sheinwoodian; *C. perneri-M. opimus* Zone), southern Baillie-Hamilton Island and northwestern Cornwallis Island, central Canadian Arctic.

1, 2. Left librigena ROM 50168, external and ventrolateral views, x7.5 (ABR TTD).
3, 8. Left librigena ROM 50169, external and internal views, x7.5 (ABR TTD).
4. Left librigena ROM 50170, external view, x7.5 (ABR TTD).
5. Left librigena ROM 50171, external view, x10 (ABR TTD).
6. Right librigena ROM 50172, external view, x10 (ABR TTD).
7. Left librigena ROM 50173, external view, x10 (ABR TTD).
9, 10. Pygidium ROM 50174, dorsal and posterior views, x7.5 (ABR TTD).
11, 15, 17. Pygidium ROM 50175, dorsal, ventral, and left lateral views, x7.5 (ABR TTD).
12, 13, 16. Pygidium ROM 50176, posterior, left lateral, and dorsal views, x7.5 (BHL 1 92 m).
14, 18, 19. Pygidium ROM 50177, dorsal, posterior, and ventral views, x7.5 except fig. 19, x10 (ABR TTD).

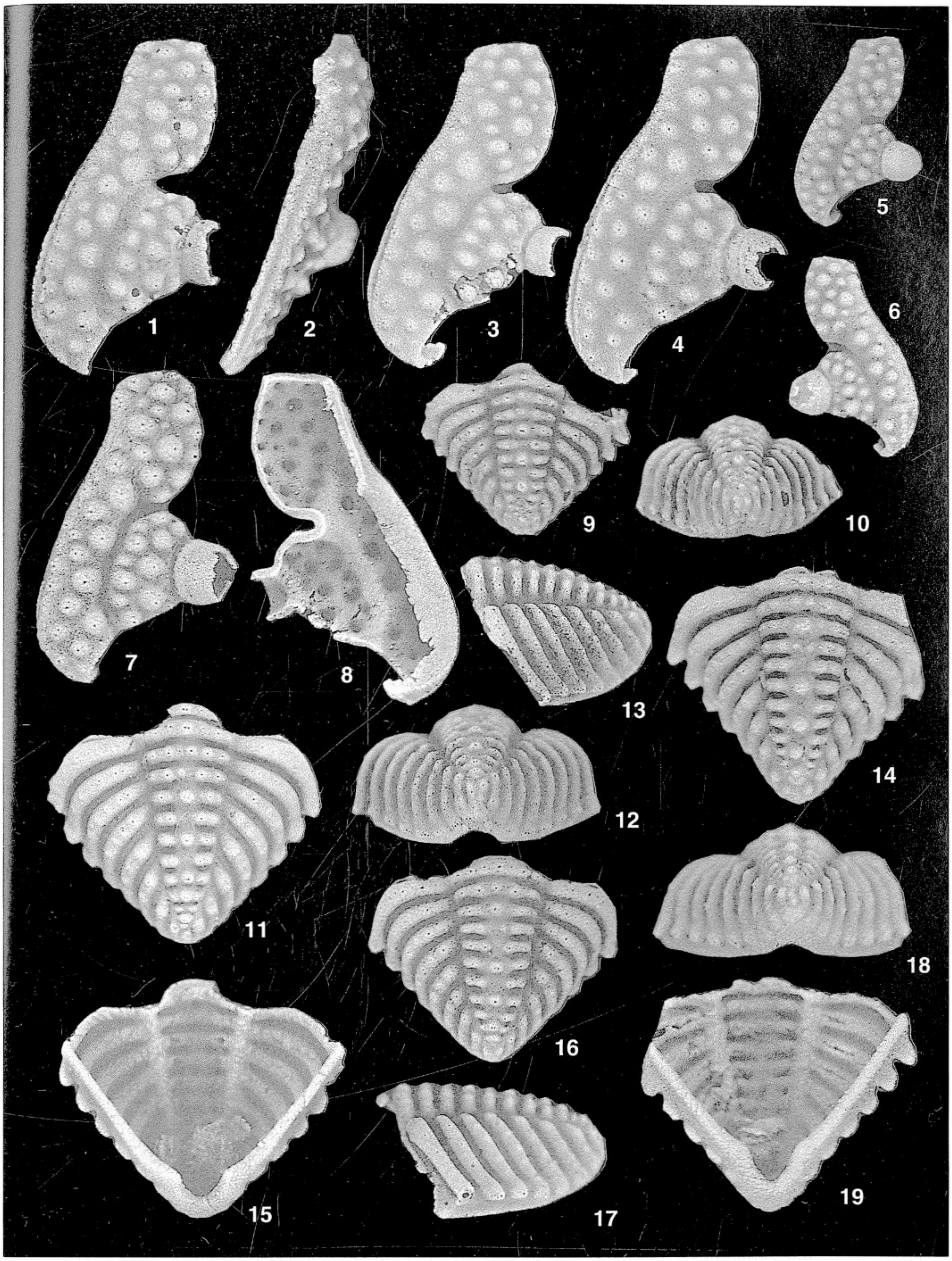

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

PLATE 11

Figs. 1-21. *Struszia* (s.l.) *martini* sp. nov.

Section ABR 2 18-27 m and talus boulders ABR TTC(3) and ABR TTC(5), Cape Phillips Formation, Wenlock (Sheinwoodian; *C. perneri-M. opimus* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic. Magnifications are x7.5 except where noted.

1. Cranidium ROM 50213, dorsal view (ABR 2 27 m).

2, 3, 5. Holotype cranidium ROM 50214, dorsal, ventral, and left lateral views (ABR TTC(3)).

4, 8, 9, 12. Cranidium and left librigena ROM 50215, dorsal, anterior, left lateral, and oblique dorsolateral views, x10 (ABR TTC(3)).

6. Cranidium ROM 50216, dorsal view (ABR TTC(5)).

7. Right librigena ROM 50217, external view, x10 (ABR TTC(3)).

10, 11, 14. Cranidium ROM 50218, dorsal, left lateral, and anterior views, x10 (ABR 2 27 m).

13. Cranidium ROM 50219, dorsal view (ABR TTC(3)).

15. Left librigena ROM 50220, external view, x10 (ABR TTC(5)).

16. Left librigena ROM 50221, external view, x10 (ABR 2 18 m).

17, 18. Left librigena ROM 50222, external and ventrolateral views (ABR TTC(3)).

19-21. Left librigena ROM 50223, external, ventrolateral, and internal views (ABR 2 27 m).

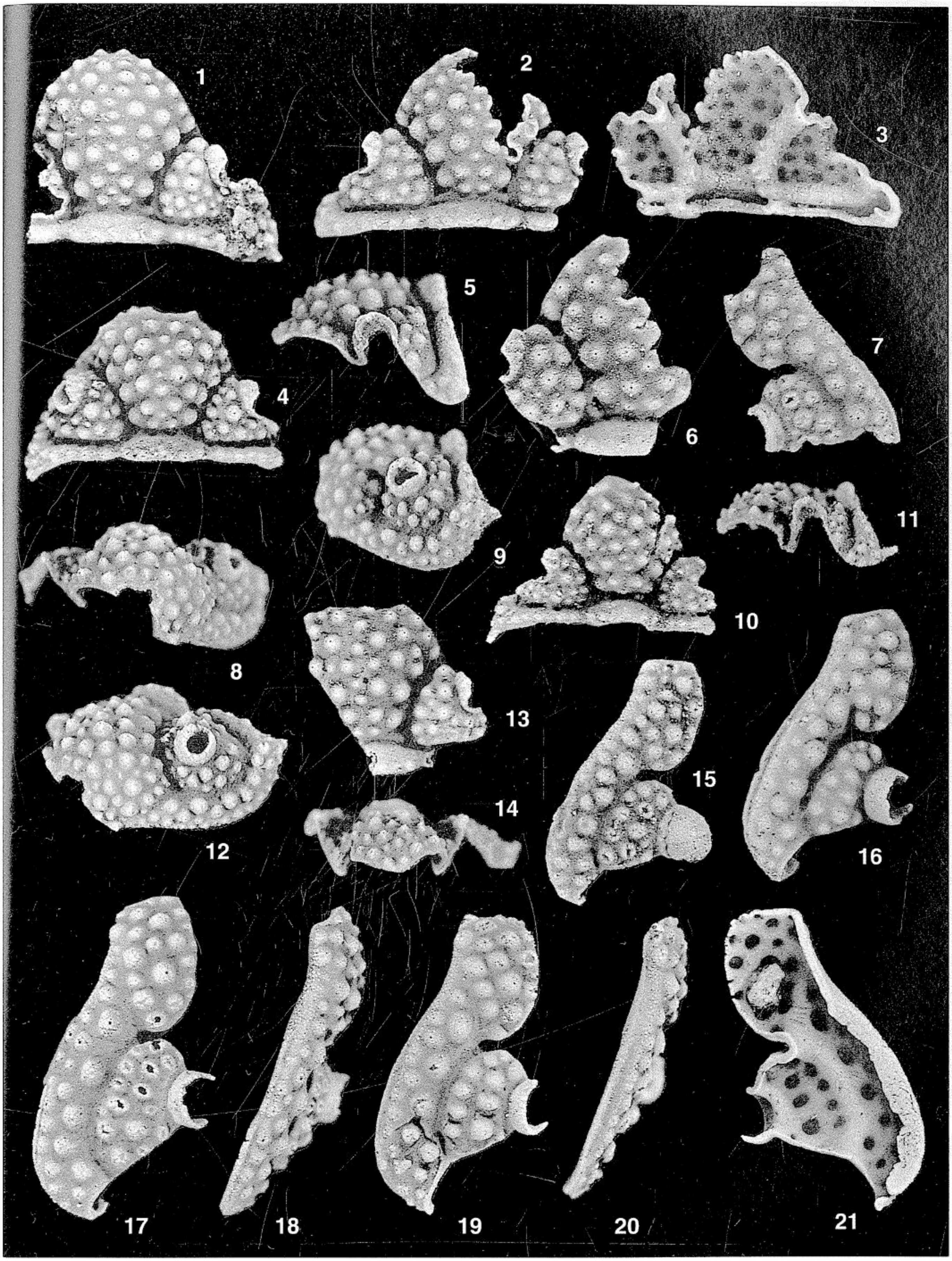

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21

PLATE 12

Figs. 1-17, 19-21. *Struszia* (s.l.) *martini* sp. nov.

Section ABR 2 18-27 m and talus boulders ABR TTC(3) and ABR TTC(7), Cape Phillips Formation, Wenlock (Sheinwoodian; *C. perneri-M. opimus* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic. Magnifications are x10 except where noted.

1, 5. Hypostome ROM 50224, ventral and right lateral views, x7.5 (ABR 2 18 m).
2, 3. Hypostome ROM 50225, ventral and dorsal views (ABR TTC(3)).
4. Hypostome ROM 50226, ventral view (ABR 2 27 m).
6, 7. Hypostome ROM 50227, ventral and left lateral views (ABR TTC(3)).
8, 9. Thoracic segment ROM 50228, dorsal and anterior views, x7.5 (ABR TTC(7)).
10, 13, 16. Pygidium ROM 50229, dorsal, posterior, and left lateral views (ABR TTC(3)).
11, 14, 17, 21. Pygidium ROM 50230, dorsal, posterior, ventral, and right lateral views (ABR TTC(3)).
12, 15. Pygidium ROM 50231, posterior and dorsal views (ABR TTC(3)).
19, 20. Pygidium ROM 50233, posterior and dorsal views (ABR TTC(3)).

Figs. 18, 22. *Struszia* sp.

Section ABR 2 27 m, Cape Phillips Formation, Wenlock (Sheinwoodian; *C. perneri-M. opimus* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic. Pygidium ROM 50232, posterior and dorsal views, x10.

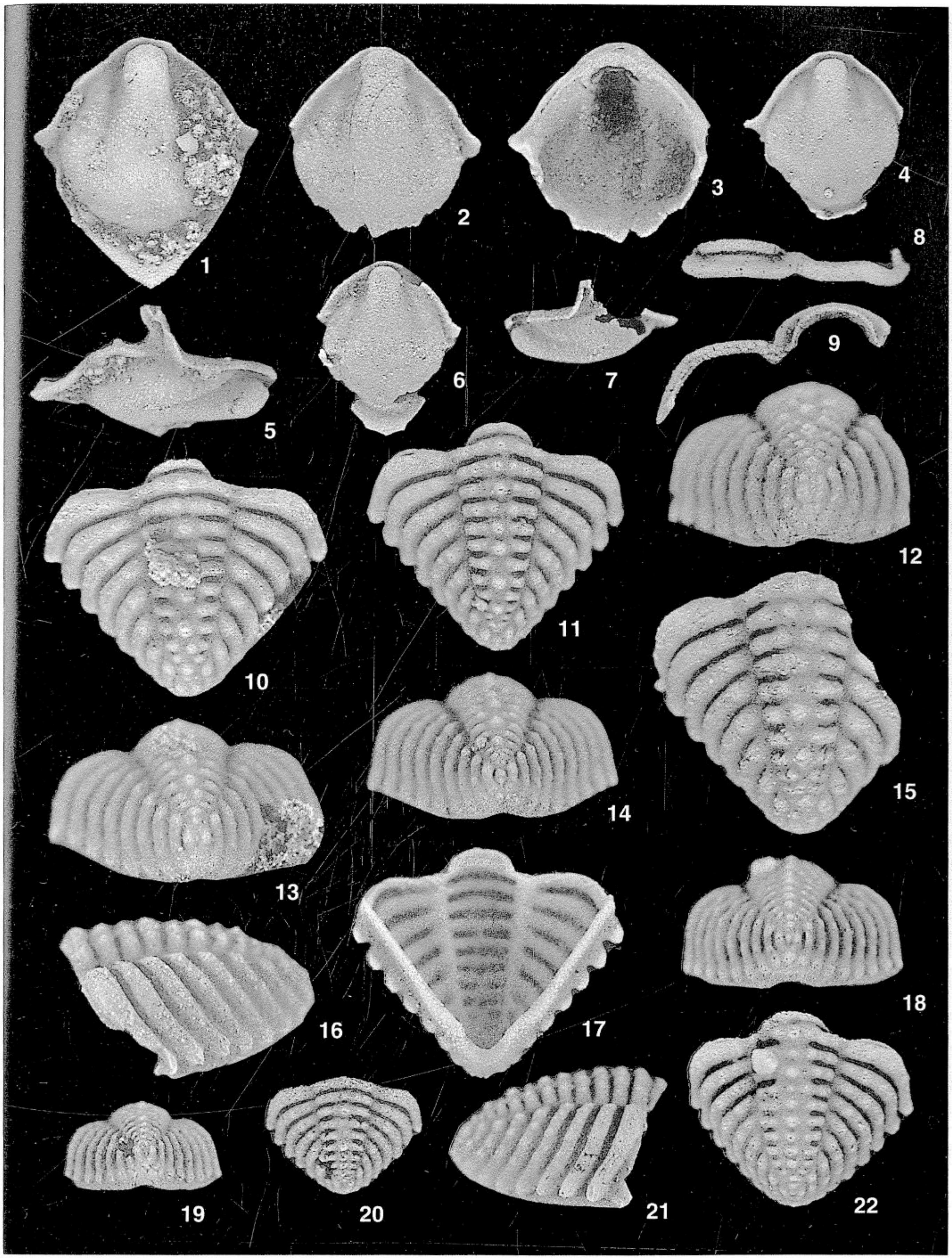

1
2
3
4
8
5
6
7
9
10
11
12
13
14
15
16
17
18
19
20
21
22

PLATE 13

Figs. 1-25. *Struszia onoae* sp. nov.

Talus boulder ABR 3TT, Cape Phillips Formation, Wenlock (probably *C. lundgreni-M. testis* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic. Magnifications are x7.5 except where noted.

- 1, 2, 5, 6. Holotype cranidium ROM 50234, dorsal, ventral, anterior, and right lateral views.
- 3, 4. Cranidium ROM 50235, dorsal and posterior views.
- 7, 8, 12. Cranidium ROM 50236, right lateral, dorsal, and anterior views.
- 9, 10, 14. Cranidium ROM 50237, dorsal, right lateral, and anterior views.
- 11, 15, 18, 19. Cranidium and right librigena ROM 50238, dorsal, oblique anterolateral, anterior, and right lateral views, x10.
- 13. Cranidium ROM 50239, dorsal view, x10.
- 16. Cranidium ROM 50240, dorsal view, x10.
- 17. Cranidium ROM 50241, dorsal view, x10.
- 20. Hypostome ROM 50242, ventral view, x10.
- 21, 23. Hypostome ROM 50243, ventral and right lateral views.
- 22. Hypostome ROM 50244, ventral view, x10.
- 24, 25. Hypostome ROM 50245, dorsal and ventral views.

