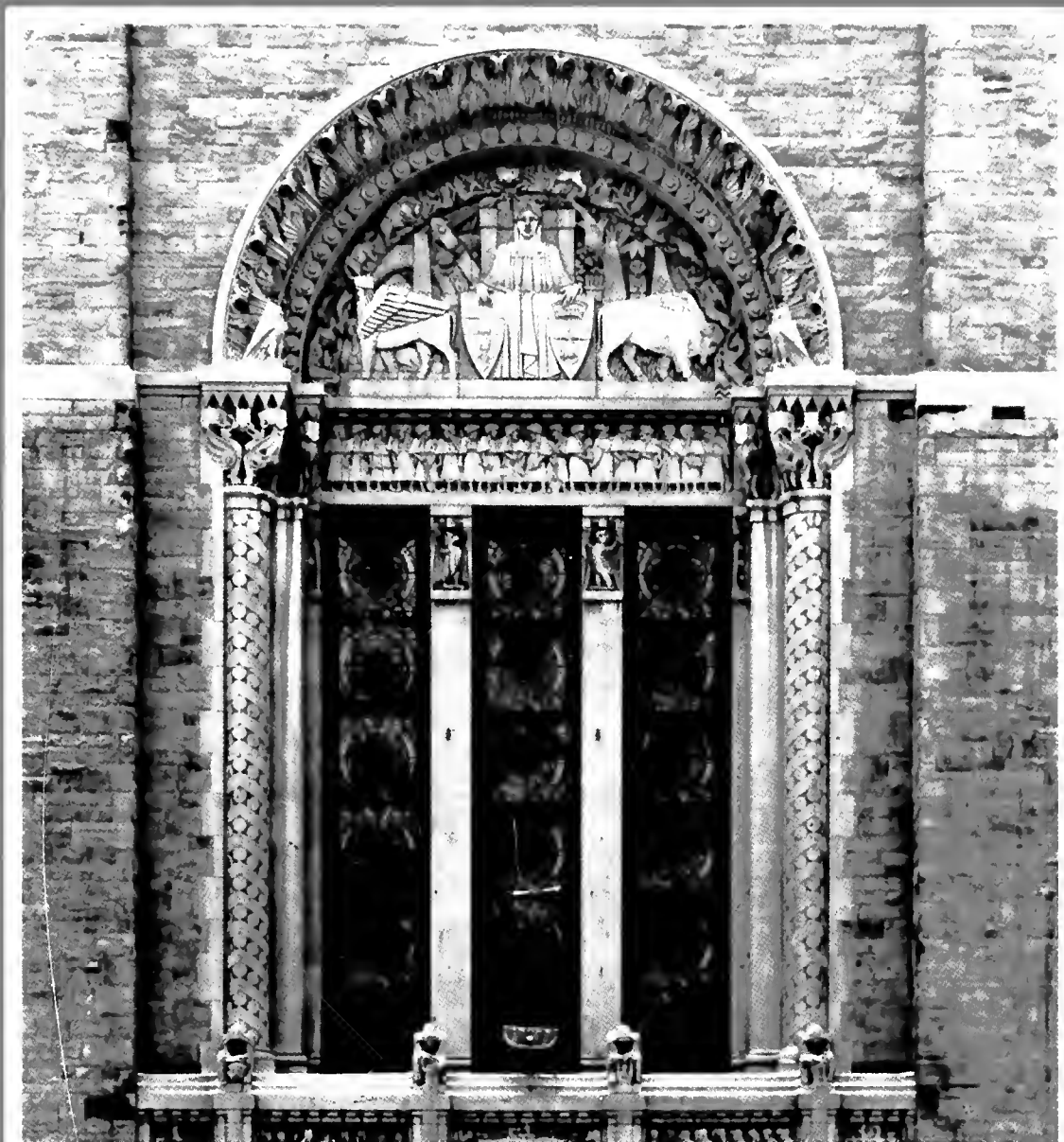


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Silurian Trilobites from the Northern Yukon Territory

Rolf Ludvigsen and Ronald P. Tripp

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Silurian Trilobites from
the Northern Yukon Territory

Rolf Ludvigsen
and
Ronald P. Tripp


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Silurian Trilobites from the Northern Yukon Territory

Abstract

Silurian trilobites are described from two contrasting facies in the northern Yukon Territory: basinal sediments of the Road River Formation at Prongs Creek and shallow-water limestones of the Illtyd Range. An *Otarion* Association from dark grey, argillaceous lime mudstones (Lower Silurian) consists of *Kosovopeltis*, *Otarion* (*Songkania*), *Cromus*, and *Leonaspis*. These trilobites are identical to those described by Poulsen (1934) from his Cape Schuchert Formation of North Greenland. A *Stenopareia* Association from off-white biosparites (Lower Silurian) includes *Stenopareia*, a bumastine, *Kosovopeltis*, and *Scotoharpes*. A *Hedstroemia* Association occurs in an Upper Silurian debris flow. It includes *Hedstroemia*, *Prantlia*, *Balizoma*, and *Paracybantyx*.

An incomplete ontogeny of *Kosovopeltis borealis* (Poulsen) comprises a protaspis and four different transitory pygidia.

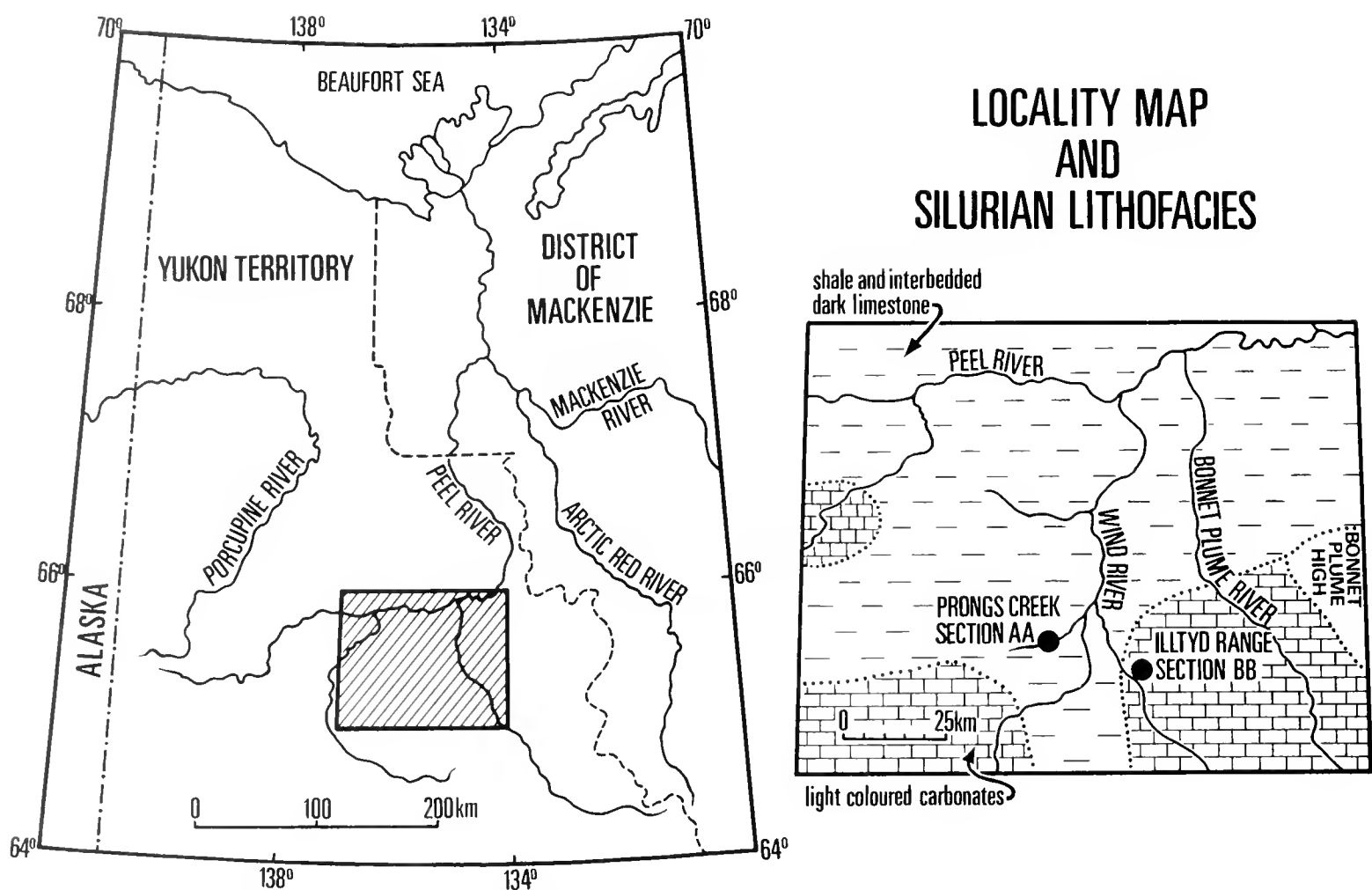
The bumastine genus *Paracybantyx* is new. New species are *Paracybantyx asulcatus*, *Stenopareia illtyd*, *Hedstroemia kutchini*, *H. sourdoughi*, and *Prantlia vagrans*.

Introduction

Silurian rocks crop out as two contrasting facies in the northern Yukon Territory: as basinal shales of the Road River Formation within the Richardson and Blackstone troughs in the Peel River–Wind River area (Lenz, 1972), and as thick-bedded to massive carbonates, yet unnamed, on the Mackenzie Platform in the Bonnet Plume River area and on the Yukon Block in the Porcupine River area (Text-fig. 1). In the basinal shales exceptionally complete stratigraphic successions of graptolites are present (Lenz and Pedder, 1972; Lenz, 1982), but in the platform carbonates well-preserved fossils of Silurian age are uncommon, with the exception of locally abundant tabulate corals and pentamerid brachiopods. The best-preserved and most-diverse assemblages of Silurian shelly fossils in the Yukon Territory are found in dark grey, argillaceous limestones deposited on the margins of the troughs, close to facies transitions with shallow-water carbonates in areas along the Wind River such as Prongs Creek (Raasch, Norford, and Wilson, 1961; Lenz, 1970) and Royal Creek (Lenz, 1977; Jackson, Lenz, and Pedder, 1978). These assemblages are strongly dominated by brachiopods, but a few include substantial numbers

of trilobites of types that are either unknown from northern Canada or incompletely documented.

Rich Silurian trilobite assemblages have been described from the Whittaker and Delorme formations farther to the south in the Mackenzie Mountains of the District of Mackenzie (Perry and Chatterton, 1977; Chatterton and Perry, 1983), and smaller assemblages have been described from different localities to the north in the Canadian Arctic Islands (Bolton, 1965; Perry and Chatterton, 1977; Thomas and Narbonne, 1979) and North Greenland (Poulsen, 1934; Lane, 1979, 1984; Lane and Owens, 1982). In the Yukon Territory, however, Silurian trilobites have been documented from only two Lower Silurian localities—one from dark grey limestones of the Road River Formation at Prongs Creek (Raasch, Norford, and Wilson, 1961) and one from off-white limestone in the nearby Illtyd Range (Norford, 1973). In this paper, we reevaluate and describe fully both these trilobite assemblages on the basis of larger and more complete collections than were available to previous investigators. We also deal with a new trilobite fauna from the Upper Silurian part of the Road River Formation on Prongs Creek.



TEXT-FIG. 1. Locality map of the northern Yukon Territory showing Section AA on Prongs Creek and Section BB in the Illtyd Range. The generalized Silurian lithofacies map is adapted from Lenz (1972, fig. 9).

Stratigraphy

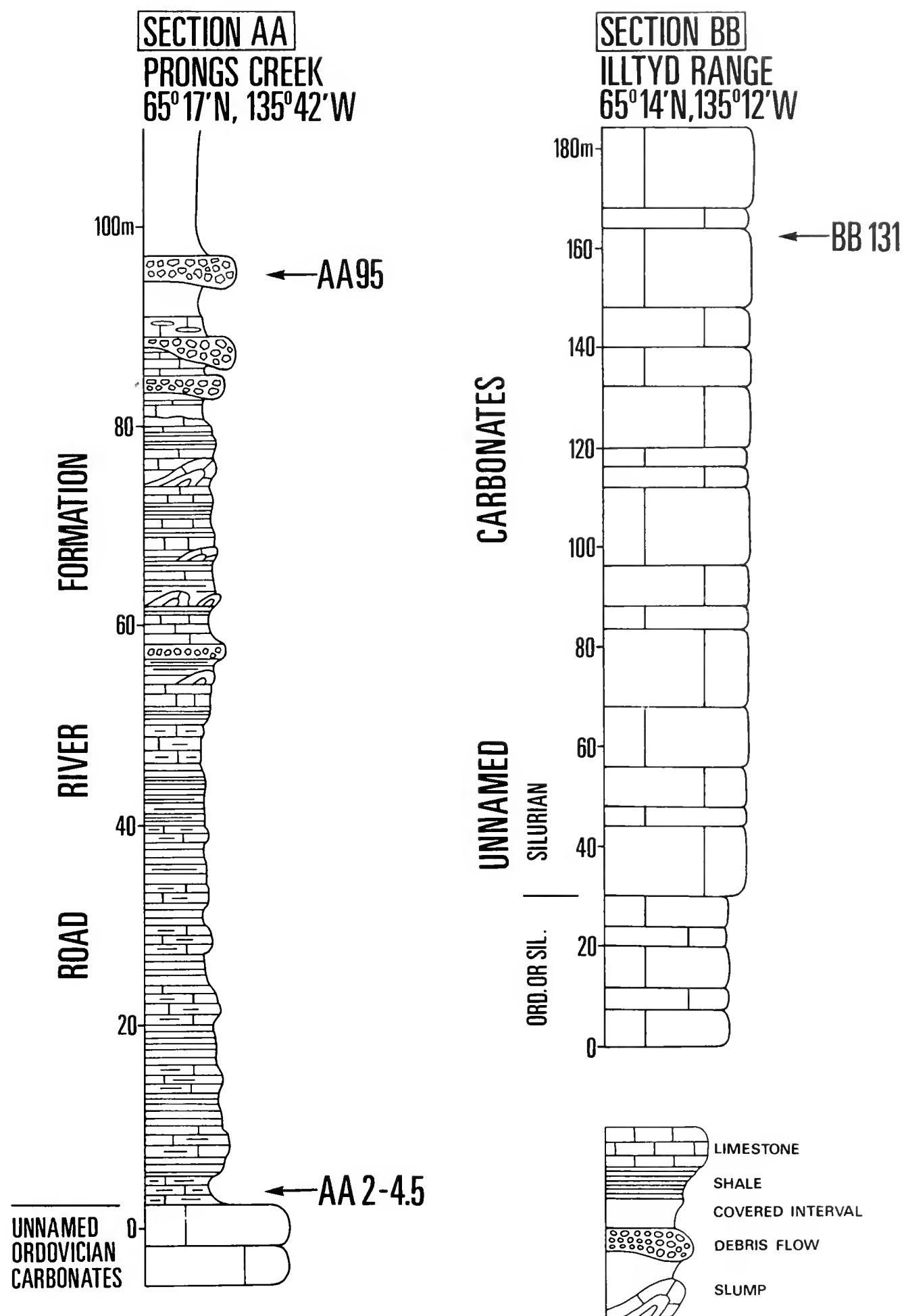
ROAD RIVER FORMATION

The Road River Formation was raised to group status by Fritz (1985), who considered four undesignated map units in the Richardson Mountains to constitute formations. Until such time as these map units are defined and formally named, we retain the formational status of the Road River. Within the Richardson Trough north of the Peel River, the Road River Formation consists of more than one thousand metres of shales, cherts, and limestones of Cambrian, Ordovician, Silurian, and Devonian age. The axis of this intracratonic trough swings east along the Bonnet Plume River to join the Selwyn Trough to the south (Lenz, 1979, fig. 1; Norris, 1985:40). During the Silurian, a narrow north-south embayment off the Richardson Trough developed near the headwaters and along the tributaries of the Wind River. Here, the Road River Formation comprises a recessive sequence of calcareous shales and argillaceous limestones which rests abruptly on resistant Ordovician carbonates (see Lenz, 1972, fig. 8; Norris, 1985, fig. 10). On Prongs Creek, the lower con-

tact of the Road River is concordant, but apparently disconformable because Upper Ordovician (Richmondian; Norford, 1964) strata are followed directly by mid-Lower Silurian strata. Unconformities of similar magnitude occur at the same interval in shelf successions of most other areas of western North America (Lenz, 1976).

Starting about 50 m above its base on Prongs Creek (Text-fig. 2), the Road River Formation begins to display evidence of relief associated with nearby carbonate banks. Contorted bedding, slumps, and thick debris flows consisting of jumbled fossils and small lithoclasts become common. The debris flows were probably derived from the flanks of shallow carbonate banks such as those now exposed in the Illtyd Range to the east or near the headwaters of the Hart River to the southwest.

Sample AA 2-4.5 was obtained from medium-bedded, highly argillaceous lime mudstones of deep-water aspect, at the base of the Road River Formation. Sample AA 95 was collected from a prominent 2-m-thick



TEXT-FIG. 2. Graphic lithological log of Section AA, through the lower part of the Road River Formation on Prongs Creek, and of Section BB, through unnamed Ordovician and Silurian carbonates in the Illtyd Range. Sample BB 131 was collected 131 m above the base of massive and resistant Silurian limestones, that is, at unit 3 of Norford's (1964) Section 5.

debris flow located 95 m above the base of the formation.

UNNAMED CARBONATES

The Iltyd Range exposes a thick sequence of poorly fossiliferous, thick-bedded to massive, shallow-water limestones of probable Ordovician, Silurian, and Devonian age (Norford, 1964; Lenz, 1972; Norris, 1985).

This carbonate bank maintained itself while sediments of the Road River Formation accumulated in the Richardson Trough farther to the north.

Norford (1964:36) measured a distinctive unit 3 of the unnamed carbonates consisting of 200 m of massive, crystalline off-white limestone, which weathers into steep pinnacles; Norford's unit 3 is probably entirely of Early Silurian age. Sample BB 131 was collected 131 m above the base of this unit.

Age and Correlation

AA 2–4.5 (ROAD RIVER FORMATION)

Raasch, Norford, and Wilson (1961) described brachiopods, trilobites, and graptolites from samples collected at unspecified levels across a 50-m interval, starting at the top of the resistant Ordovician carbonates at the gorge of Prongs Creek. These samples included a trilobite fauna with *Aulacopleura socialis*, herein referred to as *Otarion* (*Songkania*) *socialis* and identical to the fauna from our sample AA 2–4.5, as well as a graptolite fauna representing the Lower Silurian *Monograptus turriculatus* Zone. A measured section in Norford (1964:49,127) located the *O. (S.) socialis* fauna in the lower 6 m of the Road River Formation on Prongs Creek, the *M. turriculatus* Zone a few metres higher, followed by the *M. spiralis* Zone some 10 to 21 m upsection.

Both Raasch, Norford, and Wilson (1961) and Norford (1964) indicated a late Llandovery age for the *Otarion* fauna on Prongs Creek based on its position relative to the position of the *M. turriculatus* Zone. This age assessment receives support from an abundant, but low-diversity, conodont fauna from sample AA 2–4.5. According to Godfrey Nowlan of the Geological Survey of Canada (pers. comm., 1987), the sample is dominated by “*Oulodus*” *fluegeli* (Walliser) and includes *Dapsilodus obliquicostatus*, *Ozarkodina excavata excavata*, *Panderodus gracilis*, and *Walliserodus sancticlairei*. Nowlan noted that, in other parts of the Yukon Territory, “*O. fluegeli*” is common in strata bearing graptolites of the *M. turriculatus* Zone and further suggested that this association of conodont elements probably represents a deep-water biofacies.

Raasch (in Raasch, Norford, and Wilson, 1961) recognized that the four species of trilobites comprising the *O. (S.) socialis* fauna on Prongs Creek are identical to those described by Poulsen (1934), which had been collected by Lauge Koch from different localities of the Cape Schuchert Formation in Washington Land, North Greenland. These trilobites must have been conspicuous elements of the Cape Schuchert Formation because

Koch had previously referred these strata to the “*Arethusina* (= *Aulacopleura*) beds” (see Dawes and Haller, 1979; Hurst, 1980:74).

There is considerable uncertainty about the provenance of the *Otarion* fauna in North Greenland. The Silurian stratigraphic framework of Washington Land was revised by Hurst (1980), who restricted Koch's Cape Schuchert Formation to black bituminous lime mudstones of Llandovery age; the overlying shales and mudstones were assigned to the Lafayette Bugt Formation of middle Llandovery to Ludlow age. Koch's locality data were definitely generalized and possibly unreliable (Norford, 1972:9). Apparently *Otarion* occurs in both formations, but neither Norford (1972) nor Hurst (1980) located this trilobite in Lower Silurian stratigraphic sections of Washington Land. It is known with certainty from only a single stratigraphically located collection in North Greenland. According to John S. Peel of the Greenland Geological Survey, *O. (S.) socialis* and *Cromus princeps* occur in GGU sample 216841, collected from Norford's (1972:13) unit 4, which is overlain (in unit 6) by graptolites of the *M. turriculatus* Zone. These rock units were assigned to the Cape Phillips Formation by Norford (1972) and to the Lafayette Bugt Formation by Hurst (1980).

In summary, trilobite collection AA 2–4.5, with *Otarion* (*Songkania*), *Kosovopeltis*, *Cromus*, and *Leonaspis* from the lowest Road River Formation on Prongs Creek, is Early Silurian in age and equivalent to, or slightly older than, the *M. turriculatus* Zone. A faunule with *Otarion* (*Songkania*) and *Cromus* from the Lafayette Bugt Formation near Kap Schuchert in North Greenland is approximately the same age.

BB 131 (UNNAMED CARBONATES)

Norford (1964, 1973) recorded a sparse trilobite fauna of *Scotoharpes raaschi* Norford, *Encrinurus* cf. *E. princeps* Poulsen, *Scutellum* sp., and an illaenid at GSC locality 53109 from a 1-m interval 425 m above the base

of an unnamed carbonate unit in the Illtyd Range; he dated this fauna as late Llandovery. This interval of massive, off-white, coarsely crystalline biosparite, located 131 m above the base of Norford's unit 3, was re-collected as locality BB 131. A meagre conodont fauna of 14 fragmentary specimens, including ?"*Oulodus*" *fluegeli*, *Panderodus gracilis*, and *Walliserodus* sp., was identified by G. Nowlan (pers. comm., 1987), who suggested that it was probably of late Llandovery age.

AA 95 (ROAD RIVER FORMATION)

Lenz (1970) described a moderately rich fauna of Late Silurian brachiopods from a thick limestone bed located 106 m above the base of the Road River Formation on Prongs Creek. Re-collection of this bed yielded a large number of well-preserved trilobites. According to Ludvigsen's measured section, this bed is located

95 m above the base of the formation; therefore, our sample is designated AA 95. On the basis of graptolite faunas below and above, Lenz (1970) correlated the fossiliferous bed with either the latest Ludlow or the earliest Pridoli, an age assignment consistent with biostratigraphic information from a meagre conodont fauna. Later Jackson, Lenz, and Pedder (1978:20) assigned the overlying graptolite collection to the *Monograptus formosus* Zone, which in central Europe comprises the basal zone of the Pridoli.

The trilobite fauna from AA 95 consists largely of new species and, therefore, contributes little information toward an age assignment and correlation of this unit. We tentatively correlate AA 95 with the upper Ludlow on the basis of the overlying graptolites. The trilobites, in particular *Prantlia vagrans* sp. nov. and *Balizoma* aff. *B. obtusus* (Angelin), have greater affinities to Ludlow than to Pridoli species.

Trilobite Associations

Each of the three samples of Silurian trilobites from the northern Yukon Territory dealt with here is dominated numerically by a different family (Text-fig. 3, Table 1), and each association clearly owes its composition to environmental factors (see also Ludvigsen et al., 1986).

OTARION ASSOCIATION

Because of its size, *Kosovopeltis* is the most conspicuous trilobite in sample AA 2-4.5, but the association is named for *Otarion* which, though small, is numerically dominant. The *Otarion* Association occurs in dark grey, highly argillaceous lime mudstones of the lower few metres of the Road River Formation at Prongs Creek, in association with a low-diversity brachiopod fauna (Norford, in Raasch, Norford, and Wilson, 1961). The strata appear to be of deep-water aspect, a setting that receives support from the low diversity of the trilobite fauna and from the association of conodont elements (G. Nowlan, pers. comm., 1987).

Aulacopleurids typically constitute minor elements of trilobite associations in off-platform graptolite shale basins (for example, Thomas, 1979, fig. 2), but we are not aware of any published account of another trilobite assemblage such as the *Otarion* Association that is dominated by an aulacopleurid.

