WENLOCK TRILOBITES AND BRACHIOPODS FROM THE MACKENZIE MOUNTAINS NORTH-WESTERN CANADA

by D. G. PERRY *and* B. D. E. CHATTERTON

ABSTRACT. Silicified Wenlock trilobites representing at least fifteen genera are reported from argillaceous carbonates within the upper beds of the Whittaker Formation and lower beds of the Delorme Formation, Delorme Range, south-western District of Mackenzie, Canada. The associated brachiopod fauna is of low diversity (six genera), small physical size, and is dominated by neanic stages of development. Elements of this brachiopod fauna are poorly known elsewhere in north-western Canada. The trilobites were derived from five collections spanning 125 m (410 ft) of strata; the most diverse faunas are from the lower 15 m (50 ft) of the trilobite bearing interval. The trilobite collections are bounded by conodont faunas representative of the *Pterospathodus amorphognathoides* Zone below and the *Pedavis latialata* Zone 116 m (380 ft) above the youngest trilobite collection. The fauna is generically dominated by cheirurids and odontopleurids. Scutelluids, phacopids, dalmanitids, and harpids are absent from our collections. New taxa described are: *Otarion brauni*, *Scharyia redunzoi*, *Deiphon braybrooki*, *Youngia copelandi*, *Encrinurus* (*Fragiscutum*) *dimitrovi*, *Acidaspis jessi*, and *Diacanthaspis* (*Acanthalomina*) *thorsteinssoni*.

THIS diverse fauna of small-sized silicified trilobites and brachiopods was derived from approximately 30 kg of argillaceous limestones collected by D. G. Perry and A. C. Lenz during mapping of Lower Palaeozoic strata in the south-western District of Mackenzie in 1972. Remoteness and expense have precluded recollection of the section.

The fauna occurs in the upper part of the Whittaker and lower part of the Delorme Formation, Delorme Range, eastern Mackenzie Mountains (text-fig. 1). The fauna is strongly dominated numerically by ostracodes (85%), trilobites (10%), phosphatic gastropod moulds (3%), with minor constituents comprising bryozoans, machaeridians, articulate brachiopods, anaspid fish scales, conodonts, and inarticulate brachiopods. The diverse ostracode fauna was described by Copeland (1977).

The articulate brachiopods recovered from the trilobite-bearing collections are of small size (less than 4 mm maximum diameter) and are represented by only a few specimens, most of which are early growth stages. Taxa present include: *Katastrophomena* and *Aegiria*, which have only recently been recognized elsewhere in North America by Lenz (1977) who reported these taxa from other localities in the Silurian of north-western Canada; *Leptaena* and *Morinorhynchus*, which are known from Wenlock strata of central Nevada (Johnson *et al.* 1976) and probably from northern Canada (Lenz 1977); the smooth chonetid *Shagamella*? sp., which has not previously been reported from western North America, and an indeterminate mesodouvillinid.

The trilobite fauna from these five collections includes more than 600 identifiable trilobite skeletal elements, representing fifteen genera. Wenlock trilobites of western and arctic North America are poorly known and have only recently been documented in the literature (Perry and Chatterton 1977) from a locality on southern Baillie-Hamilton Island, Canadian Arctic Archipelago. Other North American Middle

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Silurian trilobite studies have been made from the American Midwest (Weller 1907; Campbell 1967) and from silicified faunas in the north-eastern United States (Whittington and Campbell 1967). As outlined in Perry and Chatterton (1977), previously described Silurian trilobite faunas from western North America are of Llandovery or Ludlow age. The Whittaker–Delorme Wenlockian trilobite fauna is not closely comparable with regard to taxonomic composition to the supposed Wenlock fauna of Lane (1972) from north-eastern Greenland, which may be partly of Llandovery age (Scrutton 1975).

At the familial level, this fauna from the Whittaker and Delorme Formations corresponds closely to that described from the Baillie-Hamilton Island Wenlock, although the number of genera within each family is variable. The absence of phacopids and dalmanitids in both areas probably reflects similar environments and similar trilobite communities in both regions, and potentially may reflect biogeographic distributions. The faunas from Baillie-Hamilton Island occur in carbonate debris flows intercalated with graptolitic shales. The debris flows are derived from the margins of the carbonate platform sequences located nearby, and thus contain 'telescoped' associations of shells that probably did not all occur together in life. The trilobites described herein are from a 'shallowing upward' sequence of shales and argillaceous limestones developed within an intra platform basinal sequence of the Root Basin of the Mackenzie Mountains.

The small physical size of all the taxa present might suggest current sorting, however, the fine state of preservation of the delicate spines and the thin shells, combined with the low diversity of the brachiopod fauna, and the absence of corals and stromatoporoids suggest deposition in a low energy, moderate depth environment.

STRATIGRAPHY AND AGE

The upper part of the stratigraphic section yielding the described fauna (text-fig. 1) was designated as the type locality of the Delorme Formation by Douglas and Norris (1961). The basal beds of the Delorme Formation were assigned a probable Ludlow age by Norford *in* Douglas and Norris (1961), although diagnostic invertebrate fossils were not mentioned. In this region both the upper part of the Whittaker Formation and the lower part of the Delorme Formation comprise a sequence of dark-grey shales and argillaceous limestones and dolostones. In the Delorme Range, the contact between the Whittaker and Delorme Formations is gradational and is picked where buff- and orange-brown-weathering strata predominate over grey- and dark-grey-weathering strata.

Only preliminary biostratigraphic studies (Perry 1974; Lenz 1977; Copeland 1977) have been made of the Wenlock shelly faunas of the District of Mackenzie. This is

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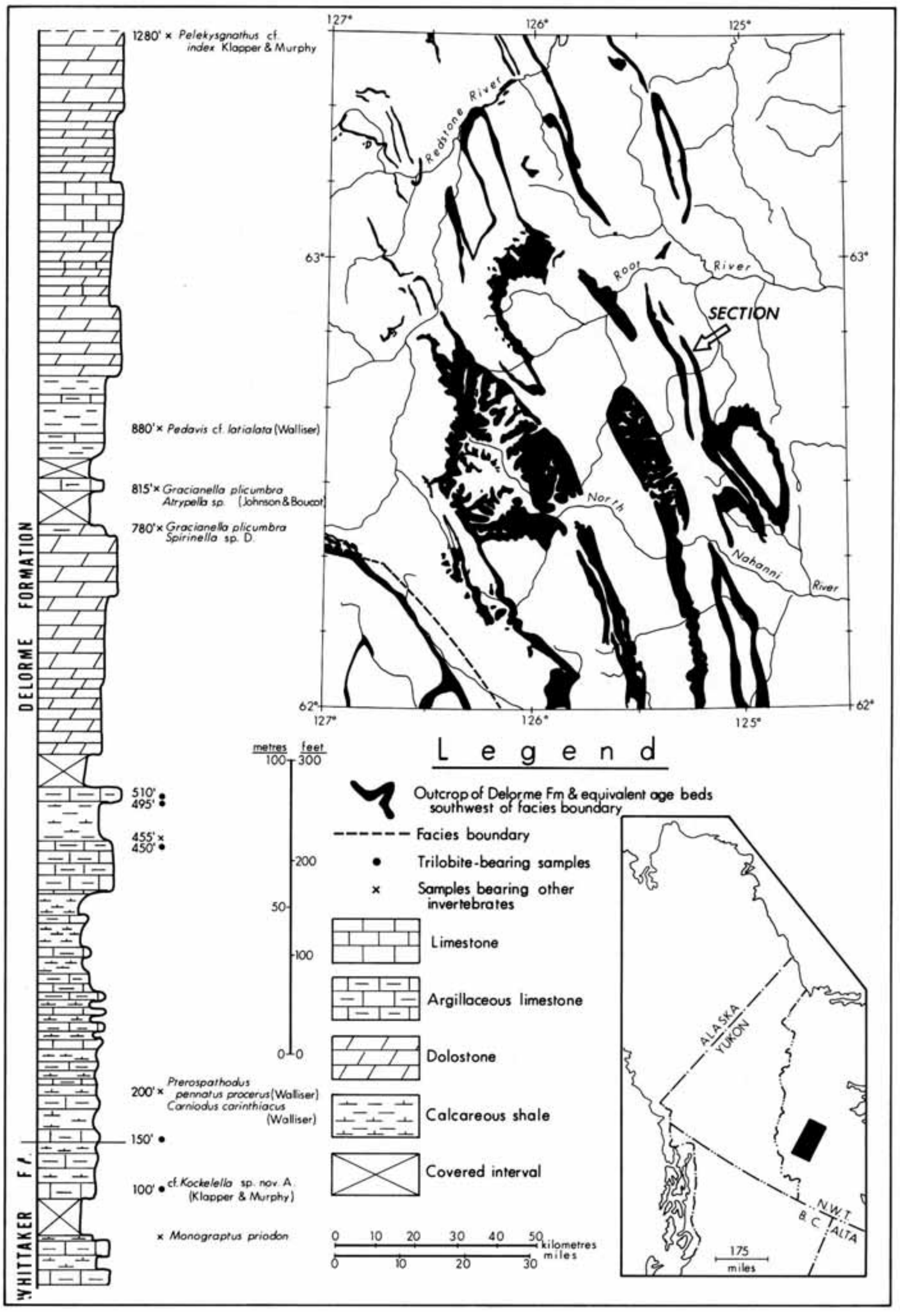
TEXT-FIG. 1. Outcrop map of the Delorme Formation in the eastern Mackenzie Mountains, Northwest Territories, showing the location of section C47. The diagrammatic stratigraphic column of section C47 shows the stratigraphic positions of the fossil collections and lists the non-trilobite components of the faunas.