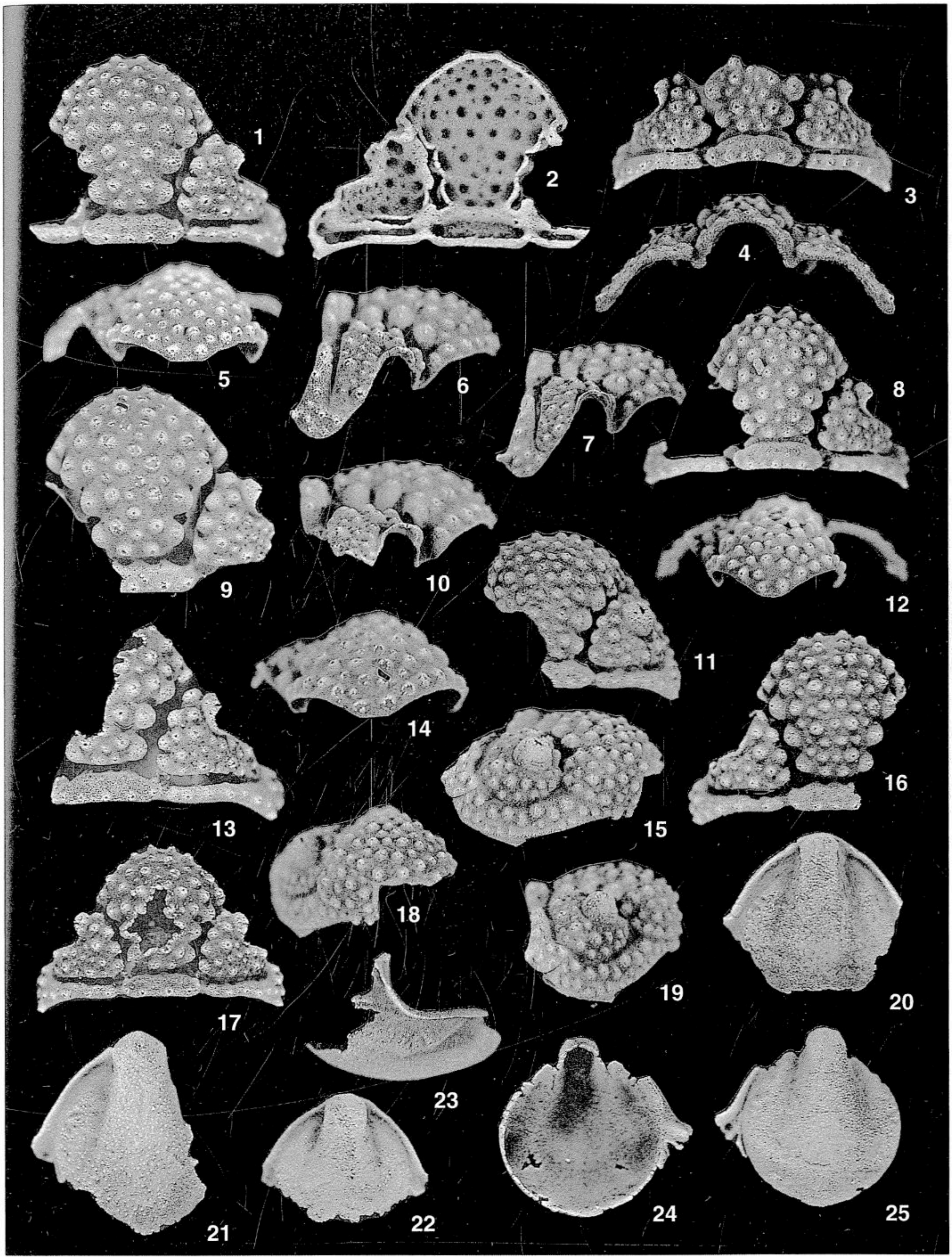

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

PLATE 14

Figs. 1-16. *Struszia onoae* sp. nov.

Talus boulder ABR 3TT, Cape Phillips Formation, Wenlock (probably *C. lundgreni-M. testis* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic. Magnifications are x7.5 except where noted.

1, 3, 7. Pygidium ROM 50246, dorsal, posterior, and right lateral views.
2, 5, 9, 11. Pygidium ROM 50247, dorsal, posterior, left lateral, and ventral views.
4. Pygidium ROM 50248, dorsal view, x10.
6. Pygidium ROM 50249, dorsal view, x10.
8, 10, 13. Pygidium ROM 50250, left lateral, dorsal, and posterior views.
12. Pygidium ROM 50251, dorsal view, x10.
14. Pygidium ROM 50252, dorsal view.
15, 16. Pygidium ROM 50253, posterior and dorsal views.

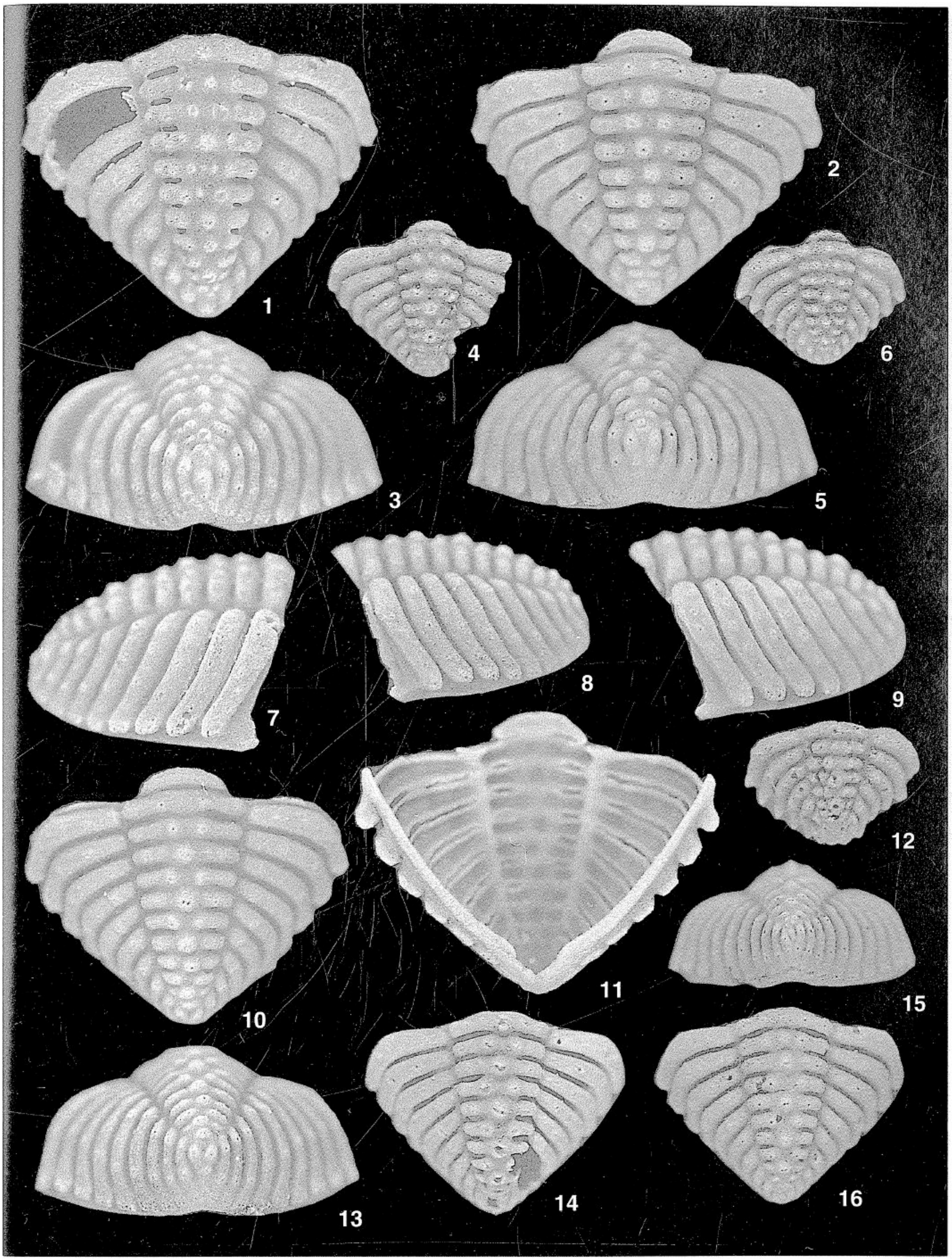

1
2
4
6
3
5
7
8
9
11
12
10
15
13
14
16

PLATE 15

Figs. 1-27. *Struszia onoae* sp. nov.

Talus boulder ABR 3TT (probably *C. lundgreni-M. testis* Zone) and section ABR 1, 5.5-13.5 m, Cape Phillips Formation, Wenlock (*C. lundgreni-M. testis* Zone to *Pristiograptus ludensis* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic, and section BH 2 2-3 m, Cape Phillips Formation, Wenlock (*C. lundgreni-M. testis* Zone), southern Baillie-Hamilton Island, central Canadian Arctic. Magnifications are x7.5 except where noted.

1. Left librigena ROM 50254, external view, x10 (ABR 3TT).
2. Left librigena ROM 50255, external view (ABR 3TT).
3. Right librigena ROM 50256, external view (ABR 3TT).

4, 6, 13. Thoracic segment ROM 50257, right lateral, dorsal, and posterior views (ABR 3TT).

5, 8, 15. Thoracic segment ROM 50258, left lateral, dorsal, and anterior views (ABR 3TT).

7, 14. Thoracic segment ROM 50259, dorsal and posterior views (ABR 3TT).

9, 16. Thoracic segment ROM 50260, dorsal and posterior views (ABR 3TT).

10, 12. Cranidium ROM 50261, dorsal and anterior views (ABR 1 9 m).

11. Right librigena ROM 50262, external view, x10 (ABR 3TT).

17, 18. Left librigena ROM 50263, external and ventrolateral views (ABR 1 13.5 m).

19. Right librigena ROM 50264, external view, x10 (BH 2 3 m).

20. Hypostome ROM 50265, ventral view, x10 (ABR 1 6 m).

21, 25-27. Pygidium ROM 50266, dorsal, posterior, right lateral, and ventral views (BH 2 2 m).

22. Right librigena ROM 50267, external view, x10 (ABR 1 6 m).

23, 24. Pygidium ROM 50268, right lateral and dorsal views, x10 (ABR 1 5.5 m).

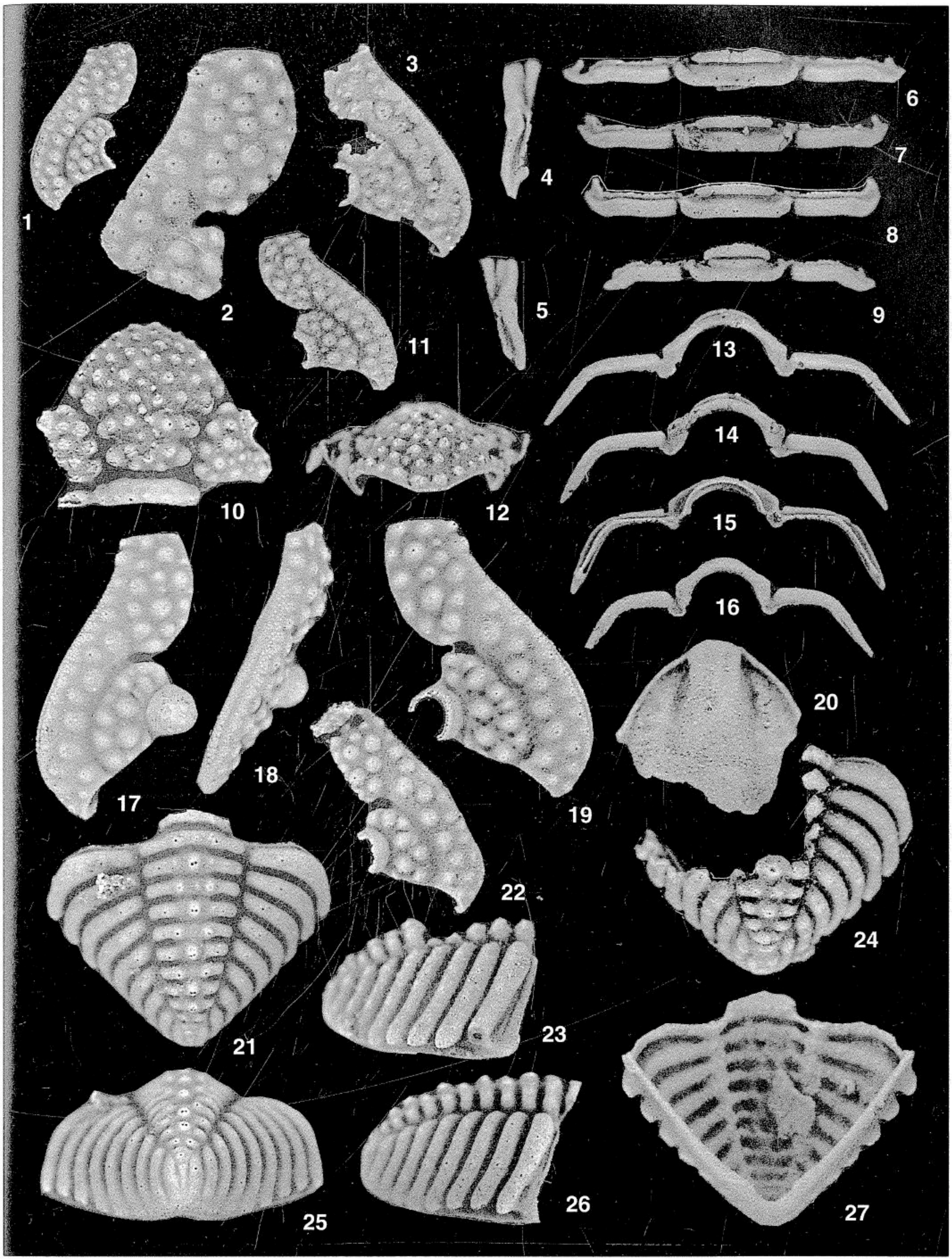
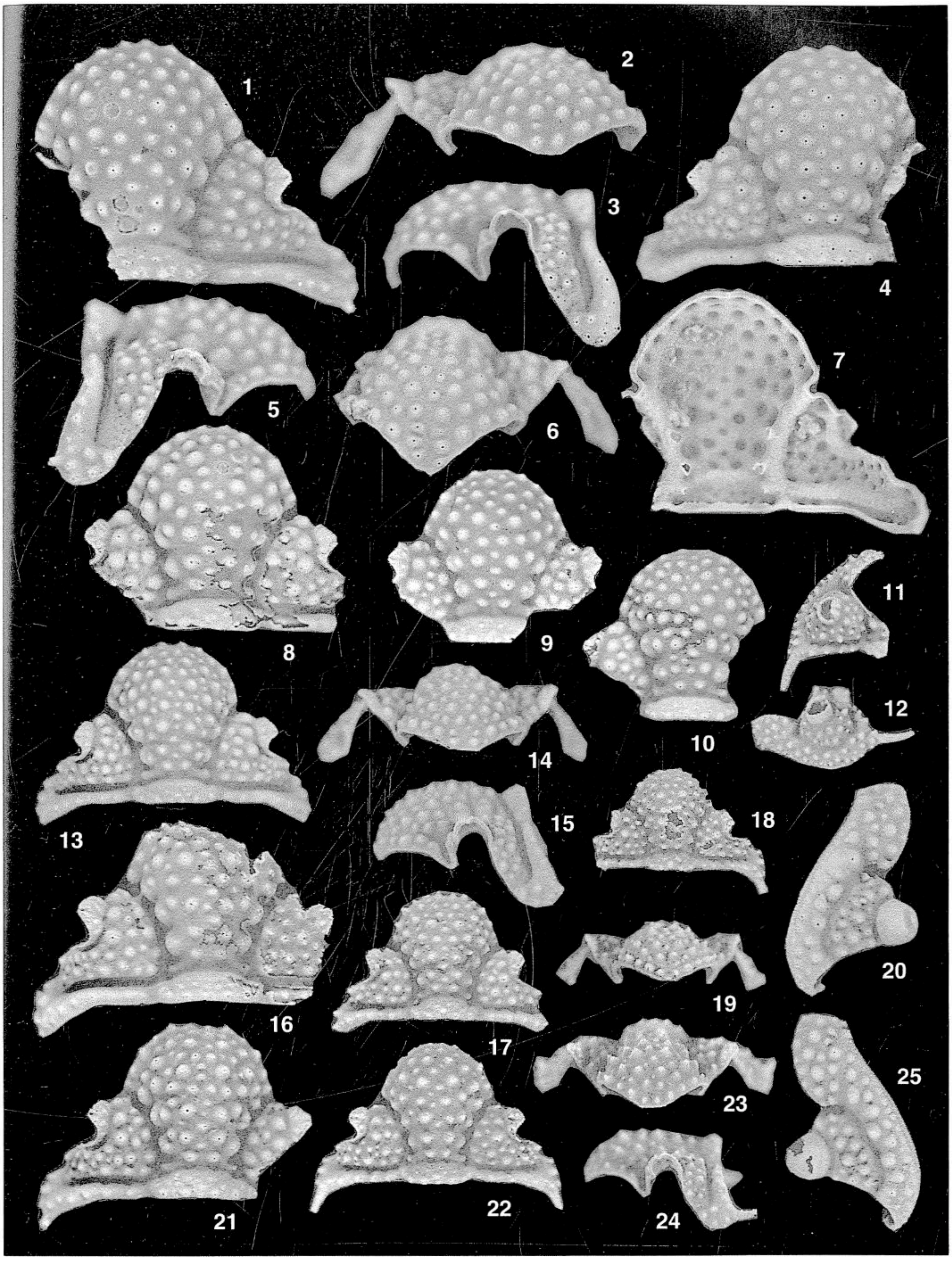

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27

PLATE 16

Figs. 1-25. *Struszia* (s.l.) *harrisoni* Edgecombe and Chatterton, 1993

Section ABR 1 22 m, Cape Phillips Formation, Wenlock (Homerian; *Pristiograptus ludensis* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic.