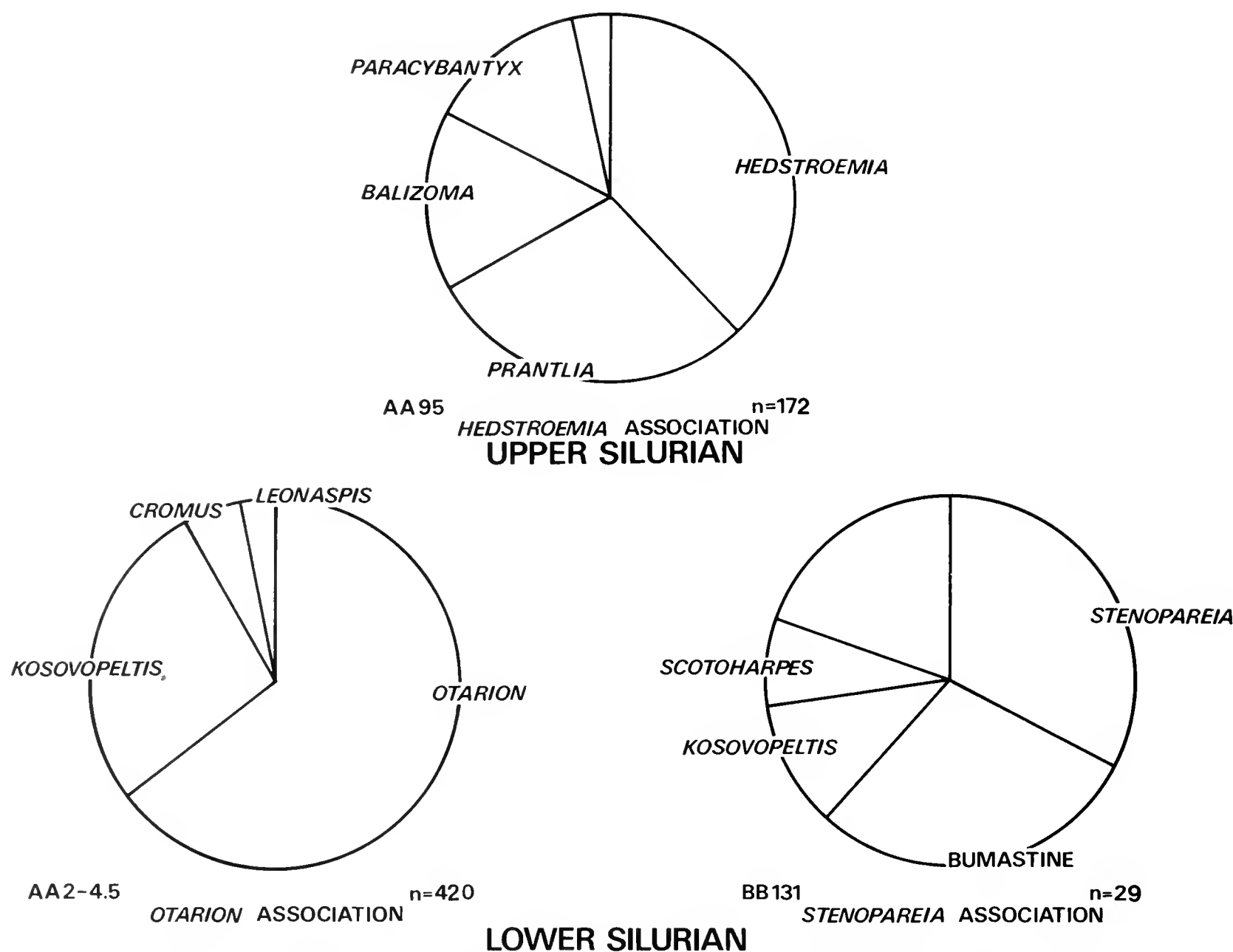
STENOPAREIA ASSOCIATION

A small collection from locality BB 131 is dominated by *Stenopareia* and an indeterminate bumastine. It came

from an interval of off-white crystalline biosparite in the Lower Silurian part of an unnamed unit in the Illtyd Range; this unit records shallow-water carbonate bank deposition during most of the Silurian and Early Devonian (Text-fig. 1). The *Stenopareia* Association shows no evidence of transportation and is, presumably, autochthonous. This association in the Illtyd Range is very similar to that described by Lane (1979) from white, coarsely crystalline limestones of the upper part of the Alequatsiad Fiord Formation (mid-Llandovery) near Kap Schuchert, North Greenland, which also is dominated by *Stenopareia* and bumastines.

The Early Silurian *Stenopareia* Association of the Yukon Territory and Greenland is clearly part of the illaenid-cheirurid associations that also occur widely in Ordovician carbonate build-ups and in subtidal shelf settings in other areas of Laurentia (Westrop, 1983). The *Stenopareia* Association itself seems to be a shelf assemblage; it differs from contemporaneous build-up assemblages in, for example, the Pentamerus Bjerg Formation of North Greenland, which is dominated by a proetine and a scutelluine (Lane and Owens, 1982), or the Hopkinson Dolomite of Iowa, which is characterized by a lichid and a cheirurid (Mikulic, 1981).

Within the limits of correlation possible using conodont biostratigraphy of the Road River Formation on Prongs Creek and of unnamed carbonates of the Illtyd Range, the *Otarion* Association from dark grey, argillaceous lime mudstones is of the same age as the higher-diversity *Stenopareia* Association from off-white biosparites.



TEXT-FIG. 3. Pie diagrams showing generic relative abundance of specimens in the three trilobite associations dealt with in this study.

HEDSTROEMIA ASSOCIATION

A 2-m-thick debris flow in the Upper Silurian part of the Road River Formation on Prongs Creek yielded a diverse brachiopod fauna of 17 species, dominated numerically by the smooth atrypoid *Cryptatrypa* (Lenz, 1970), and a trilobite assemblage of 7 species that we name the *Hedstroemia* Association. About two-thirds of the specimens in this association belong to 3 proetine and warburgelline species; the remaining specimens are bumastines, encrinurids, and lichids.

The debris flows display scoured bases and lack internal grading. They appear to be the products of slumps that swept shells and small (less than 1 cm) limestone clasts off the sides of the adjoining carbonate banks and into the centre of the shale embayment (see also

Lenz, 1977).

The *Hedstroemia* Association is different from the few Upper Silurian trilobite faunas described from northern Canada to date. Faunas from shallow subtidal settings in the Road River Formation on Cornwallis Island in the Canadian Arctic appear to be dominated by the warburgelline *Helokybe*, the encrinurid *Encrinurus*, and the lichid *Hemiarges* (Thomas and Narbonne, 1979).

The dominance of proetines and warburgellines in the *Hedstroemia* Association is matched by the *Proetus/Warburgella* Association from shelf limestones of the British Wenlock (Thomas, 1979), but that association shows considerably higher generic diversity.

TABLE 1. Summary of frequencies.

comp., complete; *cran.*, cephalon/cranidia; *hypo.*, hypostomes; *pyg.*, pygidia; *total*, number of specimens of the most frequent part; *%*, percentage of the total number of specimens.

Species	comp.	cran.	hypo.	pyg.	total	%
Lower Silurian						
AA 2-4.5, Prongs Creek						
<i>Otarion</i> Association						
<i>Kosovopeltis borealis</i>	2	78	19	116	116	27
<i>Otarion</i> (<i>Songkania</i>) <i>socialis</i>	7	270	3	78	270	65
<i>Cromus princeps</i>	1	10	4	23	23	5
<i>Leonaspis semiglabra</i>	1	8	4	11	11	3
BB 131, Illtyd Range						
<i>Stenopareia</i> Association						
<i>Kosovopeltis</i> ? spp.	—	1	—	3	3	11
Indeterminate bumastine	—	8	—	1	8	29
<i>Stenopareia illtyd</i> sp. nov.	—	9	—	6	9	32
Indeterminate illaenid	—	1	—	—	1	3
Indeterminate proetid B	—	1	1	1	1	3
<i>Scotoharpes raaschi</i>	—	2	—	—	2	7
<i>Cheirurus</i> sp.	—	1	—	1	1	3
<i>Encrinuraspis</i> sp.	—	—	—	1	1	3
Indeterminate calymenid	—	—	—	1	1	3
<i>Dicranopeltis</i> sp.	—	1	—	1	1	3
Indeterminate odontopleurine	—	1	—	—	1	3
Upper Silurian						
AA 95, Prongs Creek						
<i>Hedstroemia</i> Association						
<i>Paracybantyx asulcatus</i> gen. et sp. nov.	—	19	2	24	24	14
Indeterminate scutelluine	—	1	—	—	1	1
<i>Hedstroemia kutchini</i> sp. nov.	—	9	2	40	40	23
<i>Hedstroemia sourdoughi</i> sp. nov.	—	8	—	25	25	14
<i>Prantlia vagrans</i> sp. nov.	—	16	—	48	48	28
Indeterminate proetid A	—	—	1	—	1	1
<i>Balizoma</i> aff. <i>B. obtusus</i>	—	5	1	27	27	15
Indeterminate encrinurine	—	1	—	—	1	1
Indeterminate lichid	—	3	5	5	5	3

Materials and Methods

All the figured specimens that were collected have been deposited at the Royal Ontario Museum; their registered numbers bear the prefix ROM. Other specimens illustrated are in the collection of the Geological Survey of Canada, Ottawa, and are prefixed GSC.

As far as possible, plates are arranged in the order of the systematic section. Upper Silurian trilobites from AA 95 constitute Plates 1, 6, 7, 11. Lower Silurian trilobites from AA 2-4.5 constitute Plates 2-4, 8, 10, 12; Plate 4 comprises scanning electron micrographs prepared at the University of Toronto. Lower Silurian

trilobites from BB 131 constitute Plates 5 and 9. Plate 13 comprises photographs of plaster casts of Poulsen's (1934) original specimens from North Greenland. Originals are housed in the Mineralogical and Geological Museum, University of Copenhagen (MMH).

The terminology used is essentially that defined by Harrington, Moore, and Stubblefield (*in* Moore, 1959:117-126). Glabellar lobes, furrows, and muscle impressions are numbered from back to front and symbolized by L, S, and G, respectively. The occipital ring is regarded as part of the glabella.

Systematic Palaeontology

Family Styginidae Vogdes, 1890

DISCUSSION

Lane and Thomas (1983:141) have argued that numerous genera previously referred to separate families and subfamilies of effaced trilobites should be included in

an undivided family Styginidae. In this paper we prefer to continue the use of the subfamilies Stygininae, Scutelluinae, and Bumastinae as an aid to grouping the large number of genera in the family.

Subfamily Bumastinae Raymond, 1916

Genus *Paracybantyx* gen. nov.

DERIVATION OF NAME

Name derived from Latin *para* (beside) and *Cybantyx*. Gender masculine.

DIAGNOSIS

Cranidium broad, lacking anterior border and furrow. Axial furrow bowed inward, faint posteriorly. Pygidium convex, 85 to 100 per cent as wide as long, effaced. Surface finely pitted.

TYPE SPECIES

Paracybantyx asulcatus sp. nov., locality AA 95 (Upper Silurian), Road River Formation, Prongs Creek, Yukon Territory, Canada.

OTHER SPECIES

None.

DISCUSSION

The absence of the anterior border and furrow precludes inclusion of this species in the genus *Cybantyx*, Lane and Thomas (*in* Thomas, 1978), which it otherwise resembles.

Paracybantyx asulcatus sp. nov.

Pl. 1, figs. 1–15; Pl. 11, figs. 1–5

DERIVATION OF NAME

Specific name derived from Latin *a* (without) and *sulcatus* (furrowed), referring to the absence of the anterior border furrow.

HOLOTYPE

ROM 45344 (cranidium, Pl. 1, figs. 4,5), locality AA 95 (Upper Silurian), Road River Formation, Prongs Creek, Yukon Territory, Canada.

DIAGNOSIS

As for genus.

MATERIAL

From AA 95 (Upper Silurian), Prongs Creek: 19 cranidia, 4 librigenae, 2 hypostomes, 24 pygidia.

DESCRIPTION

Cranidium 85 to 95 per cent as long as wide, longitudinal curvature strongest toward front, evenly convex transversely, broadly rounded in outline anteriorly. Glabella wide, narrowest opposite palpebral lobe where it occupies two-thirds width between margins, widening forward and backward. Small tubercle near posteromedian margin. Occipital ring and furrow effaced. Axial furrow broad and shallow at back, deepening forward, bowed more or less strongly inward, terminating in large, rounded anterior pit opposite one-tenth cranidial length from front. On larger specimens, axial furrow effaced anteriorly and posteriorly. Genal muscle impression alongside axial furrow on fixigena almost one-fifth length of cranidium, situated at own length anterior to posterior margin; outline of impression running parallel to that of palpebral lobe. Palpebral lobe slightly swollen and gently rounded in outline, one-quarter length of cranidium, with posterior extremity opposite that of lateral muscle impression. Anterior border and furrow absent. Anterior branch of facial suture running outward, parallel to axial furrow at first, and then curving forward and inward; posterior branch directed backward and slightly outward. Cranidium faintly pitted, with faint terrace ridges running parallel to anterior margin at front.

Incomplete librigenae show a comparatively small eye without socle. Genal angle aspinous. Doublure broad, weakly convex. Anterior extension curves inward and upward; on inner margin, just in front of eye, a single pit projects inward and dorsally upward (Pl. 11, fig. 2). This pit would lie immediately below anterior pit at front of axial furrow—compare *Failleana calva* Chatterton and Ludvigsen (1976, pl. 6, figs. 5,12–16). The pit in the doublure, which opposes the anterior pit in *Remopleurides* (Whittington, 1959, fig. 3c), is analogous.

Hypostome incomplete but comparable to that of

Bumastus and *Cybantyx* in the swollen middle body, lateral lobe consisting of large macula, and depressed border. Prosopon of middle body rugose and pitted.

Pygidium strongly convex, rounded triangular to nearly subovate in outline, 85 to 100 per cent as long as wide, almost completely effaced; height 45 to 55 per cent sagittal length. Immature pygidia wider than long. Triangular axis faintly marked by slight change of convexity in some specimens. Articulating facet marked off by a faint oblique ridge; coarse terrace lines running parallel to and overstepping posterior ridge, with steep surface facing backward; raised lines bending perpendicularly backward at margin. Doublure broad, 30 per cent length of pygidium; about 15 shallow discontinuous terrace ridges, equally spaced, running parallel to margin. Surface finely pitted; fine, short raised lines running inward/backward for a short distance abaxially (Pl. 1, fig. 15).

DISCUSSION

The pygidium of this species is remarkably similar to that of specimens from the Lower Silurian of northeast Greenland, described as "Goldillaenid Genus and species indet. 2" by Lane (1972:347, pl. 62, figs. 10–14). The cranidium differs from that of Lane's material in being much wider, with wider glabella, and in having axial furrows bowed inward and shallowing posteriorly. Lane's material has a terraced anterior border and border furrow similar to that of *Cybantyx anaglyptos* Lane and Thomas (*in* Thomas, 1978:18, pl. 5, figs. 1–8). The absence of the border and border furrow in the Road River material is the main feature of the new genus *Paracybantyx*. Both the Yukon and the Greenland species resemble the type species of *Cybantyx* in the comparatively narrow, featureless pygidium. Variable features in the cranidium of *P. asulcatus* sp. nov. are the degree of inward curvature of the axial furrows, the anterior and posterior effacement of the axial fur-

rows in larger specimens, and the proportions and convexity of the pygidium.

Ptilillaenus Lu (1962), a monotypic genus from the Middle Silurian of China, has an extended axial furrow terminating in an anterior pit and lacks the anterior border, but in that taxon the glabella is narrow.

Indeterminate bumastine

Pl. 5, figs. 13,14

MATERIAL

From BB 131 (Lower Silurian), Illtyd Range: 8 cranidia, 1 pygidium.

DESCRIPTION

Cranidium 60 per cent as long as wide, strongly convex. Glabella effaced, except for lunule at 60 per cent length from front. Posteromedian tubercle at 10 per cent length from back. Anterior pits small, shallow, and rounded, 70 per cent maximum width of cranidium apart, and 20 per cent length of cranidium from front. Palpebral lobe 40 per cent length of cranidium, placed far back, weakly rounded.

Pygidium (not illustrated) 65 per cent as long as wide, strongly convex. Axis 60 per cent anterior width, dying out in a short distance. Anterolateral angle oblique. Surface smooth except for faint terrace ridges on front of cranidium.

DISCUSSION

The presence of the anterior pits suggests a relationship to species such as *Bumastus? phrix* Lane and Thomas (*in* Thomas, 1978:14, pl. 3, figs. 1–22) and *B.? xestos* Lane and Thomas (*in* Thomas, 1978:16, pl. 4, figs. 2–5, 7,18), both from the British Wenlock. The present species is distinguished by a number of features, particularly the effacement of the axial furrows.

Subfamily Scutelluinae Richter and Richter, 1955

Genus *Kosovopeltis* Šnajdr, 1958

TYPE SPECIES

Kosovopeltis svobodai Šnajdr, 1958, Kopanina Formation (Upper Silurian), Kosov, Prague district, Czechoslovakia.

Kosovopeltis borealis (Poulsen, 1934)

Pl. 2, figs. 1–12; Pl. 3, figs. 1–10; Pl. 4, figs. 1–13; Pl. 13, figs. 1,2; Text-figs. 4, 5A

Goldius borealis Poulsen, 1934:27, pl. 3, figs. 14,15.

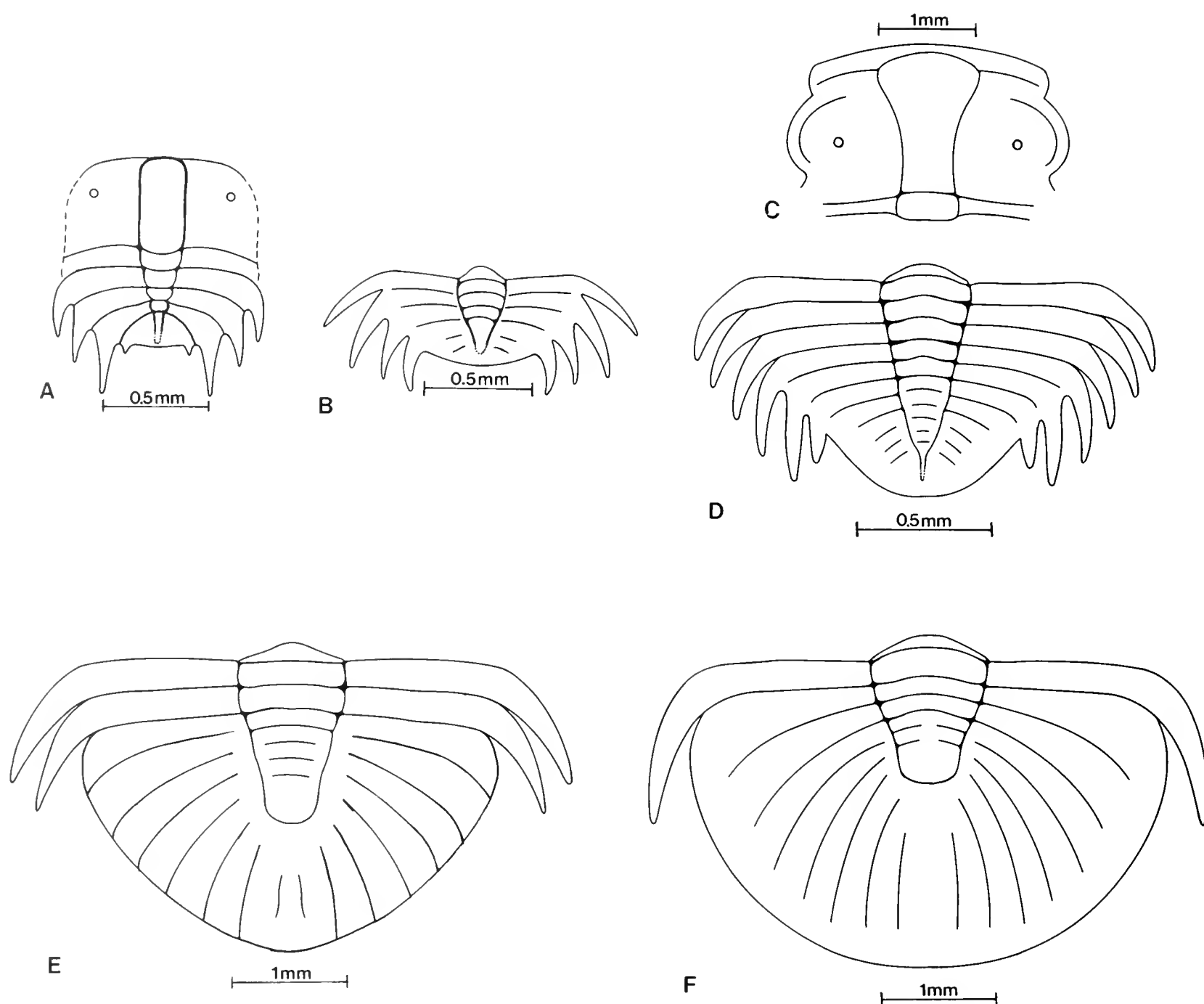
Scutellum borealis—Raasch *in* Raasch, Norford, and Wilson, 1961:477, figs. 5.6–8,10 (non fig. 5.9 = *Leonaspis semiglabra*).

Scutellum borealis—Norford, 1962, pl. 8, fig. 7.

Scutellum borealis—Norford et al., 1970, pl. 8, fig. 9.

HOLOTYPE

MMH 3267 (cranidium, figured by Poulsen, 1934, pl. 3, fig. 14; in this paper, Pl. 13, fig. 1), Cape Schuchert Formation (Lower Silurian), Kap Schuchert, North Greenland.



TEXT-FIG. 4. Incomplete ontogeny of *Kosovopeltis borealis* (Poulsen). *A*, Protaspis, ROM 42160. *B*, Smallest transitory pygidium, ROM 42166. *C*, Meraspis cranidium, ROM 42161. *D*, Transitory pygidium, ROM 42165. *E*, Transitory pygidium with two protothoracic segments attached, ROM 42163. *F*, Transitory pygidium with one protothoracic segment attached, ROM 42162.

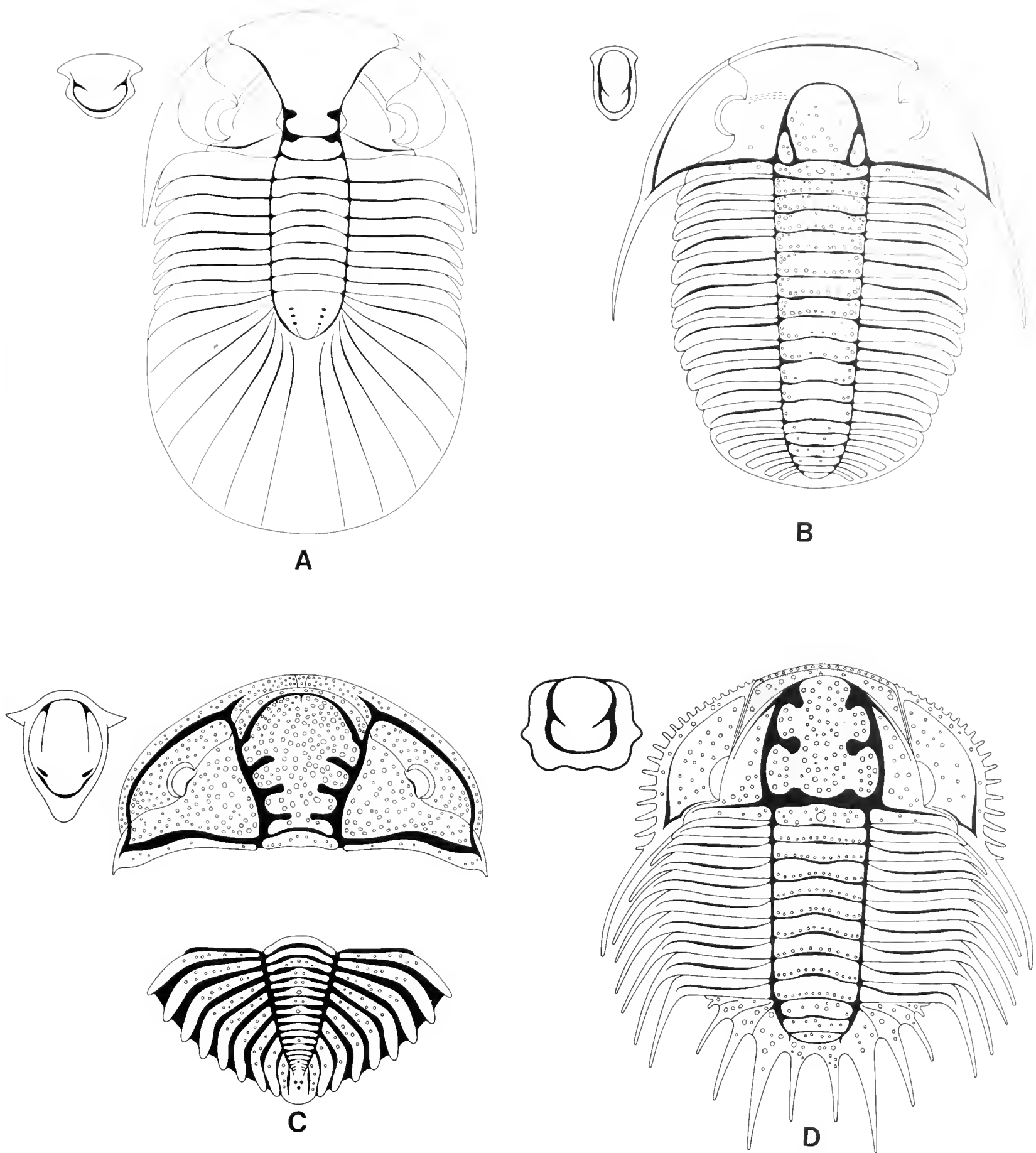
MATERIAL

From AA 2–4.5 (Lower Silurian), Prongs Creek: 2 dorsal shields, 78 cranidia, librigenae, rostral plates, 19 hypostomes, 116 pygidia.

DESCRIPTION

Cephalon about 25 per cent as long as wide. Glabella moderately convex for most of its length, strongly convex and downturned at front, narrowing strongly backward to 30 to 40 per cent anterior width; anterolateral angles strongly rounded. Width of occipital ring greater than width across posterior glabellar ring. Occipital ring bowed backward, summit at posterior margin; minute occipital tubercle centrally situated. Occipital

furrow deep and broad mesially, expanding laterally into large, smooth muscle impressions. L1 not swollen, defined only by short, oblique S1; a faint transverse depression marks off preoccipital ring on internal surface only. Muscle scar G1 slightly depressed, 15 per cent length of glabella, placed at about own length anterior to occipital furrow, 30 per cent width of glabella; G2 and G3 indicated by faint, short, smooth lateral depressions at 50 per cent and 25 per cent length of glabella from front, respectively. Anterior border of cranidium extending only a short distance laterally in front of glabella and fixigena. Axial furrow deepening steadily backward, bowed inward. Fixigena broad, convex. Genal muscle area extending alongside L1 and



TEXT-FIG. 5. Reconstructions of the four trilobite species from AA 2-4.5, Prongs Creek. A, *Kosovopeltis borealis* (Poulsen). B, *Otarion (Songkania) socialis* (Poulsen). C, *Cromus princeps* (Poulsen). D, *Leonaspis semiglabra* (Poulsen).