DELORME FORMATION
WHITTAKER F.
1280' × Pelekysgnathus cf. index Klapper & Murphy
880' × Pedavis cf. latialata (Walliser)
815' × Gracianella plicumbra Atrypella sp. (Johnson & Boucot)
780' × Gracianella plicumbra Spirinella sp. D.
510' ●
495' ●
455' ×
450' ●
200' × Pterospathodus pennatus procerus (Walliser) Carniodus carinthiacus (Walliser)
150' ●
100' ● cf. Kockelella sp. nov. A. (Klapper & Murphy)
× Monograptus priodon
metres
feet
100
300
200
50
100
0
0
127°
126°
125°
63°
62°
Redstone River
Root River
SECTION
North Nahanni River
Legend
Outcrop of Delorme Fm & equivalent age beds southwest of facies boundary
Facies boundary
● Trilobite-bearing samples
× Samples bearing other invertebrates
Limestone
Argillaceous limestone
Dolostone
Calcareous shale
Covered interval
0 10 20 30 40 50 kilometres
0 10 20 30 miles
ALASKA
YUKON
N.W.T.
B.C.
ALTA
175
miles

due to the combined effects of the remoteness of the area and the absence of well-preserved fossils in the crystalline, shallow water shelf dolostones which cover a large part of the area of outcrop. Areas near the regional facies change from platform carbonates to basinal shales have the most potential for detailed biostratigraphic work because of the diversity and well-preserved nature of the invertebrate faunas. Wenlock strata are poorly known in western Canada in both the graptolitic and shelly facies. One exception to this is a diverse graptolite fauna listed by Jackson and Etherington (1969) from the shaly, basinal clastic facies of the Whittaker Formation at Clearwater Creek (61° 39′ N., 125° 35′ W.), where the Wenlock interval is only 21 m (70 ft) thick. The Wenlock is apparently represented by much thinner stratigraphic intervals in the north-western Canadian shelly and graptolitic facies than it is in the type areas in Britain.

The Wenlock and Ludlow of the eastern Mackenzie Mountains are represented by the diachronous shaly limestones and calcareous shales of the upper part of the Whittaker Formation and the more carbonate-rich argillaceous limestones and dolostones of the Delorme Formation.

In the Delorme Range, the upper beds of the Whittaker Formation and the lower beds of the Delorme Formation display a regional outcrop trend from south to north; and locally a vertical facies change towards more carbonate-rich, more dolomitized strata, with less diverse faunas from south to north. Etherington (1966) did not recognize Wenlock graptolites with certainty from a section some 10 km to the south of the described fauna, although Ludlow graptolites were identified. Here he reported a *Monograptus nilssoni* Zone fauna through 293 m (960 ft) of strata above the base of the Delorme Formation; listed an interval of 40 m (130 ft) between graptolites of certain Llandovery and Ludlow ages; and had difficulty in recognizing a distinct contact between the upper Whittaker Formation and the lower Delorme Formation. The absence of clearly recognizable Wenlock graptolites in this trilobite-bearing section does not necessarily indicate the absence of Wenlock strata because graptolites are much less abundant and more poorly preserved in the thin-bedded carbonates to the north than in similar age shales to the south.

Conodonts from a sample at 372 m (1220 ft) in section C47 (see text-fig. 1) are close to *Pelekysgnathus index* Klapper and Murphy (1975), a form found in early Pridoli beds in central Nevada. Conodonts recovered from a sample 268 m (880 ft) above the base of the section shown in text-fig. 1 belong to the *Pedavis latialata* Zone. The occurrence of the brachiopods *Gracianella plicumbra* Johnson and Boucot, *Spirinella* sp. D. Johnson, Boucot, and Murphy (1976), *Reticulatrypa variabilis* Johnson, Boucot, and Murphy, and *Atrypella* sp. suggests a Ludlow age assignment for beds at 238 and 248 m (780 and 815 ft). Conodonts recovered from samples at 151, 139, and 137 m (495, 455, and 450 ft) comprise a few fragmental, non-diagnostic forms. Conodonts from 61 m (200 ft) indicate an assignment to either the *Pterospathodus amorphognathoides* or the lower *Kockelella patula* Zones of early Wenlock age. At 30 m (100 ft) a form very close to *Kockelella* sp. A. Klapper and Murphy, occurs. The exact dating of *Kockelella* sp. A. is uncertain in central Nevada (based on an extrapolation of beds, Klapper, pers. comm., 1976) although it does occur above a form similar to *Ozarkodina* cf. *ranuliformis* (Walliser), a taxon characteristic of the lower two-thirds of the *amorphognathoides* Zone in Austria (Walliser 1971). Therefore, the available evidence would suggest that samples 100, 150, and 200 (hereafter, all numerical references to samples refer to footages on text-fig. 1) are of probable early Wenlock age. The age of the other trilobite-bearing horizons is of uncertain Wenlock–early Ludlow age although considering the similarity of the trilobite faunas they also may be of Wenlock age. There appears to be some disagreement as to the exact range of the *amorphognathoides* Zone into the late Llandovery (Walliser 1971; Aldridge 1975). Unfortunately Silurian conodont studies in western North America are in their infancy, and more refined dating is uncertain without zonal graptolites, which are rarely found in the carbonate facies.

Copeland (1977) placed the Wenlock/Ludlow boundary between samples 100 and 150 on the basis of the ostracode faunas, although the conodont faunas suggest a higher placement. It should be pointed out that the ostracodes are even more poorly known than the conodonts in the western North American Silurian. Many Silurian and Devonian ostracode taxa appear to have their oldest stratigraphic records in north-western North America, and this commonly results in the ostracode biostratigraphy suggesting younger ages than associated invertebrate faunas.

SYSTEMATIC PALAEONTOLOGY

All illustrated specimens are housed in the Department of Geology, University of Alberta, Edmonton, Canada and have been assigned 'UA' type collection numbers. All material is from a single stratigraphic section at 62° 46′ N., 125° 15′ W. within the Whittaker and Delorme Formations (text-fig. 1), with the exception of Plate 70, fig. 21, which is noted otherwise. All localities and sample numbers refer to footages above the base of the lithologic column presented in text-fig. 1. Scanning electron microscope photographs are labelled SEM.

Phylum ARTHROPODA

Class TRILOBITA

Family ILLAENIDAE Hawle and Corda, 1847

Indeterminate illaenid

Plate 68, figs. 1–9

Figured material. Numerous hypostomes, few free cheeks, and fragments of the exoskeleton are present of which UA 2005–2011 from locality 150 are illustrated. The material is only tentatively associated together because of the fragmentary record.

Discussion. The shape of the hypostome and rostral plate are strongly suggestive of the subfamily Bumastinae. The pygidial fragments are very similar to that illustrated by Perry and Chatterton (1977) from Wenlock beds of Baillie-Hamilton Island, Canadian Arctic Archipelago. The free cheeks of the Baillie-Hamilton material possess a prominent prosopon of anastomozing terrace lines, a feature not preserved in the Delorme Range materials.

The illaenid scherites from Wenlockian strata of the Mackenzie Mountains and Baillie-Hamilton Island are typical of those illaenids which some workers consider might be better included in the Scutelluidae, as effaced scutelluids. A study of the ontogeny of *Failleana* Chatterton and Ludvigsen (1976) by one of us (B. D. E. C.) lends some support to this possibility, in that the protaspid stage of *Failleana* is very similar to those of scutelluids (see Chatterton 1971).