1, 2, 5. Cranidium ROM 50291, dorsal, anterior, and right lateral views, x7.5.
3, 4, 6, 7. Cranidium ROM 50292, left lateral, dorsal, anterior, and ventral views, x5.
8. Cranidium ROM 50293, dorsal view, x7.5.
9. Cranidium ROM 50294, dorsal view, x7.5.
10. Cranidium ROM 50295, dorsal view, x5.
11, 12. Left librigena and cranidial fragment ROM 50296, dorsal and left lateral views, x10.
13-15. Cranidium ROM 50297, dorsal, anterior, and left lateral views, x7.5.
16. Cranidium ROM 50298, dorsal view, x10.
17, 19. Cranidium ROM 50299, dorsal and anterior views, x10.
18. Cranidium ROM 50300, dorsal view, x10.
20. Left librigena ROM 50301, external view, x10.
21. Cranidium ROM 50302, dorsal view, x10.
22-24. Cranidium ROM 50303, dorsal, anterior, and left lateral views, x10.
25. Right librigena ROM 50304, external view, x10.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

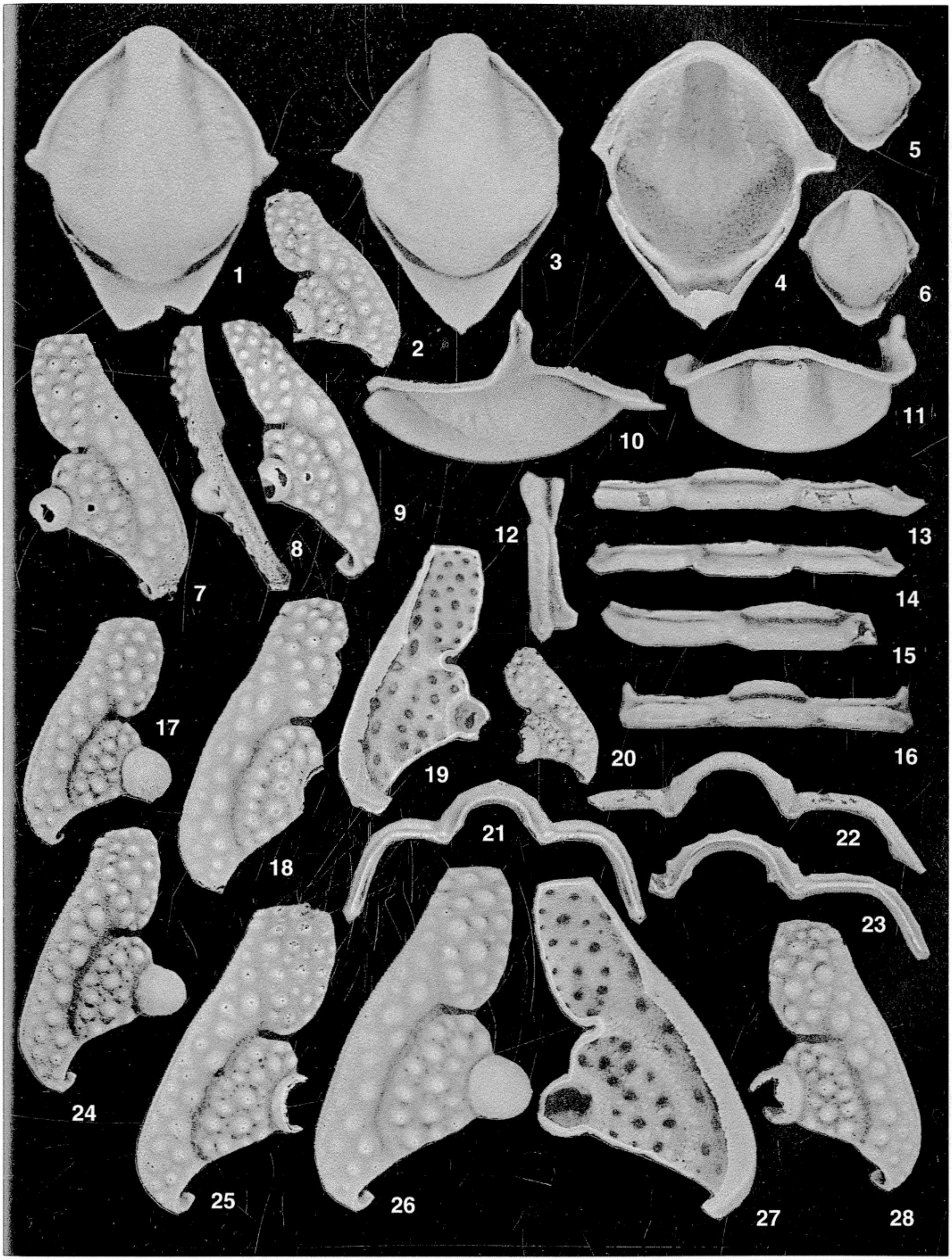
SII

PLATE 17

Figs. 1-28. *Struszia* (s.l.) *harrisoni* Edgecombe and Chatterton, 1993

Section ABR 1 22 m, Cape Phillips Formation, Wenlock (Homerian; *Pristiograptus ludensis* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic.

- 1, 10, 11. Hypostome ROM 50305, ventral, left lateral, and anterior views, x10.
- 2. Right librigena ROM 50306, external view, x10.
- 3, 4. Hypostome ROM 50307, ventral and dorsal views, x10.
- 5. Hypostome ROM 50308, ventral view, x10.
- 6. Hypostome ROM 50309, ventral view, x10.
- 7-9, 19. Right librigena ROM 503010, external, ventrolateral, dorsal, and internal views, x5.
- 12, 16, 21. Thoracic segment ROM 50311, right lateral, dorsal, and anterior views, x10.
- 13, 22. Thoracic segment ROM 50312, dorsal and posterior views, x7.5.
- 14. Thoracic segment ROM 50313, dorsal view, x10.
- 15, 23. Thoracic segment ROM 50314, dorsal and anterior views, x7.5.
- 17. Left librigena ROM 50315, external view, x10.
- 18. Left librigena ROM 50316, external view, x5.
- 20. Right librigena ROM 50317, external view, x10.
- 24. Left librigena ROM 50318, external view, x7.5.
- 25. Left librigena ROM 50319, external view, x7.5.
- 26, 27. Left librigena ROM 50320, external and internal views, x7.5.
- 28. Right librigena ROM 50321, external view, x10.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28

SILU

PLATE 18

Figs. 1-16. *Struszia* (s.l.) *harrisoni* Edgecombe and Chatterton, 1993

Section ABR 1 22 m, Cape Phillips Formation, Wenlock (Homerian; *Pristiograptus ludensis* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic. Magnifications are x10 except where noted.

1, 4, 8. Pygidium ROM 50322, dorsal, posterior, and right lateral views, x7.5.
2, 5, 6, 16. Pygidium ROM 50323, dorsal, posterior, left lateral, and ventral views, fig. 16 x7.5.
3. Pygidium ROM 50324, dorsal view.
7. Pygidium ROM 50325, dorsal view.
9, 10, 12. Pygidium ROM 50326, posterior, left lateral, and dorsal views.
11, 14, 15. Pygidium ROM 50327, dorsal, posterior, and left lateral views.
13. Pygidium ROM 50328, dorsal view.

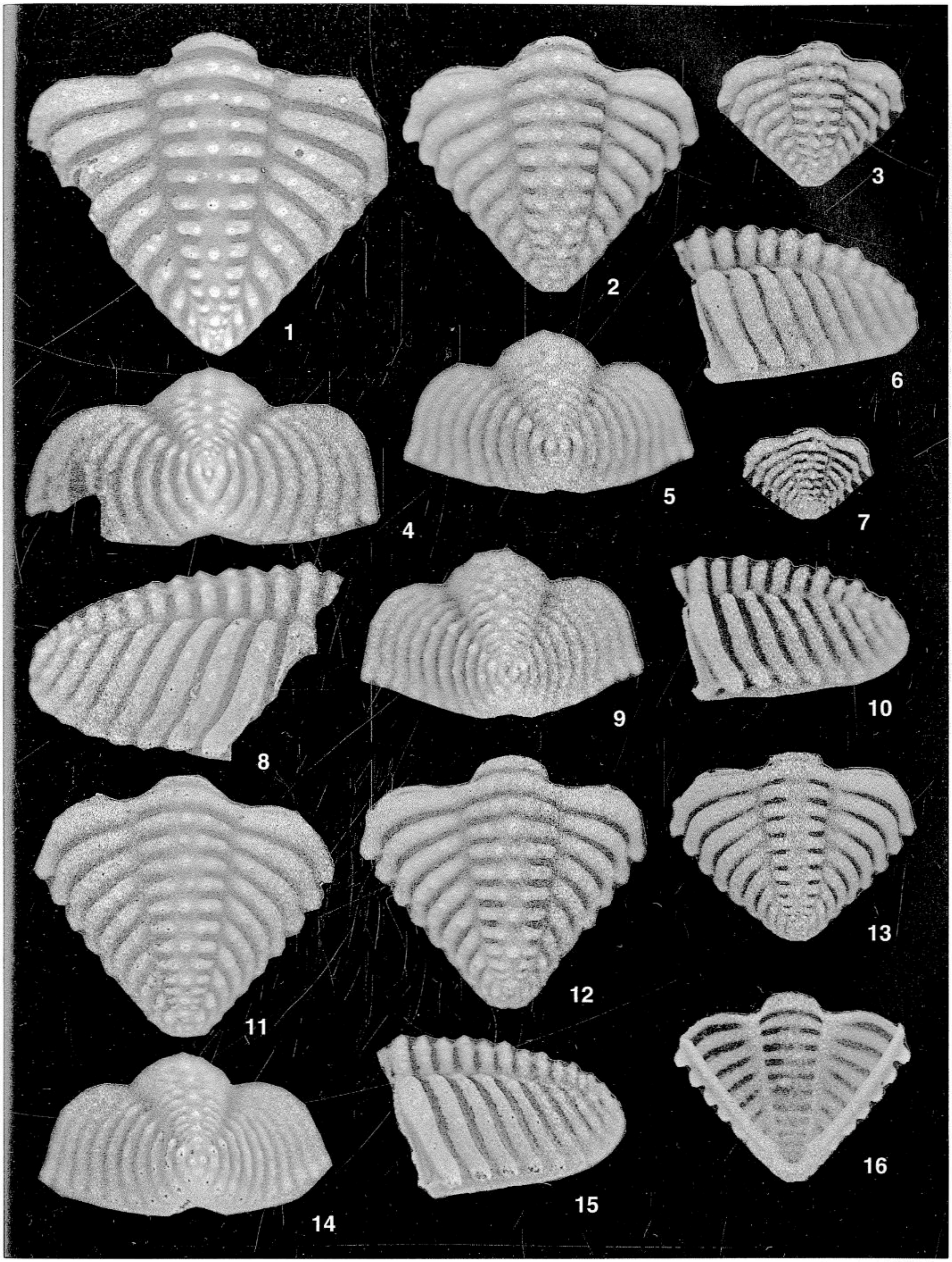

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

PLATE 19

Figs. 1-3, 6. *Struszia* (s.l.) sp. nov. B

Sections BHL 1 0 m and BH 1 110 m, Cape Phillips Formation, Wenlock (Sheinwoodian; *M. instrenuus-C. kolobus* Zone), southern Baillie-Hamilton Island, central Canadian Arctic.

1, 2, 6. Cephalon lacking rostral plate ROM 50329, dorsal, anterior, and oblique views, x7.5 (BHL 1 0 m).
3. Left librigena ROM 50330, external view, x10 (BH 1 110 m).

Figs. 4, 5, 7-9, 11-13, 17. *Struszia* (s.l.) sp. nov. C

Section BH 2 42 m, Cape Phillips Formation, Ludlow (Gorstian; *Lobograptus progenitor* Zone), southern Baillie-Hamilton Island, central Canadian Arctic. All magnifications are x10.

4, 8. Left librigena ROM 50331, external and internal views (posterior of specimen broken during photography).
5. Left librigena ROM 50332, external view.
7. Cranidium ROM 50333, dorsal view.
9. Hypostome ROM 50334, ventral view.
11-13. Pygidium ROM 50335, dorsal, right lateral, and posterior views.
17. Pygidium ROM 50336, dorsal view.

Fig. 10. *Struszia* (s.l.) *epsteini* sp. nov.?

Section ABR 2 27 m, Cape Phillips Formation, Wenlock (Sheinwoodian; *C. perneri-M. opimus* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic, hypostome ROM 50337, ventral view, x10.

Figs. 14-16. Indeterminate encrinurine

Talus boulder ABR TTC(1), Cape Phillips Formation, Wenlock (probably *Pristiograptus ludensis* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic, cranidium ROM 50338, anterior, right lateral, and dorsal views, x10.

Fig. 18. *Struszia* sp. 2

Section ABR 1 22 m, Cape Phillips Formation, Wenlock (*Pristiograptus ludensis* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic, cranidium ROM 50339, dorsal view, x7.5.

Figs. 19-21. *Struszia* sp. 3 aff. *S.* (s.l.) *epsteini* sp. nov.

Section BH 2 42 m, Cape Phillips Formation, Ludlow (Gorstian; *Lobograptus progenitor* Zone), southern Baillie-Hamilton Island, central Canadian Arctic. All magnifications are x10.

19, 20. Pygidium ROM 50340, posterior and dorsal views.
21. Left librigena ROM 50341, external view.

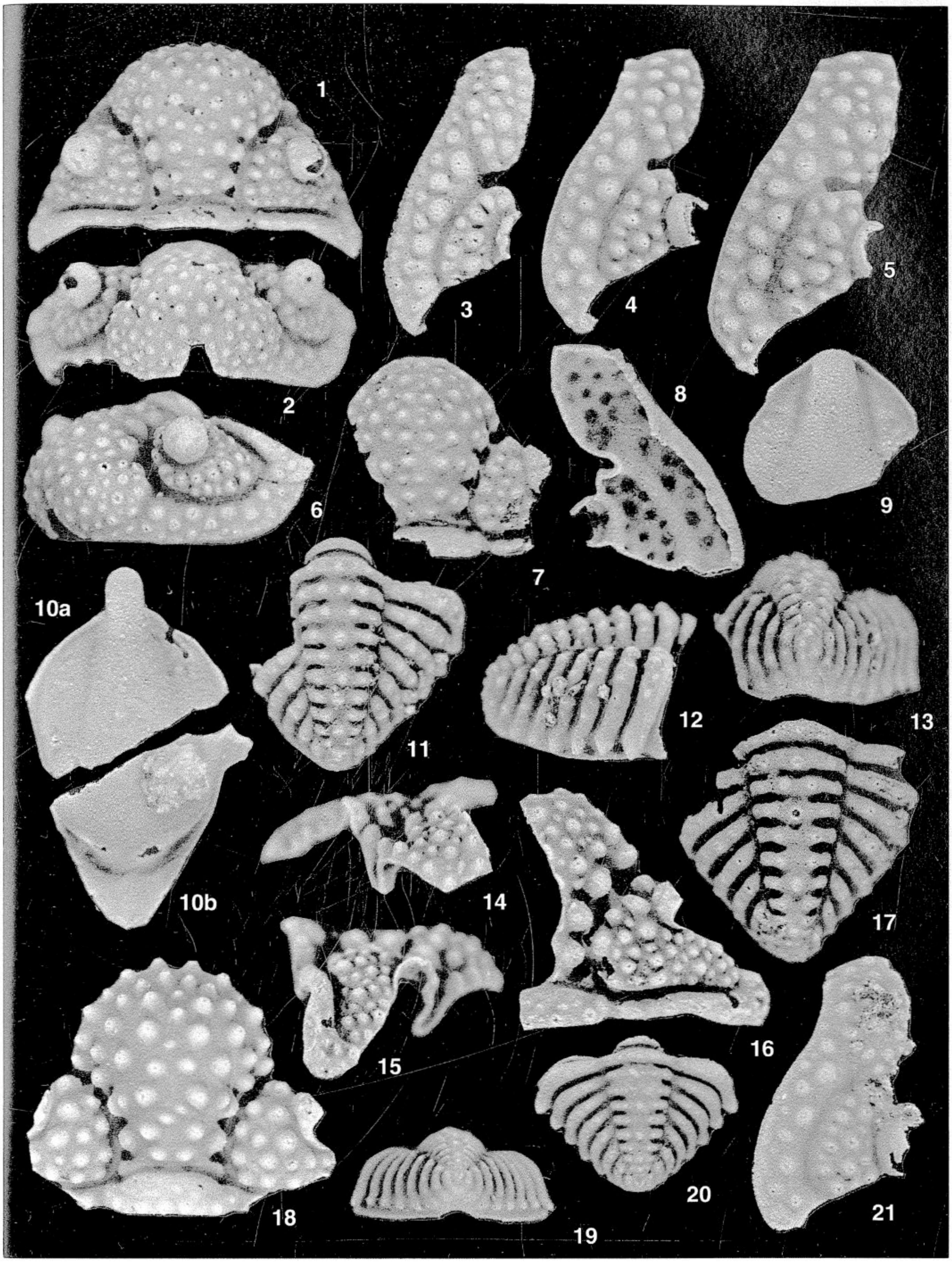

1
2
3
4
5
6
7
8
9
10a
10b
11
12
13
14
15
16
17
18
19
20
21

PLATE 20

Figs. 1-24. *Struszia*? sp. nov. D, section HI 1 69.5-70 m, Cape Phillips Formation, latest Wenlock or early Ludlow, Hoved Island, north-central Canadian Arctic. Specimens are from HI 1 69.5 m except where noted otherwise.