G1, smooth, slightly depressed. Posterior border much wider (exsag.) than occipital ring adaxially, narrowing strongly to midwidth of fixigena. Posterior border furrow shallow and strongly oblique adaxially. Palpebral lobe at summit of fixigena, opposite L1, 25 per cent length of glabella, horizontal, standing higher than glabella. Eye ridge running obliquely backward and outward from opposite G3, dying out toward back of palpebral lobe. Anterior branch of facial suture running forward and outward, curving forward strongly at anterior margin. Posterior branch curving obliquely outward, cutting posterior margin slightly beyond extent of palpebral lobe.

Librigena falcate, sloping steeply outward; genal spine narrowing slowly backward, extending to third thoracic segment. Eye strongly convex; fully developed lenses hexagonal in outline, 0.02 mm in diameter (Pl. 4, figs. 8,9). Socle absent. Subocular furrow broad. Field divided by a depression widening and curving inward toward back; outer area narrower and more strongly swollen, widening backward. Lateral border sloping inward to a broad border furrow, furrow also widening backward. Doublure strongly convex, widening and projecting at front, extending to inner area of librigena, and becoming less convex posteriorly.

Rostral plate 25 per cent as long as wide, as wide as glabella anteriorly, extending 30 per cent sagittal length of cranidium, subtrapezoidal in outline, with anterior and posterior margins evenly convex forward and parallel. Convexity moderate; posterolateral angle upturned. Rostral suture submarginal, with connective sutures bowed gently inward.

Hypostome shield-shaped, 80 per cent as long as wide. Anterior wing narrowly pointed, wide (tr.), without articulating process. Middle body strongly swollen. Middle furrow short but strong, marking off small lateral lobe and macula. Lateral furrow broad. Posterolateral border of uniform width, with inward slope decreasing posteriorly. Posterior margin broadly rounded.

Number of thoracic segments uncertain (dorsal shield [Pl. 2, fig. 2] appears to be complete with eight segments, but has some telescoping at the back). Axis 25 per cent width of thorax, narrowing slightly backward, gently convex transversely. Articulating half-rings half sagittal length of rings, bearing faint, transverse raised lines. Pleural lobe horizontally extended as far as fulcrum at 70 per cent width, sloping gently outward abaxially. Pleura narrows abaxially; articulating facet bluntly terminated. Doublure extends to fulcrum.

Pygidium 70 to 85 per cent as long as wide, gently convex. Axis 20 per cent length and width of pygidium, swollen. Articulating half-ring strongly marked off by

continuous furrow. Three rings distinguishable on internal surface. Posterior area tripartite, with median lobe swollen, and marked off by longitudinal depressions; three apodemal pits in longitudinal depression marking positions of fourth to sixth ring furrows. Axial furrow uniformly deep throughout. Pleural lobe with seven subequal pairs of ribs, and a median rib flaring posteriorly to three times anterior width. Rib furrows almost straight, progressively wider and shallower toward back, not quite reaching margin. Longitudinal ridge extending for much of postaxial length. Doublure 35 per cent sagittal length of pygidium, weakly convex in ventral view; anterior margin simple, marked on dorsal surface by a low ridge separating convex inner area of pleural lobe from concave outer area (holcos of Helbert et al., 1982:132). Seven broad depressions corresponding to pleural ribs. Longitudinal ridge anteriorly. Fifteen or more semicontinuous terrace ridges running parallel to anterior margin, fainter, wavy, and more closely spaced in outer area.

Wavy, raised lines on surface, except in furrows and muscle areas, distantly spaced, but more closely spaced near margins. Lines run as follows: gently convex forward on glabella; convex inward on fixigena, outward on field of librigena; V backward on lateral border, with outer limbs longer and more closely spaced; longitudinal on inner side of genal spine; forming a reticulate pattern at base of genal spine; parallel to margin on rostral plate; convex backward on hypostome, including macula; longitudinal on thoracic segments; oblique on first two pygidial ribs and essentially transverse on subsequent ribs.

Protaspides. Protaspis 0.8–0.9 mm in sagittal length (Pl. 4, figs. 1,2; Text-fig. 4A), subquadrate, slightly wider than long. Cranidium 55 per cent total length; glabella parallel sided, 25 per cent width of cranidium, strongly convex transversely, weakly convex longitudinally. Occipital ring as wide as glabella, convex. Occipital furrow broad, more shallow than axial furrow. Axial furrow deep and broad. Cheek broad and subquadrate, strongly convex and downturned laterally, apparently without border or librigena; a pair of tubercles, 70 per cent maximum width of protaspis apart, toward front. Posterior border 15 per cent sagittal length of cranidium, sharply convex. Posterior border furrow deep and broad. Genal spine not preserved. Pygidium tripartite, very strongly inflated, comprising three segments ending in free points, and a broadly rounded unsegmented area with a fourth pair of small free points laterally. Axis 15 per cent width of pygidium anteriorly; narrowing backward to a point at posterior margin; separating, but lower than, the even more strongly con-

vex pleural lobes; with three rings strongly marked off by broad ring furrows. Axial furrow strong. First and second pleural ribs almost as strongly developed as occipital segment, becoming less swollen laterally and produced into slender, backwardly directed spines 15 per cent sagittal length of protaspis. Third pleural rib weak. Third spine at least as long as first and second, projecting beyond margin for half its length.

Meraspides. Meraspid cranium 1.5 mm in sagittal length (Pl. 4, figs. 3,4; Text-fig. 4C), *Raymondaspis*-like in its subparallel-sided glabella. Glabella 80 per cent as wide as long, with basal width 60 per cent anterior width, strongly convex anteriorly. Axial furrow deep. Anterior border indistinct mesially, developing abaxially; anterior margin flexed upward mesially. Fixigena strongly convex, twice width of glabella at back; eye ridge near front almost transverse. Posterior border depressed, transverse. Posterior border furrow widens abaxially, shallow. Transverse raised lines on glabella; fixigena faintly granular.

Smallest transitory pygidium 0.4 mm in sagittal length (Pl. 4, figs. 12,13; Text-fig. 4B), incorporating four segments with free points. Articulating half-ring as long as first ring, strongly convex. First free point directed outwardly, second obliquely, third and fourth posteriorly, hindmost longest and projecting well beyond posterior margin. Convexity of pleural lobe of future pygidium increasing rapidly backward, rising above axial area. Surface finely granular.

Transitory pygidium 0.8 mm in sagittal length (Pl. 4, figs. 10,11; Text-fig. 4D), incorporating six segments with free points. Triangular in outline, 50 per cent as long as wide. Segments decreasing in definition backward, and free points becoming less oblique. Future pygidium strongly convex; axis shorter, more elevated above convex pleural lobe. Surface granular.

Transitory pygidium 2.5 mm in sagittal length (Pl. 4, figs. 6,7; Text-fig. 4E), incorporating two protothoracic segments with free points and pygidium with seven pleural ribs. Triangular in outline, 55 per cent as long as wide. Axis 20 per cent anterior width, 50 per cent length. Free points becoming successively shorter. Pygidium convex toward back, axis not depressed. Surface smooth.

Transitory pygidium 2.8 mm in sagittal length (Pl. 4, fig. 5; Text-fig. 4F), incorporating one protothoracic segment with free points. Future pygidium with four axial rings, large and swollen terminus, and seven pleural ribs; broadly rounded and more adult in outline, 60 per cent as long as wide. Pygidium strongly convex, particularly at back. Axis 20 per cent width and 35 per cent length. First two pygidial ribs much wider (exsag.)

than subsequent pleurae. Surface smooth.

DISCUSSION

K. borealis (Poulsen, 1934:27, pl. 3, figs. 14,15) from the Cape Schuchert Formation, North Greenland, was based on four cranidia. Cranidia from the Road River Formation are identical in gross morphology. Minor features supporting specific identity are the minute occipital tubercle and heavy occipital prosopon. The Road River specimens are distinguished from the Kap Schuchert material by the following differences: (1) the prosopon of raised lines is more dense; (2) granulation of the exoskeleton is absent; (3) the eye ridge is broader (exsag.).

The species complies with Šnajdr's diagnosis of *Kosovopeltis* (1958:177; 1960:65). It differs from the type species, *K. svobodai* Šnajdr, and from *K. partschi*, both from the Kopanina Formation of Czechoslovakia, in that the glabella expands evenly and not abruptly near the front, and that the pygidium is more broadly rounded.

Two scutelline ontogenies have been described from well-preserved material of the Taemas Formation (Lower Devonian) of New South Wales: *Dentaloscutellum hudsoni* Chatterton (1971:12, pl. 1, figs. 1–22; pl. 2, figs. 1–14; pl. 3, figs. 1–12; pl. 24, fig. 15) and *Scutellum calvum* Chatterton (1971:22, pl. 3, figs. 21,22; pl. 4, figs. 1–24; pl. 5, figs. 1–24). The Road River Formation protaspides described above bear a general resemblance to the late protaspides of both species from the Taemas Formation, differing in having a narrow and parallel-sided glabella, broad fixigena, and longer spines. The meraspid cranium from the Road River Formation differs in having broader fixigena and large eyes that are forwardly placed, and in lacking an occipital spine. There is a close resemblance between the smallest transitory pygidia of *K. borealis* and *S. calvum* (Chatterton, 1971, text-fig. 6D); larger transitory pygidia of *K. borealis* differ from those of *S. calvum* in having protothoracic spines of equal length (cf. alternating lengths). The adult of *K. borealis* does not resemble the adult of either Taemas Formation species.

Šnajdr (1960, pl. 3, fig. 6) has illustrated a meraspid cranium of the type species bearing an occipital spine; this spine was lost in the holaspis. It is unlikely that such a spine was present in *K. borealis*.

Feist (1970) has described protaspides and meraspides of *Breviscutellum* (*Meridioscutellum*) sp. from the Emsian and Eifelian of the Montagne Noire, France. The smallest protaspis, 1.96 mm in sagittal length, has 8 protothoracic segments developed; the largest has 10, the number in the adult. These protaspides contrast sharply with those from the Road River Formation

described above in most features; our largest protaspides are 0.9 mm in length and have only 4 segments, indicated by free points. There is some similarity in the meraspides in the development of the adult pygidial characters.

***Kosovopeltis?* spp.**

Pl. 9, figs. 8–11

MATERIAL

From BB 131 (Lower Silurian), Illtyd Range: 1 cranium, 3 pygidia.

DISCUSSION

The fragmentary cranium differs from *K. borealis* in having a straighter axial furrow, longer occipital ring, weaker occipital furrow, narrower fixigena, and small palpebral lobe posteriorly placed. The three pygidia belong to more than one species. All differ from *K. borealis* in having a wider axis, more strongly curved posterior rib furrows, and an evenly convex surface; one specimen shows the doublure, which is longer than

in *K. borealis*, with terrace ridges more widely spaced and more strongly scalloped. The three pygidia differ from each other in the construction of the axis and the median rib, amongst other features, but all are probably attributable to *Kosovopeltis*.

Indeterminate scutelline

Pl. 11, figs. 6,7

MATERIAL

From AA 95 (Upper Silurian), Prongs Creek: 1 cranium.

DISCUSSION

This cranium differs from *Paracybantyx asulcatus* sp. nov. in being less convex and in having an anterior border, a faint occipital furrow, a smaller genal muscle area and palpebral lobe, broader fixigena, a conspicuous eye line, and coarsely pitted prosopon. The cranium is somewhat similar to that of *Planiscutellum kitharos* Lane and Thomas (*in* Thomas, 1978:27, pl. 6, figs. 1–8) from the British Wenlock, but it has a much wider axis and a faint occipital furrow.

Family Illaenidae Hawle and Corda, 1847
Subfamily Illaeninae Hawle and Corda, 1847

Genus *Stenopareia* Holm, 1886

TYPE SPECIES

Illaeus linnarssoni Holm, 1882, Boda Limestone (Ashgill), Dalarna, Sweden.

***Stenopareia illtyd* sp. nov.**

Pl. 5, figs. 1–11

DERIVATION OF NAME

Specific name derived from the Illtyd Range, Yukon Territory.

HOLOTYPE

ROM 42168 (cranium, Pl. 5, figs. 3,4), locality BB 131 (Lower Silurian), unnamed carbonates, Illtyd Range, Yukon Territory, Canada.

MATERIAL

From BB 131 (Lower Silurian), Illtyd Range: 9 crania, 6 pygidia.

DIAGNOSIS

Cranidium with strong convexity; palpebral lobes 10 per

cent length of cranium, at own length from posterior margin. Axial furrows convergent. Dendritic muscle impressions strongly developed on glabella and fixigena. Axis of pygidium subtriangular, long, and wide.

DESCRIPTION

Length (in normal view) 65 to 80 per cent width, convexity strong. Glabella 55 per cent basal width, narrowing forward, but widening slightly at forefont; independent convexity slight. On internal moulds of glabella, shallow radiating ridges and furrows arranged in dendritic pattern alongside smooth median area; foremost ridge large, extending beyond glabella, and continuous with ridges radiating in a quarter segment from posterior inner extremity of fixigena. Axial furrow broad, directed inward for most of length, widening into shallow depressed lunule, and curving outward at front. Fixigena sloping steeply outward with weak convexity. Palpebral lobe 10 per cent length of cranium, situated at own length from posterior margin, level, and continuous with fixigena. Anterior branch of facial suture running almost straight forward from eye; posterior branch running outward and backward. Internal surface smooth except for muscle impressions.

External surface sparsely pitted. Faint, transverse raised lines on front of cranidium.

Pygidium 50 to 60 per cent as long as wide, convexity strong posteriorly. Axis subtriangular, 35 per cent anterior width, undefined at back except by slight convexity. Axial furrow broad and shallow anteriorly, becoming steadily shallower and dying out anterior to midlength. Pleural lobe sloping steeply outward, anterolateral angle narrowly rounded, facet steep. Surface covered with transverse anastomosing wavy lines on well-preserved specimens.

DISCUSSION

S. illtyd sp. nov. closely resembles *S. ? julli* Norford (1981:7, pl. 6; pl. 10, figs. 8–10) from the Attawapiskat Formation of northern Ontario, but differs in having much stronger cranidial axial furrows and a less triangular pygidium. In both species, the muscle scars, or caecal markings, on glabellae and fixigenae are comparable. Both species also resemble *Stenopareia* sp. of Lane (1972:348, pl. 61, figs. 13–15) from the Drommebjerg Limestone (Lower Silurian), northeastern Greenland, a species with comparable muscle scars that are preserved on the external surface of the glabella only.

Indeterminate illaenid

Pl. 5, fig. 12

MATERIAL

From BB 131 (Lower Silurian), Illtyd Range: 1 cephalon.

DESCRIPTION

Cephalon 50 per cent as long as wide, strongly convex. Glabella as long as wide, parallel sided. Palpebral lobe 35 per cent length of cephalon, 50 per cent own length from posterior margin. Librigena narrow, gently convex. Eye separated from cheek by broad depression. Genal angle broadly rounded. Surface of cranidium with extremely faint raised lines convergent backward on glabella; minute occipital tubercle posteriorly placed.

DISCUSSION

The cephalon differs from *S. illtyd* in having a parallel-sided glabella, shallower axial furrows, and comparatively large eyes sited far back. It is unlikely that this cephalon can be included in *Stenopareia*, and its generic affinities are not clear.

Family Proetidae Salter, 1864

?Subfamily Crassiproetinae Osmólska, 1970

Genus *Hedstroemia* Přibyl and Vaněk, 1978

TYPE SPECIES

Proetus delicatus Hedström (1923:4, pl. 1, figs. 1–15), Halla Beds, unit b (upper, probably uppermost, Wenlock), Hörsne Canal, Gotland, Sweden.

Hedstroemia kutchini sp. nov.

Pl. 6, figs. 1–14

DERIVATION OF NAME

Species named after the Kutchin tribe who formerly inhabited extensive areas of the northern Yukon Territory.

HOLOTYPE

ROM 45347 (cranidium, Pl. 6, figs. 3,4), locality AA 95 (Upper Silurian), Road River Formation, Prongs Creek, Yukon Territory, Canada.

DIAGNOSIS

Cephalon with intramarginal ridge between field and border. Genal spine absent. Pygidium elongate with

nine rings and eight pairs of pleurae. Prosopon finely granular.

MATERIAL

From AA 95 (Upper Silurian), Prongs Creek: 9 cranidia, 14 librigenae, 2 hypostomes, 40 pygidia.

DESCRIPTION

Glabella 90 per cent sagittal length of cranidium, 80 to 90 per cent as wide as long, moderately convex, strongly defined, olive shaped or tongue shaped in outline. Occipital ring narrowing rapidly abaxially, with small occipital tubercle placed slightly posterior to midlength. Occipital furrow and axial furrow moderately deep and narrow. Occipital lobe large, convex, strongly demarcated, extending sideways well beyond main part of ring. L1 faintly defined, with slight independent convexity, almost 30 per cent maximum glabellar width. S1 convex forward, directed inward and backward, widening near midlength, fading at back; S1 bifurcates adaxially, with anterior branch short, shallow, and transverse. S2 shallow, 25 per cent width of glabella, directed slightly backward, situated at 35 per cent length of glabella from front. S3 faint, parallel to S2, situated at 25 per cent length of glabella from front.

Anterior border of uniform width (sag., exsag.), upturned, convex, wider (tr.) than glabella. Anterior border furrow deep and broad. Between front of fixigena and anterior border furrow, a uniformly narrow and slightly oblique intramarginal ridge, continuous or discontinuous mesially, marked off from preocular area of fixigena by a clear-cut furrow and by independent convexity; prosopon agreeing with the anterior border and differing from the preocular fixigena in lacking granulation; this ridge continuing onto the librigena. Preocular area of fixigena moderately swollen. Palpebral lobe 25 per cent length of cranidium, horizontal, with midlength just posterior to front of S1 and anterior extremity just posterior to S2; palpebral furrow faint, shallow, running parallel to margin. Postocular fixigena unknown. Anterior branch of facial suture commencing close to axial furrow, curving forward and outward at first, and then running longitudinally. Glabella, preocular fixigena, and palpebral lobe, except in furrows, closely, uniformly, and finely granular; anterior border smooth except for raised lines running parallel to margin.

Eye strongly convex, sloping outward, with subocular furrow deep and broad. Socle swollen, narrowing backward, marked off by a strong furrow. Field gently convex; intramarginal ridge at front of fixigena continuing abaxially on field of librigena as a lateral ridge, widening somewhat backward and dying out before reaching posterior border furrow. Lateral border furrow slightly stronger than furrow marking off the lateral ridge and also dying out before posterior border furrow. Lateral and posterior borders strongly convex, confluent. Genal angle broadly rounded. Field coarsely and shallowly pitted, matching prosopon of fixigena. Surface of field roughened, with raised lines parallel to margin on lateral border.

Hypostome as wide as long. Middle body large, well defined, convex, extending to anterior margin. Middle furrow oblique, short and shallow, commencing at 65 per cent length of middle body from front. Lateral lobe with oval macula abaxially, merging with middle body adaxially. Lateral furrow deepens and widens steadily backward, continuous with posterior furrow, which is broad and strongly convex backward. Lateral borders raised, subparallel, widening steadily backward, and slightly outturned just posterior to level of middle furrows. Posterior border depressed, strongly convex backward in outline. Anterolateral wing subquadrate, downturned; articulating process absent. Middle body faintly and coarsely pitted, bearing raised lines mesially, divergent backward for most of length, transverse anteriorly. Raised lines on lateral border running parallel to margin.

Pygidium 60 to 75 per cent as long as wide, strongly

convex in both directions, high in profile, with height 60 to 70 per cent sagittal length. Axis convex, 45 to 50 per cent maximum width and 80 to 90 per cent length of pygidium, narrowing strongly backward to rounded tip, composed of nine rings and a short terminus. Ring furrows shallow, gently sinuous, bowed backward mesially; furrows toward front strong, becoming successively fainter toward back, particularly abaxially. Paired muscle insertion scars distinguishable on some specimens. Axial furrow clear cut. Pleural lobe convex. Seven well-defined pleurae; eighth faint. First pleural furrow broad, narrowing abaxially, but reaching lateral margin; first interpleural furrow well developed, dying out at lateral depression. Subsequent pleural and interpleural furrows successively fainter, dying out at lateral depression. Lateral border uniformly narrow, sloping outward with moderate convexity. Border depression strong but ending at first pleura. Articulating facet smooth. Surface densely but somewhat variably granular.

DISCUSSION

H. kutchini sp. nov. closely resembles the type species, *H. delicata* (Hedström, 1923:4, pl. 1, figs. 1–15), Halla Beds, Hörsne Canal, Gotland, Sweden; an allied form has been described under open nomenclature by Helbert et al. (1982:138) from the Lower Silurian of the Oslo Region, Norway. Bob Owens (pers. comm., 1987) confirms that *H. delicata* has a flat intramarginal area between the border furrow and the change of slope of the field of the fixigena and librigena, comparable with the intramarginal ridge of *H. kutchini*; Owens also confirms that *H. kutchini* differs from *H. delicata* in having stronger lateral glabellar furrows and a less-angular frontal glabellar lobe, in lacking a genal spine, in having a hypostome with more pronounced posterior wings and a broader posterior border furrow, and in having a pygidium composed of fewer segments with a narrower border. Shared features are the greatly swollen occipital lobes; similar hypostomes, particularly as regards the prosopon; and the faint pygidial ring furrows with paired muscle scars abaxially. *H. kutchini* bears a resemblance to *Coniproetus* (*Coniproetus*) *affinis affinis* (Bouček, 1933; see Šnajdr, 1980:73, pl. 9, figs. 3–11), from the basal Lochov Formation (Lochovian), Reporyje, Prague, Czechoslovakia, particularly as regards glabellar features, the librigena, the hypostome, and the distinctably faint ring furrows of the pygidium. *H. kutchini* differs in having stronger lateral glabellar furrows, a narrower (sag., exsag.) anterior border, more posteriorly placed palpebral lobes, an intramarginal ridge, and a more elongate pygidium with eight pleural ribs. The pygidium of *H. kutchini* also differs in proportions, and in having stronger pleural segmentation, and a much

narrower and more strongly defined border; these pygidial features readily distinguish *Hedstroemia* from *Coniproetus*.

The hypostome bears a resemblance to that of *Coniproetus* (*C.*) *whittakerensis* (Chatterton and Perry, 1977, pl. 1, figs. 7–10) from the Early Devonian of northwestern Canada, but differs in having a more rounded posterior border and raised lines on the front of the middle body that run transversely, not longitudinally. There is little resemblance between the cranidia of the two species—*H. kutchini* has a much broader (tr.) glabella, and narrower (sag., exsag.) anterior border.

***Hedstroemia sourdoughi* sp. nov.**

Pl. 6, figs. 16–24

DERIVATION OF NAME

Species named after those prospectors (Sourdoughs) who chose the all-Canadian route to the goldfields—down the Mackenzie River, up the Peel River, up the Wind River, past Prongs Creek, and then overland to the Klondike.

HOLOTYPE

ROM 45332 (cranidium, Pl. 6, figs. 22,23), locality AA 95 (Upper Silurian), Road River Formation, Prongs Creek, Yukon Territory, Canada.

DIAGNOSIS

Glabella strongly convex, frontal lobe rounded. Pygidium short, composed of eight rings and six pairs of pleurae; axis comparatively narrow; ring furrows well defined; border broad. Prosopon coarsely granular.

MATERIAL

From AA 95 (Upper Silurian), Prongs Creek: 8 cranidia, 2 librigenae, 25 pygidia.

DESCRIPTION

Cranidium closely similar to *H. kutchini* sp. nov. in many respects, differing in the following features. Glabella more convex. Occipital tubercle small or absent. Occipital furrow deeper, S1 stronger, S2 and S3 fainter. Intramarginal ridge present but discontinuous mesially. Pygidium shorter, 50 to 60 per cent as long as wide. Axis of eight rings and a short terminus; ring furrows much deeper and less sinuous. Paired muscle insertion scars distinct on surface of most specimens. Pleural lobe more convex, with six pleurae and deeper and broader border depression; border broader, of uniform width. Prosopon of cranidium and pygidium coarsely and densely (cf. finely) granular.

DISCUSSION

H. sourdoughi sp. nov. closely resembles *H. kutchini* sp. nov. in cranidial features, particularly in the presence of the intramarginal ridge. It also stands close to *Coniproetus bohemicus* Hawle and Corda (see Šnajdr, 1980:58, pl. 6, figs. 1–14; pl. 61, fig. 4; pl. 63, fig. 6) from the Koneprusy Limestone, Czechoslovakia, particularly as regards glabellar outline, the definition of the lateral glabellar furrows, strong pygidial ring furrows, broad pygidial border, and coarse prosopon. *H. sourdoughi* sp. nov. differs from *H. kutchini* in having an intramarginal ridge and stronger pygidial furrows. The cranidium of *H. sourdoughi* differs from that of *C. bohemicus* in having a narrower (sag.) anterior border, smaller palpebral lobes, and an intramarginal ridge (discontinuous mesially).

Subfamily Warburgellinae Owens, 1973

Genus *Prantlia* Přibyl, 1946

TYPE SPECIES

Proetus longulus Hawle and Corda, 1847, Kopanina Formation, Upper Silurian, Prague district, Czechoslovakia.

***Prantlia vagrans* sp. nov.**

Pl. 7, figs. 1–15

DERIVATION OF NAME

Specific name derived from Latin *vagrans* (wandering), in allusion to the wide distribution of this genus.