Family PROETIDAE Salter, 1864
Subfamily PROETINAE Salter, 1864
Genus PROETUS Steininger, 1831

Type species. Calymene concinna Dalman, 1827, from the Wenlock of Gotland.

Subgenus CONIPROETUS Alberti, 1966

Type species. Coniproetus glandiferus Novák, 1890, from the Lower Devonian of Bohemia.

Proetus (*Coniproetus*) sp.

Plate 68, figs. 10–23

Figured material. Coniproetus sp. is represented by several fragmented distorted and coarsely silicified cephala, pygidia, free cheeks, and hypostomes, at localities 100 and 150, of which UA 2012–2023 are illustrated.

Discussion. Proetus (*Coniproetus*) sp. is somewhat similar to *P.* (*Coniproetus*) *whittakerensis* Chatterton and Perry (1977), of early Lochkov age, from the Mackenzie Mountains. The glabellar and occipital furrows are more strongly impressed on the Wenlock species, and the pygidial axis is narrower. The hypostome of the Lochkov taxon has a more curved anterior margin, and the anterior wings are more prominent.

The available ontogenetic series of *P.* (*Coniproetus*) sp. shows that the length of the preglabellar field diminishes in more mature ontogenetic stages.

EXPLANATION OF PLATE 68

Figs. 1–9. Indeterminate illaenid. All material from loc. 150. 1, UA 2005, ventral view of hypostome, ×3·5. 2, UA 2006, dorsal view of incomplete large left free cheek, ×3·5. 3, 4, UA 2007, posterior and ventral views of rostral plate, ×3·5. 5, 8, UA 2008, ventral and lateral views of hypostome, ×3·5. 6, UA 2009, dorsal view of pygidium fragment, ×4·7. 7, UA 2010, dorsal view of left free cheek, ×5·0. 9, UA 2011, ventral view of hypostome, ×8·0.

Figs. 10–23. *Proetus* (*Coniproetus*) sp. 10, 11, UA 2012, ventral and dorsal views of pygidium, loc. 150, ×6·5. 12, UA 2013, dorsal view of cranidium, loc. 150, ×6·5. 13, UA 2014, ventral view of hypostome, loc. 150, ×9·0. 14, UA 2015, ventral view of cranidium, loc. 150, ×6·5. 15, UA 2016, dorsal view of right free cheek, loc. 150, ×6·5. 16, UA 2017, dorsal view of pygidium, loc. 150, ×8·0. 17, UA 2018, dorsal view of right free cheek fragment, loc. 150, ×8·0. 18, UA 2019, dorsal view of left free cheek fragment, loc. 150, ×6·0. 19, 20, UA 2020, dorsal and ventral views of left free cheek, loc. 150, ×6·0. 21, UA 2021, dorsal view of pygidium, loc. 100, ×5·5. 22, UA 2022, dorsal view of cranidium, loc. 100, ×6·5. 23, UA 2023, dorsal view of cranidium, loc. 100, ×6·2.

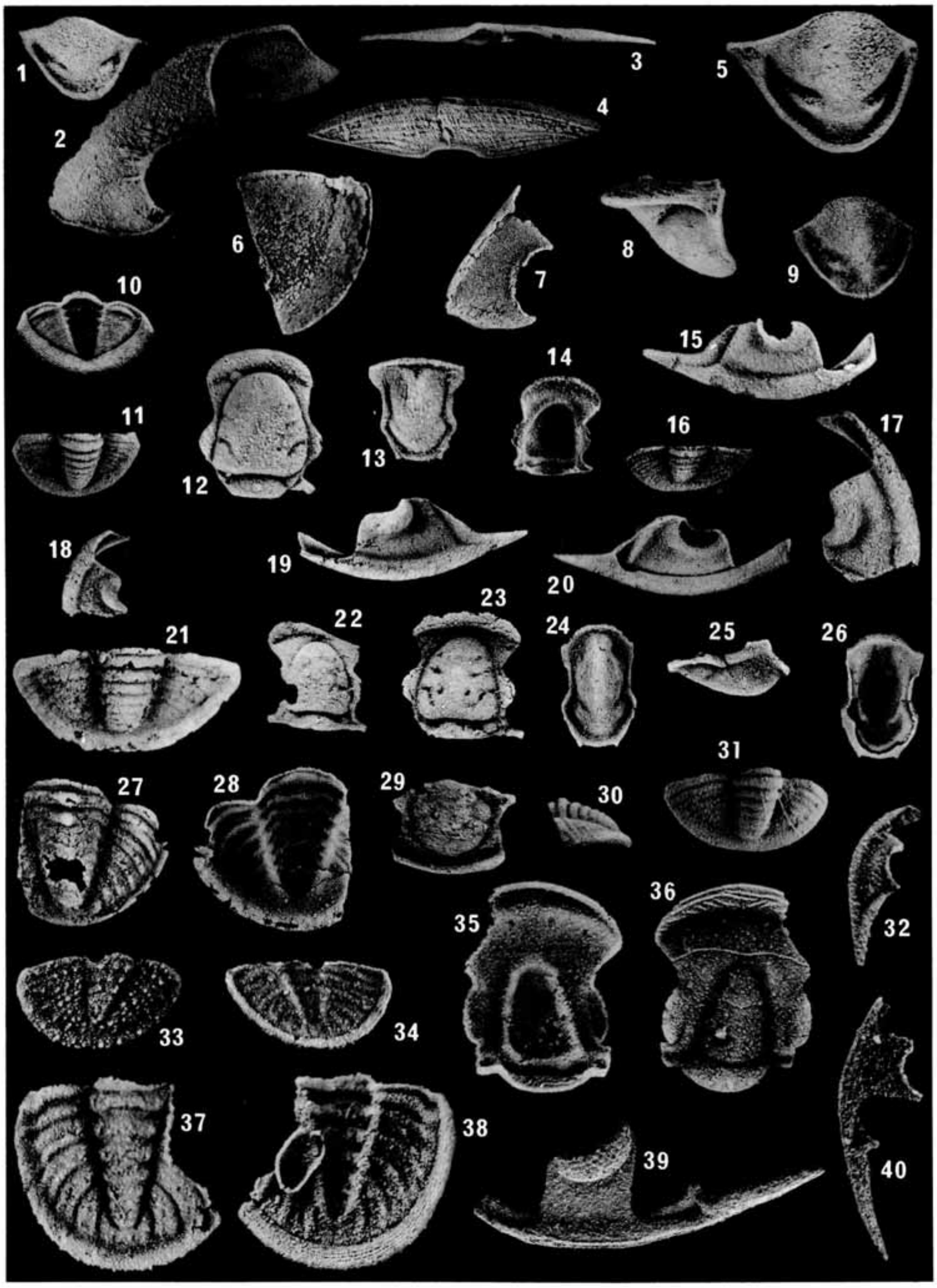
Figs. 24–26. Indeterminate proetid. UA 2024, ventral, lateral, and dorsal views of hypostome, loc. 100, ×6·0.

Figs. 27, 28, 32. ?*Schizoproetus* sp. 27, 28, UA 2025, dorsal and ventral views of pygidium, loc. 450, ×6·1. 32, UA 2028, dorsal view of left free cheek, loc. 450, ×11·0.

Figs. 29–31. *Proetus* (?*Coniproetus*) sp. 29, UA 2026, anterior view of cranidium fragment, loc. 450, ×5·2. 30, 31, UA 2027, lateral and dorsal views of pygidium, loc. 450, ×6·1.

Figs. 33–40. *Scharyia redunzoi* sp. nov. All material from loc. 150. 33, 34, paratype UA 2029, dorsal and ventral views of small pygidium, ×15·0. 35, 36, holotype UA 2030, ventral and dorsal views of cranidium, ×16·0. 37, 38, paratype UA 2031, dorsal and ventral views of pygidium, ×16·0. 39, paratype UA 2032, SEM dorsal view of left free cheek, ×17·5. 40, paratype UA 2033, dorsal view of left free cheek, ×15.0.

PLATE 68



PERRY and CHATTERTON, Wenlock trilobites

The slightly distorted pygidium and cranidium illustrated from locality 450 (Pl. 68, figs. 29–31) may well be conspecific with *P.* (*Coniproetus*) sp., as the pygidium appears to have similar outline and similar pleural and axial furrow development. The hypostome illustrated in Plate 68, figs. 24–26, and labelled 'indeterminate proetid', belongs to a different taxon. Compared to the hypostome of *P.* (*Coniproetus*), this taxon is more elongate, has more prominent middle furrows, more curved and convex anterior margin, more dorsally directed wings, and has a less prominent prosopon of terrace lines. This hypostome appears similar to those of some members of the genus *Warburgella* although no cranidia or pygidia can be confidently associated with it.