1, 4, 5, 10. Cranidium ROM 50342, dorsal, right lateral, anterior, and ventral views, x15.
2, 6, 8, 12. Pygidium ROM 50343, dorsal, ventral, posterior, and right lateral views, x10 (HI 1 70 m).
3, 7. Cranidium ROM 50344, dorsal and anterior views, x15.
9. Left librigena ROM 50345, external view, x15.
11, 15-17. Cranidium and right librigena ROM 50346, dorsal, anterior, oblique, and right lateral views, x10.
13. Pygidium ROM 50347, dorsal view, x10.
14, 21. Pygidium ROM 50348, dorsal and posterior views, x10.
18. Hypostome ROM 50349, ventral view, x15.
19. Pygidium ROM 50350, dorsal view, x10.
20. Hypostome ROM 50351, ventral view, x15.
22. Left librigena ROM 50352, external view, x10.
23, 24. Right librigena ROM 50353, internal and external views, x10.

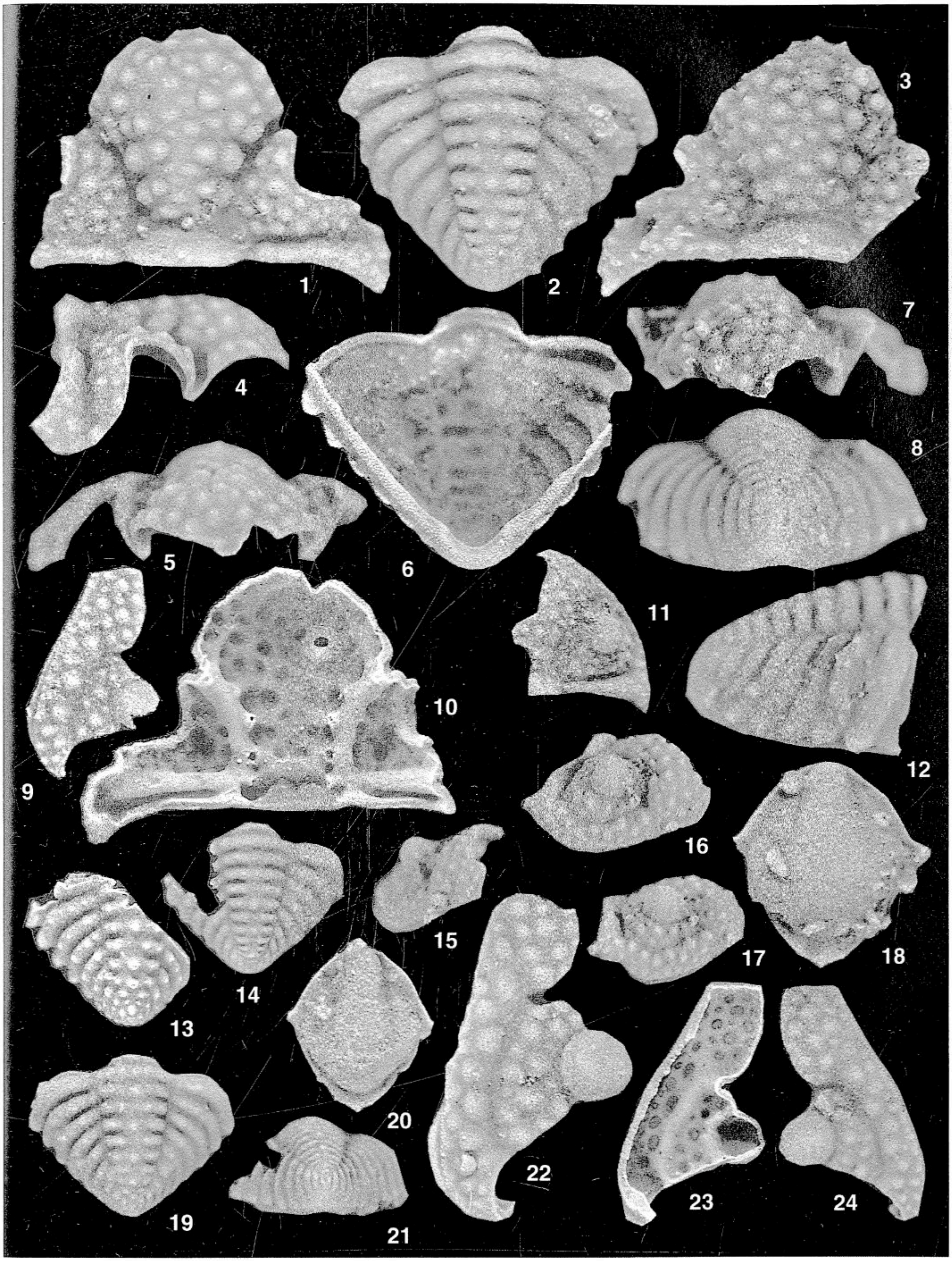

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

PLATE 21

Figs. 1-15, 18-20. *Frammia bachae* sp. nov.

Section BH 2 2-7.5 m and talus boulder ABR 3TT, Cape Phillips Formation, Wenlock (*C. lundgreni-M. testis* Zone), southern Baillie-Hamilton and northwestern Cornwallis Islands, central Canadian Arctic. Magnifications are x10 except where noted.

1, 4, 7, 11. Holotype cranidium ROM 50269, dorsal, anterior, left lateral, and ventral views (BH 2 3 m).
2, 5, 6. Cranidium ROM 50270, dorsal, anterior, and left lateral views (BH 2 2 m).
3, 10. Cranidium ROM 50271, dorsal and anterior views (BH 2 3 m).
8, 9. Cranidium ROM 50272, dorsal and left lateral views (BH 2 3 m).
12. Cranidium ROM 50273, dorsal view (BH 2 7.5 m).
13, 14. Cranidium ROM 50274, dorsal and anterior views, x15 (BH 2 2 m).
15. Cranidium ROM 50275, dorsal view, x7.5 (ABR 3TT).
18. Hypostome ROM 50276, ventral view (ABR 3TT).
19. Hypostome ROM 50277, ventral view (ABR 3TT).
20. Hypostome ROM 50278, ventral view (ABR 3TT).

Figs. 16, 17, 21. "*Struszia*" *mccartneyi* Edgecombe and Chatterton, 1993

Talus boulder ABR 3TT, Cape Phillips Formation, Wenlock (*C. lundgreni-M. testis* Zone to *Pristiograptus ludensis* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic, cranidium ROM 50673, anterior, dorsal, and right lateral views.

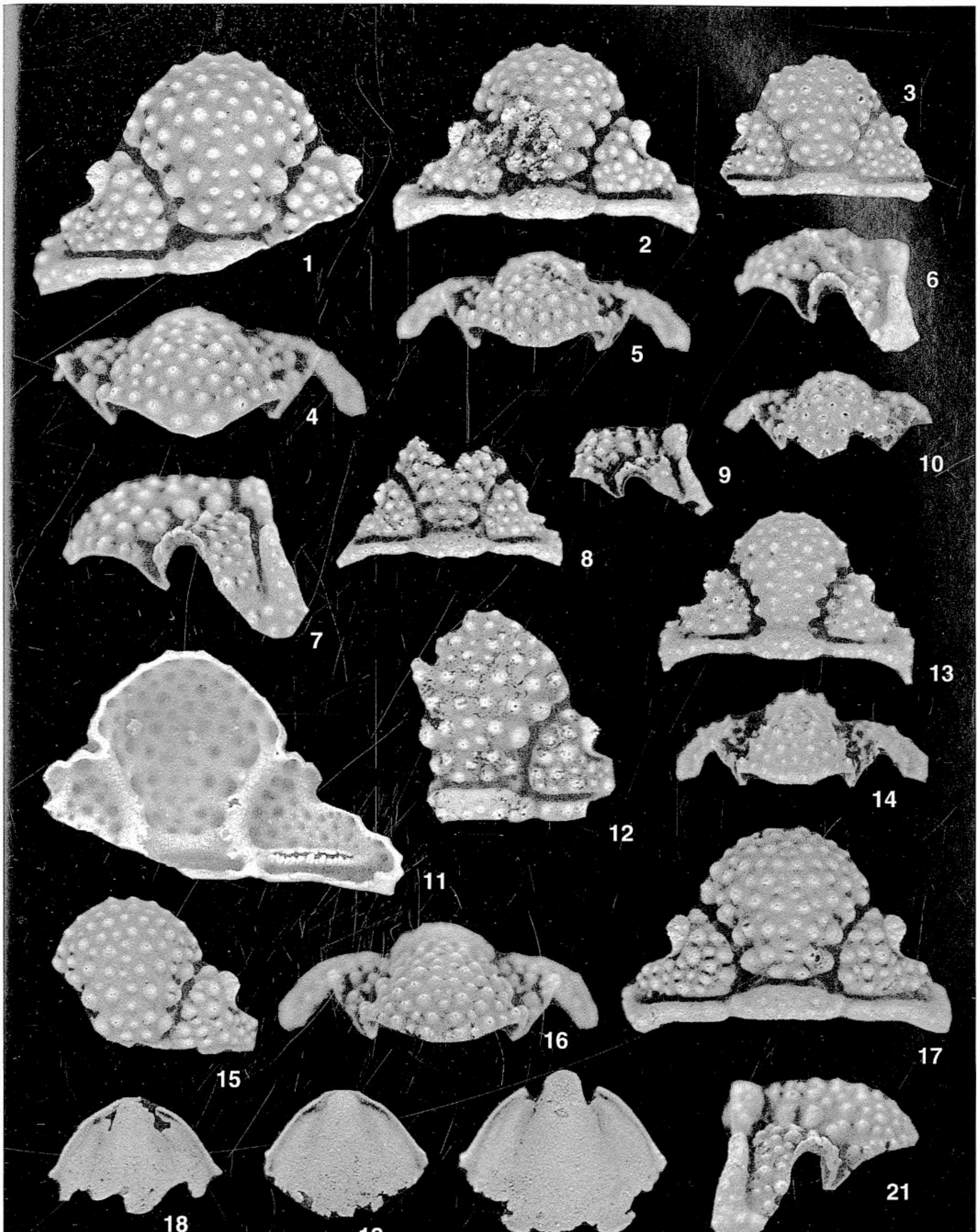

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21

PLATE 22

Figs. 1-16. *Frammia bachae* sp. nov.

Sections BH 2 2-3 m and ABR 1 9 m, Cape Phillips Formation, Wenlock (*C. lundgreni-M. testis* Zone), southern Baillie-Hamilton and northwestern Cornwallis Islands, central Canadian Arctic. Magnifications are x10 except where noted.

1-4. Hypostome ROM 50279, ventral, dorsal, anterior, and left lateral views (BH 2 3 m).
5. Left librigena ROM 50280, external view (BH 2 2 m).
6. Left librigena ROM 50281, external view (BH 2 3 m).
7, 8. Left librigena ROM 50282, external and internal views (BH 2 3 m).
9, 10. Thoracic segment ROM 50283, dorsal and anterior views (BH 2 3 m).
11. Thoracic segment ROM 50284, posterior view (BH 2 3 m).
12. Pygidium ROM 50285, dorsal view, x5 (ABR 1 9 m).
13, 16. Pygidium ROM 50286, left lateral and dorsal views (BH 2 3 m).
14, 15. Pygidium ROM 50287, dorsal and posterior views (BH 2 3 m).

Figs. 17-20. "*Struszia*" *mccartneyi* Edgecombe and Chatterton, 1993

Talus boulder ABR 3TT and section ABR 1 13.5 m, Cape Phillips Formation, Wenlock (*C. lundgreni-M. testis* Zone to *Pristiograptus ludensis* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic. All magnifications are x7.5.

17. Cranidium ROM 50288, dorsal view (ABR 3TT).
18. Cranidium ROM 50289, dorsal view (ABR 1 13.5 m).
19, 20. Right librigena ROM 50290, external and internal views (ABR 3TT).

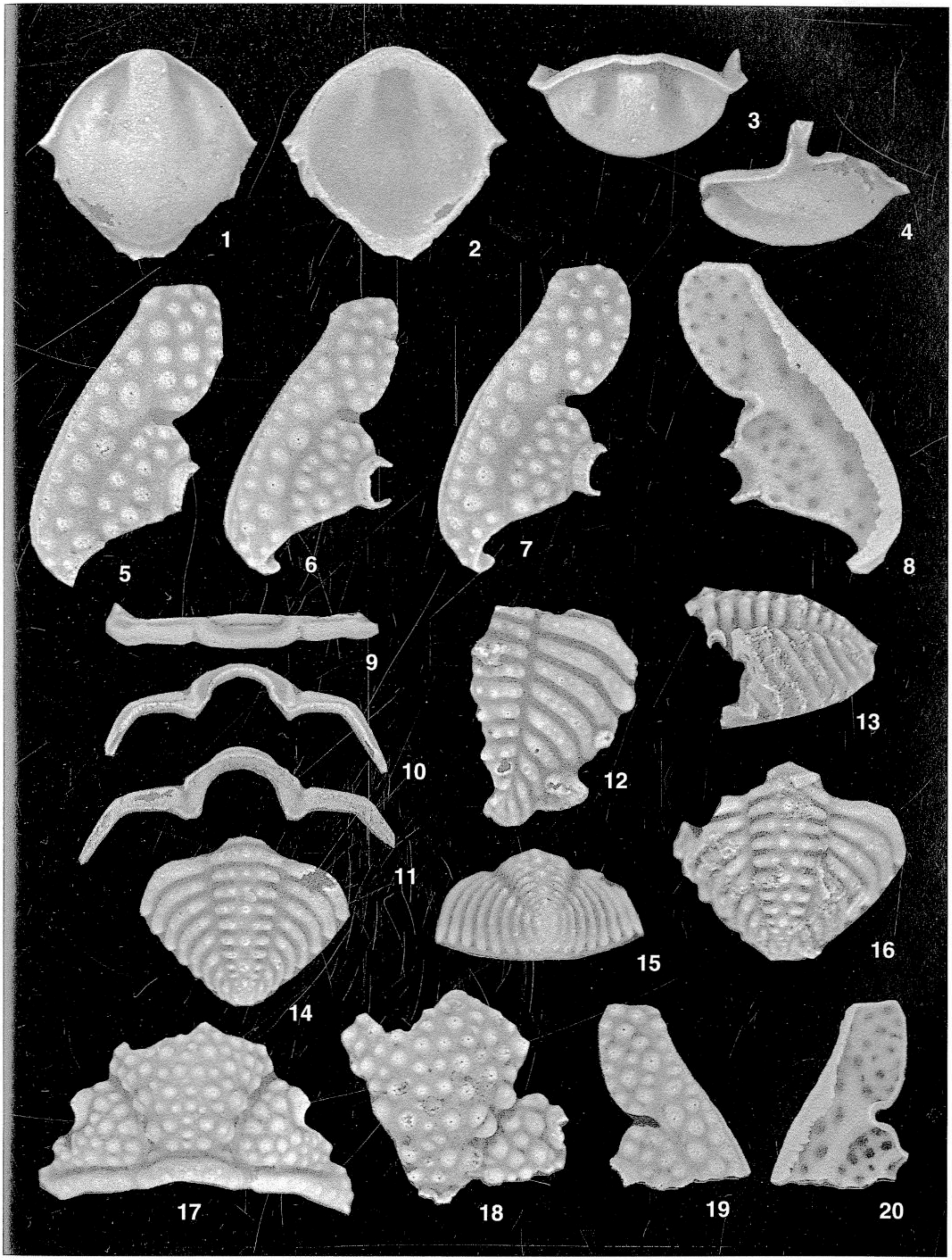

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

PLATE 23

Figs. 1-23. *Avalanchurus simoni* sp. nov.