HOLOTYPE

ROM 45363 (pygidium, Pl. 7, figs. 6,7), locality AA 95 (Upper Silurian), Road River Formation, Prongs Creek, Yukon Territory, Canada.

DIAGNOSIS

A warburgelline with short frontal area, glabella 80 per cent sagittal length of cranidium, supplementary lobe adaxial to L1, strong S1, and posterior bands of second and third pygidial pleurae crossing border.

MATERIAL

From AA 95 (Upper Silurian), Prongs Creek: 16 cranidia, 22 librigenae, 48 pygidia.

DESCRIPTION

Glabella 80 per cent sagittal length of cranium, 75 per cent as wide as long, moderately convex, strongly defined, anterior outline narrowly rounded. Occipital ring narrowing rapidly abaxially; occipital tubercle small, centrally placed. Occipital lobe large, convex, strongly demarcated, extending sideways well beyond main part of ring. Occipital furrow deep and moderately broad. L1 strongly defined, subtriangular, with strong independent convexity, 30 per cent maximum glabellar width. S1 deepening rapidly, running obliquely inward and backward, shallowing and widening at back. In several specimens, S1 forming a short, transverse branch of varying strength toward front of L1, defining a small supplementary lobe marked by a short furrow posteriorly and by slight independent convexity. S2 faintly impressed, 25 per cent width of glabella, almost transverse, situated at 30 per cent length of glabella from front. S3 as S2 but slightly convergent forward, situated at 25 per cent length of glabella from front. Axial furrow straight, extremely deep and broad. Preglabellar area marked off from preocular fixigenae by a shallow, almost transverse depression. Anterior border one-third length of prelabellar area, hardly narrowing abaxially, convex. Anterior border furrow shallow but distinct. Frontal area weakly convex and marked off from the more strongly convex preocular fixigena by a faint but broad depression convex forward. Palpebral lobe small, 25 per cent length of cranium, horizontal, with anterior extremity opposite S2; palpebral furrow faint, shallow. Postocular fixigena unknown. Anterior branch of facial suture commencing close to axial furrow, curving forward and outward, and bending inward at anterior border furrow. Glabella closely granular, except in furrows, with granulation becoming finer toward front; anterior border finely granular, with delicate raised lines running parallel to that border; prelabellar area and preocular fixigena coarsely and shallowly pitted, with raised lines and a few scattered granules; palpebral lobe finely granular.

Eye strongly convex and sloping outward, separated by shallow furrow from low, narrow socle set on a ridge narrowing backward. Field convex. Lateral border furrow deep and broad, continuing into genal spine; lateral border ill defined, half minimum width of field, extending alongside genal spine. Posterior border strongly developed and extended alongside broad-based genal spine reaching backward for about 35 per cent estimated sagittal length of cephalon. Field coarsely and shallowly pitted, matching prosopon of fixigena. Closely spaced raised lines run forward and inward on outer area of lateral border; posterior to midlength, raised lines become chevron shaped, with shorter, posteriorly

directed limb on inner area of border; posterior border with similar prosopon alongside spine.

Pygidium 60 to 70 per cent as long as wide, moderately convex in both directions. Axis 30 to 35 per cent maximum width of pygidium, 85 to 90 per cent length of pygidium, narrowing slowly backward to rounded tip, composed of twelve rings and a short terminus. Ring furrows gently sinuous, strong anteriorly, becoming successively fainter, particularly abaxially. Axial furrow narrow. Pleural lobe convex; border depression strong but dying out at first pleura. Seven well-defined pleurae; eighth faint. First pleural furrow broad, narrowing abaxially, but reaching lateral margin; first interpleural furrow uniformly narrow and shallow, just reaching lateral margin. Subsequent pleural and interpleural furrows deep and broad adaxially, successively fainter, and dying out at lateral border furrow, except second and third posterior bands and interpleural furrows extending halfway across lateral border. Lateral border narrowing slightly forward, sloping outward with moderate convexity. Articulating facet smooth. Doublure as wide as lateral border. Ten almost-continuous terrace lines running subparallel to margin. Surface granular; raised lines directed inward and forward on anterior part of border. One pygidium (Pl. 7, fig. 13) showing a deformity in having a slight embayment in the posterior outline.

A meraspid cranium, 2.2 mm in sagittal length (Pl. 7, fig. 10), differing little from adult cranium except in its narrower glabella and smaller occipital lobe.

DISCUSSION

P. vagrans sp. nov. bears a close resemblance to the type species, *Prantlia longula* Šnajdr (1980:180, pl. 34, figs. 1–8), in many respects, such as the following: glabellar outline, development of the lateral glabellar furrows, large occipital lobes, segmentation and narrow axis of pygidium, and the manner in which the lateral border furrow dies out at the first pleura. *P. vagrans* differs from the type species in the following features: (1) the glabella is 80 per cent the length of the cranium (cf. 65 to 70 per cent), the prelabellar field being much shorter; (2) S2 is transverse (cf. slightly convergent backward); (3) the frontal lobe is narrower; (4) the pygidium is relatively longer, being comprised of 12 (cf. 10) rings, and has a narrower and more convex border; (5) the postaxial ridge on the pygidium is absent.

The librigena of *P. vagrans* resembles that of the warburgelline *Tetinia* in morphology and also particularly in the oblique raised lines on the outer area of the lateral border. *Prantlia* differs from *Warburgella* in the

absence of the tropidium.

Other species of *Prantlia*—*P. longifrons* (Lindström, 1885), from the Hemse Beds (Upper Silurian), Gotland, Sweden; *P. grindrodi* Owens (1973; Thomas, 1978), Wenlock Shale, Malvern, United Kingdom; and *P. canberrensis* Chatterton and Campbell (1980), Lower Silurian, Canberra, Australia—differ considerably from the type species and from *P. vagrans*, as the comparison in Table 2 demonstrates; the subgenus *Malvernocare* has been proposed for *P. grindrodi* by Přibyl and Vaněk (1978). Chatterton and Campbell (1980:85) considered *Latiproetus* Lu (1962:162) to be synonymous

with *Prantlia*, drawing attention to the similarity between the type species *L. latilimbatus* (Grabau) and *P. grindrodi*. Kobayashi (1985:419) considered *Latiproetus* to be valid, and he referred *Prantlia biloba* Kobayashi and Hamada (1974:118, pl. 12, figs. 8,9a,b), Okanari, Shikoku Island, Japan, to *Latiproetus*; he regarded *Chuanqianoproetus* Wu, 1977; *Xiushuioproetus* Q. Zhang in Qiu et al., 1983; and possibly *Malvernocare* as subgenera of the genus. In our opinion, more detailed knowledge about the morphology of the taxa concerned is required before a satisfactory revision can be proposed.

TABLE 2. Summary of diagnostic characters of the species of *Prantlia*.
glab., glabellar; %, as percentage of; *cranid.*, cranidial; *no.*, number.

	<i>longula</i>	<i>vagrans</i>	Species <i>canberrensis</i>	<i>longifrons</i>	<i>grindrodi</i>
CEPHALON					
glab. shape	triangular	triangular	bell	bell	bell
glab. length % cranid. length	68	82	66	61	62
genal spines	yes	yes	yes	?	yes
THORAX					
no. of segments	9	?	8	9	10
PYGIDIUM					
no. of rings	10	12	9–10	10	7
no. of pleurae	8	8	faint	8	5

Subfamily uncertain

Indeterminate proetid A

Pl. 6, fig. 15

MATERIAL

From AA 95 (Upper Silurian), Prongs Creek: 1 hypostome.

DISCUSSION

One small hypostome (Pl. 6, fig. 15) lacks the posterior embayment of warburgellines, and differs greatly from the hypostome of *H. kutchini* in the following features: it is much more elongate, with different prosopon; the middle body is pinched in and produced anteriorly; paired posterolateral denticles are present. We do not know of a comparable hypostome and leave its systematic position undecided.

Indeterminate proetid B

Pl. 9, figs. 4,5

MATERIAL

From BB 131 (Lower Silurian), Illtyd Range: 1 cranidium, 1 hypostome, 1 pygidium.

DESCRIPTION

Fragmentary cranidium with subquadrate glabella as long as wide. Lateral lobes apparently absent. Preglabellar and axial furrows shallow. Occipital ring 10 per cent length of cranidium. Occipital tubercle and lobe absent. Preglabellar area 20 per cent length of cranidium, not downturned; preglabellar field gently convex. Anterior border short. Anterior furrow shallow.

On hypostome, width across posterior wings 85 per cent length. Middle body swollen, strongly defined.

Middle furrow commencing at 60 per cent length of hypostome from front, inclined backward and inward for 20 per cent width. Lateral lobe composed almost entirely of strongly swollen, smooth macula. Lateral furrow shallow anteriorly, becoming deeper and broader toward back, bending outward opposite macula. Posterior furrow convex backward, broad, and shallow. Lateral border narrow, raised, continuous with posterior border; posterior border broader mesially; lateral denticle absent. Raised lines running backward

and outward on middle body, parallel to margin on borders.

DISCUSSION

The hypostome resembles that of *Hedstroemia kutchini* sp. nov., particularly in the rounded posterior outline and large maculae, but differs in having an undepressed posterior border and in prosopon. The cranidium and unillustrated pygidium are unlike *Hedstroemia* and are unidentifiable.

Family Aulacopleuridae Angelin, 1854

Genus *Otarion* Zenker, 1833

TYPE SPECIES

Otarion diffractum Zenker, 1833, from Upper Silurian rocks near Beroun, Prague district, Czechoslovakia.

DISCUSSION

In their review of the family Aulacopleuridae, Thomas and Owens (1978) suggested that *Otarion* (*Otarion*) be restricted to Late Silurian aulacopleurid species with, among other features, faint eye ridges visible on internal moulds, a subparallel-sided glabella, weakly divergent preocular facial sutures, and 13 to 17 thoracic segments, the sixth segment bearing an axial spine. They proposed that *O.* (*Aulacopleura*) be restricted to species from the Ordovician to Middle Devonian with strong eye ridges evident on the external surface and with 18 to 22 thoracic segments, none bearing an axial spine. *Aulacopleura socialis* (Poulsen), from the Early Silurian, bears conspicuous eye ridges, a glabella of parabolic outline, widely divergent facial sutures, and 12 thoracic segments, with an axial spine on the sixth segment in some specimens. These features preclude assignment to either subgenus, but are shared with *Songkania* Chang from the Early Silurian of southwest China, which we regard as a third subgenus of *Otarion*.

Subgenus *Songkania* Chang, 1974

TYPE SPECIES

Songkania hanjiadianensis Chang, 1974, Early Silurian, southwest China.

Otarion (*Songkania*) *socialis* (Poulsen, 1934)

Pl. 4, fig. 14; Pl. 8, figs. 1–12; Pl. 12, figs. 14–16; Pl. 13, figs. 3–6; Text-fig. 5B

Aulacopleura socialis Poulsen, 1934:21, pl. 2, figs. 24–27.

Aulacopleura socialis—Raasch in Raasch, Norford, and Wilson, 1961:471, fig. 4.1–9.

HOLOTYPE

MMH 3251 (cranidium, figured by Poulsen, 1934, pl. 2, fig. 25; in this paper, Pl. 13, figs. 3,4), Cape Schuchert Formation (Lower Silurian), Kap Schuchert, North Greenland.

MATERIAL

From AA 2–4.5 (Lower Silurian), Prongs Creek: 7 dorsal shields, 270 cranidia, librigenae, 3 hypostomes, 78 pygidia.

DESCRIPTION

Length of cephalon 40 per cent width opposite occipital ring. Glabella 80 to 90 per cent as wide as long, 55 to 60 per cent length of cranidium (in normal view), subquadrate, gently convex; anterolateral angles broadly rounded. Occipital ring moderately convex, with posterior margin bowed backward. Occipital tubercle centrally placed. Occipital furrow shallower than axial furrow. L1 with slight independent convexity, 30 per cent length of glabella and 20 per cent width of glabella. S1 broad and strong anteriorly, becoming weak posteriorly, running obliquely backward to occipital furrow. S2 short, distinct only on internal surface. Preglabellar and axial furrows continuous, deepening posteriorly. Preglabellar field as long as glabella when measured along surface, curving downward with moderate convexity, confluent with fixigena. Fixigena wide, sloping inward from palpebral lobe. Palpebral lobe horizontally extended, with extremities almost twice width of glabella apart; midlength of palpebral lobe opposite midlength of glabella. Eye ridge strong, slightly oblique, divided by a median furrow. Anterior border moderately wide and convex, with sagittal length greater than exsagittal length. Anterior border furrow uniformly well defined. Anterior branch of facial suture running sinuously forward and outward, cutting anterior margin

at 65 per cent width across genal angles. Posterior branch running backward and outward, cutting margin at 80 per cent width across genal angles. Doublure extending to border furrow.

Eye 20 per cent sagittal length of cephalon; strong convexity differentiating from narrow socle; socle marked off from librigena by a broad, shallow furrow. Field of librigena considerably wider than preglabellar area, moderately convex, sloping outward; caecae present on some specimens. Lateral border convex, 30 per cent minimum width of field, continuous with anterior and posterior borders; anterior and posterior borders widening rapidly adaxially. Genal spine long and slender, extending to sixth thoracic segment, arising abruptly at genal angle, directed slightly outward and backward, almost straight.

Rostral plate unknown. Hypostome elongate. Middle body large, extending to anterior margin, strongly convex. Lateral lobes large, uniting to form a posterior lobe with independent convexity. Middle furrow oblique, shallow. Anterior wing small. Lateral border narrow, convex, directed longitudinally for much of length, diverging posteriorly, and curving round to unite with rounded posterior border. Lateral denticle absent.

Thorax composed of 12 segments. Axis 30 per cent width of thorax anteriorly, narrowing to 65 per cent anterior width of axis posteriorly, gently convex transversely. Axial furrow well defined. First five rings with swollen lateral nodes. Articulating half-ring more than half length of ring. Pleural lobe horizontally extended adaxially, gently downturned at fulcrum at 60 per cent width. Pleura composed of anterior and more strongly swollen posterior bands, separated by median pleural furrow; extremity of pleura rectangular. Axial spine on sixth ring on at least two individuals (Pl. 8, figs. 6–8), tapering slowly and curving low over axis to twelfth ring; spine certainly absent on other specimens (Pl. 8, fig. 5).

Pygidium 35 to 40 per cent as long as wide. Axis 30 per cent anterior width of pygidium, 85 per cent length of pygidium, moderately convex. Terminus broadly rounded. Five rings clearly marked by continuous ring furrows, successively shorter. Pleural area increases strongly in convexity toward back. Border uniformly narrow, continuous. Four well-defined pleurae and a posterior area; anterior bands confluent with border, widening abaxially. Posterior bands more swollen, narrowing out at border furrow, delimited by pleural and interpleural furrows; pleural and interpleural furrows fuse to form border depression. Doublure narrow.

Surface smooth except as follows: coarse granules on glabella; two pairs of small granules on adaxial area of fixigena, anterior pair closer to axial furrow than posterior pair; a row of granules on occipital and thoracic rings; faint granules on axis of pygidium. External surface of field of librigena closely and shallowly pitted; lateral border of librigena with very faint, closely spaced raised lines running parallel to margin. Internal surface of librigena smooth.

DISCUSSION

The only differences between the specimens from the Road River Formation and the type material from North Greenland are the stronger granulation and the weaker development of S2 in the Road River Formation material. It is not known whether or not an axial thoracic spine was present in the Greenland material; the material under description is dimorphic in this respect.

The cranidium of *O. (S.) socialis* resembles *O. (S.) pijiazhaiensis* Chang (1974:174, pl. 81, fig. 10) more closely than it does the type species, *O. (S.) hanjiadianensis* Chang (1974:174, pl. 80, figs. 3,4; pl. 81, fig. 9); differences in the Road River Formation material from that of both other species are the broader L1, the longer preglabellar field, and the presence of granulation.

Family Harpidae Hawle and Corda, 1847

Genus *Scotoharpes* Lamont, 1948

TYPE SPECIES

Scotoharpes domina Lamont, 1948, Whether Law Linn Formation (upper Llandoverly), Whether Law Linn, North Esk Inlier, Scotland.

Scotoharpes raaschi Norford, 1973

Pl. 9, figs. 1–3

Scotoharpes raaschi Norford, 1973:20, pl. 2, figs. 1,3–5.

HOLOTYPE

GSC 27794 (cephalon, figured by Norford, 1973, pl. 2, figs. 1,3–5), Lower Silurian, GSC locality 53109 (probably the same as BB 131), Illyd Range, Yukon Territory, Canada.

MATERIAL

From BB 131 (Lower Silurian), Illyd Range: 2 cephal.

DESCRIPTION

Cephalon 65 per cent as long (sag.) as wide. Glabella

40 to 45 per cent length of cephalon and 20 per cent width of cephalon, moderately swollen, as wide as long. Width of occipital ring equal to width across L1; occipital tubercle strong, anteriorly placed. Occipital furrow shallow, transverse. L1 small, 30 per cent length of glabella, projecting only slightly sideways. S1 shallow, curving inward and dying out anterior to midlength of L1. Preglabellar and axial furrows continuous, shallow. Ala moderately large, 30 per cent width of glabella, sloping outward and depressed abaxially, narrowing and dying out anterior to midlength of glabella. Fixed cheek convex; a low ridge outlining ala anteriorly. Eye tubercle only slightly elevated, 30 per cent width of cephalon from midline, situated opposite forefront of glabella. Eye ridge clearly defined, essentially transverse; ridge of comparable strength running obliquely outward from eye tubercle to cheek roll. Cheek roll extending almost to glabella anteriorly, sloping steeply outward, narrowing and dying out at 60 per cent length

from front. Posterior border short, convex, curving strongly backward abaxially. Girder weak. Brim flattened, slightly wider anteriorly than laterally; prolongation 40 per cent sagittal length of cephalon, narrowing slowly backward, slightly inturned posteriorly. Marginal band narrow, smooth. Doublure of occipital ring almost reaches occipital furrow. Glabella, occipital ring, and ala smooth; cheek coarsely pitted, with pits on cheek roll finer than on cheek and arranged in ramifying, radiating rows separated by fine caecae. Caecae continuing 20 per cent distance across brim. Brim finely pitted. Pits on either side of girder larger.

DISCUSSION

A point of particular resemblance of our material to *S. raaschi* Norford is the ridge running obliquely outward from the eye tubercle. The occipital tubercle described above is present on the external surface only and is not preserved on the holotype cephalon.

Family Cheiruridae Hawle and Corda, 1847 Subfamily Cheirurinae Hawle and Corda, 1847

Genus *Cheirurus* Beyrich, 1845

TYPE SPECIES

Cheirurus insignis Beyrich, 1845, Liten Formation (Upper Silurian), Prague district, Czechoslovakia.

Cheirurus sp.

Pl. 5, figs. 15,16

MATERIAL

From BB 131 (Lower Silurian), Illyd Range: 1 cranium, 1 fragmentary librigena.

DESCRIPTION

Anterior part of glabella (all that is known) expanding slightly forward, moderately convex. S2 and S3 curving gently backward, 30 per cent width of glabella. Anterior border short; anterior border furrow shallow mesially, deeper abaxially. Prosopon faintly granular. The unillustrated librigena is of generalized cheirurine type.

DISCUSSION

This species differs from *C. certus* Poulsen (1934:28, pl. 3, fig. 16) and *C. hyperboreus* Poulsen (1934:29, pl. 3, figs. 17,18), both from the Cape Schuchert Formation, North Greenland, in its shorter, less-expanded frontal lobe.

Family Encrinuridae Angelin, 1854 Subfamily Encrinurinae Angelin, 1854

Genus *Cromus* Barrande, 1852

TYPE SPECIES

Trilobites intercostatus Barrande, 1846, Kopanina Formation (Upper Silurian), Prague district, Czechoslovakia.

Cromus princeps (Poulsen, 1934)

Pl. 10, figs. 1–8; Pl. 13, figs. 7–12; Text-fig. 5C

Encrinurus moderatus Poulsen, 1934:31, pl. 3, fig. 20

(non figs. 21,22).

Encrinurus princeps Poulsen, 1934:33, pl. 3, figs. 23–27.

Encrinurus princeps—Raasch in Raasch, Norford, and Wilson, 1961, fig. 5.1–5.

Encrinurus cf. *E. princeps*—Norford, 1962, pl. 8, fig. 14.

Encrinurus cf. *E. princeps*—Norford et al., 1970, pl. 8, fig. 14.

Cromus princeps—Strusz, 1980:10.

Cromus princeps—Šnajdr, 1985:16.

Encrinurus moderatus—Lane, 1988:99, pl. 5, figs. 7,?8.

HOLOTYPE

MMH 3276 (cranidium, figured by Poulsen, 1934, pl. 3, fig. 23; in this paper, Pl. 13, figs. 10, 11), Cape Schuchert Formation (Lower Silurian), Kap Schuchert, North Greenland.

MATERIAL

From AA 2–4.5 (Lower Silurian), Prongs Creek: 1 dorsal shield, 10 cranidia, librigenae, 4 hypostomes, 23 pygidia.

DESCRIPTION

Cranidium 45 per cent as long as wide. Glabella 70 to 80 per cent as wide as long, moderately convex in both directions; width across L2 60 to 65 per cent maximum width. Occipital ring wider than width across L1, with transverse posterior margin narrowing slightly abaxially. Occipital furrow broad and shallow mesially, shallower than axial furrow abaxially; rounded apodeme at extremity. L1 consisting of a ridge 35 per cent width of glabella, directed somewhat forward adaxially; L2 shorter than L3, nodular; L3 subquadrate. S1 almost continuous; S2 and S3 broad abaxially, dying out adaxially, 35 per cent width of glabella. Frontal lobe 40 to 45 per cent length of glabella, evenly and strongly rounded in outline. Axial furrow deeper and broader than preglabellar furrow, widening backward; apodemes adaxially at extremities of S1 and S2. Preglabellar furrow deep and wide abaxially, becoming shallower and narrower mesially. Anterior border of cranidium moderately wide abaxially, narrowing and almost dying out mesially. A longitudinal median depression crossing anterior border and preglabellar furrow, and running onto forefront of glabella; this depression stronger in small specimens. Fixigena wide, sloping inward from eye with strong convexity and outward to genal angle with weaker convexity. Palpebral lobe almost 20 per cent length of cranidium and marked off from fixigena by a broad, shallow depression; anterior extremity of palpebral lobe placed opposite, and at twice width across, L3. Posterior border narrower (exsag.) than occipital ring, widening slowly abaxially and rapidly adjacent to genal angle, depressed well below level of fixigena abaxially. Lateral border ill defined. Posterior border furrow deep adaxially, where continuous with lateral furrow. Genal spine thornlike, very short, directed backward and slightly outward. Anterior branch of facial suture curving forward and inward, delimiting anterior border of cranidium. Posterior branch curving outward and backward, cutting lateral margin opposite occipital furrow.

Eye pedunculate; lens surface occupying half height of stalk; stalk marked off by a broad depression from

field. Field of librigena gently convex. Preglabellar lobe 25 per cent length of cranidium, weakly convex. Lateral border strongly convex, less than half minimum width of field, continuous with anterior border, curving inward and widening at back. Lateral border furrow uniformly deep and broad. Anterior border furrow deep and broad at axial furrow, narrowing and dying out by midwidth of preglabellar lobe.

Rostral plate unknown, but conformation between librigenae indicating a narrow plate widening forward, as shown in reconstruction.

Hypostome 75 per cent as wide as long. Middle body strongly swollen, longitudinally ovate, with a less-inflated terminal area. Rhynchos broad, with independent convexity anteriorly but projecting slightly, length equalling half that of middle body. Lateral lobe comprising a small, smooth macula. Lateral furrow demarcating middle body strongly. Lateral border narrow, flattened, merging with posterior tongue; tongue 25 per cent length of hypostome and with rounded tip. Middle body closely and shallowly pitted, more coarsely so anteriorly.

Pygidium triangular in outline, 55 to 60 per cent as long as wide. Axis 25 per cent anterior width and 90 per cent length of pygidium, composed of 20 rings; first six rings continuous, subsequent rings becoming discontinuous mesially. Ring furrows successively shallower toward back. Axial furrow deep and broad anteriorly, becoming narrower and shallower posteriorly. Pleural lobe weakly convex to midwidth, downcurved abaxially. Ten pleural ribs; tenth rib postaxial, with tip generally bluntly fused with ninth; ribs flat topped, widening steadily; tips of ribs pointed and outturned, more bluntly so posteriorly. Ribs successively directed increasingly backward and outward, tenth parallel. Rib furrows deep and broad, widening slightly abaxially. Anterior band of first pleura with clear articulating facet. Four congruent axial and pleural segments. Ventral border uniformly narrow; inner margin straight; junction evenly rounded, unembayed.

Surface of cephalon, except on occipital segment and in furrows, closely tuberculate; tubercles of mixed sizes, diameter of largest being 8 per cent maximum width of frontal lobe; about one hundred tubercles on adult glabella, many perforate. A quincunx of small tubercles composed of L1–1; S1–0; L2–1. Remainder of tubercles randomly distributed. Occipital segment finely and sparsely granular. A single row of tubercles on anterior border of cranidium. Tubercles on genae larger adaxially. Pygidium granular; three or four small median tubercles on axis of pygidium randomly spaced. Attribute coding (Temple and Tripp, 1979): 1-0; 2-20; 3-0; 4-1; 5-1; 6-10; 7-0; 8-1; 9-4; 10-1; 11-½; 12-1; 13-1; 14-1; 15-0; 16-1; 17-0; 18-0; 19-0; 20-0; 21-1; 22-1; 23-0; 24-

0; 25-1; 26-0; 27-100; 28-12; 29-0; 30-2.5; 31-0; 32-1; 33-8; 34-0.

Small pygidia have fewer segments and more strongly developed ring furrows. On one pygidium, 3 mm in sagittal length (Pl. 10, fig. 5), ninth and tenth rings bifurcate laterally, third and fourth right ribs fused abaxially.