Subfamily ?SCHIZOPROETINAE Yolkin, 1968

Genus ?SCHIZOPROETUS R. Richter, 1912

Type species. Proteus celechovicensis Smyčka, 1895, p. 11, from the Givetian of Czechoslovakia.

?*Schizoproetus* sp.

Plate 68, figs. 27–28, 32

Figured material. The material representative of the taxon is only tentatively associated together because of the fragmentary record. The taxon is represented by a single pygidium and several free cheeks, UA 2025, 2028, from locality 450.

Discussion. Owens (1973) placed specimens close to *Proteus delicatus* (Hedström) in the genus *Schizoproetus* although it is beyond the scope of this discussion to comment on this placement. The material at hand shows some similarity to both *Decoroproetus* and *Schizoproetus* although assignment to the latter is favoured. The gently convex and narrow field of the free cheek is similar to members of *Schizoproetus*, *Decoroproetus*, and the *Warburgella*. The pygidial axial tubercle-like structures appear to

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EXPLANATION OF PLATE 69

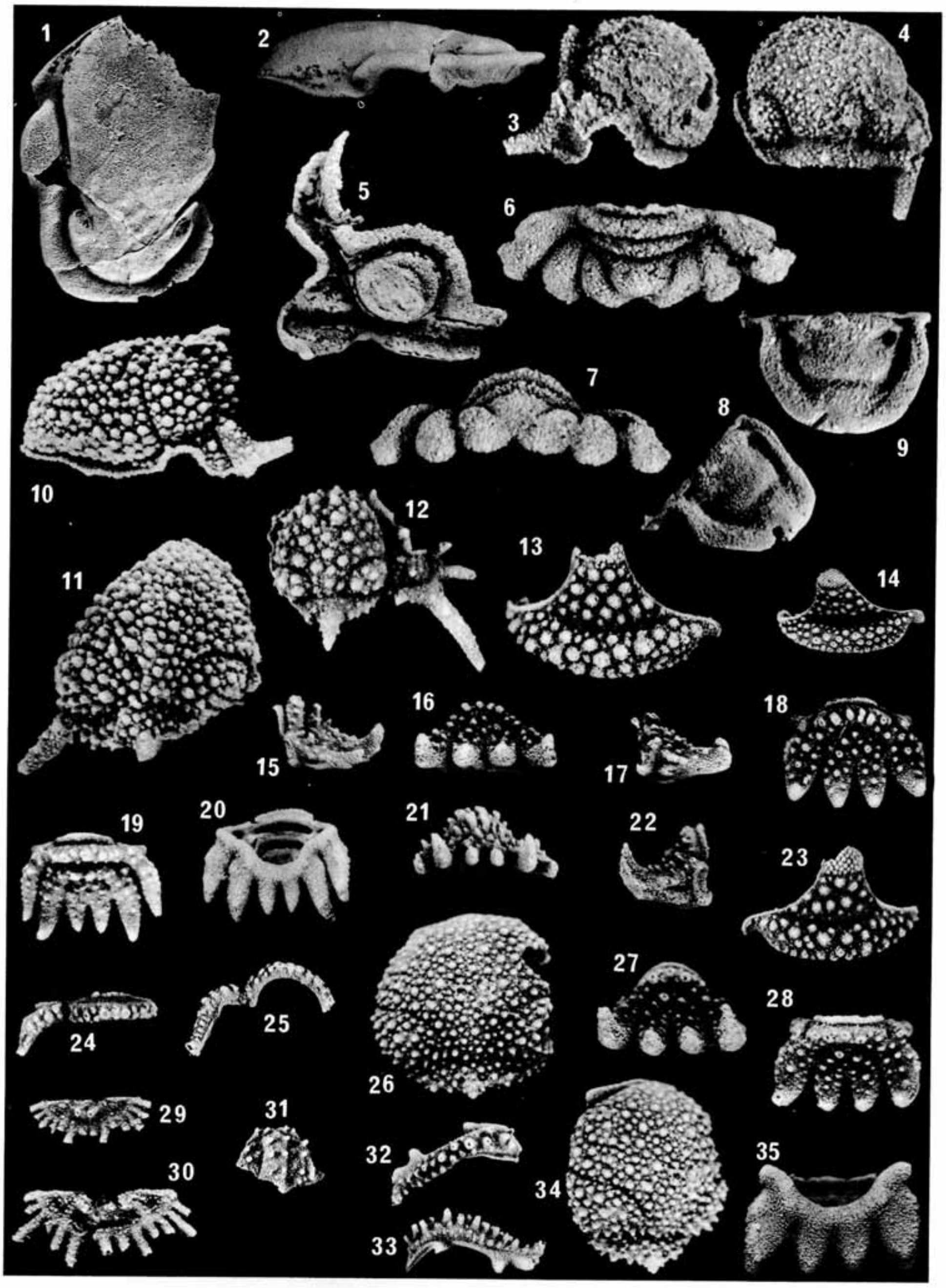
Figs. 1, 2. ?*Cheirurus* sp. UA 2034, ventral and lateral views of large hypostome, loc. 150, ×2·2.

Figs. 3–9. *Sphaerexochus* sp. 3, 4, UA 2035, lateral and dorsal views of small cranidium (note fixed cheek broken and recemented asymmetrically), loc. 150, ×12·5. 5, UA 2036, right lateral fragment of cranidium, loc. 150, ×6·0. 6, 7, UA 2037, dorsal and posterior views of pygidium, loc. 150, ×13·4. 8, 9, UA 2038, oblique lateral and ventral views of hypostome, loc. 450, ×10·0.

Figs. 10–28, 32–35. *Youngia copelandi* sp. nov. 10, 11, holotype UA 2039, lateral and dorsal views of cranidium, loc. 150, ×11·0. 12, paratype UA 2040, dorsal view of small cranidium, loc. 150, ×13·5. 13, paratype UA 2041, dorsolateral view of left free cheek, loc. 150, ×15·0. 14, paratype UA 2042, dorsolateral view of left free cheek, loc. 150, ×8·0. 15, 19–21, paratype UA 2043, lateral, dorsal, ventral, and posterior views of pygidium with thoracic segment attached, loc. 150, ×8·8. 16–18, paratype UA 2044, posterior, lateral, and dorsal views of pygidium, loc. 150, ×8·0. 22, 27, 28, paratype UA 2045, lateral, posterior, and dorsal views of pygidium, loc. 100, ×10·0. 23, paratype UA 2046, dorsolateral view of right free cheek, loc. 100, ×15·0. 24, 25, paratype UA 2047, dorsal and posterior views of thoracic segment, loc. 150, ×6·1. 26, 34, paratype UA 2048, dorsal and oblique dorsal views of cranidium, loc. 100, ×4·6. 32, 33, paratype UA 2049, dorsal and anterior views of thoracic pleura, loc. 100, ×5·2. 35, paratype UA 2050, ventral view of pygidium, loc. 100, ×10·0.

Figs. 29–31. ?*Xanionurus* sp. 29, UA 2051, dorsal view of pygidium, loc. 150, ×15·0. 30, UA 2052, dorsal view of pygidium, loc. 150, ×15·0. 31, UA 2053, dorsal view of small incomplete cranidium, loc. 150, ×8·0.

PLATE 69



PERRY and CHATTERTON, Wenlock trilobites

ally the specimen with *Decoroproetus* although species such as *P. delicatus* Hedström (1923) and *S.* cf. *delicatus* of Owens (1973) show anterior axial rings which are arched gently backwards sagittally. These may be the structures that appear tubercle-like on the poorly silicified specimen available for study. The extension of the pygidial axial lobe close to the posterior border and the breadth of the axial segment suggest closer affinity to *Schizoproetus* sensu Owens than to *Decoroproetus*. Both Hedström's and Owens's materials are from Wenlock beds of Gotland and the Dudley area respectively.

Family OTARIONIDAE Richter and Richter, 1926
Genus OTARION Zenker, 1833

Type species. Otarion diffractum Zenker, 1833, from the Ludlow of Bohemia.

Otarion brauni sp. nov.

Plate 70, figs. 1–22, ?30

Derivation of name. This species is named for Willi Braun of the University of Saskatchewan.

Holotype. Cranidium UA 2054 from locality 450.