Sections BH 1 195-209 m and BHL 1 92 m, and locality BHH, Cape Phillips Formation, Wenlock (Sheinwoodian; *C. perneri-M. opimus* Zone), southern Baillie-Hamilton Island, central Canadian Arctic.

1. Cranidium ROM 50354, dorsal view, x10 (BHL 1 92 m).

2, 5, 6. Holotype cranidium ROM 50355, dorsal, anterior, and right lateral views, x7.5 (BH 1 204 m).

3. Cranidium ROM 50356, dorsal view, x7.5 (BH 1 204 m).

4. Cranidium ROM 50357, dorsal view, x7.5 (BH 1 204 m).

7. Left librigena ROM 50358, external view, x10 (BHL 1 92 m).

8, 9. Cranidium ROM 50359, dorsal and left lateral views, x10 (BHH-C).

10, 11. Left librigena ROM 50360, external and internal views, x7.5 (BHH-C).

12. Right librigena ROM 50361, external view, x7.5 (BH 1 209 m).

13. Right librigena ROM 50362, external view, x10 (BHH-C).

14. Right librigena ROM 50363, external view, x10 (BHH-C).

15. Left librigena ROM 50364, external view, x7.5 (BHH-C).

16. Hypostome ROM 50365, ventral view, x10 (BHH-A).

17-19. Thoracic segment ROM 50366, right lateral, dorsal, and posterior views, x4 (BHH-A).

20-22. Hypostome ROM 50367, anterior, right lateral, and ventral views, x10 (BH 1 195 m).

23. Hypostome ROM 50368, ventral view, x10 (BHL 1 92 m).

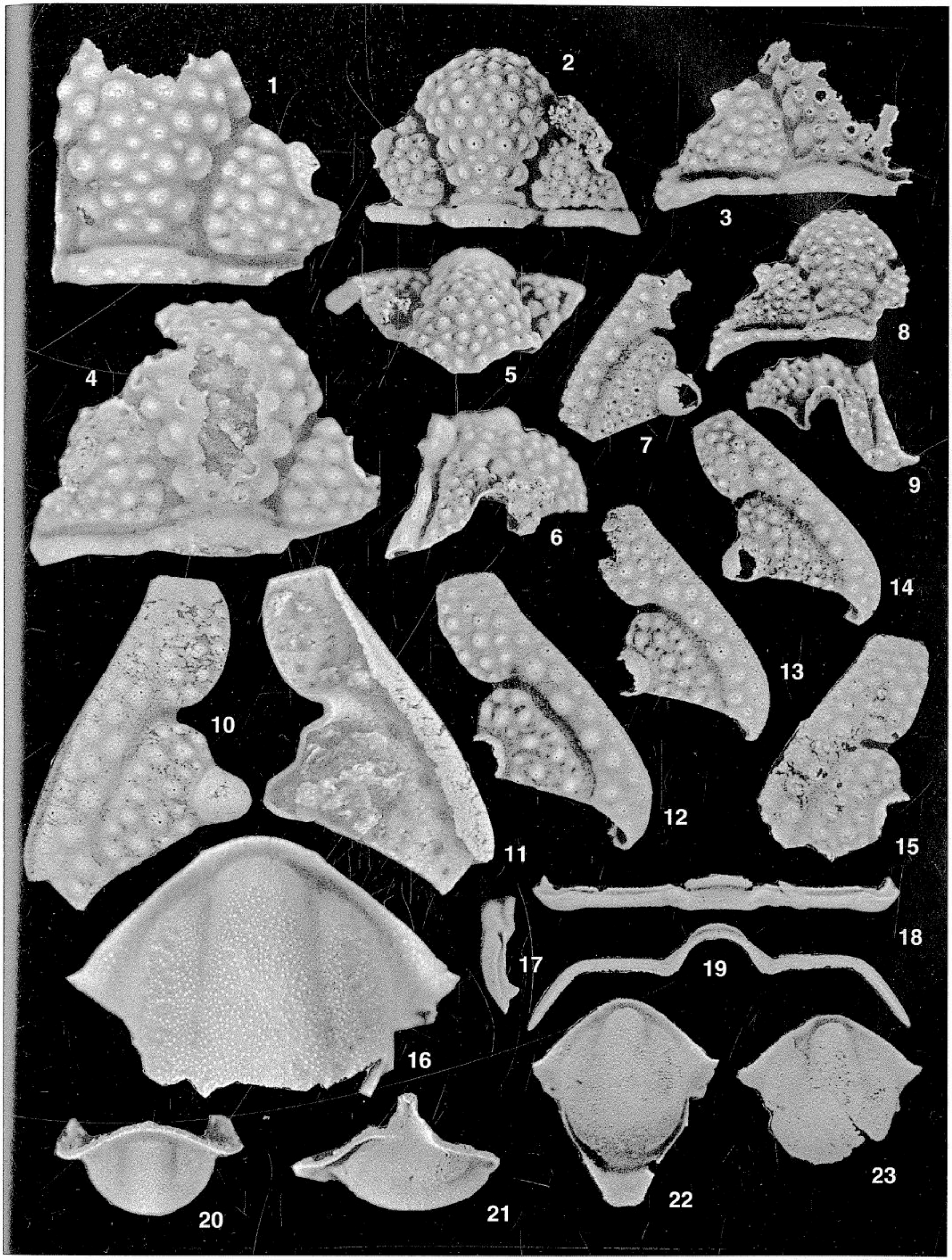

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23

PLATE 24

Figs. 1-10, 12. *Avalanchurus simoni* sp. nov.

Section BH 1 204 m and locality BHH, Cape Phillips Formation, Wenlock (Sheinwoodian; *C. perneri-M. opimus* Zone), southern Baillie-Hamilton Island, central Canadian Arctic.

1, 2, 4, 9. Pygidium ROM 50369, dorsal, left lateral, posterior, and ventral views, x5 (BHH-C).
3, 5, 6. Pygidium ROM 50370, left lateral, posterior, and dorsal views, x10 (BHH-C).
7, 8. Pygidium ROM 50371, dorsal and left lateral views, x10 (BH 1 204 m).
10. Pygidium ROM 50372, dorsal view, x10 (BHH-C).
12. Pygidium ROM 50373, dorsal view, x10 (BHH-C).

Figs. 11, 13-16. *Avalanchurus* sp. nov. A

Section ABR 2 27 m and talus boulder ABR TTC(3), Cape Phillips Formation, Wenlock (Sheinwoodian; *C. perneri-M. opimus* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic.

11. Cranidium ROM 50374, dorsal view, x7.5 (ABR TTC(3)).
13, 15. Hypostome ROM 50375, ventral and anterior views, x7.5 (ABR TTC(3)).
14. Cranidium ROM 50376, dorsal view, x10 (ABR 2 27 m).
16. Right librigena ROM 50377, external view, x6 (ABR 2 27 m).

Fig. 17. *Avalanchurus* sp. 1 aff. *A. garfunkeli* sp. nov.

Locality BHH-C, Cape Phillips Formation, Wenlock (Sheinwoodian; *C. perneri-M. opimus* Zone), southern Baillie-Hamilton Island, central Canadian Arctic, right librigena ROM 50378, external view, x7.5.

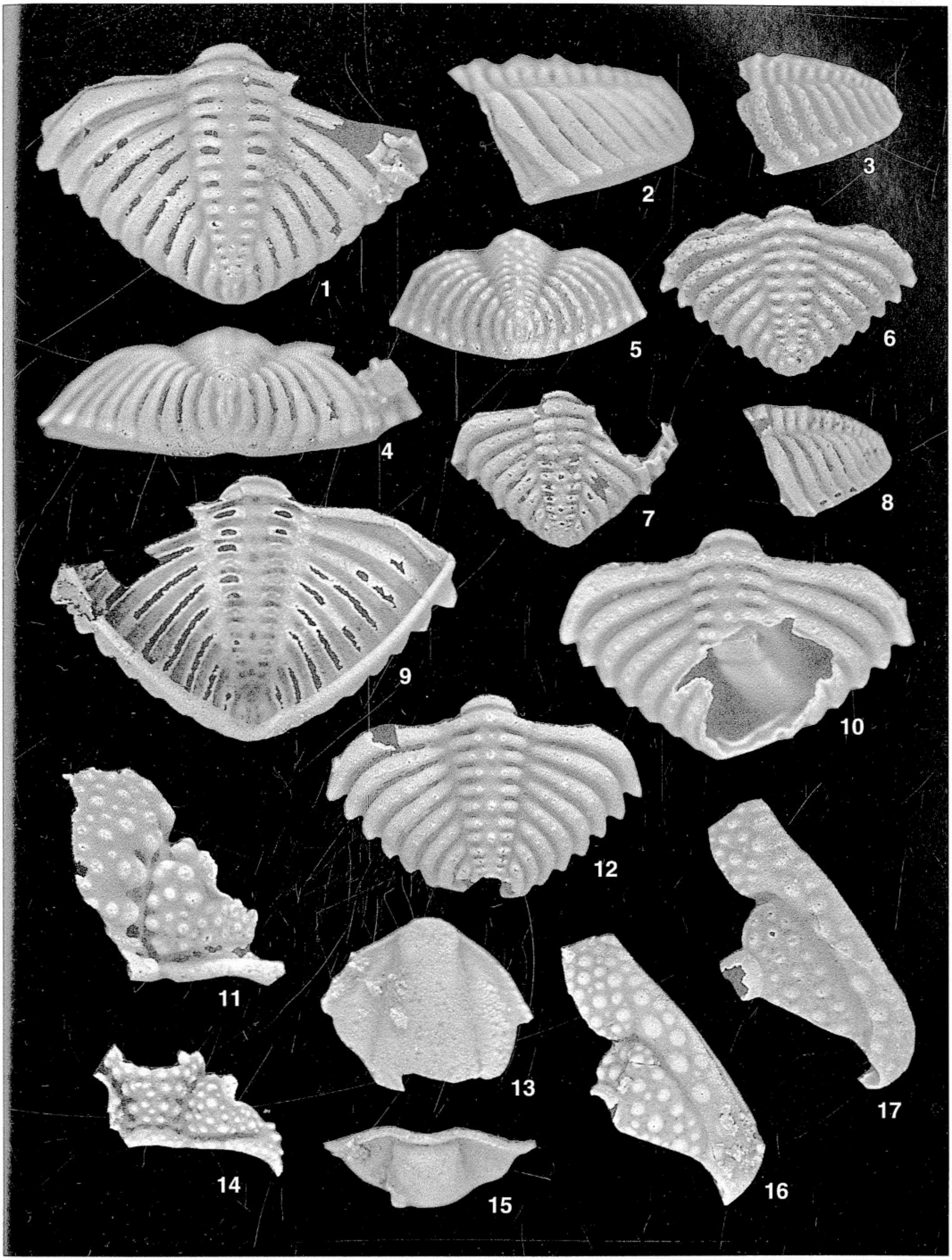

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

PLATE 25

Figs. 1-21. *Avalanchurus garfunkeli* sp. nov.

Sections ABR 1 9 m and BH 2 2-3 m, Cape Phillips Formation, Wenlock (Homerian; *C. lundgreni*-*M. testis* Zone), northwestern Cornwallis Island and southern Baillie-Hamilton Island, central Canadian Arctic. Magnifications are x10 except where noted.

1-3, 6. Holotype cranidium ROM 50392, dorsal, anterior, left lateral, and ventral views, fig. 6 x7.5 (ABR 1 9 m).
4. Right librigena ROM 50393, external view (BH 2 2 m).
5. Right librigena ROM 50394, external view (BH 2 2 m).
7. Left librigena ROM 50395, external view (BH 2 2 m).
8. Right librigena ROM 50396, internal view (ABR 1 9 m).
9, 10. Right librigena ROM 50397, external and ventrolateral views (BH 2 3 m).
11. Hypostome ROM 50398, ventral view (BH 2 3 m).
12. Left librigena ROM 50399, external view (BH 2 3 m).
13. Left librigena ROM 50400, external view (BH 2 3 m).
14, 15. Hypostome ROM 50401, ventral and left lateral views (BH 2 3 m).
16, 19. Hypostome ROM 50402, anterior and ventral views, x7.5 (BH 2 3 m).
17. Pygidium ROM 50403, dorsal view, x7.5 (BH 2 3 m).
18, 20, 21. Pygidium ROM 50404, dorsal, right lateral, and ventral views (BH 2 2 m).

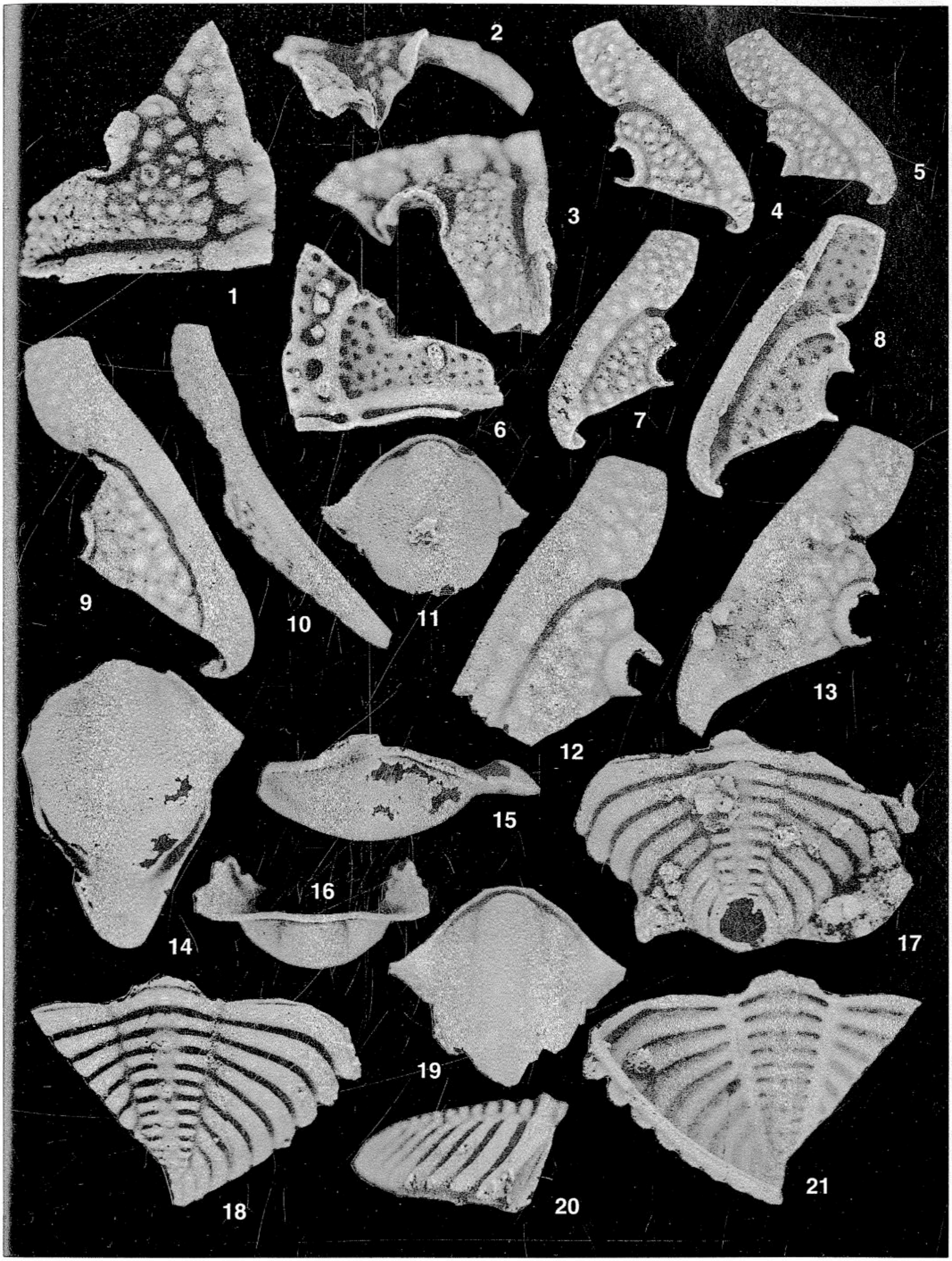

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21

PLATE 26

Figs. 1-12, 16. *Avalanchurus* cf. *A. lennoni* Edgecombe and Chatterton, 1993

Talus boulder ABR TTD, Cape Phillips Formation, Wenlock (Sheinwoodian; associated with shale talus containing graptolites of the *C. perneri-M. opimus* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic. Magnifications are x7.5 except where noted.

1, 2. Cranidium ROM 50379, dorsal and ventral views, x5.
3. Cranidium ROM 50380, dorsal view, x10.
4, 5, 6. Left librigena ROM 50381, external, ventrolateral, and internal views.
7. Right librigena ROM 50382, external view.
8. Right librigena ROM 5083, external view, x10.
9, 10. Hypostome ROM 50384, ventral and dorsal views, x10.
11. Hypostome ROM 50385, ventral view.
12. Left librigena ROM 50386, external view, x10.
16. Hypostome ROM 50387, ventral view.