DISCUSSION

The holotype of *Encrinurus moderatus* Poulsen (1934:31, pl. 3, fig. 20), from the Cape Schuchert Formation, St. George Fiord, North Greenland, is a small cranium, 5.0 mm in length, attributable to *Cromus princeps*; thus *moderatus* is a junior subjective synonym of *princeps*. The two pygidia from the same horizon and locality referred to *E. moderatus* by Poulsen (1934, pl. 3, figs. 21,22) are not attributable to *Cromus*; they are distinct from the pygidium from Cape Constitution named *Encrinurus inflatus* by Poulsen (1934, pl. 3, fig. 19).

C. princeps most closely resembles *C. novaki* (Frech, 1888:735, pl. 29, figs. 5-9), from beds of Middle Silurian age in the Carnic Alps; *C. novaki* also possesses an anteromedian furrow and short genal spines. *C. princeps* differs in that the eyes are placed farther back and the tuberculation is coarser.

Genus *Encrinuraspis* Webby, Moors, and McLean, 1970

TYPE SPECIES

Encrinuraspis optimus Webby, Moors, and McLean, 1970, Malongulli Formation (?Caradoc Series), New South Wales, Australia.

Encrinuraspis sp.

Pl. 9, fig. 6

MATERIAL

From BB 131 (Lower Silurian), Illtyd Range: 1 pygidium.

DESCRIPTION

Pygidium 70 per cent as long as wide, moderately and evenly convex. Axis 30 per cent anterior width and 80 per cent length, tapering to a point. Twelve rings, of which first six continuous; a longitudinal median depression as deep as ring furrows interrupting posterior rings. Large median tubercles on fourth, sixth, and eighth rings. Pleural lobe downcurved with seven ribs widening slightly and a broad postaxial ridge comprising fused eighth ribs. Ring-to-pleura ratio 1.7. Two

congruent axial and pleural segments. Apart from the four axial tubercles, prosopon greatly subdued.

DISCUSSION

This pygidium has much in common with *Balizoma*—the low number of rings and pleurae, large axial tubercles, and longitudinal axial furrow—but must be excluded from *Balizoma* under Ramsköld's (1986) definition on account of the high ring-to-pleura ratio. Furthermore, the pleural area is not strongly downturned, and the pleural ribs are narrow and without large tubercles.

Šnajdr (1985) reestablished *Encrinuraspis* Webby, Moors, and McLean (1970), considered by Strusz (1980) as a junior synonym of *Cromus*. The case for retention is disputable, but *Encrinuraspis* may prove to be a useful taxon for species not readily attributable elsewhere, and the Illtyd Range pygidium is a case in question.

Genus *Balizoma* Holloway, 1980

TYPE SPECIES

Calymene variolaris Brongniart, 1822, Much Wenlock Limestone Formation, Dudley, West Midlands, United Kingdom.

Balizoma aff. *B. obtusus* (Angelin, 1851)

Pl. 11, figs. 8-10, 12-18

MATERIAL

From AA 95 (Upper Silurian), Prongs Creek: 5 crania, 1 librigena, 1 hypostome, 27 pygidia.

DESCRIPTION

Glabella 90 per cent as wide as long, with width across L2 60 per cent width across frontal lobe, moderately rounded in outline, uniformly convex longitudinally and transversely. Occipital ring short (sag.), wider than base of preoccipital glabella, strongly arched transversely; occipital furrow deep and broad. Frontal lobe 45 per cent sagittal length of glabella. L1 and S1 almost obsolete. L2 and L3 represented by comparatively small nodular tubercles. S2 and S3 short, broad, shallow furrows, discontinuous mesially. Axial furrow deep and broad, with fossula near front. Preglabellar furrow shallow. Eleven moderately sized tubercles on anterior border of cranium; lateral tubercle not enlarged. Fixigena convex. Posterior border short (sag.), incomplete; posterior border furrow deep and broad. Genal angle unknown. Cranium finely and densely tuberculate; larger tubercles perforate. Basal diameter of wid-

est glabellar tubercles 10 per cent maximum width of glabella across L4; a pair of larger tubercles opposite L2; remaining tubercles not clearly symmetrically arranged; total number about 60. A single row of small tubercles on occipital ring and posterior border.

Librigena incompletely known, with comparatively small field and broad lateral border. Rostral plate unknown.

Hypostome rhombic, with width (excluding anterior wings) 75 per cent length and anterior margin narrowly rounded. Middle body inflated, well defined by strong lateral furrow. Rhynchos large, projecting somewhat anterior to middle body, widening slightly backward, and dying out near midlength of middle body. Macula small but distinct. Anterior border short. Anterior wing large, sloping obliquely upward. Lateral border narrow, depressed. Posterior tongue almost 20 per cent length of hypostome, horizontally extended. Surface of middle body granular, with a few pits and folds.

Pygidium triangular in outline, strongly convex in both directions, high in profile, with width 85 to 95 per cent length (average width-to-length ratio 1.1:1). Axis 35 per cent maximum width of pygidium, strongly convex transversely, with 13 rings and a terminus; postaxial ridge short, reaching posterior margin in a few specimens. Rings continuous. Sagittal groove lacking on external moulds, shallower than ring furrows alongside tubercles on internal moulds. Ring furrows broad and deep. Sagittal tubercles only slightly larger than abaxial ring tubercles, absent on first and second rings, frequently on successive rings toward back. Axial furrow deep anteriorly, becoming weaker posteriorly. Nine strong pleural ribs; tenth pair short and joined at tips, or fused in a postaxial ridge; ribs parallel sided, directed increasingly strongly backward, curving downward at fulcrum. Four or five small tubercles on each pleural rib. Tips of ribs projecting in short free points. Four rings and pleurae congruent. Rib furrows deep and broad throughout. Ring-to-pleura ratio (R/P) as defined by Ramsköld (1986:529) 1.2–1.3.

DISCUSSION

It is Ramsköld's opinion (pers. comm., 1987) that this material falls within the range of the abundant Swedish species *B. obtusus* (Angelin, 1851:3, pl. 4, fig. 9; see Ramsköld, 1986:561, pl. 40, fig. 2; pl. 48, figs. 1–14; pl. 49, figs. 1–10), from the Mulde Beds (Middle Silurian), Klinteberg Marl, Hemse Beds, and Eke Beds (Upper Silurian), Gotland, Sweden. Ramsköld recognized three morphological forms: Form A, the "type form," restricted to the northeastern limestone areas in the Hemse Beds and the Eke Beds at Lau Backar; Form

B, restricted to the "marl" west and south of the southwestern outcrops of the Hemse Beds limestone area; and Form C, known only from pygidia from the upper Eke Beds. The hypostome from AA 95 is similar in main characters to that of *B. obtusus* (Ramsköld, 1986, pl. 48, fig. 1) but differs in having a less strongly defined, unwaisted rhynchos; in size, it is appropriate to *B. aff. B. obtusus*, but it should possibly be attributed to the indeterminate encrinurine described below. The pygidia under description most closely resemble *B. obtusus* Form B, but differ in the width-to-length proportions—85 to 95 per cent for Road River Formation specimens, compared to 65 to 85 per cent for *B. obtusus* Form B.

Ramsköld (1986:66) has discussed the possibility that *B. rosensteinae* (Tripp, Temple, and Gass, 1977:860, pl. 115, figs. 1–13), from the Ludlow Series, United Kingdom, and *B. dimitrovi* Perry and Chatterton (1979:589, pl. 72, figs. 1–3; pl. 73, figs. 1–17, 29–31; pl. 74, figs. 1–14, 18–23, 30–35), from the upper Whittaker and lower Delorme formations (Wenlock to lower Ludlow), Delorme Range, Mackenzie Mountains, Canada, are synonymous with *B. obtusus*. Ramsköld (1986:561) has restricted the genus *Balizoma* to species with a ring-to-pleura ratio (R/P) of 1.1–1.4, thus excluding the two Bohemian species of Pridoli age *Encrinuraspis? subvariolaris concomitans* Přibyl and Vaněk, 1962, and *Encrinuraspis? testosteron* Šnajdr, 1981, which have higher ring-to-pleura ratios (R/P) of 1.6 and 1.8, respectively.

Indeterminate encrinurine

Pl. 11, fig. 11

MATERIAL

From AA 95 (Upper Silurian), Prongs Creek: 1 cranidium.

DISCUSSION

This single cranidium differs considerably from that of *Balizoma* aff. *B. obtusus* and of most other species of *Balizoma* in the following features: (1) twice as large; (2) glabella narrowing more strongly backward; (3) smaller, multituberculate lateral lobes; (4) tubercles on glabella and anterior border of cranidium double in number and much smaller in size; (5) smaller tubercles adaxially on fixigena. *Balizoma* is the genus that this cranidium most closely resembles, but the small tubercles and lateral glabellar lobes exclude this cranidium from that genus as currently understood. The lateral lobes are completely unlike *Cromus*, and the shape of the cranidium and features of the prosopon are unlike *Encrinuraspis*.

Family Calymenidae Milne-Edwards, 1840
Subfamily uncertain

Indeterminate calymenid

Pl. 9, fig. 7

MATERIAL

From BB 131 (Lower Silurian), Illtyd Range: 1 pygidium.

DESCRIPTION

Length 65 per cent width; convexity strong. Axis 35 per cent anterior width, 95 per cent length of pygidium, narrowing steadily backward to broadly rounded tip, composed of eight rings and a terminus. Ring furrows deep and broad anteriorly, becoming successively

weaker toward back. Articulating half-ring and furrow well developed. Axial furrow deep, increasing in width toward back. Pleural lobe evenly convex; four strongly developed, flat-topped ribs curving outward and backward; fifth rib flanking axial furrow and directed backward. Interpleural furrows weak, dying out adaxially; pleural furrows strong. Articulating half pleura strong adaxially. Surface smooth.

DISCUSSION

It is impossible to assign this single pygidium to a genus or subfamily.

Family Lichidae Hawle and Corda, 1847
Subfamily Lichinae Hawle and Corda, 1847

Genus *Dicranopeltis* Beyrich, 1845

TYPE SPECIES

Lichas Scabra Beyrich, 1845, Liten Formation (Upper Silurian), Prague district, Czechoslovakia.

***Dicranopeltis* sp.**

Pl. 10, figs. 10–12

MATERIAL

From BB 131 (Lower Silurian), Illtyd Range: 1 cranium, 1 pygidium.

DESCRIPTION

Cranidium strongly convex in both directions. Occipital ring incomplete. Occipital furrow as deep as axial furrow. Median lobe narrowing slowly and steadily backward to about 50 per cent anterior width when opposite S1, and then expanding posteriorly; preoccipital depression connecting inner extremities of S1. Bullar lobe half length of cranium, with strong independent convexity. L1 and fixigena fused. Basal glabellar lobe

absent. Longitudinal furrow deep and narrow. Axial furrow continuous with S1, curving gently inward to longitudinal furrow.

Pygidium 65 per cent as long as wide. Axis strongly convex, 30 per cent anterior width, narrowing steadily backward, not pointed; three rings and furrows continuous across axis; a swollen terminus sloping downward and backward to depressed tip of axis. Axial furrows deep and narrow anteriorly, becoming shallow posteriorly, convergent. Pleural lobe flattened; three pairs of furrowed pleurae ending in short, free points. Double gently convex; terrace ridges strong.

Prosopon tuberculate, coarser on pygidium than on cranium.

DISCUSSION

The cranium resembles that of the type species *D. scabra* (Beyrich; see Barrande, 1852, pl. 28, figs. 22–26) in conformation and in the presence of the preoccipital furrow, but differs in the absence of basal glabellar lobes. The pygidium is distinctive in its long, swollen, and strongly segmented axis.

Subfamily uncertain

Indeterminate lichid

Pl. 7, figs. 16–20

MATERIAL

From AA 95 (Upper Silurian), Prongs Creek: 3 crania, 2 hypostomes, 5 pygidia.

DISCUSSION

This lichid material is too sparse to justify formal description. The two incomplete crania illustrated are similar in gross morphology, but have different prosopon features and slight differences in convexity of lobes and in courses of furrows; in both crania, the

longitudinal furrow is continuous anteriorly, and it is unknown whether a basal glabellar lobe was present or not. The specimens appear to belong to the subfamily Trochurinae (= Ceratarginae, see Thomas and Holloway, 1988). The two hypostomes would unhesitatingly be referred to the subfamily Trochurinae on account of the broad, unembayed posterior border and circumscribed middle body. All the pygidia are remarkable in that they resemble *Amphilichas* (subfamily Tetralichinae, recorded only from the Ordovician System) in the pointed axis and absence of pleural furrows on the third pleurae; there is a small median embayment in the posterior margin, but no extended free point to the third pleura. These pygidia differ conspicuously from those of the Trochurinae in outline, in having an unswollen posterior band, and in the absence of a lateral border. At first sight, therefore, the pygidia belong to a different subfamily from that of the cranidia and hypostomes.

A comparable conflict arises regarding the lichid described as *Dicranognomus skinneri* by Perry and Chatterton (1977:308, pl. 6, figs. 16–21), from Cape Phillips Formation (Middle Silurian), Baillie-Hamilton Island, Canadian Arctic Archipelago. The cranidium of this

species closely resembles that of the trochurine *Dicranognomus pustulatus* Hawle and Corda (1847:146, pl. 7, fig. 77a,b), the type species, from the Upper Silurian, Czechoslovakia, the hypostome and pygidium of which are unknown. The hypostome of *D. skinneri* is trochurine also. The pygidium is *Amphilichas*-like in its pointed axis and unfurrowed, flattened third pleurae. The original grounds for associating the parts, based on occurrence and particularly on the prosopon, are convincing.

Although the Prongs Creek and the Baillie-Hamilton Island specimens are dissimilar in many respects, these two enigmatic associations in northern Canada are unlikely to be coincidental. The Tetralichinae and Trochurinae are sister subfamilies, and it may be that a rootstock persisted in this area into the Silurian Period.

Subfamilies of the Lichidae are consistent in the morphology and comparative anatomy of the parts with the exception of the above examples and another surprising anomaly in the Cape Phillips Formation. This is the form described as Lichid n. gen., n. sp. (subfamily Ceratarginae) by Perry and Chatterton (1977:303, pl. 7, figs. 1–9), in which pygidia of *Radiolichas* type are associated with inappropriate cranidia.

Family Odontopleuridae Burmeister, 1843 Subfamily Odontopleurinae Burmeister, 1843

Genus *Leonaspis* Richter and Richter, 1917

TYPE SPECIES

Odontopleura leonhardi Barrande, 1846, Kopanina Formation (Upper Silurian), Prague district, Czechoslovakia.

Leonaspis semiglabra (Poulsen, 1934)

Pl. 12, figs. 1–13; Pl. 13, figs. 13,14; Text-fig. 5D

Ceratocephala (sens. lat.) *groenlandica* Poulsen, 1934:24, pl. 3, fig. 5 (non figs. 6,7).

Ceratocephala (*Leonaspis*?) *semiglabra* Poulsen, 1934:25, pl. 3, fig. 8 (non fig. 9 = *groenlandica*).

Leonaspis semiglabra—Raasch in Raasch, Norford, and Wilson, 1961:474, fig. 4.10–18.

Scutellum borealis—Raasch in Raasch, Norford, and Wilson, 1961:474, fig. 5.9 (non figs. 6–8).

HOLOTYPE

MMH 3261 (cranidium, figured by Poulsen, 1934, pl. 3, fig. 8; in this paper, Pl. 13, fig. 13), Cape Schuchert Formation (Lower Silurian), Kap Schuchert, North Greenland.

MATERIAL

From AA 2–4.5 (Lower Silurian), Prongs Creek: 1 dorsal shield, 8 cranidia, librigenae, 4 hypostomes, 11 pygidia.

DESCRIPTION

Cranidium 25 per cent length of dorsal shield, 60 per cent as long as wide, moderately convex. Glabella 80 to 85 per cent as wide as long. Occipital ring 20 per cent length of cranidium, without lobes or spines; occipital tubercle somewhat enlarged. Central lobe well defined by strong independent convexity, subparallel sided but constricted opposite L1 and L2, expanding anteriorly; frontal lobe, where broadly rounded, 60 per cent width across L1. L1 rounded, swollen, 30 per cent basal width of glabella. S1 deep, oblique, widening at apodeme at extremity, shallow at back. L2 elongatedly ovate, swollen, 25 per cent glabellar width, circumscribed. S2 oblique, apodeme at extremity, thence running backward, shallowing at S1. L3 and S3 absent. Axial furrows strongly divergent backward, comparatively shallow. Anterior border uniformly short, transverse. Fixigena 15 per cent width of cranidium, narrowing steadily forward, gently convex. Eye ridge narrow (tr.), extending almost to posterior border furrow.

Librigena sloping outward. Eye sessile, posteriorly placed. Field broad, gently convex. Lateral border 20 per cent minimum width of field, widening backward. Lateral border furrow shallow. Genal spine curving backward and outward, extending as far as seventh thoracic segment. Seventeen or more outwardly directed lateral spines, hindmost on genal spine; anterior few spines shorter than width of border, squat, and blunt; subsequent spines longer than width of border and successively longer, slender, and pointed. Double smooth, extending to lateral border furrow.

Hypostome subquadrate, squat, slightly wider than long. Middle body subquadrate, gently swollen, extending to anterior margin. Middle furrow short, oblique. Lateral lobe half length of middle body abaxially, narrow. Lateral border narrow, convex, widening and less swollen posterior to midlength; posterior wings project strongly, situated 60 per cent length from front. Lateral furrow very shallow alongside lateral lobe, broad and well defined posteriorly. Posterior border essentially transverse but bowed backward mesially, weakly convex.

Thorax 55 per cent length of dorsal shield; nine thoracic segments on disarticulated dorsal shield. Axis 30 per cent anterior width of thorax, arched transversely; lateral nodes well developed. Axial furrow shallow and broad. Pleura horizontal, comprising a short (exsag.), slightly swollen anterior band separated by a broad, shallow furrow from longer (exsag.) and much more swollen posterior band; posterior band terminating in a long, slender spine. Spines successively longer and more backwardly directed. A row of granules on posterior margin of rings; posterior bands of pleurae weakly granular.

Pygidium, excluding spines, 30 to 35 per cent as long as wide. First ring and furrow strong. Second ring almost equally swollen; ring furrow dying out abaxially. Third ring stunted; posterior margin bowed backward. Axial furrow shallow alongside first ring, deep and broad posteriorly. Pleural lobe largely occupied by swollen rib running obliquely from opposite first ring to great spine. Lateral border widening backward, faintly developed at great spine. Five pairs of spines: foremost

pair small; second and third pairs gradational in length to fourth pair (great spines); fourth pair twice sagittal length of pygidium; fifth pair as long as third pair.

Prosopon consisting of tubercles of various sizes; a single row of tubercles on anterior border and eye ridge.

DISCUSSION

The holotype cranidium of *L. semiglabra* (Poulsen) is incomplete posteriorly, and it is not possible to be certain whether occipital spines were present or not. The Road River Formation cranidia agree in other features, and we follow Raasch *in* Raasch, Norford, and Wilson (1961) in considering these cranidia conspecific with the *L. semiglabra* holotype. The holotype cranidium of *L. groenlandica* (Poulsen, 1934:24, pl. 3, fig. 6), also from Kap Schuchert, differs markedly from *L. semiglabra* in its rounded anterior margin and broader fixigena. Only one form of the various odontopleurid skeletal elements is present in the Road River Formation material, indicating a single species. The librigena attributed to *L. groenlandica* by Poulsen (1934, pl. 3, fig. 5; this paper, Pl. 13, fig. 14) corresponds to our material; it differs from the one referred to *semiglabra* by Poulsen (1934, pl. 3, fig. 9) in its narrower border and denser tuberculation.

Indeterminate odontopleurine

Pl. 10, fig. 9

MATERIAL

From BB 131 (Lower Silurian), Iltyd Range: 1 cranidium.

DISCUSSION

This cranidium differs from the cranidia attributed to *L. semiglabra* in having a more parallel-sided median glabellar lobe, a more convex frontal lobe, coarser tuberculation, and a nontuberculate adaxial portion of the fixigena. Although this specimen is probably attributable to *Leonaspis*, the generic reference is best left undecided.

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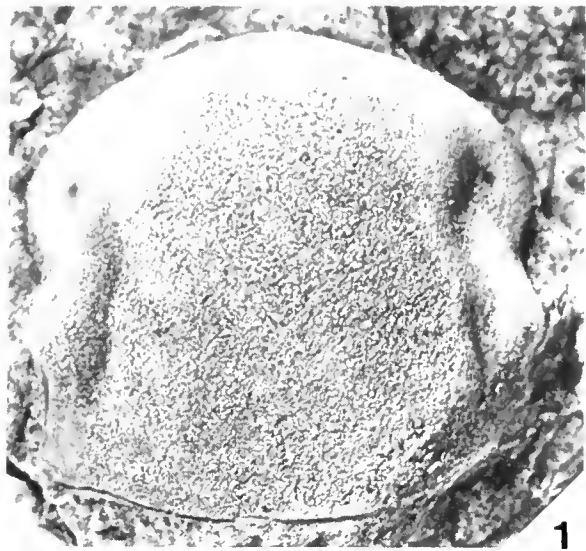
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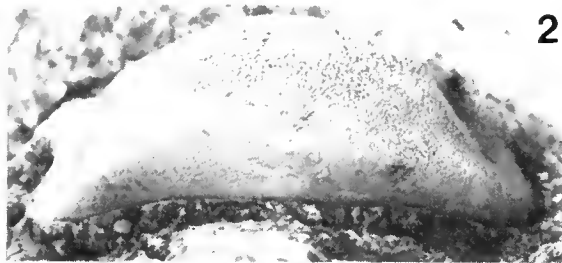
PLATE 1, figs. 1–15.

Paracybantyx asulcatus gen. et sp. nov., locality AA 95, Road River Formation, Prongs Creek, Yukon Territory, Canada.

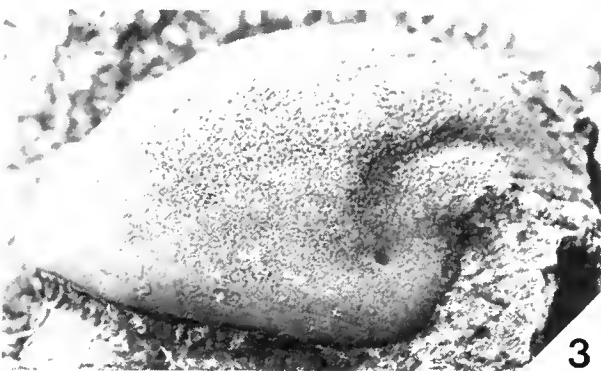
- 1–3. Cranidium, dorsal, frontal, and oblique views, ROM 45343, × 2.
- 4,5. Holotype cranidium, lateral and dorsal views, ROM 45344, × 4.
6. Cranidium, dorsal view, ROM 45376, × 3.
- 7–9. Cranidium, dorsal, frontal, and oblique views, ROM 45330, × 4.
- 10,11. Pygidium, lateral and dorsal views, ROM 45342, × 2.
12. Hypostome, latex impression, ventral view, ROM 45375, × 6.
- 13,14. Pygidium, lateral and dorsal views, ROM 45360, × 2.
15. Pygidium, lateral view enlarged to show prosopon, ROM 45360, × 4.