Other figured material. Specimens UA 2055–2063, 2068, 2069 from locality 450; UA 2064–2067, 2070 from locality 495; UA 2071 from beds of the same stratigraphic level at 62° 47′ N., 125° 15′ W.; UA 2072, 2076 from locality 150. *Otarion brauni* is represented by 45 cranidia, 20 pygidia, and 84 free cheeks.

Diagnosis. An *Otarion* species with broad fixigenae and a prominent prosopon of pustules and pits; free cheek with a pitted and pustulose caecal prosopon, and a weak socle; pygidium transverse, high relief, clearly segmented with three or four distinct axial rings and a terminal piece.

EXPLANATION OF PLATE 70

Figs. 1–22. *Otarion brauni* sp. nov. 1, holotype UA 2054, dorsal view of cranidium, loc. 450, ×6·8. 2, 3, paratype UA 2055, dorsal and ventral views, loc. 450, ×5·8. 4, paratype UA 2056, outer view of small left free cheek, loc. 450, ×5·8. 5, paratype UA 2057, ventral view of pygidium, loc. 450, ×11·3. 6, paratype UA 2058, posterodorsal view of pygidium, loc. 450, ×8·8. 7, paratype UA 2059, posterodorsal view of pygidium, loc. 450, ×8·8. 8, paratype UA 2060, outer view of left free cheek, loc. 450, ×5·8. 9, paratype UA 2061, inner view of left free cheek, loc. 450, ×5·8. 10, paratype UA 2062, outer view of left free cheek, loc. 450, ×5·8. 11–13, paratype UA 2063, posterodorsal, posterior, and lateral views of pygidium, loc. 450, ×11·3. 14, paratype UA 2064, outer view of left free cheek, loc. 495, ×8·0. 15, paratype UA 2065, outer view of left free cheek, loc. 495, ×8·0. 16, paratype UA 2066, dorsal view of cranidium, loc. 495, ×8·0. 17, paratype UA 2067, outer view of left free cheek fragment, loc. 495, ×8·0. 18, paratype UA 2068, dorsal view of thoracic segment, loc. 450, ×6·8. 19, paratype UA 2069, dorsal view of probable sixth thoracic segment, loc. 450, ×6·8. 20, paratype UA 2070, internal view of thoracic pleura showing panderian notch, loc. 495, ×8·0. 21, paratype UA 2071, dorsal view of small cranidium, loc. 62° 47′ N., 125° 15′ W., ×10·0. 22, paratype UA 2072, dorsal view of small right free cheek, loc. 150, ×15·0.

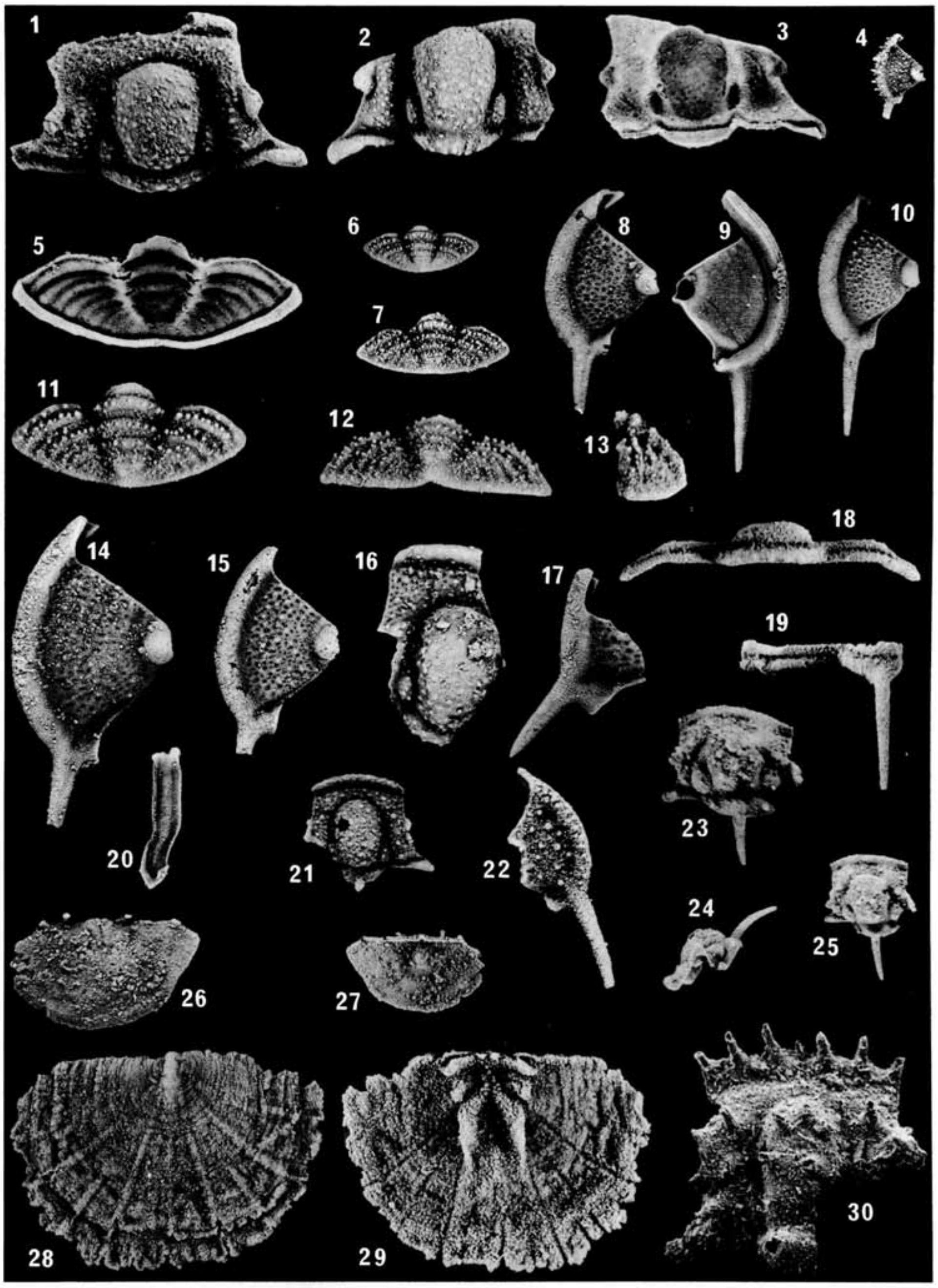
Figs. 23–25. *Otarion* sp. UA 2073, dorsal, lateral, and oblique dorsal views of small cranidium, loc. 150, ×10·3 and ×6·3 respectively.

Figs. 26, 27. ?*Shagamella* sp. UA 2074, exterior and interior of pedicle valve, loc. 450, ×15·0 and ×10·0 respectively.

Figs. 28, 29. *Katastrophomena* sp. UA 2075, exterior and interior of brachial valve, loc. 150, ×15·0.

Fig. 30. ?*Otarion brauni* sp. nov. UA 2076, SEM dorsal view of meraspid cranidium, loc. 150, ×45·0.

PLATE 70



PERRY and CHATTERTON, Wenlock trilobites and brachiopods

Description. Cranidium subtrapezoidal in outline, strongly convex in profile. Glabella widest across the oval-shaped, moderately inflated basal lobes 1p, subparallel sided anterior to 1p lobes, gently rounded anteriorly, and strongly convex. Axial furrow shallows anteriorly. Occipital furrow U-shaped in profile (sag.), moderate depth, and transverse. Occipital ring narrows towards axial furrow; early growth stages bear prominent posterodorsally inclined occipital spine. Deep 1s furrow extends from opposite mid point of palpebral lobe diagonally inward and backward to occipital furrow. 2s not obvious. Broad (tr.) fixigenal lobes present between glabella and small, elevated, medially pitted, semicircular palpebral lobes. Preglabellar field of moderate length (sag.) one-quarter to one-fifth length of glabella, gently convex; separated from the raised anterior border by a prominent U-shaped (in sag. profile) border furrow. Anterior border and free cheek border raised, semicircular in cross section and largely devoid of prosopon in mature stages of development. Cranidial prosopon of prominent pustules and variably developed shallow pits on all dorsal surfaces. Doublure sharply infolded along occipital ring, more gently infolded along anterior and lateral borders.