Figs. 13-15, 17, 18. *Avalanchurus* sp. nov. B

Section ABR 1 17 m, Cape Phillips Formation, Wenlock (Homerian; *Pristiograptus ludensis* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic.

13, 17. Cranidium ROM 50388, dorsal and ventral views, x6.
14, 15. Right librigena ROM 50389, internal and external views, x5.
18. Cranidium ROM 50390, ventral view, x6.

Fig. 19. *Avalanchurus* sp. 2

Section BH 2 42 m, Cape Phillips Formation, Ludlow (Gorstian; *Lobograptus progenitor* Zone), southern Baillie-Hamilton Island, central Canadian Arctic. Cranidium ROM 50391, dorsal view, x5.

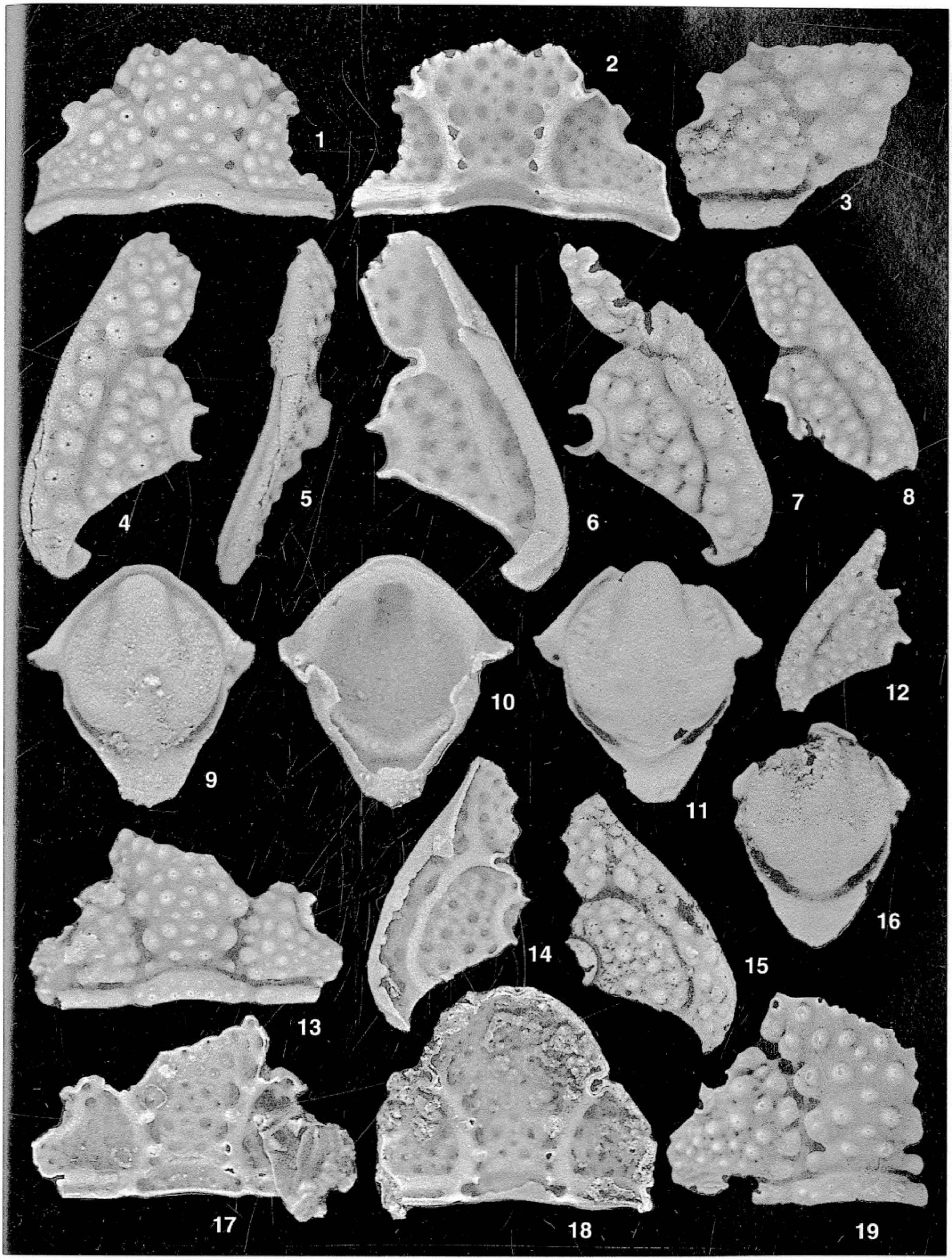

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

PLATE 27

Figs. 1-19, 20-23? *Mackenziurus joeyi* sp. nov.

Section BHL 1 92 m, Cape Phillips Formation, Wenlock (Sheinwoodian; *C. perneri-M. opimus* Zone), southern Baillie-Hamilton Island, central Canadian Arctic. Magnifications are x10 except where noted.

1, 4, 7, 8. Holotype cranidium ROM 50405, dorsal, anterior, right lateral, and ventral views, x7.5.
2, 5, 9. Cranidium ROM 50406, dorsal, anterior, and left lateral views.
3. Cranidium ROM 50407, dorsal view.
6, 10. Cranidium and left librigena ROM 50408, dorsal and anterior views, x7.5.
11, 13. Cranidium ROM 50409, dorsal and right lateral views.
12, 14, 15. Cranidium ROM 50410, anterior, dorsal, and left lateral views.
16, 18, 19. Cranidium ROM 50411, dorsal, anterior, and left lateral views.
17. Cranidium ROM 50412, dorsal view.
20-23. Hypostome ROM 50413, ventral, dorsal, right lateral, and anterior views, tentatively referred to species.

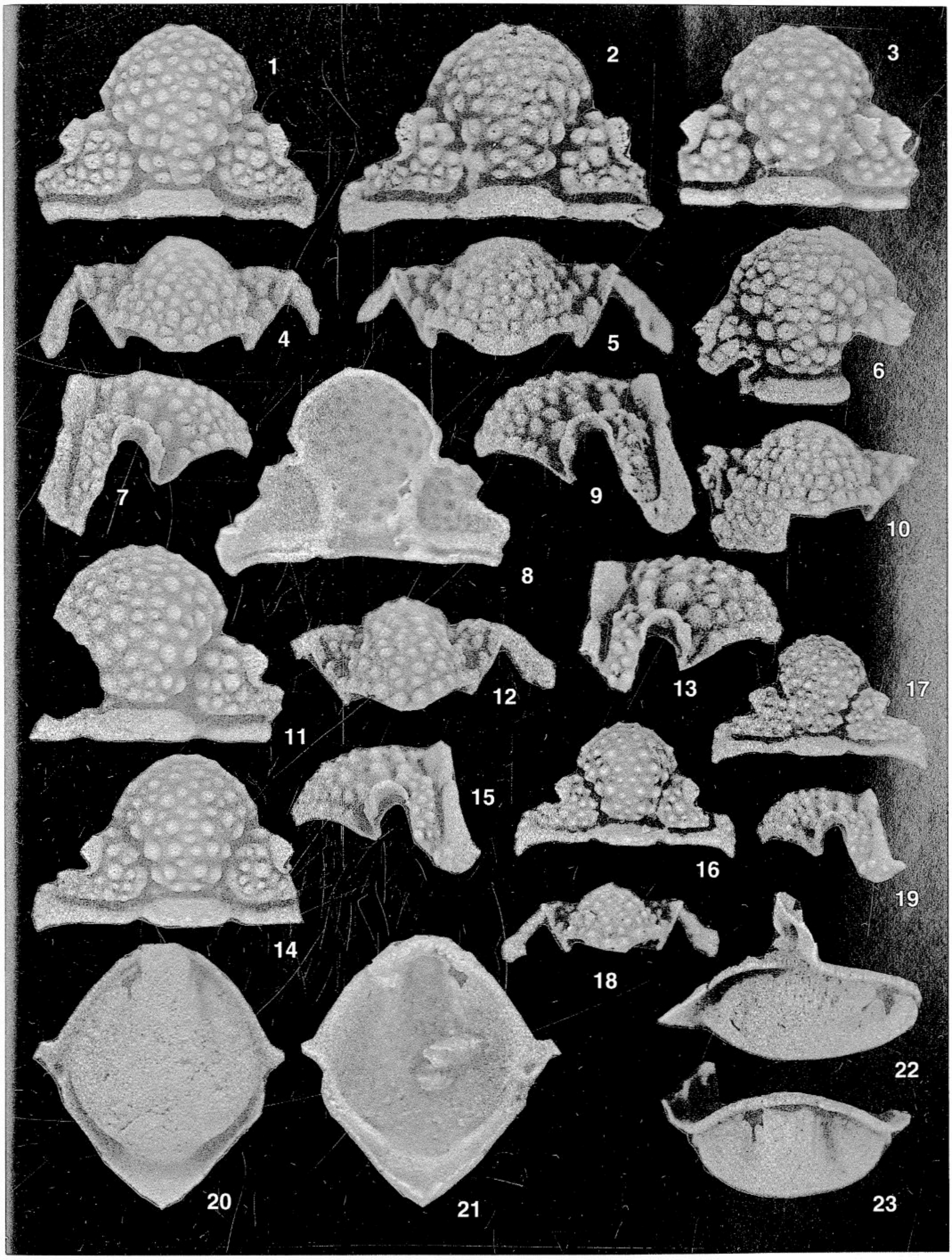

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23

PLATE 28

Figs. 1-22. *Mackenziurus joeyi* sp. nov.

Section BHL 1 92 m, Cape Phillips Formation, Wenlock (Sheinwoodian; *C. perneri-M. opimus* Zone), southern Baillie-Hamilton Island, central Canadian Arctic. Magnifications are x10 except where noted.

1, 2, 6, 7. Cranidium and right librigena ROM 50414, dorsal, anterior, right lateral, and oblique views, x7.5.
3, 8. Right librigena ROM 50415, internal and external views.
4. Left librigena ROM 50416, external view.
5. Left librigena ROM 50417, external view.
9, 17, 19. Pygidium ROM 50418, left lateral, dorsal, and posterior view.
10, 11. Right librigena ROM 50419, ventrolateral and external views.
12. Right librigena ROM 50420, external view.
13, 14. Thoracic segment ROM 50422, posterior and dorsal views.
15, 20. Pygidium ROM 50423, posterior and dorsal views.
16, 18. Pygidium ROM 50424, dorsal and posterior views.
21, 22. Pygidium ROM 50425, dorsal and posterior views.

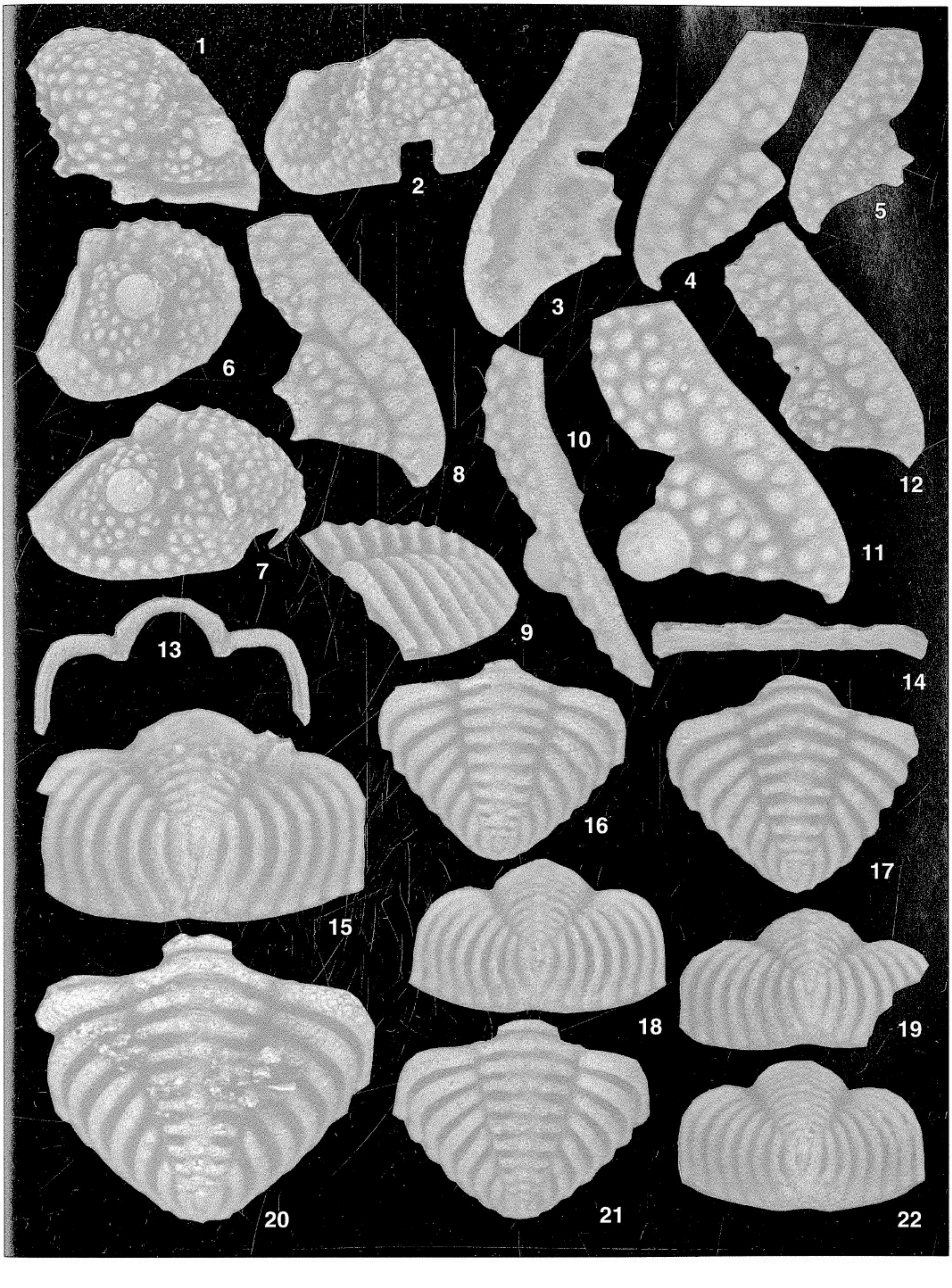

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

PLATE 29

Figs. 1-22. *Mackenziurus ceejayi* sp. nov.

Talus boulder ABR TTD, Cape Phillips Formation, Wenlock (Sheinwoodian, *C. perneri-M. opimus* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic. Magnifications are x10 except where otherwise noted.

1, 4. Cranidium ROM 50426, dorsal and right lateral views.
2, 5, 8. Holotype cranidium ROM 50427, dorsal, left lateral, and anterior views.
3, 6. Cranidium ROM 50428, dorsal and left lateral views.
7, 10. Cranidium ROM 50429, dorsal and left lateral views, x7.5.
9, 12, 13. Hypostome ROM 50430, ventral, dorsal, and anterior views.
11, 14-16. Cranidium ROM 50431, dorsal, left lateral, ventral, and anterior views.
17. Hypostome ROM 50432, ventral view.
18. Cranidium ROM 50433, dorsal view.
19. Cranidium ROM 50434, dorsal view.
20-22. Thoracic segment ROM 50435, right lateral, dorsal, and anterior views, x7.5.