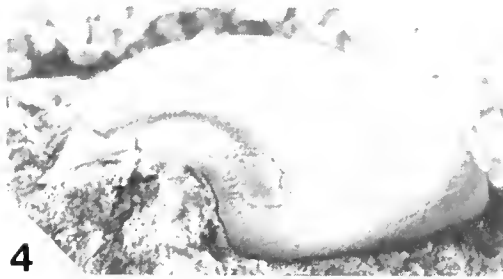
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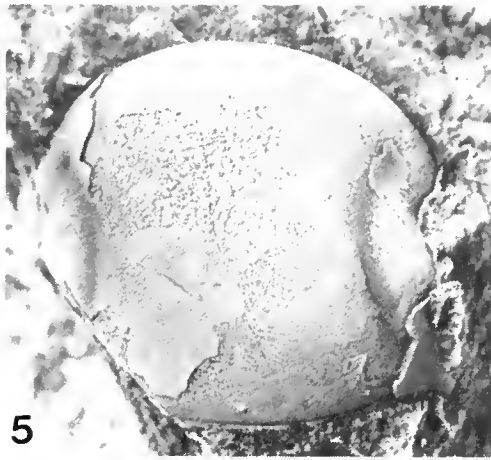
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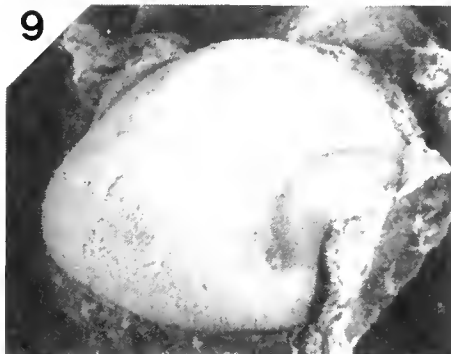
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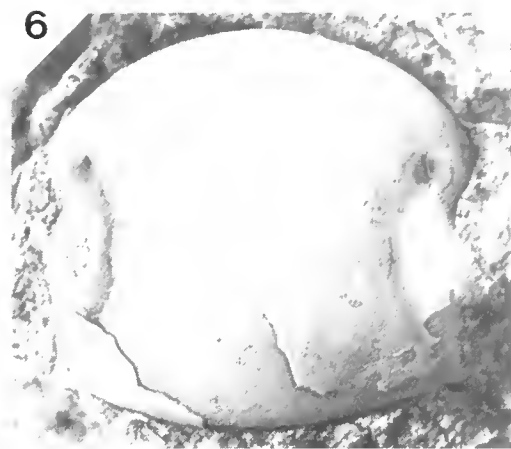
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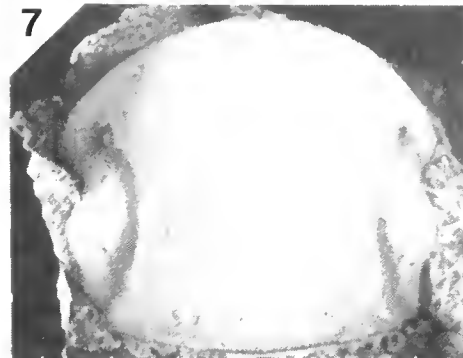
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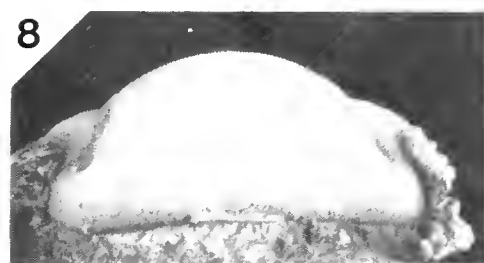
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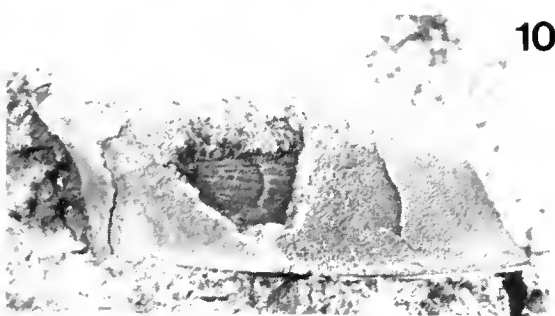
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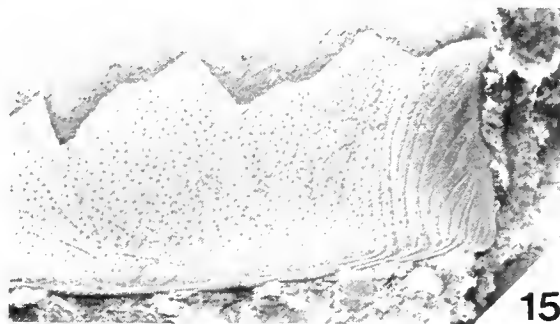
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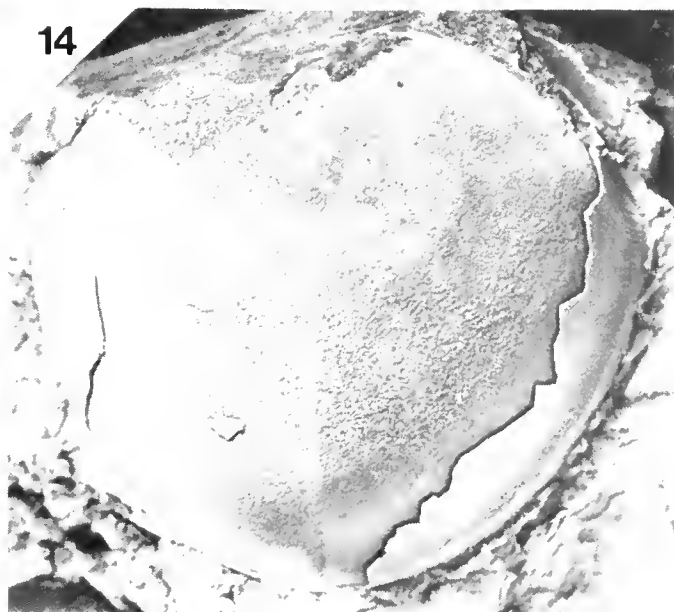
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PLATE 2, figs. 1–12.

Kosovopeltis borealis (Poulsen), locality AA 2–4.5, Road River Formation, Prongs Creek, Yukon Territory, Canada.

- 1,2. Complete specimen, dorsal views, ROM 42143, $\times 4$.
3. Librigena, ventral view, ROM 42144, $\times 3$.
4. Rostral plate, ventral view, ROM 42145, $\times 4$.
- 5,6. Cranidium, dorsal and oblique views, ROM 42146, $\times 4$.
7. Hypostome, ventral view, ROM 42147, $\times 9$.
8. Hypostome, ventral view, ROM 42148, $\times 9$.
9. Cranidium, dorsal view, ROM 42149, $\times 9$.
10. Pygidium, latex impression, dorsal view, ROM 42150, $\times 9$.
11. Pygidium, dorsal view, ROM 42151, $\times 1.4$.
12. Pygidium, dorsal view, ROM 42152, $\times 1.4$.



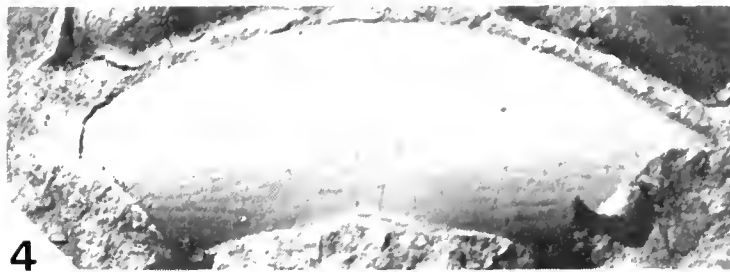
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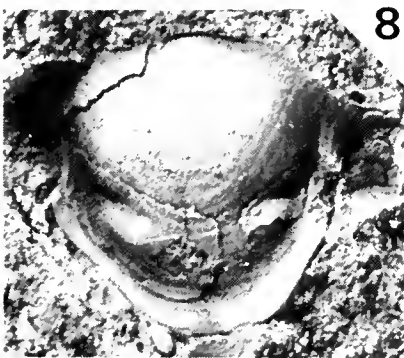
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PLATE 3, figs. 1–10.

Kosovopeltis borealis (Poulsen), locality AA 2–4.5, Road River Formation, Prongs Creek, Yukon Territory, Canada.

1. Cranidium, latex impression, dorsal view, ROM 42153, $\times 4$.
2. Pygidium, latex impression, dorsal view, ROM 42154, $\times 1.7$.
- 3–5. Cranidium with rostral plate, dorsal, anterior, and ventral views, ROM 42155, $\times 2$.
6. Librigena, dorsal view, ROM 42156, $\times 3$.
7. Pygidium, latex impression, ventral view, ROM 42157a, $\times 1.7$.
8. Slab crowded with pygidia, ROM 42157, $\times 1$.
9. Librigena, dorsal view, ROM 42158, $\times 4$.
10. Cranidium, latex impression, dorsal view, ROM 42159, $\times 4$.

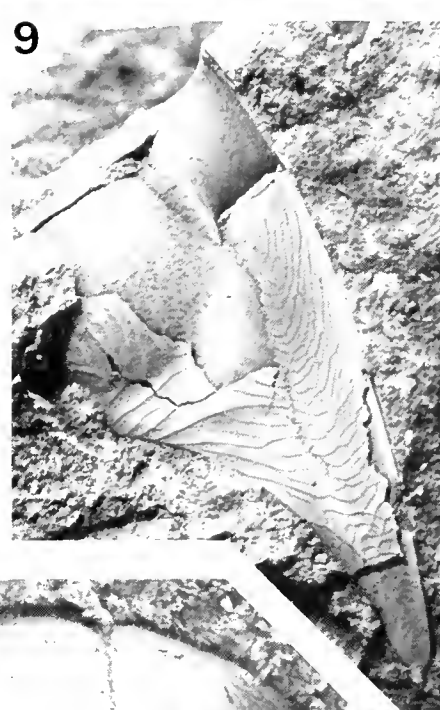
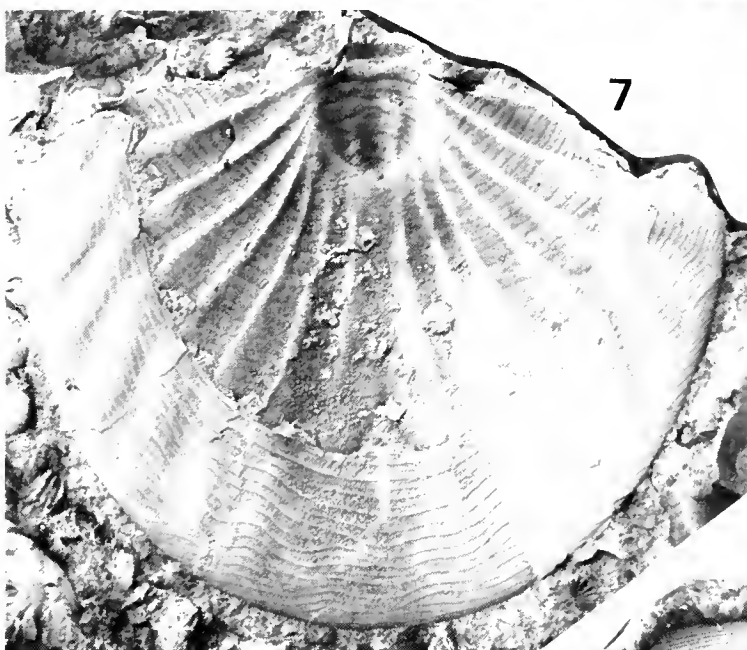
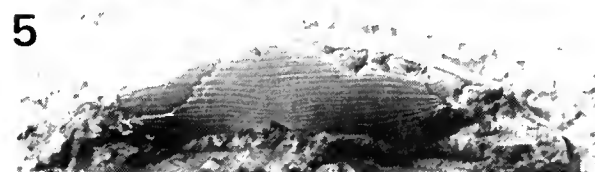
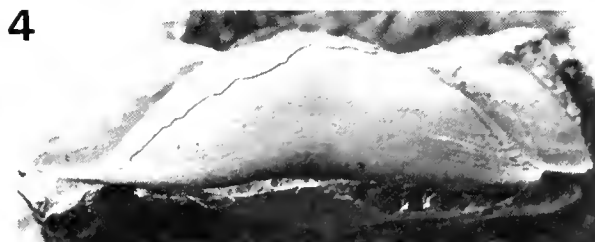
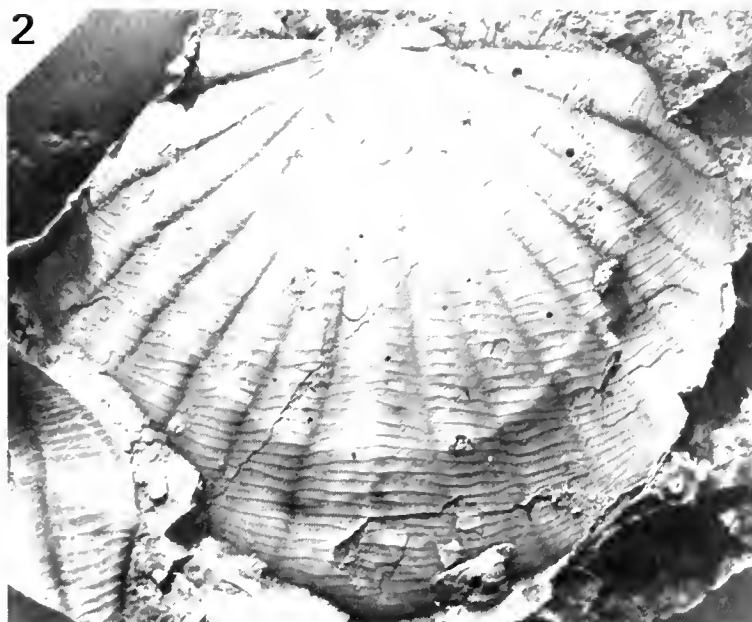


PLATE 4, figs. 1–14.

Figs. 1–13. *Kosovopeltis borealis* (Poulsen), locality AA 2–4.5, Road River Formation, Prongs Creek, Yukon Territory, Canada.

1,2. Protaspis, latex impression, dorsal and oblique views, ROM 42160, $\times 56$.

3,4. Meraspis cranidium, oblique and dorsal views, ROM 42161, $\times 24$.

5. Transitory pygidium with one protothoracic segment attached, dorsal view, ROM 42162, $\times 12$.

6,7. Transitory pygidium with two protothoracic segments attached, latex impression, dorsal and oblique views, ROM 42163, $\times 12$.

8,9. Internal mould of lens surface of holaspis eye, ROM 42164, $\times 100$ and $\times 500$.

10,11. Transitory pygidium, latex impression, oblique and dorsal views, ROM 42165, $\times 50$.

12,13. Smallest transitory pygidium, ROM 42166, $\times 56$ and $\times 92$.

Fig. 14. *Otarion* (*Songkania*) *socialis* (Poulsen), locality AA 2–4.5, Road River Formation, Prongs Creek, Yukon Territory, Canada, hypostome, ventral view, ROM 42204, $\times 24$.

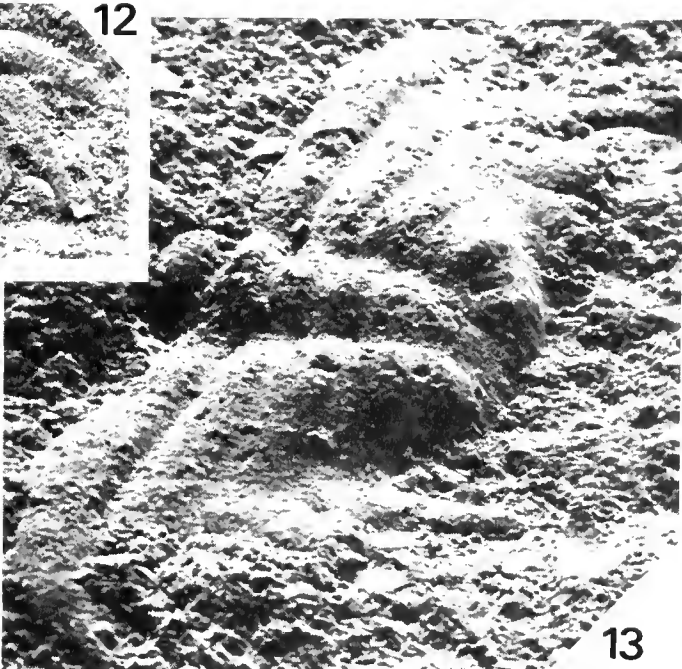
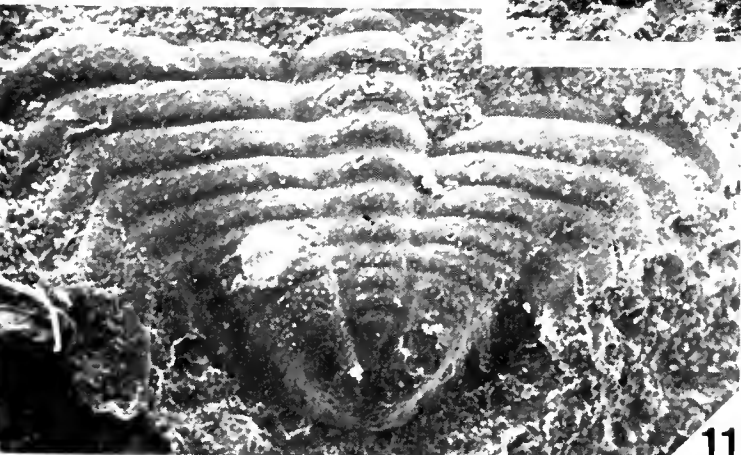
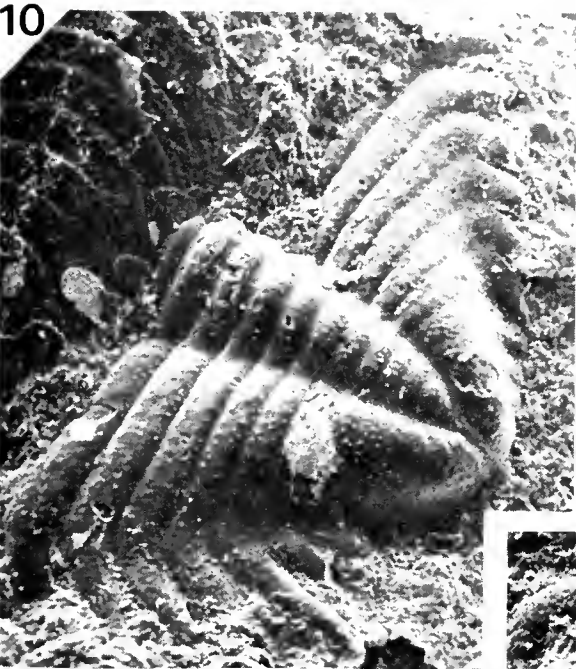
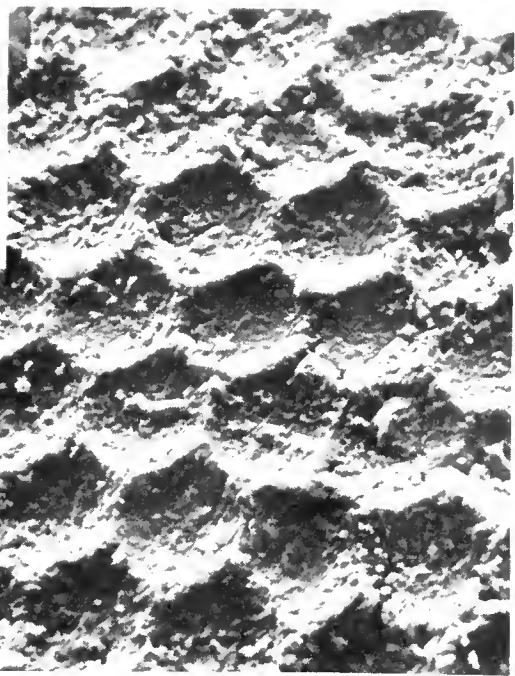
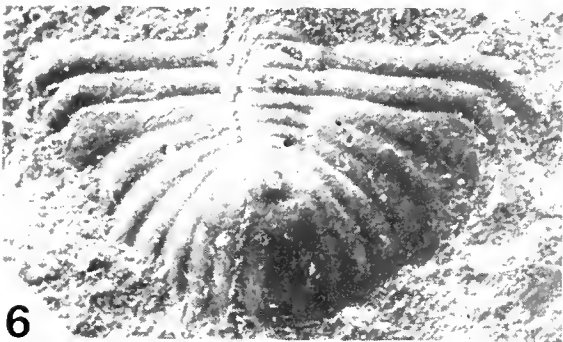
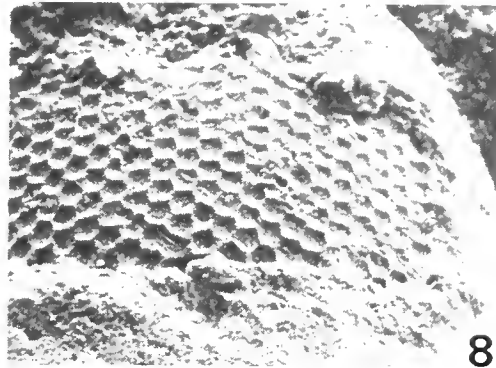
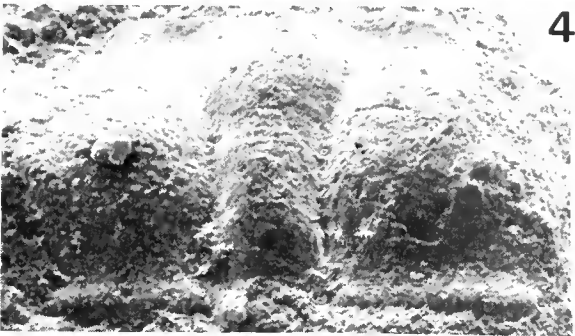
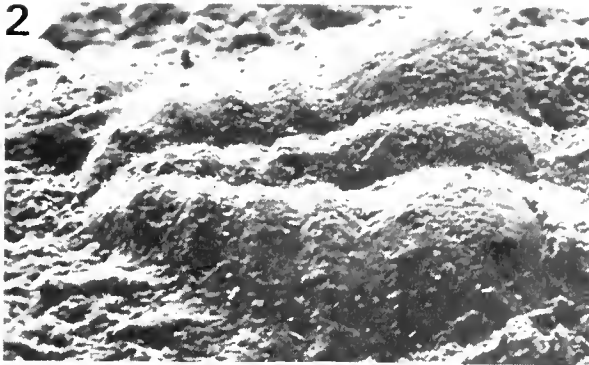
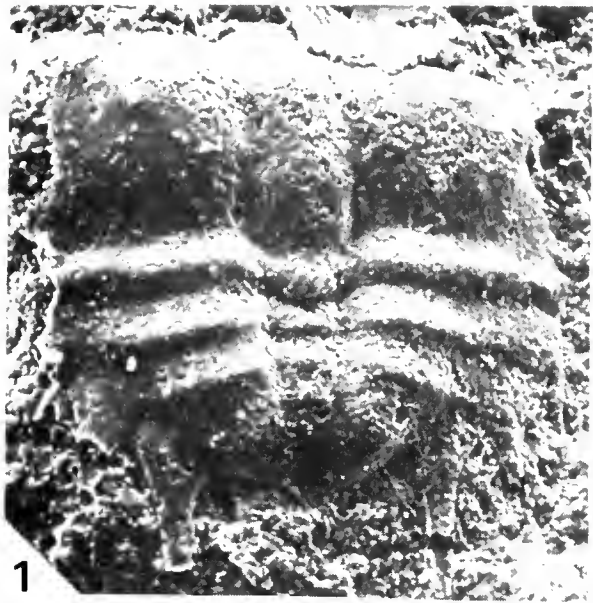


PLATE 5, figs. 1–16.

All specimens are from locality BB 131, unnamed carbonates, Illtyd Range, Yukon Territory, Canada.

Figs. 1–11. *Stenopareia illtyd* sp. nov.

1,2. Cranidium, dorsal and oblique views, ROM 42167, $\times 3$.

3,4. Holotype cranidium, dorsal and anterior views, ROM 42168, $\times 3$.

5,6. Cranidium, dorsal and anterior views, ROM 42169, $\times 3$.

7. Pygidium, dorsal view, ROM 42170, $\times 9$.

8,9. Pygidium, dorsal and lateral views, ROM 42171, $\times 4$.

10,11. Pygidium, dorsal and oblique views, ROM 42172, $\times 5$.

Fig. 12. Indeterminate illaenid, cephalon, dorsal view, ROM 42173, $\times 3$.

Figs. 13,14. Indeterminate bumastine, cranidium, dorsal and anterior views, ROM 42174, $\times 9$.

Figs. 15,16. *Cheirurus* sp., cranidium, lateral and dorsal views, ROM 42175, $\times 5$.

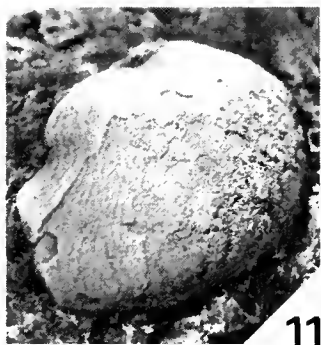
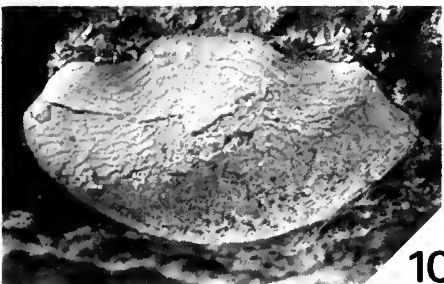
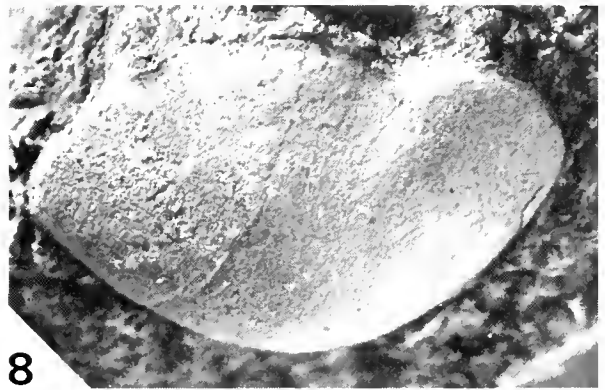
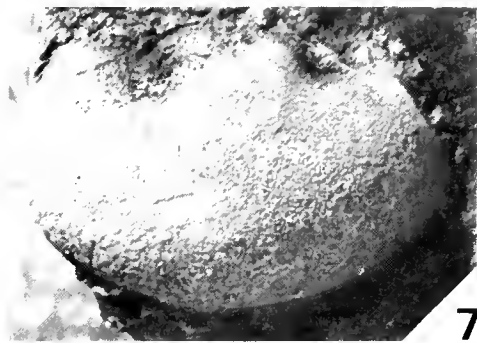
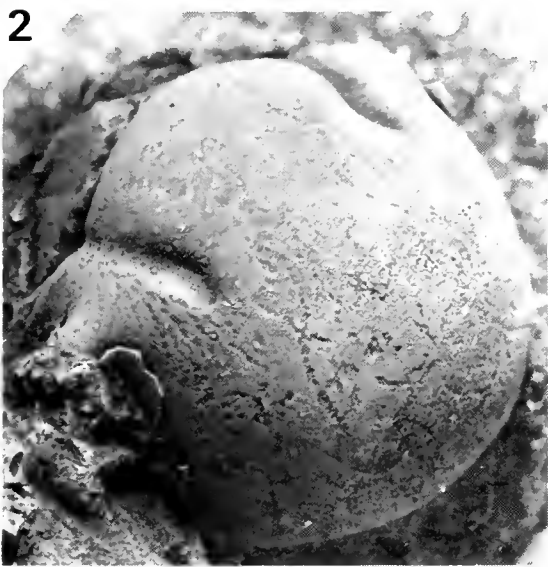
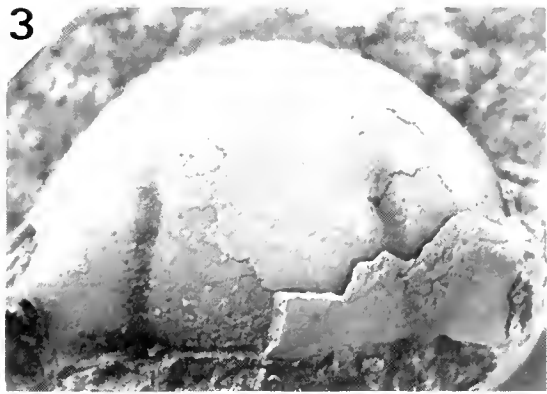
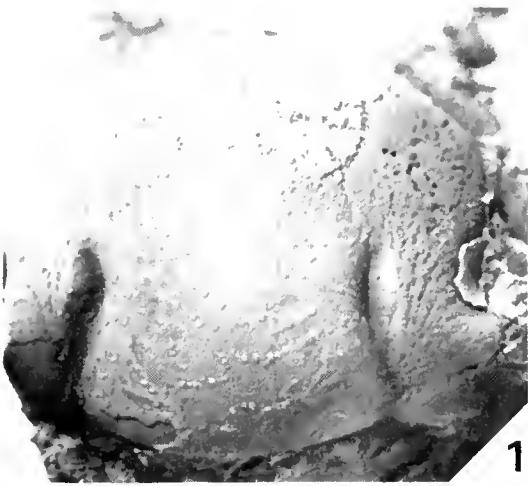


PLATE 6, figs. 1–24.