Free cheek body arcuate in outline. Border furrow of moderate depth separates raised border from the gently convex, broad (tr.) free cheek body, which tapers very markedly to a weakly developed socle surrounding the small arcuate eye. Genal spine narrow, rod-like, and tapers gently posterolaterally. Posterior branch of facial suture runs outward strongly from palpebral lobe before turning backward to cut posterior border at about 90°, just inside genal spine. Prosopon of very fine granules on genal spine and border, with prominent pits and more widely spaced pustules on free cheek body. Pits apparently arranged to form a caecal system. Immature growth stages bear numerous prominent marginal border spines. Doublure narrow, evenly incurved with subparallel terrace lines extending along the ventrolateral surface. Dorsal pits clearly preserved as small raised knobs on ventral free cheek body (Pl. 70, fig. 9). A fine granular prosopon is also present on inner surface. Convex eye surface apparently smooth dorsally although very fine facets visible ventrally.

No hypostome belonging to *O. brauni* was recovered.

Thoracic segments bear a broad articulating half ring. Tubercles better developed on axial ring. Pleural furrow prominent and extends close to lateral margin of thoracic segment. Inner part of pleura slightly narrower (exsag.) than more distal portion (in more posterior segments). Narrow doublure confined to distal portion of segment with a prominent panderian notch and panderian protuberance. Some segments (? the sixth segment) bear a long posteriorly directed axial spine (Pl. 70, fig. 19).

Pygidium approximately two to three times wider than long, convex in lateral profile. Axis between one-third and one-quarter width, and bounded by prominent axial furrows which converge strongly and shallow posteriorly. Four axial rings clearly differentiated; and only three pairs of pleural ribs are readily distinguished on each pleura. Pleural furrows slightly deeper than interpleural furrows. Pleural areas with narrow border uninterrupted by furrows. Prosopon of spinose pustules well developed on axial rings and pleural ribs. Doublure strongly inturned, narrow, widens slightly laterally and bears weakly developed terrace lines.

Discussion. O. brauni sp. nov. is quite unlike the Silurian *O. instita* Whittington and Campbell and *O. plautum* Whittington and Campbell, both of which have convex (sag.) preglabellar margins and short preglabellar fields. *O. brauni* perhaps has closest affinity with *O.* (*O.*) *diffractum diffractum* Zenker as illustrated by Prantl and Přibyl (1951, pl. 1, figs. 1, 2, 17, 18) from early Ludlow beds of Bohemia. The type species of *Otarion* has a longer (sag.) preglabellar field and apparently a greater number of pygidial rings and a more prominent pygidial border. The early growth stages of *O. brauni* (Pl. 70, fig. 30) are similar to those of early growth stages of *O. instita* and *O. plautum* of Whittington and Campbell (1967) and *O. dabrowni* of Chatterton (1971), including the greater spinosity of the prosopon, the pattern of spines on the cranidium, and the shorter preglabellar field. The growth allometry of species of *Otarion* usually involves a regular relative increase in the size of the 1p lobes with increasing maturity. For this reason, the specimen illustrated on Plate 70, figs. 23–25 is not included in *O. brauni*.

Otarion sp.

Plate 70, figs. 23–25

Figured material. UA 2073 from locality 150.

Discussion. The cranidium included in this taxon has 1p lobes that are distinctly larger than any of the specimens confidently assigned to *O. brauni* sp. nov. Since this is a small specimen, and 1p lobes normally increase in relative size during ontogeny, we believe that this specimen belongs to another species of *Otarion*.

Subfamily SCHARYIINAE Osmolska, 1957

Genus SCHARYIA Přibyl, 1946

Type species. Proetus micropygus Hawle and Corda, 1847, from the Silurian of Czechoslovakia.

Scharyia redunzoi sp. nov.

Plate 68, figs. 33–40

Derivation of name. This species is named for Anthony Redunzo of the University of Alberta.

Holotype. Cranidium UA 2030 from locality 150.

Other figured material. Paratypes UA 2029, UA 2031–2033 from locality 150. *S. redunzoi* is represented by 2 cranidia, 6 pygidia, and 7 free cheeks.

Diagnosis. A *Scharyia* species with a broad (sag.) preglabellar field crossed by a fine tropidium, oblique terrace lines on the anterior and lateral borders, a prosopon of fine granules, firmly impressed interpleural and shallower pleural furrows (except for the first pleural furrow) on the pygidium, and a distinct border furrow on the pygidium.

Description. Deep axial furrows converge forward from occipital ring to outline conical glabella. Glabellar furrows very faint on large specimen, indistinct on small cranidium. Occipital furrow firmly impressed. Anterior border furrow firmly impressed and delineates anterior border that is covered by terrace lines that run parallel to the margin anteriorly, and form a broken chevron pattern posteriorly. Broad preglabellar field crossed by a fine linear tropidium that is convex forward laterally, concave forward medially, and closer to glabella than to anterior border. Glabella extends forward slightly less than two-thirds length (sag.) of cranidium. Posterior border furrow is firmly impressed. The angle at *x* (see Owens 1974) is approximately 70 degrees. Palpebral lobes well developed and raised slightly above fixed cheeks, with palpebral furrows distinct opposite posterior half of lobes. Prosopon consists of four distinct granules arrayed in a row along front of preglabellar field, and some finer, almost indistinct granules on rest of cranidium.

Free cheek with long, slightly curved genal spines. Lateral border furrow shallow to moderate in depth, angular shaped cross-section, terrace lines running parallel to margin distally, and shorter and less distinct terrace lines running at an angle to margin medially. Eye one-third length of cranidium, with individual lenses visible on outer surface of holochroal visual surface. Anterior and posterior branches of suture run subparallel for a short distance lateral of eye before curving sharply forward and backward close to border furrow. Doublure increases slightly in width backward and is ornamented with terrace lines that run parallel to margin.

Hypostome and thorax not known for this species.

Pygidium semicircular to semielliptical. Axial furrows deep and converge in straight line backward until they turn inward sharply behind axis a short distance in front of distinct border furrow. Seven axial rings and a terminal piece delineated by shallow ring furrows. Short (sag.) interannular regions visible between more anterior axial rings. Interpleural furrows more firmly impressed than pleural furrows (except the first pleural furrow), and both sets die out distally at border furrow. Five pairs of pleural ribs and a U-shaped posteromedian raised area present on pleurae. Prosopon consists of fine granules concentrated on posterior pleural bands and axial rings. Granules are relatively larger and more obvious on small pygidia than on large specimens, and are visible on both anterior and posterior bands. Doublure narrow; ornamented with terrace lines that run parallel to margin; and is slightly broader (sag.) posteromedially than it is anterolaterally (tr.).

Discussion. *S. redunzoi* sp. nov. appears to be unique within the genus *Scharyia* in possessing a tropidium and chevron terrace lines. This species is close to such Wenlock taxa as *S. micropyga wenlockiana* Přibyl, 1967, and *Scharyia* sp. of Lane (1972, pl. 61, fig. 11). It differs, however, from *S. micropyga wenlockiana* in having a tropidial ridge and from *Scharyia* sp. of Lane in having a pygidial ornament of fine granules, and from both of these taxa in having interpleural furrows that are deeper than the pleural furrows.

Family CHEIRURIDAE Hawle and Corda, 1847
Subfamily CHEIRURINAE Hawle and Corda, 1847
Genus CHEIRURUS Beyrich, 1845

Type species. *Cheirurus insignis* Beyrich, 1845, from the Wenlock of Czechoslovakia.

Cheirurus sp.

Plate 72, figs. 10–25; Plate 69, ?figs. 1, 2

Figured material. *Cheirurus* sp. is represented by fragmental remains UA 2091, 2092 from locality 100; UA 2034, 2097–2103 from locality 150; and UA 2093–2096 from locality 450.