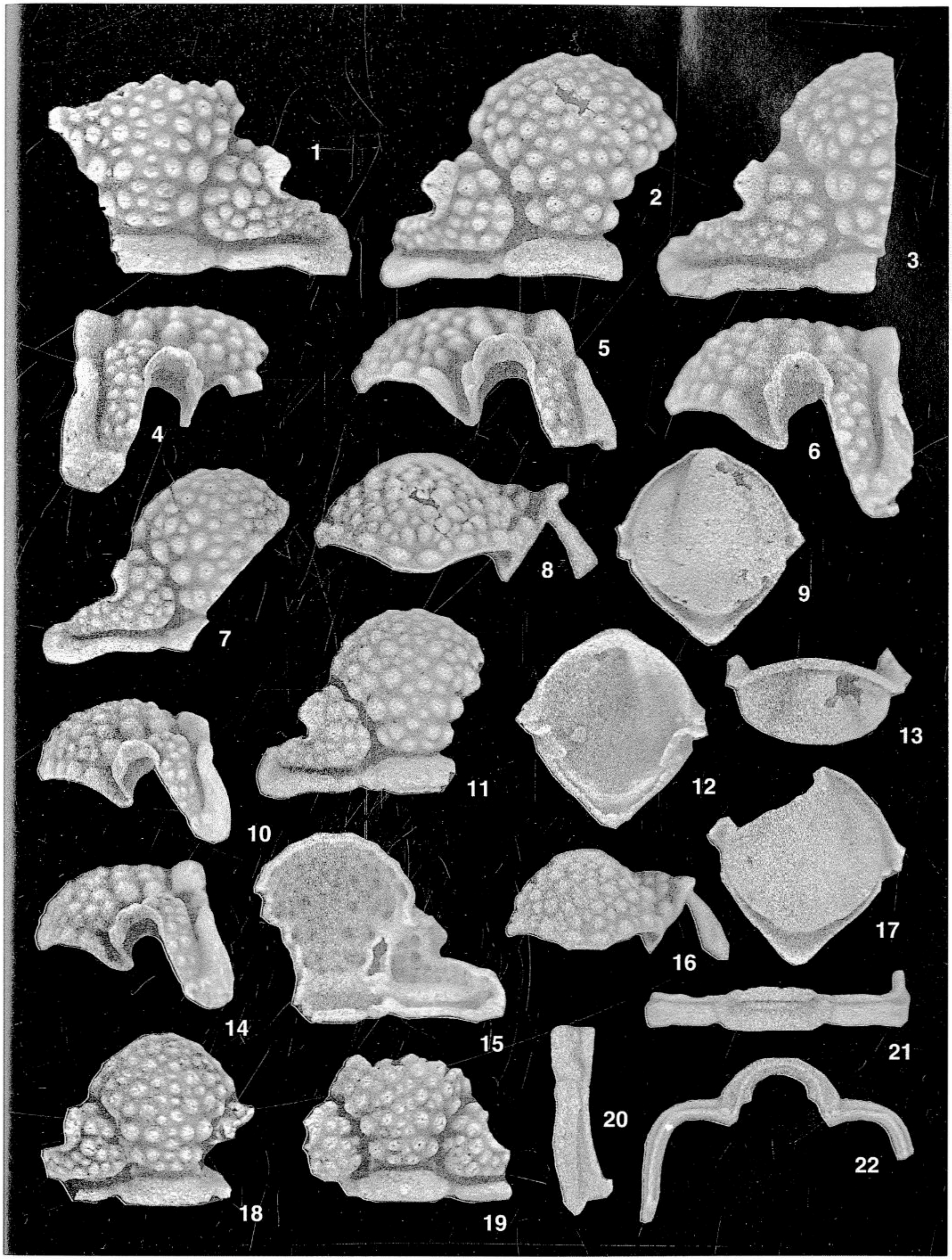

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

PLATE 30

Figs. 1-22. *Mackenziurus ceejayi* sp. nov.

Talus boulder ABR TTD, Cape Phillips Formation, Wenlock (Sheinwoodian, *C. perneri*-*M. opimus* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic. Magnifications are x10 except where otherwise noted.

1. Left librigena ROM 50436, external view.
2, 3. Left librigena ROM 50437, external and internal views.
4. Right librigena ROM 50438, external view.
5. Right librigena ROM 50439, external view.
6. Left librigena ROM 50440, external view.
7, 8, 9, 10. Pygidium ROM 50441, posterior, left lateral, ventral, and dorsal views, x10 except fig. 9, x7.5.
11, 15. Pygidium ROM 50442, left lateral and dorsal views, x7.5.
12. Right librigena ROM 50443, external views.
13, 14. Pygidium ROM 50444, posterior and dorsal views, x7.5.
16, 17, 22. Pygidium ROM 50445, posterior, left lateral, and dorsal views.
18, 19. Pygidium ROM 50446, posterior and dorsal views, x7.5.
20, 21. Pygidium ROM 50447, dorsal and posterior views.

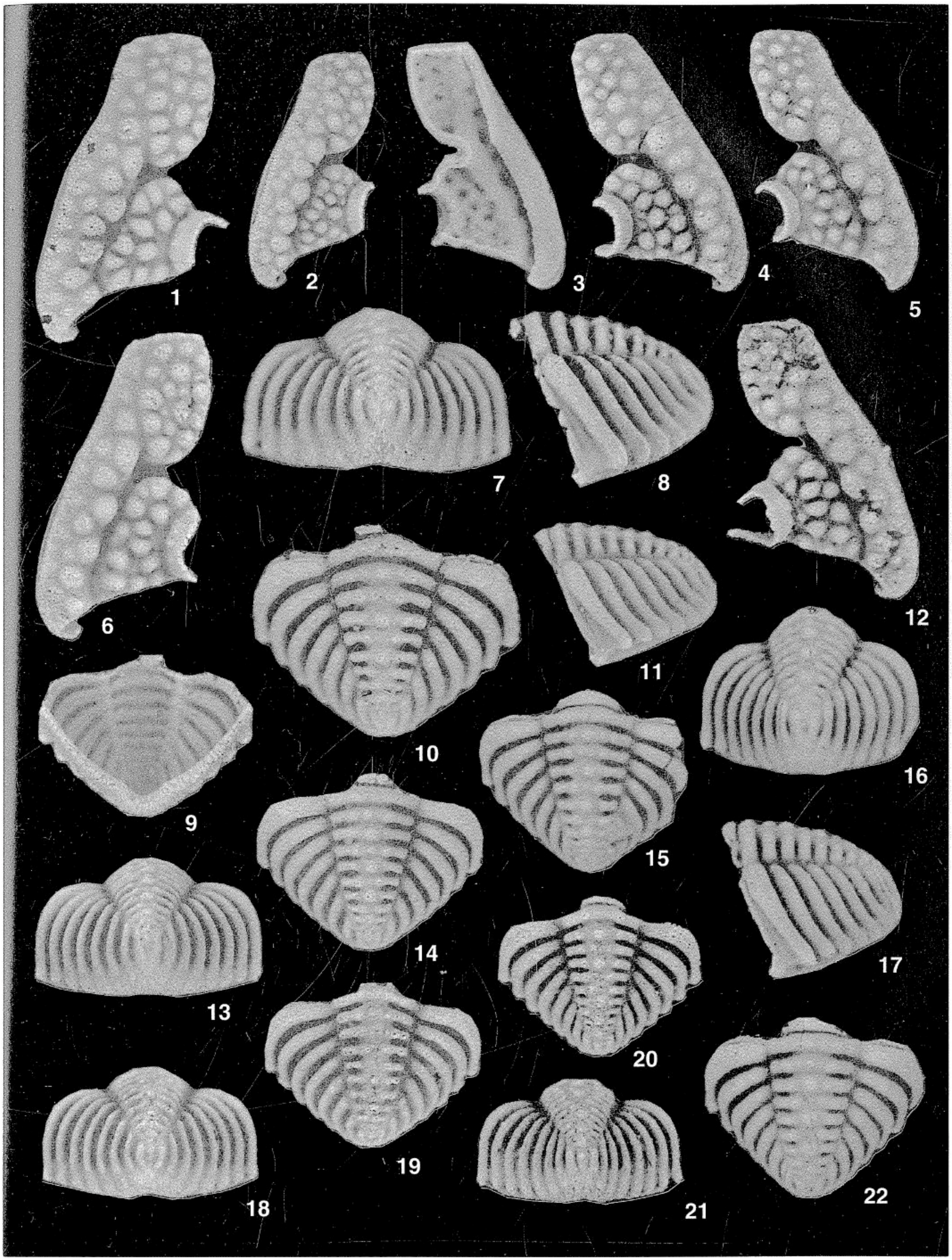

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

PLATE 31

Figs. 1-26. *Mackenziurus deedeei* sp. nov.

Section ABR 1 5.5-13.5 m, Cape Phillips Formation, Wenlock (*C. lundgreni-M. testis* Zone to *Pristiograptus ludensis* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic. Magnifications are x10 except where noted otherwise.

1, 2, 5. Holotype cranidium and left librigena ROM 50448, dorsal, left lateral, and anterior views, x7.5 (ABR 1 6 m).
3, 6. Cranidium ROM 50449, dorsal and right lateral views (ABR 1 5.5 m).
4. Right librigena ROM 50450, external view (ABR 1 5.5 m).
7, 12. Pygidium ROM 50451, dorsal and posterior views, x7.5 (ABR 1 9 m).
8. Left librigena ROM 50452, external view (ABR 1 13.5 m).
9. Left librigena ROM 50453, external view (ABR 1 13.5 m).
10. Left librigena ROM 50454, external view (ABR 1 6 m).
11. Cranidium ROM 50455, dorsal view (ABR 1 13.5 m).
13, 16, 20. Pygidium ROM 50456, right lateral, dorsal, and posterior views (ABR 1 13.5 m).
14, 18. Pygidium ROM 50457, posterior and dorsal views, x7.5 (ABR 1 13.5 m).
15. Right librigena ROM 50458, external view (ABR 1 5.5 m).
17, 21. Pygidium ROM 50459, posterior and dorsal views (ABR 1 6 m).
19, 22, 25. Hypostome ROM 50460, anterior, ventral, and right lateral views (ABR 1 13.5 m).
23, 24, 26. Hypostome ROM 50461, anterior, right lateral, and ventral views (ABR 1 9 m).

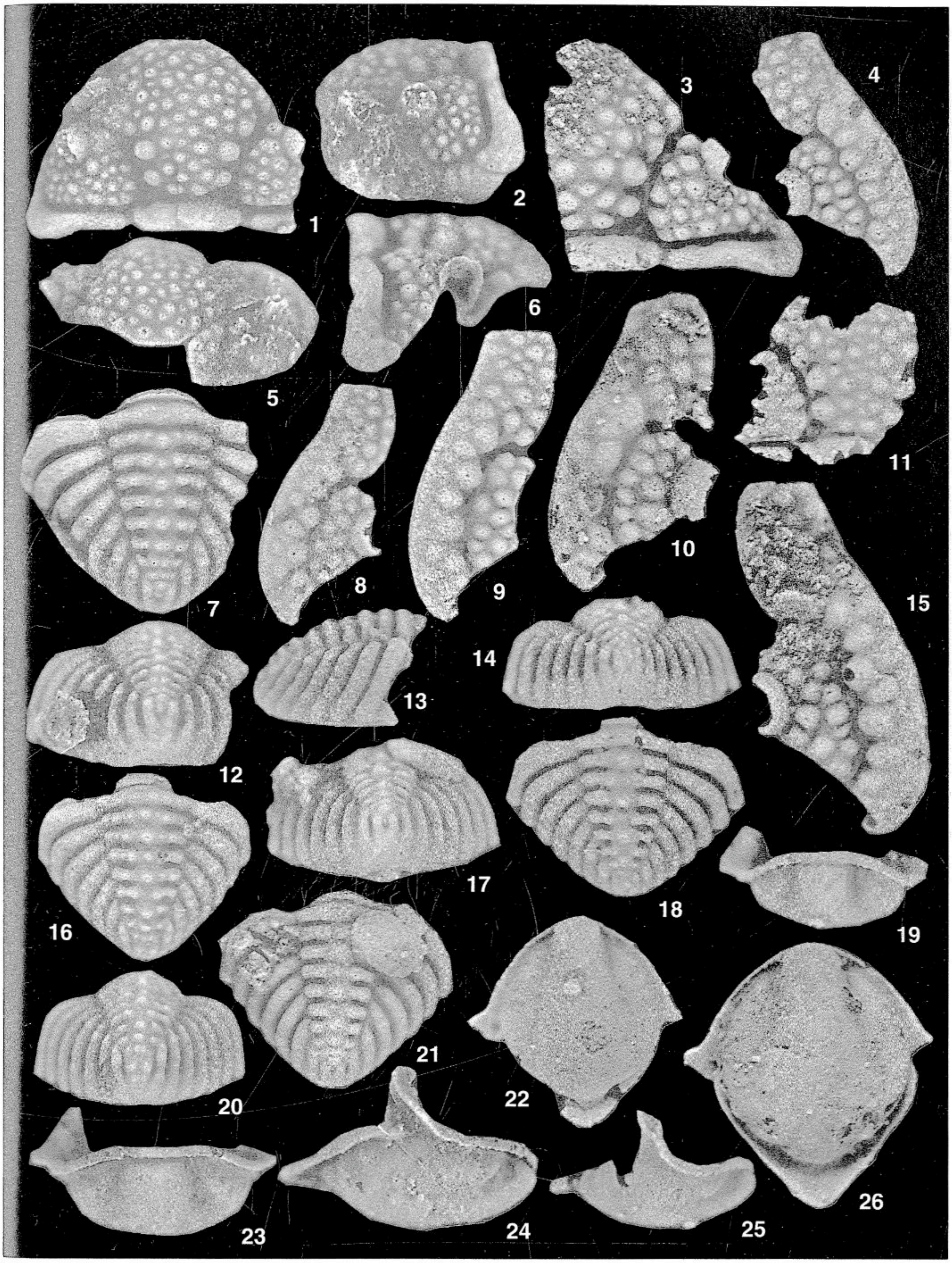

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26

PLATE 32

Figs. 1-24. *Mackenziurus deedeei* sp. nov.

Section BH 2 2-6.5 m, Cape Phillips Formation, Wenlock (Homerian; *C. lundgreni-M. testis* Zone), southern Baillie-Hamilton Island, central Canadian Arctic. All magnifications are x10.

1, 4, 7, 8. Cranidium ROM 50462, dorsal, left lateral, anterior, and ventral views (BH 2 3 m).
2, 5. Cranidium ROM 50463, dorsal and anterior views (BH 2 2 m); specimen assigned with question (see text).
3, 6, 9. Cranidium ROM 50464, dorsal, right lateral, and anterior views (BH 2 3 m).
10, 11. Cranidium ROM 50465, dorsal and right lateral views (BH 2 3 m).
12, 14. Cranidium ROM 50466, dorsal and left lateral views (BH 2 3 m).
13, 16. Cranidium ROM 50467, dorsal and left lateral views (BH 2 6.5 m).
15, 18, 22, 23. Hypostome ROM 50469, left lateral, ventral, and dorsal views (BH 2 3 m).
17. Cranidium ROM 50468, dorsal view (BH 2 6.5 m).
19, 20. Hypostome ROM 50470, left lateral and ventral views (BH 2 6.5 m).
21. Hypostome ROM 50471, ventral view (BH 2 3 m).
24. Hypostome ROM 50472, ventral view (BH 2 6.5 m).

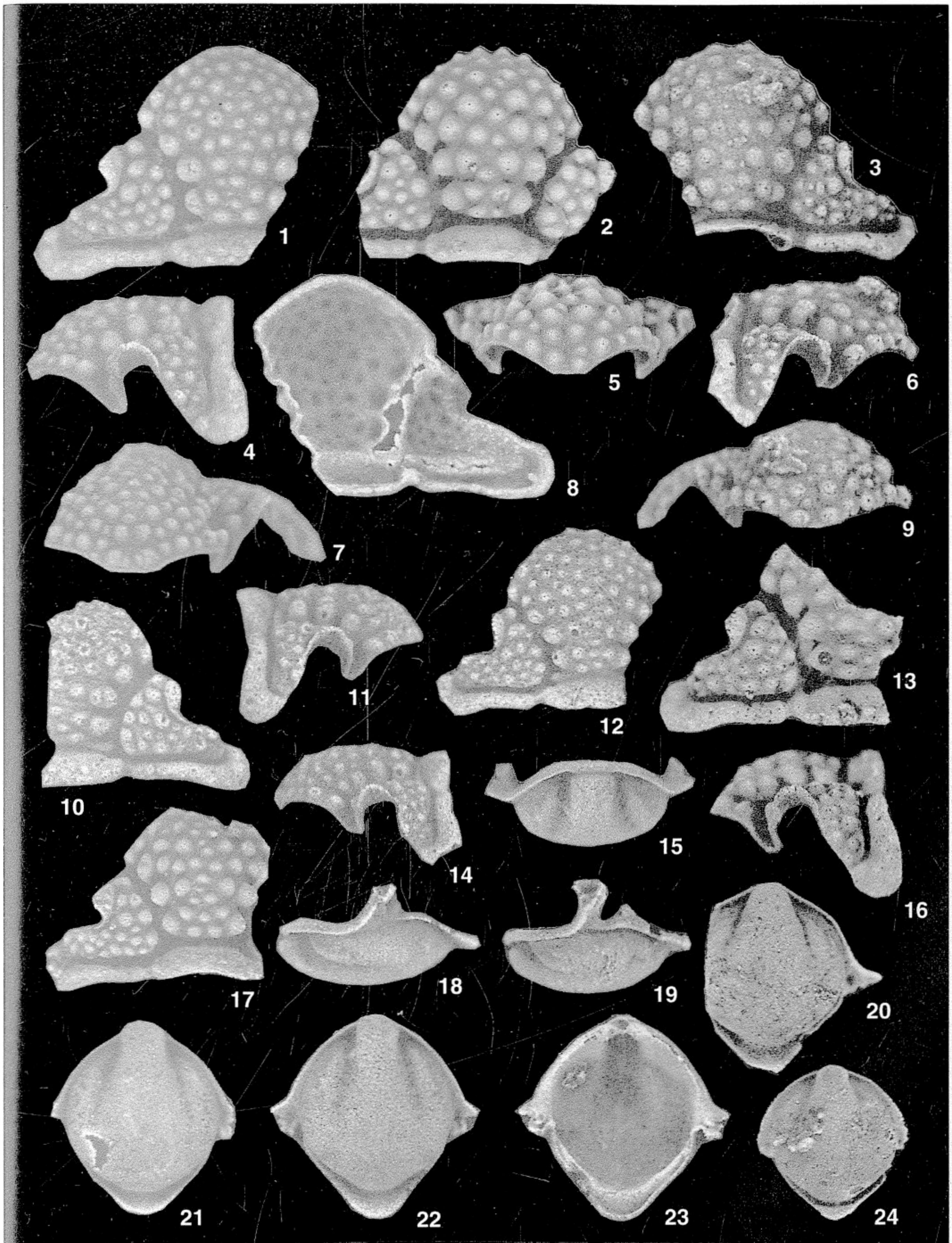

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

PLATE 33

Figs. 1-22. *Mackenziurus deedeei* sp. nov.