Figs. 1–14. *Hedstroemia kutchini* sp. nov., locality AA 95, Road River Formation, Prongs Creek, Yukon Territory, Canada.

- 1,2. Cranidium, dorsal and oblique views, ROM 45371, \times 5.
- 3,4. Holotype cranidium, dorsal and oblique views, ROM 45347, \times 6.
5. Cranidium, dorsal view, ROM 45348, \times 6.
- 6,7. Pygidium, dorsal and lateral views, ROM 45334, \times 4.
8. Pygidium, dorsal view, ROM 45335, \times 4.
- 9,10. Pygidium, dorsal and lateral views, ROM 45328a, \times 4.
11. Librigena, dorsal view, ROM 45372, \times 6.
12. Librigena, latex impression, dorsal view, ROM 45358, \times 5.
13. Hypostome, ventral view, ROM 45329, \times 8.
14. Hypostome, ventral view, ROM 45370, \times 8.

Fig. 15. Indeterminate proetid A, locality AA 95, Road River Formation, Prongs Creek, Yukon Territory, Canada, hypostome, ventral view, ROM 45338b, \times 8.

Figs. 16–24. *Hedstroemia sourdoughi* sp. nov., locality AA 95, Road River Formation, Prongs Creek, Yukon Territory, Canada.

16. Pygidium, dorsal view, ROM 45333, \times 4.
- 17–19. Pygidium, posterior, lateral, and dorsal views, ROM 45331, \times 6.
20. Pygidium, dorsal view, ROM 45323, \times 5.
21. Cranidium, latex impression, dorsal view, ROM 45357, \times 4.
- 22,23. Holotype cranidium, dorsal and oblique views, ROM 45332, \times 4.
24. Cranidium, dorsal view, ROM 45326, \times 6.

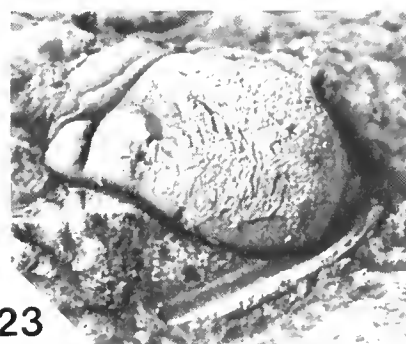
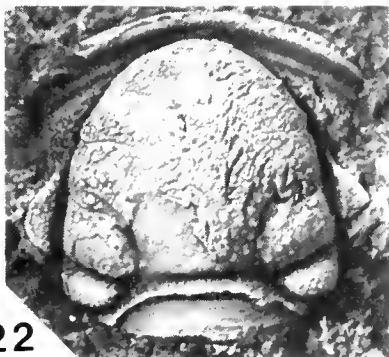
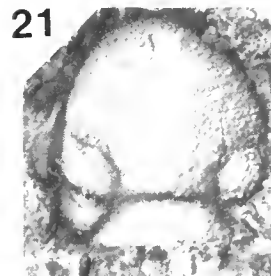
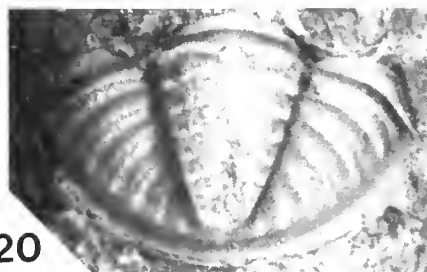
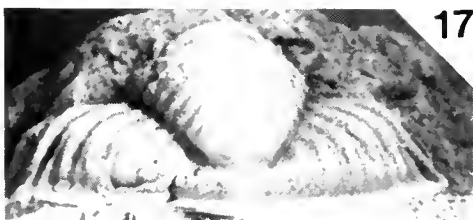
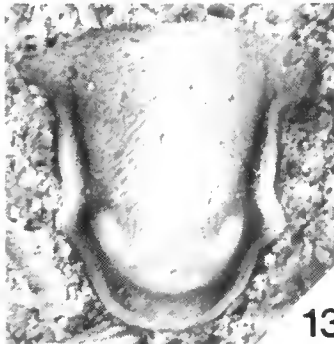
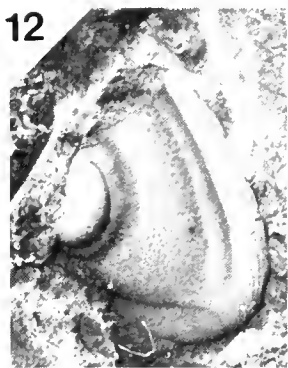
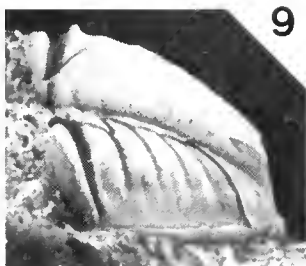
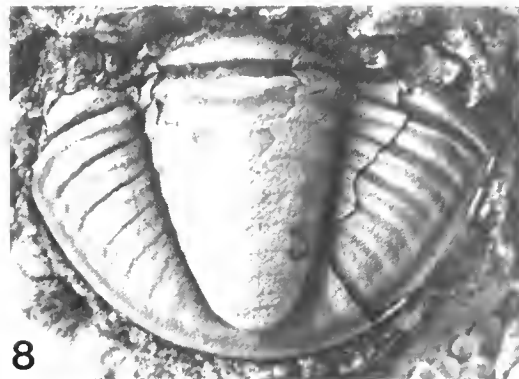
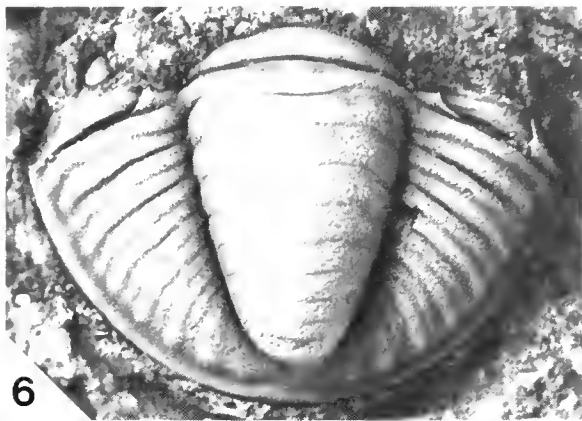
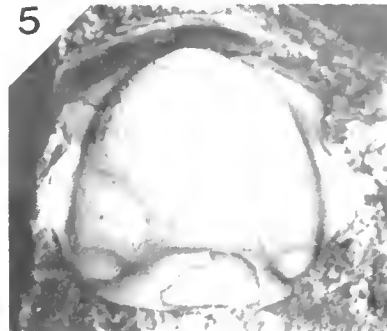
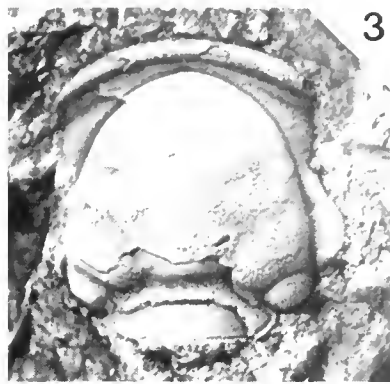


PLATE 7, figs. 1–20.

Figs. 1–15. *Prantlia vagrans* sp. nov., locality AA 95, Road River Formation, Prongs Creek, Yukon Territory, Canada.

1. Cranidium, dorsal view, ROM 45339, $\times 4$.
2. Cranidium, dorsal view, ROM 45340, $\times 4$.
3. Cranidium, latex impression, dorsal view, ROM 45353, $\times 6$.
4. Cranidium, dorsal view, ROM 45365, $\times 6$.
5. Librigena, showing narrow doublure, ventral view, ROM 45327, $\times 5$.
- 6,7. Holotype pygidium, dorsal and oblique views, ROM 45363, $\times 6$.
8. Pygidium, dorsal view, ROM 45337, $\times 4$.
9. Pygidium, dorsal view, ROM 45336a, $\times 4$.
10. Meraspid cranidium, latex impression, ROM 45351, $\times 8$.
11. Pygidium, showing narrow doublure, ventral view, ROM 45364, $\times 4$.
12. Pygidium, dorsal view, ROM 45328b, $\times 4$.
13. Pygidium, dorsal view, ROM 45341, $\times 5$.
14. Librigena, oblique view, ROM 45338a, $\times 5$.
15. Librigena, latex impression, oblique view, ROM 45355, $\times 4$.

Figs. 16–20. Indeterminate lichid, locality AA 95, Road River Formation, Prongs Creek, Yukon Territory, Canada.

16. Pygidium, dorsal view, ROM 45361, $\times 2$.
17. Pygidium, dorsal view, ROM 45366b, $\times 2$.
18. Cranidium, dorsal view, ROM 45349, $\times 5$.
19. Cranidium, dorsal view, ROM 47356, $\times 5$.
20. Hypostome, latex impression, ventral view, ROM 45354, $\times 5$.

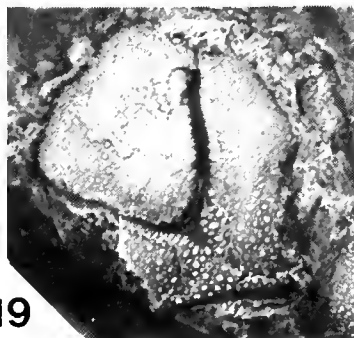
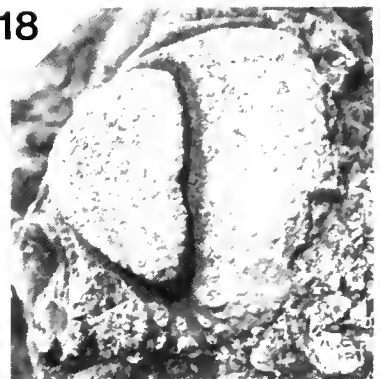
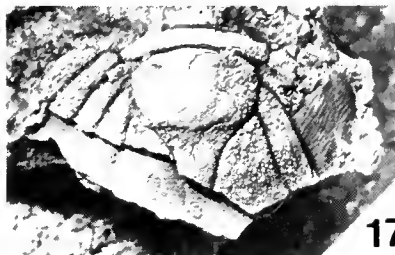
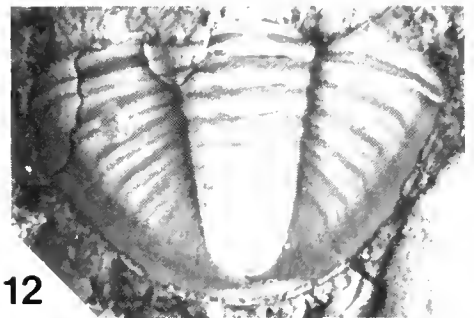
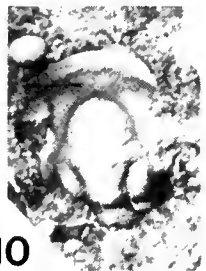
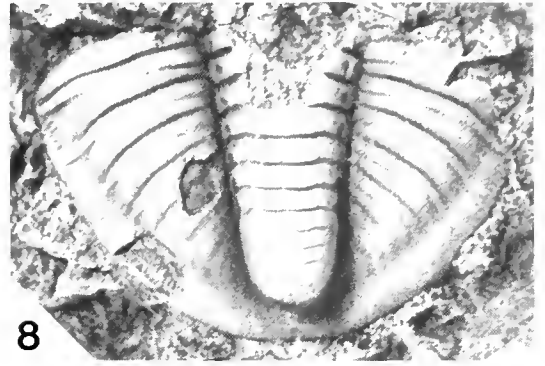
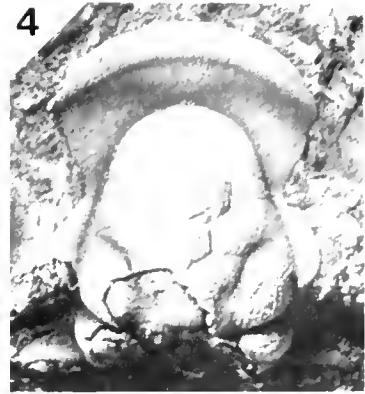
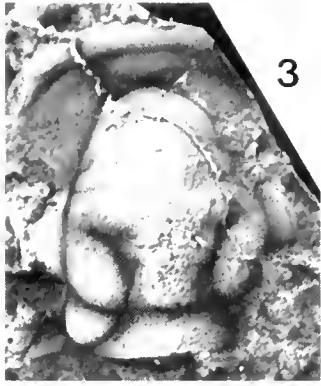
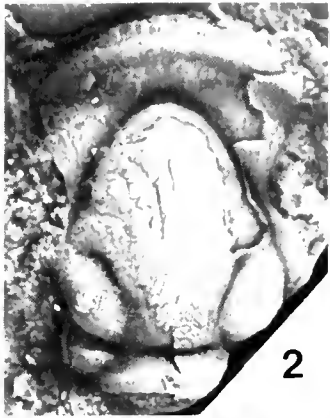


PLATE 8, figs. 1–12.

Otarion (*Songkania*) *socialis* (Poulsen), locality AA 2–4.5, Road River Formation, Prongs Creek, Yukon Territory, Canada.

- 1,2. Complete specimen, dorsal and oblique views, ROM 42176, $\times 7.5$.
- 3,4. Cranidium, dorsal and anterior views, ROM 42177, $\times 9$.
5. Complete specimen lacking axial spine on sixth segment, dorsal view, ROM 42178, $\times 7.5$.
- 6,7. Complete specimen with axial spine on sixth segment, dorsal and oblique views, ROM 42179, $\times 6$.
8. Cephalon and thorax with axial spine on sixth segment, oblique view, ROM 42180, $\times 5$.
9. Librigena, oblique view, ROM 42181, $\times 9$.
- 10,11. Complete specimen, dorsal and oblique views, ROM 42182, $\times 7.5$.
12. Librigena, oblique view, ROM 42183, $\times 9$.

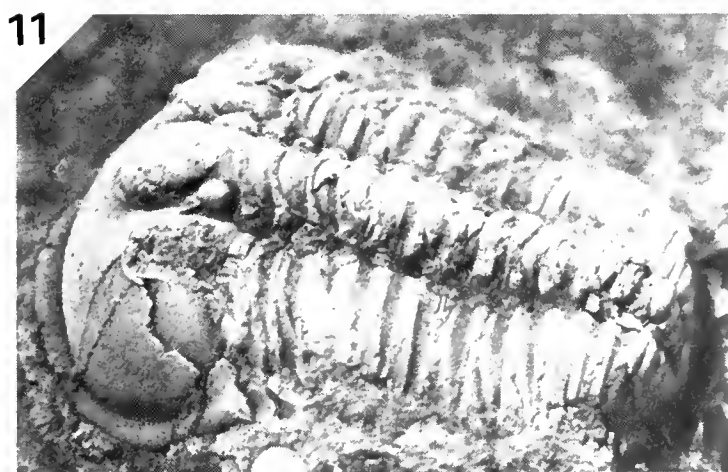
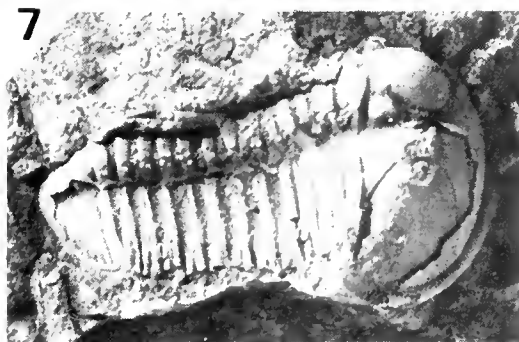
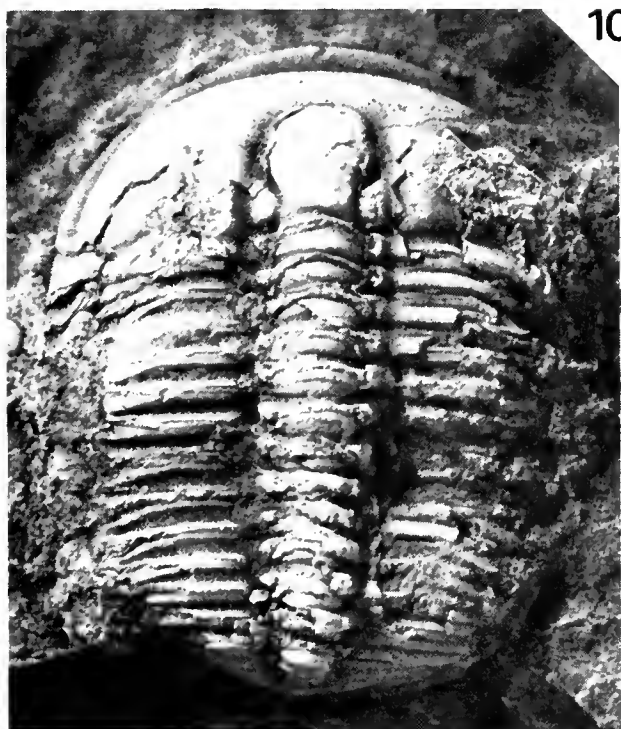
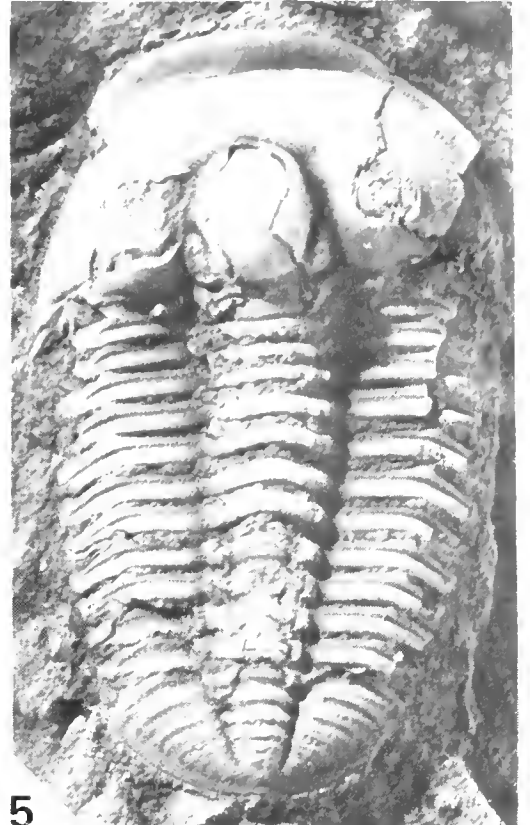
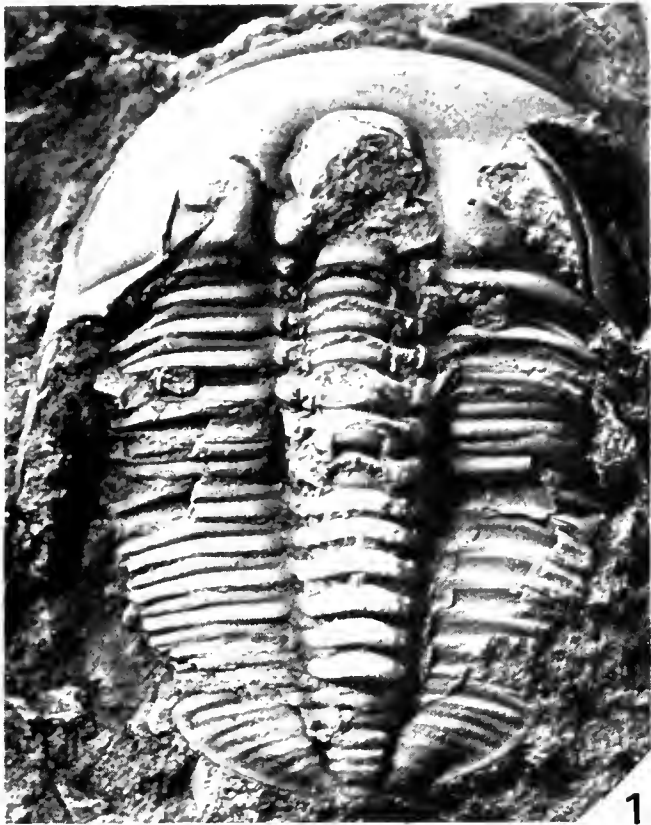


PLATE 9, figs. 1–11.

All specimens are from locality BB 131, unnamed carbonates, Illtyd Range, Yukon Territory, Canada.

Figs. 1–3. *Scotoharpes raaschi* Norford, 1973.

1,3. Cephalon, dorsal and oblique views, ROM 42184, $\times 5$.

2. Cephalon, latex impression, dorsal view, ROM 42185, $\times 5$.

Figs. 4,5. Indeterminate proetid B.

4. Hypostome, ventral view, ROM 42186, $\times 5$.

5. Cranidium, dorsal view, ROM 42187, $\times 5$.

Fig. 6. *Encrinuraspis* sp., pygidium, dorsal view, ROM 42188, $\times 9$.

Fig. 7. Indeterminate calymenid, pygidium, dorsal view, ROM 42189, $\times 4$.

Figs. 8–11. *Kosovopeltis*? spp.

8. Pygidium, dorsal view, ROM 42190, $\times 5$.

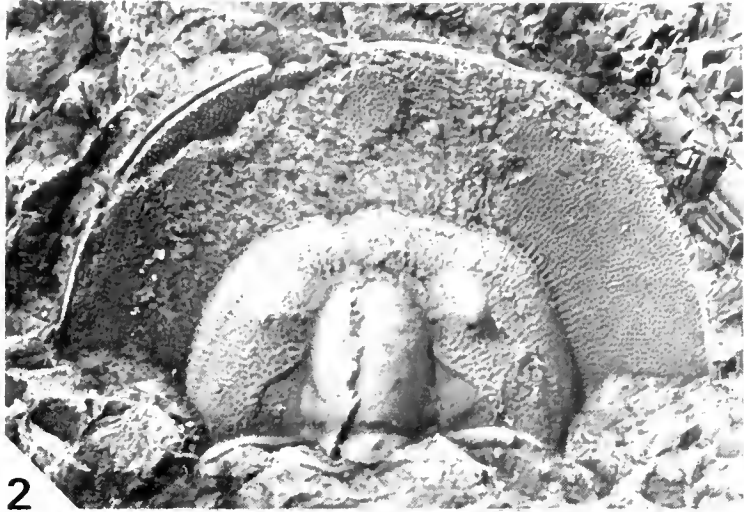
9. Cranidium, dorsal view, ROM 42191, $\times 9$.

10. Pygidium, dorsal view, ROM 42192, $\times 4$.

11. Pygidium, dorsal view, ROM 42193, $\times 4$.



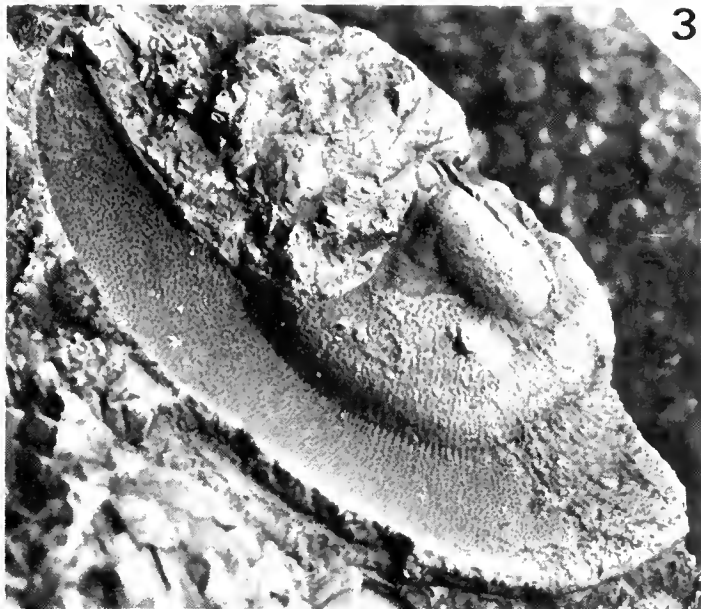
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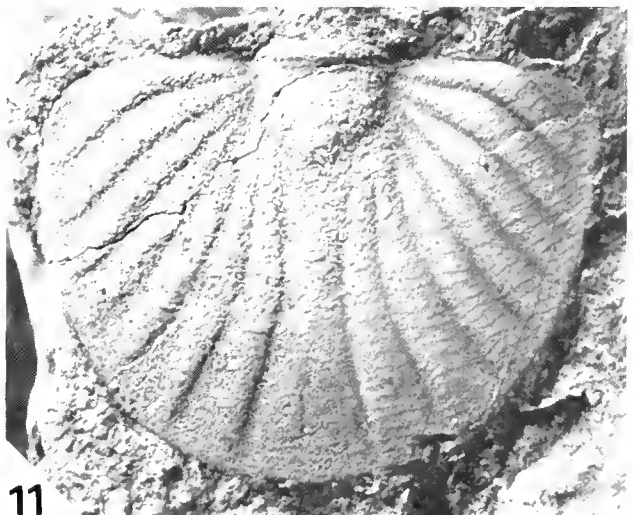
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PLATE 10, figs. 1–12.