Discussion. The lack of a mature pygidium makes it difficult to compare this species with other cheirurid taxa. *Cheirurus* sp. bears some resemblance to *C. infensus* Campbell from the Henryhouse Formation of Oklahoma. *C. infensus* has a less deeply incised axial portion of the occipital furrow, less quadrate 1p lobes, and the glabellar furrows extend further medially than in *Cheirurus* sp. The Oklahoma material appears to have a prosopon of finer granules although this may reflect the calcareous versus silicified mode of preservation. The hypostome of *C. infensus* has slightly reentrant posterior margins compared to *Cheirurus* sp. The thoracic segments appear very similar. The marginal spines on the pygidium of *Cheirurus* sp. are more tubular and elongate than those of *C. infensus*, but this difference may be partly ontogenetic. This taxon is not very close to any of the European Silurian cheirurids

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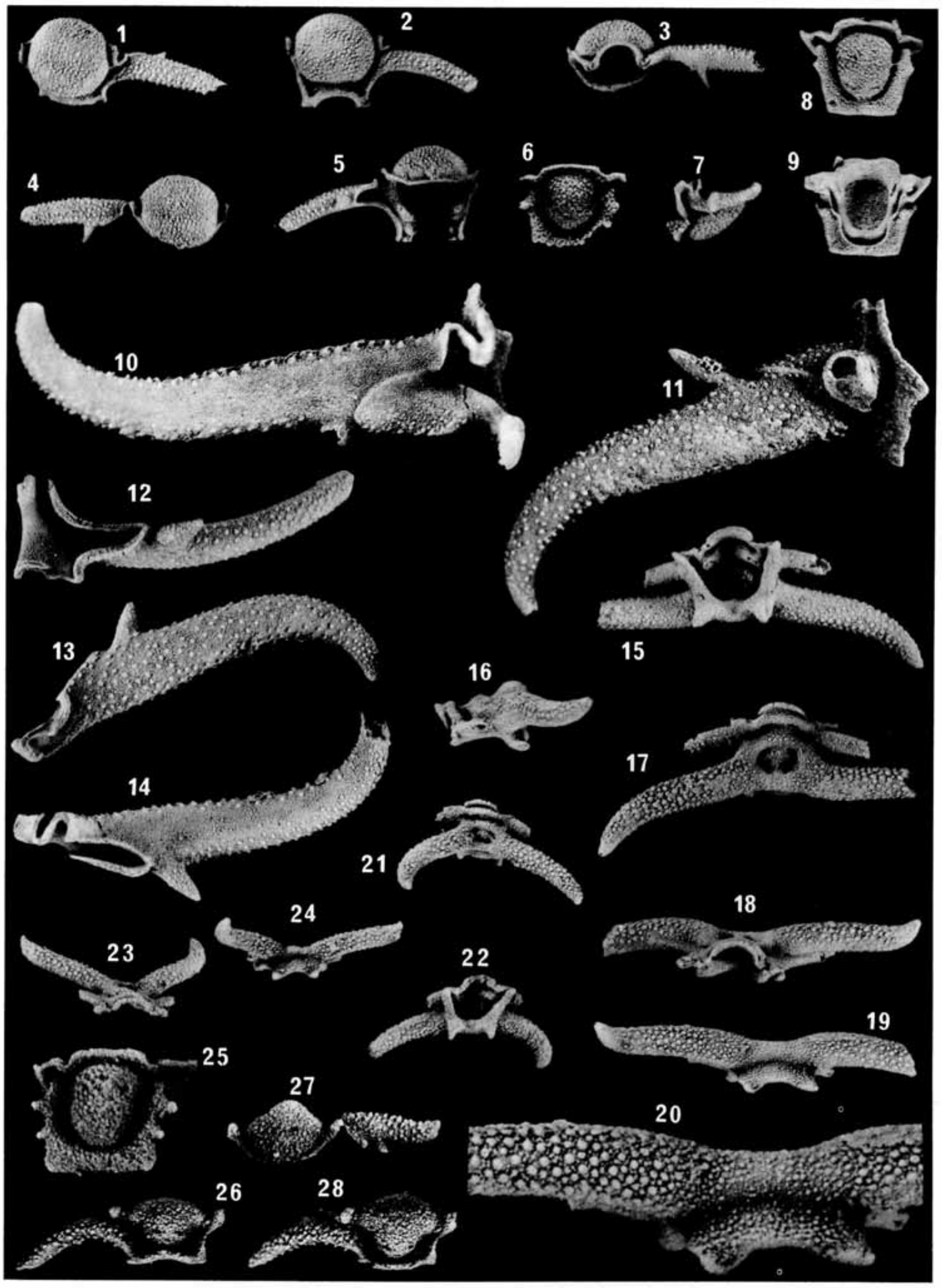
EXPLANATION OF PLATE 71

Figs. 1–28. *Deiphon braybrooki* sp. nov. 1–9, loc. 100; 10–28, loc. 150. 1–5, holotype UA 2077, dorsal, posterodorsal, posterior, anterior, and ventral views of cranidium, × 5·0. 6, paratype UA 2078, ventral view of small hypostome, × 15·0. 7–9, paratype UA 2079, lateral, ventral, and dorsal views of hypostome, × 5·0. 10, 11, paratype UA 2080, posteroventral and dorsal views of left lateral cephalon fragment, × 8·0. 12–14, paratype UA 2081, anterolateral, dorsal, and ventral views of right fixed cheek, × 5·0. 15–19, paratype UA 2082, ventral, lateral, dorsal, anterior, and posterior views of pygidium, × 5·0. 20, paratype UA 2082, enlargement of fig. 19, showing fine ornament, × 11·5. 21–24, paratype UA 2083, dorsal, ventral, anterior, and posterior views of pygidium, × 5·0. 25, paratype UA 2084, ventral view of small hypostome, × 14·4. 26–28, paratype UA 2085, dorsal, anterior, and anterodorsal views of small cranidium, × 15·0.

PLATE 71



PERRY and CHATTERTON, Wenlock trilobites

described by Lane (1971). Upon initial inspection the Mackenzie Mountains *Cheirurus* appears close to *C. centralis* Salter of the Wenlock of Britain, however, *C. centralis* has 1p lobes which meet axially whereas in *Cheirurus* sp. the 1p lobes are clearly separated axially.

Subfamily SPHAEREXOCHINAE Öpik, 1937
Genus SPHAEREXOCHUS Beyrich, 1845

Type species. Sphaerexochus mirus Beyrich, 1845 from the Wenlock of Czechoslovakia.

Sphaerexochus sp.

Plate 69, figs. 3–9

Figured material. Sphaerexochus sp. is represented by fragmental materials from several collections including illustrated specimens UA 2035–2037 from locality 150 and UA 2038 from locality 450.

Discussion. Unfortunately the only almost complete cranidium available for study is immature, and the pygidium and hypostome are not particularly distinctive. *Sphaerexochus* is a common taxon in Wenlock strata. The terminal piece of the pygidial axis is clearly shorter than that of *S. dimorphus* Perry and Chatterton from the Wenlock of Baillie-Hamilton Island.

Subfamily DEIPHONINAE Raymond, 1913
Genus DEIPHON Barrande, 1850

Type species. Deiphon forbesi Barrande, 1850, from the Wenlock of Czechoslovakia.

Deiphon braybrooki sp. nov.

Plate 71, figs. 1–28

Derivation of name. This species is named after George Braybrook of the University of Alberta.