Section BH 2 2-3 m, Cape Phillips Formation, Wenlock (Homerian; *C. lundgreni-M. testis* Zone), southern Baillie-Hamilton Island, central Canadian Arctic. Magnifications are x10, except where noted otherwise.

1-3. Thoracic segment ROM 50473, dorsal, anterior, and right lateral views (BH 2 3 m).
4, 5. Thoracic segment ROM 50474, anterior and dorsal views (BH 2 3 m).
6. Cranidium ROM 50475, dorsal view, x7.5 (BH 2 3 m).
7, 10, 12. Pygidium ROM 50476, dorsal, posterior, and left lateral views (BH 2 2 m).
8, 11, 13, 14. Pygidium ROM 50477, dorsal, left lateral, posterior, and ventral views (BH 2 3 m).
9. Pygidium ROM 50478, dorsal view (BH 2 3 m).
15, 19. Pygidium ROM 50479, dorsal and posterior views (BH 2 3 m).
16, 17. Pygidium ROM 50480, dorsal and left lateral views (BH 2 2 m).
18, 22. Pygidium ROM 50481, dorsal and left lateral views (BH 2 2 m).
20, 21. Pygidium ROM 50482, dorsal and left lateral views (BH 2 2 m).

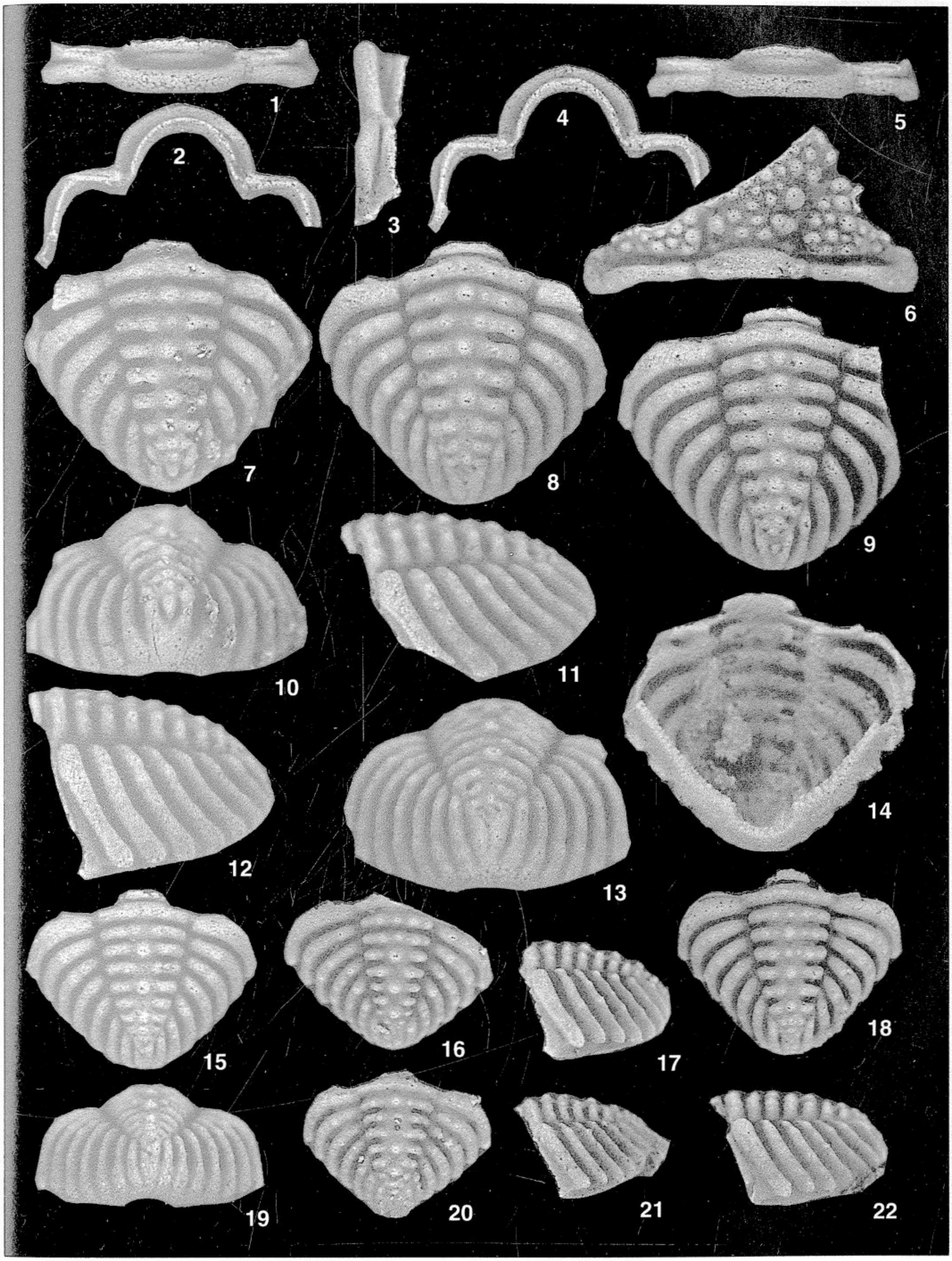

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

PLATE 34

Figs. 1-11. *Mackenziurus deedeei* sp. nov.

Section BH 2 2-3 m, Cape Phillips Formation, Wenlock (Homerian; *C. lundgreni-M. testis* Zone), southern Baillie-Hamilton Island, central Canadian Arctic. Magnifications are x10.

1-3. Right librigena ROM 50483, internal, external, and ventrolateral views (BH 2 3 m).
4. Right librigena ROM 50484, external view (BH 2 2 m).
5. Right librigena ROM 50485, external view (BH 2 2 m).
6. Right librigena ROM 50486, external view (BH 2 3 m).
7. Left librigena ROM 50487, external view (BH 2 3 m).
8. Left librigena ROM 50650, external view (BH 2 2 m).
9. Left librigena ROM 50651, external view (BH 2 3 m).
10. Left librigena ROM 50652, external view (BH 2 3 m).
11. Left librigena and rostral plate ROM 50653, internal view (BH 2 2 m).

Figs. 12-23, 25, 26. *Mackenziurus deedeei* sp. nov.?

Talus boulder ABR 3TT, Cape Phillips Formation, Wenlock (Homerian; probably *C. lundgreni-M. testis* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic. Magnifications are 10, except where noted otherwise.

12. Cranidium ROM 50654, dorsal view, x7.5.
13, 17. Left librigena ROM 50655, internal and external views.
14. Right librigena ROM 50656, external view.
15, 21, 22, 26. Pygidium ROM 50657, right lateral, dorsal, ventral, and posterior views.
16, 23, 25. Pygidium ROM 50658, left lateral, dorsal, and posterior views.
18-20. Thoracic segment ROM 50659, dorsal, anterior, and left lateral views, x7.5.

Figs. 24, 27-29. *Mackenziurus* aff. *M. joeyi* sp. nov.

Section ABR 2 27 m and talus boulder ABR TTC(3), Cape Phillips Formation, Wenlock (Sheinwoodian; *C. perneri-M. opimus* Zone), near Abbott River, northwestern Cornwallis Island, central Canadian Arctic.

24, 27, 28. Pygidium ROM 50660, posterior, dorsal, and right lateral views, x10 (ABR 2 27 m).
29. Right librigena ROM 50661, external view, x7.5 (ABR TTC(3)).

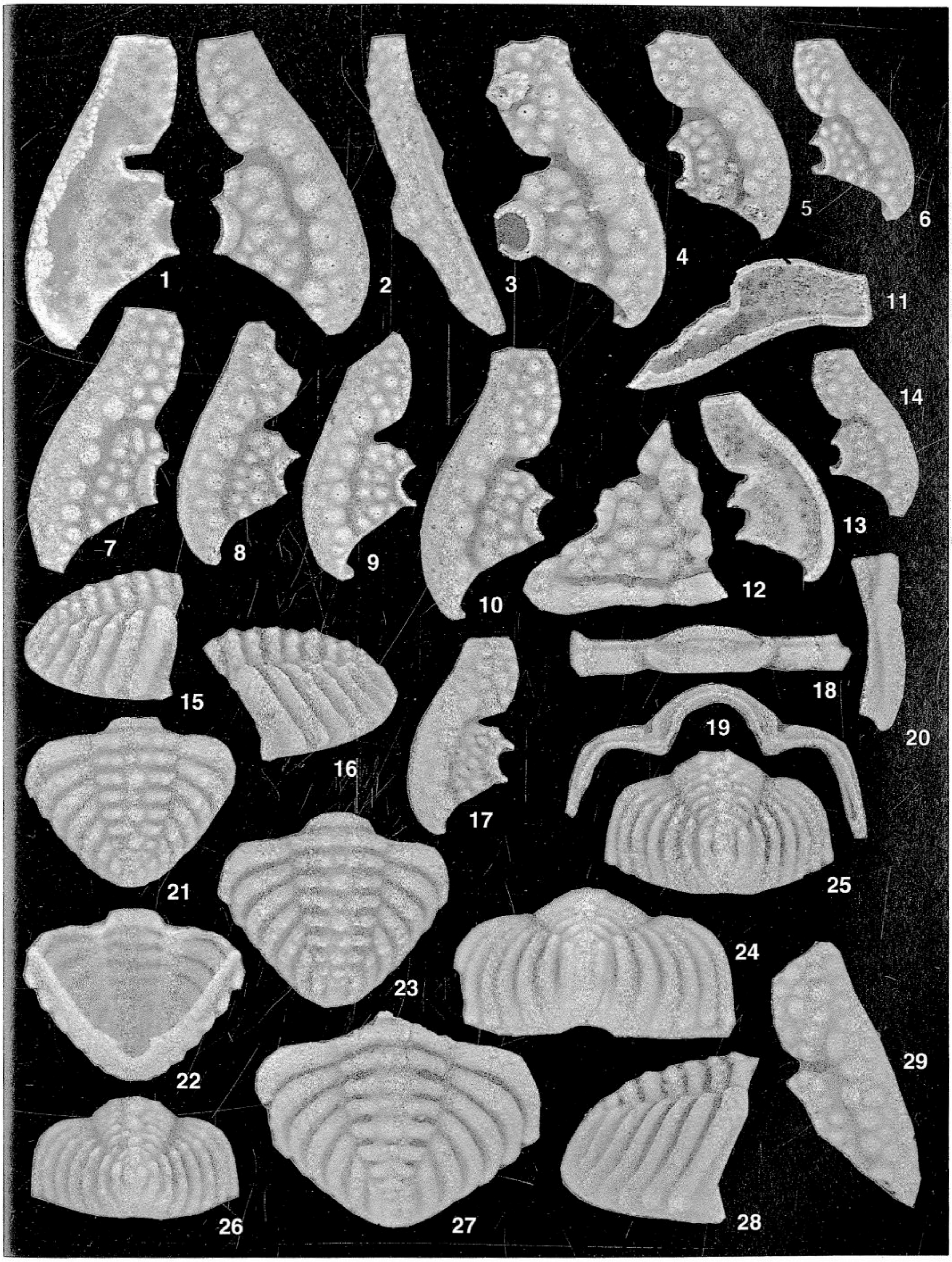
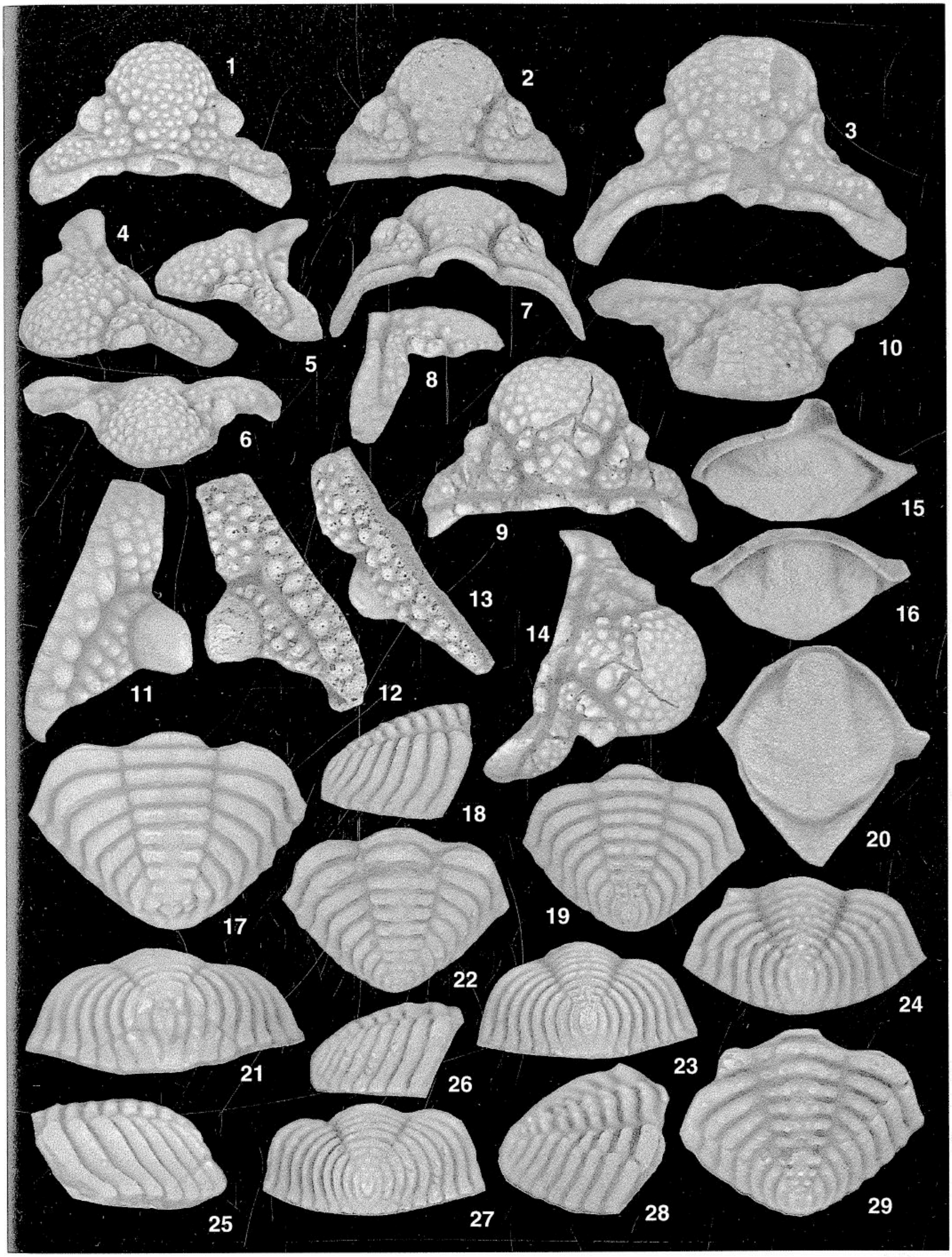

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

PLATE 35

Figs. 1-29. *Mackenziurus johnnyi* sp. nov.

Localities GSC 3, GSC 7, and GSC 8, Douro Formation, upper Ludlow, near Goodsir Creek, eastern Cornwallis Island, central Canadian Arctic. All specimens are calcareous.

1, 4-6. Holotype cranidium ROM 50662, dorsal, oblique, left dorsolateral, and anterior views, x5 (GSC 3).
2, 7, 8. Cranidium ROM 50663, dorsal, posterior, and right lateral views, x5 (GSC 8).
3, 10. Cranidium ROM 50664, dorsal and anterior views, x5 (GSC 8).
9, 14. Cranidium ROM 50665, dorsal and oblique views, x5 (GSC 8).
11. Left librigena ROM 50666, external view, x7.5 (GSC 3).
12, 13. Right librigena ROM 50667, external and ventrolateral views, x10 (GSC 8).
15, 16, 20. Hypostome ROM 50668, left lateral, anterior, and ventral views, x10 (GSC 7).
17, 21, 25. Pygidium ROM 50669, dorsal, posterior, and left lateral views, x5 (GSC 8).
18, 19, 23. Pygidium ROM 50670, right lateral, dorsal, and posterior views, x5 (GSC 8).
22, 26, 27. Pygidium ROM 50671, dorsal, right lateral, and posterior views, x5 (GSC 8).
24, 28, 29. Pygidium ROM 50672, posterior, right lateral, and dorsal views, x7.5 (GSC 8).


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29