Figs. 1–8. *Cromus princeps* (Poulsen), locality AA 2–4.5, Road River Formation, Prongs Creek, Yukon Territory, Canada.

- 1,2. Cranidium, oblique and dorsal views, ROM 42194, \times 4.
3. Hypostome, ventral view, ROM 42195, \times 9.
4. Librigena, oblique view, ROM 42196, \times 5.
5. Pygidium (deformed), dorsal view, ROM 42197, \times 9.
6. Cranidium, dorsal view, ROM 42198, \times 9.
7. Pygidium, dorsal view, ROM 42199, \times 4.
8. Pygidium, dorsal view, ROM 42200, \times 4.

Fig. 9. Indeterminate odontopleurine, locality BB 131, unnamed carbonates, Illtyd Range, Yukon Territory, Canada, cranidium, dorsal view, ROM 42201, \times 9.

Figs. 10–12. *Dicranopeltis* sp., locality BB 131, unnamed carbonates, Illtyd Range, Yukon Territory, Canada.

- 10,11. Cranidium, dorsal and oblique views, latex impression, ROM 42202, \times 9.
12. Pygidium, dorsal view, ROM 42203, \times 9.

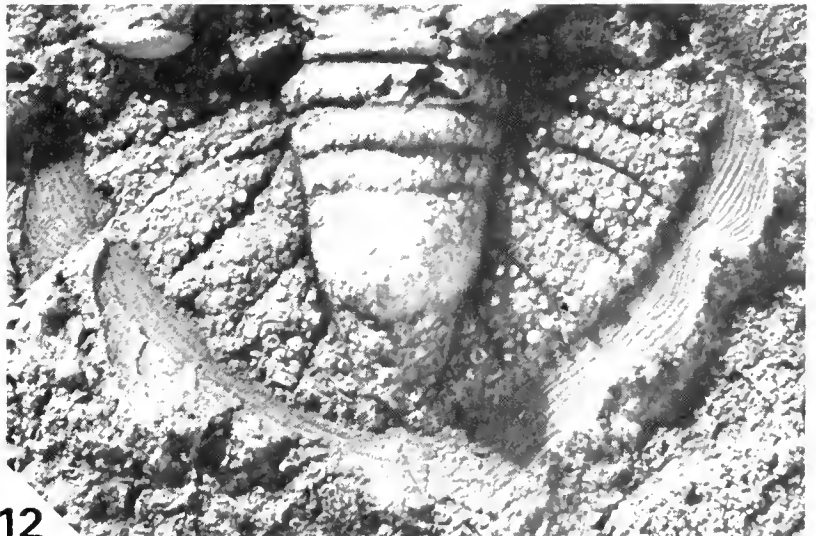
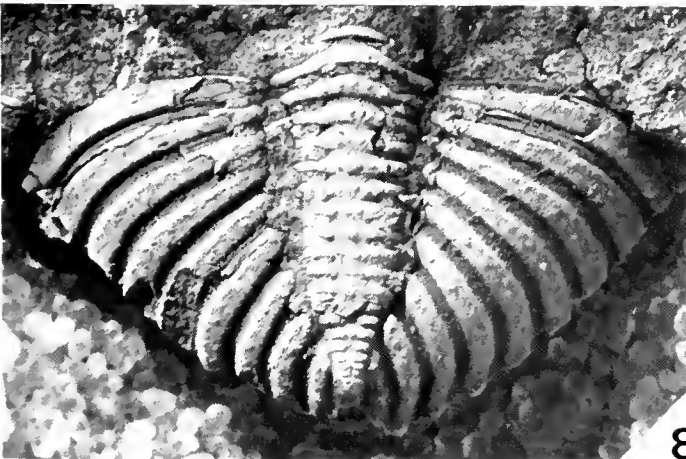
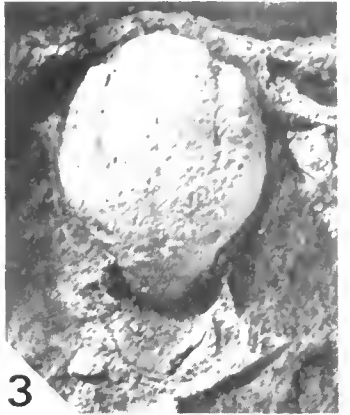
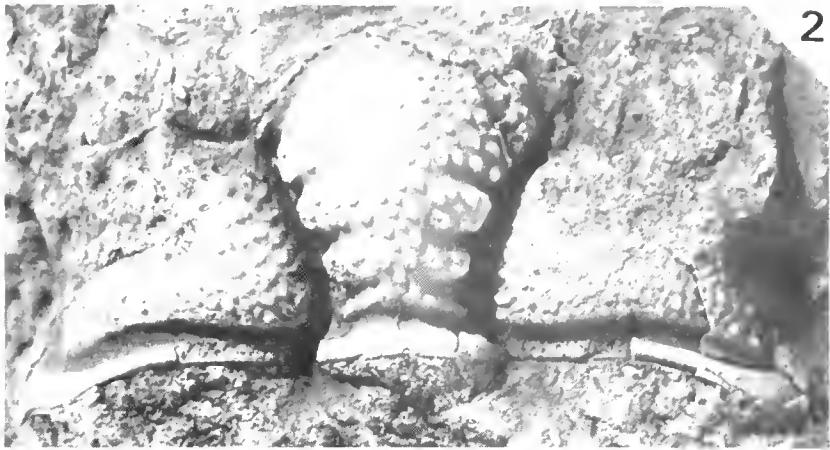


PLATE 11, figs. 1–18.

Figs. 1–5. *Paracybantyx asulcatus* gen. et sp. nov., locality AA 95, Road River Formation, Prongs Creek, Yukon Territory, Canada.

1. Pygidium, dorsal view, ROM 45345, $\times 2$.
2. Librigena, ventral view showing pit in doublure, ROM 45366a, $\times 4$.
3. Librigena, latex impression, oblique view showing doublure, ROM 45352, $\times 4$.
4. Pygidial doublure, latex impression, ventral view, ROM 45374, $\times 4$.
5. Pygidium, dorsal view, ROM 45369, $\times 6$.

Figs. 6,7. Indeterminate scutelluine, locality AA 95, Road River Formation, Prongs Creek, Yukon Territory, Canada, cranidium, dorsal view, ROM 45359, $\times 4$ and $\times 8$.

Figs. 8–10, 12–18. *Balizoma* aff. *B. obtusus* (Angelin), locality AA 95, Road River Formation, Prongs Creek, Yukon Territory, Canada.

8. Pygidium, dorsal view, ROM 45325, $\times 6$.
- 9,10. Pygidium, latex impression, oblique and dorsal views, ROM 45350, $\times 4$.
12. Cranidium, dorsal view, ROM 45336b, $\times 4$.
- 13,14. Pygidium, dorsal and lateral views, ROM 45324, $\times 4$.
- 15,16. Pygidium, posterior and dorsal views, ROM 45367, $\times 4$.
- 17,18. Hypostome, oblique and ventral views, ROM 45362, $\times 6$.

Fig. 11. Indeterminate encrinurine, locality AA 95, Road River Formation, Prongs Creek, Yukon Territory, Canada, cranidium, dorsal view, ROM 45373, $\times 3$.

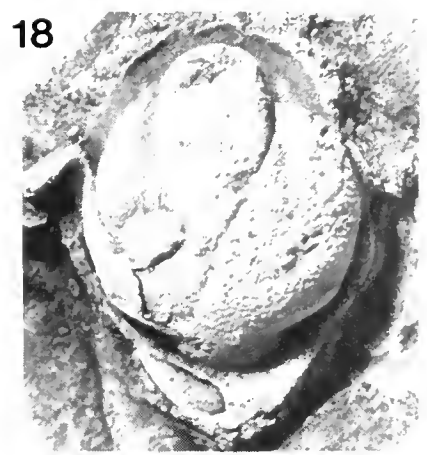
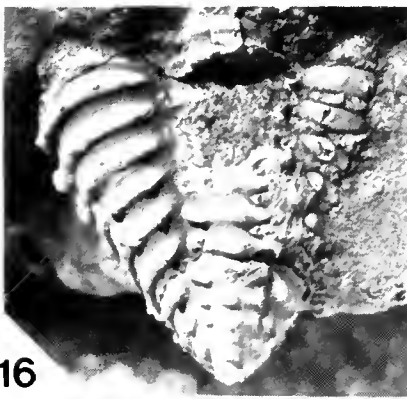
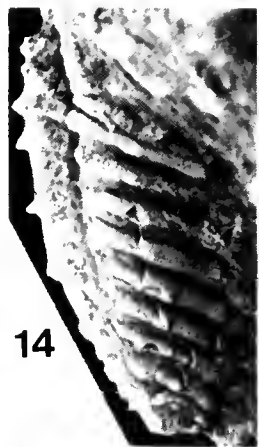
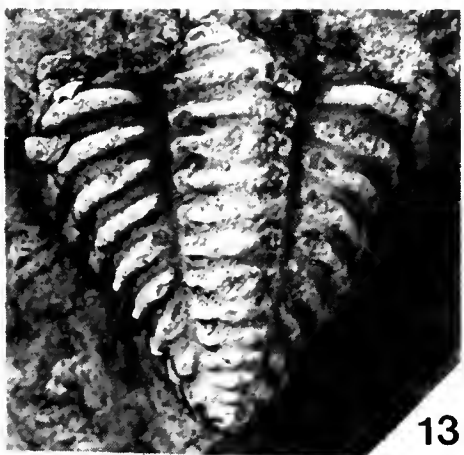
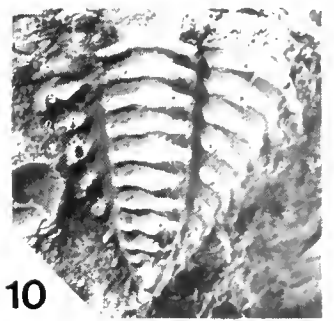
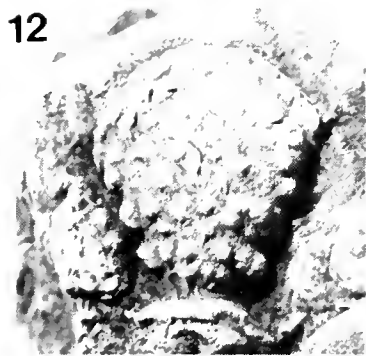
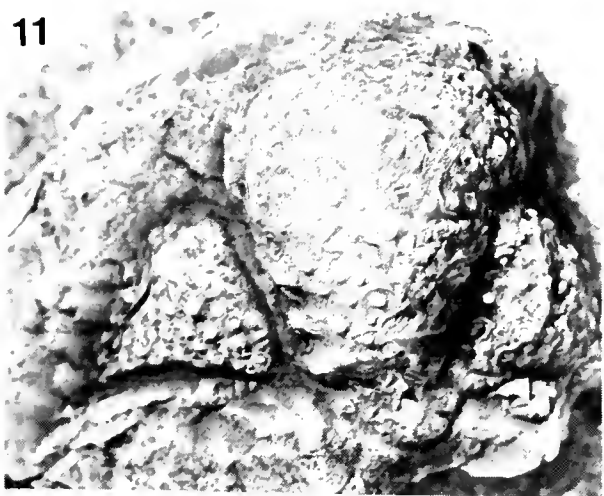
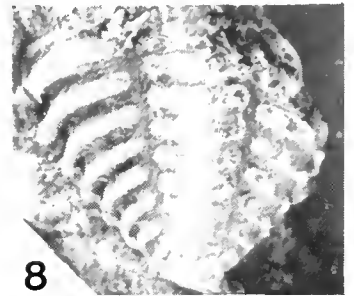
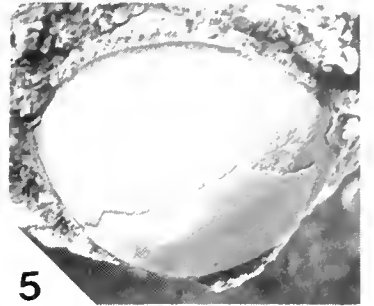
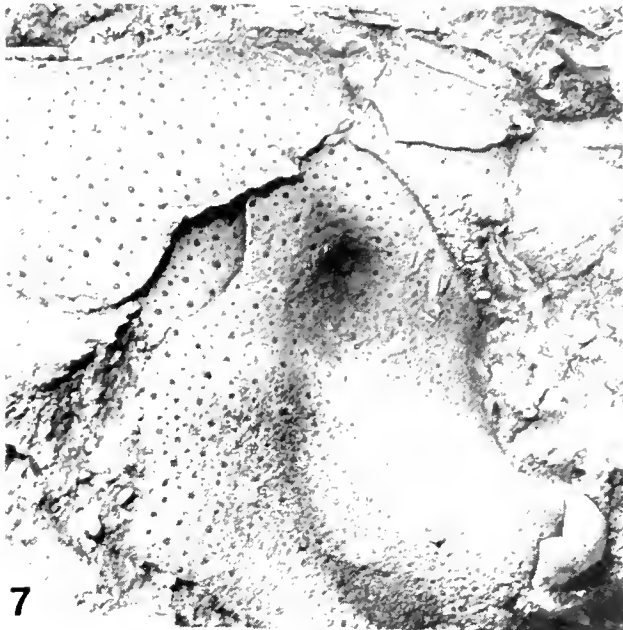
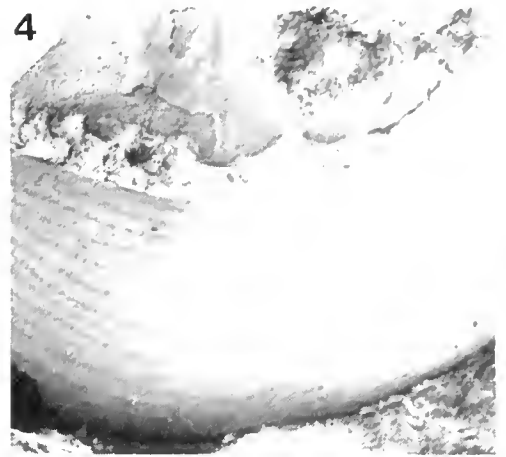
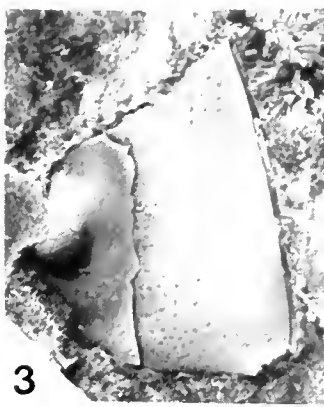
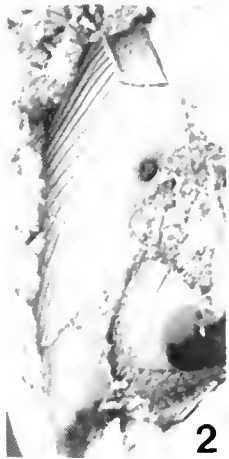
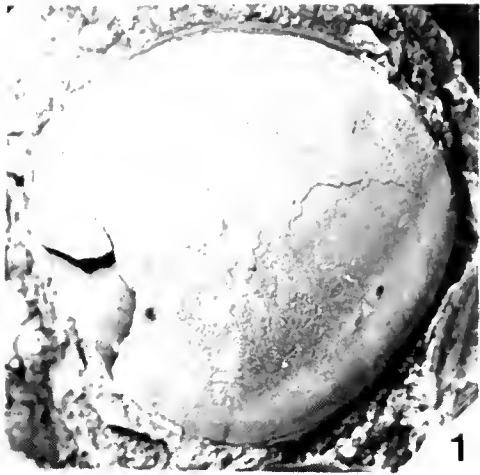


PLATE 12, figs. 1–16.

Figs. 1–13. *Leonaspis semiglabra* (Poulsen), locality AA 2–4.5, Road River Formation, Prongs Creek, Yukon Territory, Canada.

1. Cranidium, latex impression, dorsal view, ROM 42205, × 9.
2. Hypostome, ventral view, ROM 42206, × 9.
3. Pygidium, dorsal view, ROM 42207, × 9.
4. Cranidium, latex impression, dorsal view, ROM 42208, × 9.
5. Cranidium, latex impression, dorsal view, GSC 15399, × 9.
6. Cranidium, latex impression, dorsal view, GSC 15398, × 9.
7. Cranidium, latex impression, dorsal view, ROM 42209, × 9.
8. Pygidium, dorsal view, GSC 15700, × 9.
9. Pygidium, dorsal view, GSC 15701, × 9.
10. Pygidium, dorsal view, ROM 42210, × 9.
11. Librigena, oblique view, ROM 42211, × 9.
12. Pygidium, dorsal view, ROM 42212, × 9.
13. Incomplete specimen, dorsal view, ROM 42213, × 6.

Figs. 14–16. *Otarion (Songkania) socialis* (Poulsen), locality AA 2–4.5, Road River Formation, Prongs Creek, Yukon Territory, Canada.

14. Cranidium, dorsal view, GSC 15392, × 9.
15. Pygidium, dorsal view, ROM 42214, × 9.
16. Pygidium, dorsal view, GSC 15393, × 9.

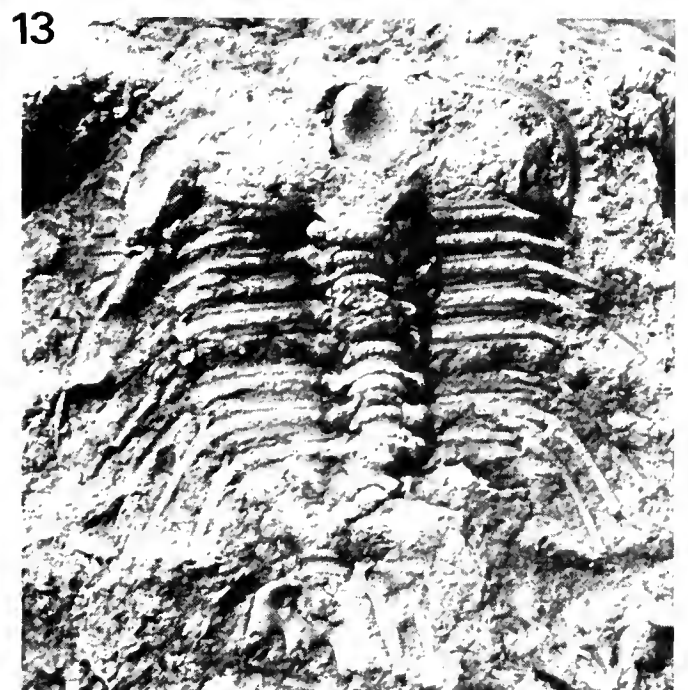
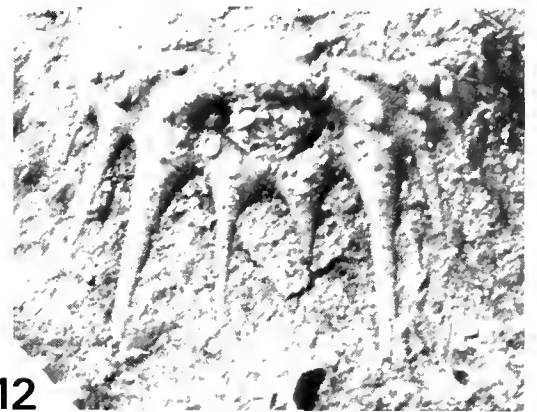
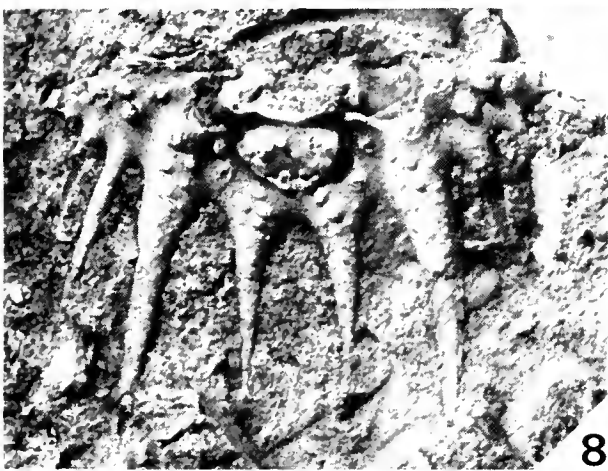
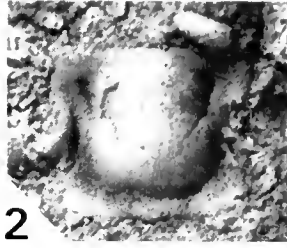


PLATE 13, figs. 1–14.

Figs. 1,2. *Kosovopeltis borealis* (Poulsen), Cape Schuchert Formation of Poulsen (1934), Kap Schuchert, North Greenland.

1. Holotype cranidium, dorsal view, MMH 3267, $\times 3$.
2. Cranidium, dorsal view, MMH 3268, $\times 3$.

Figs. 3–6. *Otarion (Songkania) socialis* (Poulsen), Cape Schuchert Formation, Kap Schuchert, North Greenland.

- 3,4. Holotype cranidium, dorsal and anterior views, MMH 3251, $\times 9$. Note caecae crossing prelabelar field abaxially.
5. Librigena, oblique view, MMH 3252, $\times 6$.
6. Pygidium, dorsal view, MMH 3253, $\times 9$.

Figs. 7–12. *Cromus princeps* (Poulsen), Cape Schuchert Formation, Kap Schuchert, North Greenland.

7. Pygidium, dorsal view, MMH 3278, $\times 3$.
8. Pygidium, dorsal view, MMH 3279, $\times 3$.
9. Pygidium, dorsal view, MMH 3280, $\times 3$.
- 10,11. Holotype cranidium, dorsal and oblique views, MMH 3276, $\times 4$.
12. Librigena, oblique view, MMH 3277, $\times 3$.

Figs. 13,14. *Leonaspis semiglabra* (Poulsen), Cape Schuchert Formation, Kap Schuchert, North Greenland.

13. Holotype cranidium, dorsal view, MMH 3261, $\times 9$.
14. Librigena, oblique view, attributed to *L. groenlandica* by Poulsen, MMH 3258, $\times 9$.



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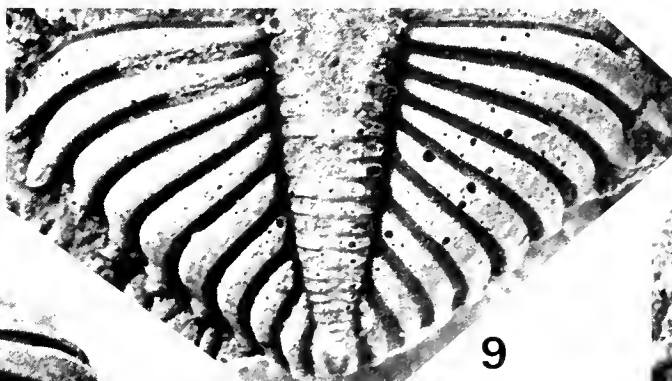
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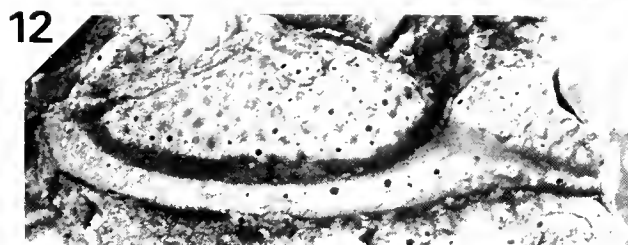
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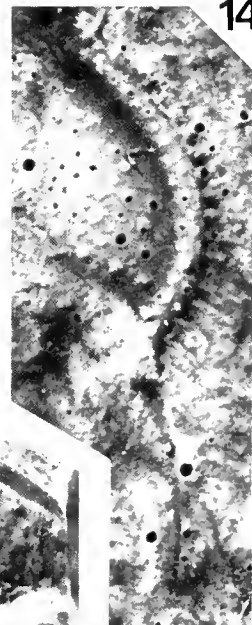
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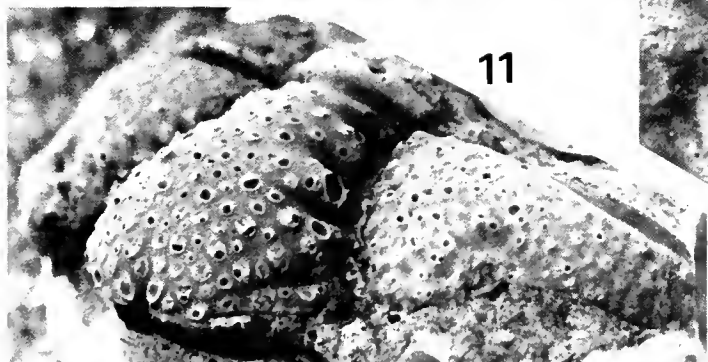
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- 146** *Stipatocrinus*, a New and Unusual Camerate Crinoid from the Lower Silurian of Western New York
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- 147** Biostratigraphy and Palaeontology of the Scollard Formation, Late Cretaceous and Paleocene of Alberta
Loris S. Russell
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- 148** Shallow-Water Hydroids of Bermuda: The Athecatae
Dale R. Calder
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- 149** Occurrence of the Cladid Inadunate Crinoid *Thalamocrinus* in the Silurian (Wenlockian) of New York and Ontario
George C. McIntosh and Carlton E. Brett
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- 150** Late Cretaceous–Early Tertiary Dinoflagellates and Acritarchs from the Kashi Area, Tarim Basin, Xinjiang Province, China
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- 151** The Structure of the Call Note System of the Warbling Vireo
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