EXPLANATION OF PLATE 72

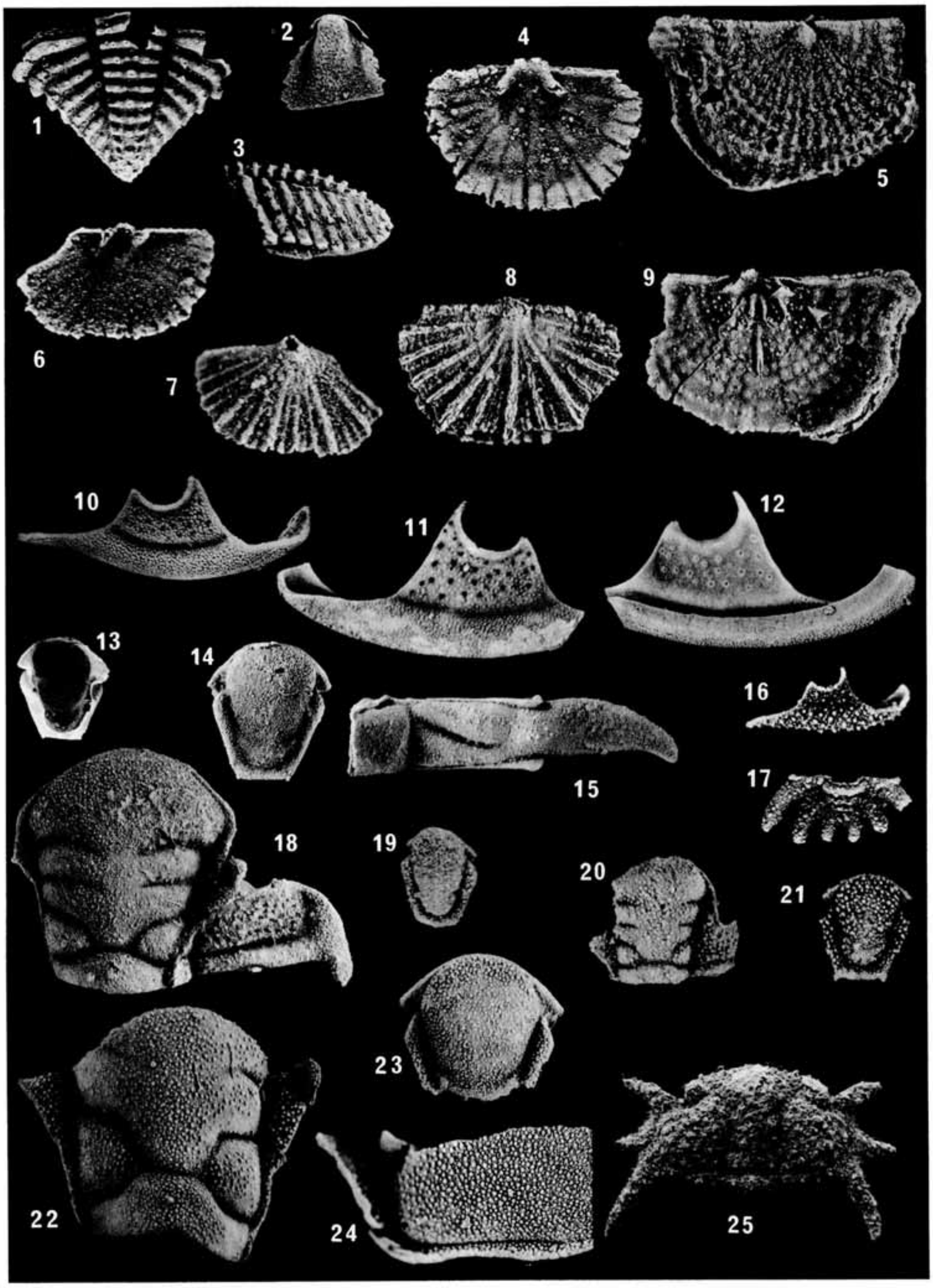
Figs. 1–3. *Encrinurus dimitrovi* sp. nov. 1, 3, paratype UA 2086, dorsal and lateral views of pygidium, loc. 495, ×3·8. 2, paratype UA 2087, ventral view of anterior hypostome fragment, loc. 495, ×3·8.

Figs. 4, 6–8. *Morinorhynchus* sp. 4, 8, UA 2088, interior and exterior views of brachial valve, loc. 450, ×15·0. 6, 7, UA 2089, interior and exterior views of pedicle valve, loc. 450, ×15·0.

Figs. 5, 9. *Leptaena* sp. UA 2090, exterior and interior views of brachial valve, cardinalia broken, loc. 450, ×9·0.

Figs. 10–25. *Cheirurus* sp. 10, UA 2091, outer view of right free cheek, loc. 100, ×5·6. 11, 12, UA 2092, outer and inner views of right free cheek fragment, loc. 100, ×5·6. 13, 14, UA 2093, dorsal and ventral views of hypostome, loc. 450, ×4·3 and ×5·6 respectively. 15, UA 2094, dorsal view of right thoracic pleura, loc. 450, ×5·6. 16, UA 2095, outer view of left free cheek, loc. 450, ×15·0. 17, UA 2104, dorsal view of small pygidium, loc. 450, ×5·6. 18, UA 2096, dorsal view of cranidium, loc. 450, ×5·6. 19, UA 2097, ventral view of small hypostome, loc. 150, ×9·0. 20, UA 2098, dorsal view of small cranidium, loc. 150, ×9·0. 21, UA 2099, ventral view of small hypostome loc. 150, ×15·0. 22, UA 2100, dorsal view of cranidium, loc. 150, ×6·1. 23, UA 2101, ventral view of hypostome, loc. 150, ×9·0. 24, UA 2102, anterodorsal view of cranidium fragment, loc. 150, ×8·0. 25, UA 2103, SEM dorsal view of meraspid cephalon, loc. 150, ×25·0.

PLATE 72



PERRY and CHATTERTON, Wenlock trilobites and brachiopods

Holotype. Cranidium UA 2077, from locality 100.

Other figured material. Paratypes UA 2078, 2079 from locality 100; UA 2080–2085, from locality 150. *D. braybrooki* is represented by 7 cranidia, 5 hypostomes, and 2 pygidia.

Diagnosis. A species of *Deiphon* with an ornament of fine tubercles separated by fine granules on both the cephalon and pygidium; a subspherical anterior glabellar lobe that is wider (tr.) than long; and pygidial border spines that project outwards proximally, and curve gently backward distally.

Description. Anterior portion of glabella subspherical in large specimens and rounded subtriangular in small specimens. Occipital ring narrower than subspherical portion of glabella; and separated from it by short (sag.) low area, with very small 1p lobes laterally. 1s furrows join occipital furrow medially. Anterior border very short (sag.), and separated from overhanging anterior lobe of glabella by shallow preglabellar furrow. Axial furrows shallow opposite occipital ring and deeper further forward; slightly divergent from posterior margin to 1s; and then curve outward around subspherical anterior lobe of glabella. They are slightly deeper opposite distal ends of occipital furrow and 1s furrows, the ventral expression of the deeper areas of the furrows are short, blunt apodemal processes. An additional pair of apodemal processes, representing 2s, present under the axial furrows a short distance in front of 1s furrows. Two large and prominent genal spines project outward and backward from fixigenae near mid-length of cranidium. A smaller pair of spines projects slightly below anterolaterally from anterior margins of genal spines just distal to free cheeks (two pairs of spines project from genal spines of neanic specimens, see Pl. 71, fig. 27). A pair of small, weakly laterally convex palpebral lobes is placed opposite and immediately adjacent to mid length of anterior lobe of glabella. Eyes raised above genae, and subspherical in shape. Prosopon of fine tubercles separated by fine granules (bimodal distribution). Genal doublure ornamented by fine granules. Occipital doublure very short (sag.).

Free cheeks small and dominated by relatively large and highly convex (tr. and hor.) holochroal visual surfaces. Margin weakly convex anterolaterally and turns through 90 degrees near medial end. Doublure of free cheek broad (larger area than dorsal surface of free cheek); prosopon of fine granules; and indented medially.

Hypostome subrectangular to subtrapezoidal, with deep anterior, lateral and posterior border furrows. Middle body suboval, moderately inflated and not distinctly divided by middle furrows (very small specimens have weakly developed middle furrows, Pl. 71, fig. 6). Small shoulders subangular in ephebic specimens, but spinose in neanic specimens. Not only are shoulders spinose in small specimens, but an additional pair of spines also projects from lateral margins half way from shoulders to posterior margin. A pair of prominent anterior wings subdivided by pair of deep furrows that projects dorsally to form wing processes. Outer surface prosopon of fine granules and very fine tubercles. Fine pits are also present in very small specimens. Posterior and lateral borders relatively flat; anterior border sharply turned ventrally. Posterior margin almost straight and subtransverse. Lateral margins converge weakly backward. Doublure of moderate width; and slightly wider just behind the shoulders to form a pair of weak posterior wings. Rostral plate not recovered.

No thoracic segments were found that could be assigned to this species with certainty.

Subtrapezoidal-shaped pygidium with a smaller pair of subtransversely directed marginal spines originating near the anterolateral margin; and a much larger and longer pair of subtransversely to posterolaterally directed marginal spines next to posterior margin. Both pairs of spines curve slightly backward and dorsally distally. Axial furrows weak to absent opposite axial rings of first two segments, but firmly impressed posteriorly opposite an additional one or two (in large specimens) axial rings. Prosopon consists of fine tubercles with fine granules interspersed between them. Doublure raised ventrally, widest posteriorly, and with two prominent posteroventral spinose projections at posterolateral corners. Ventral surface slightly notched medially in posterior view.

Discussion. *Deiphon braybrooki* sp. nov. shows affinity to European taxa such as *D. barrandei* Whittard with its anteriorly positioned eyes whereas eastern North American species, *D. americanus* Weller and *D. longifrons* Whittard, have more posteriorly located eyes. *D. braybrooki* has a proportionately wider (tr.) occipital ring than *D. barrandei*. *D. forbesi* Barrande as illustrated by Barrande (1872, pl. 2, fig. 19) bears coarser, more widely spaced glabellar tubercles separated by fine granules. *D. barrandei* Whittard (Lane 1971), bears coarser, more regularly spaced tubercles than the fine, closely set glabellar tubercles of *D. braybrooki*; and has more massive, strongly posteriorly curved pygidial spines compared to the gently curved spines of *D. braybrooki*. Other new species of *Deiphon* have been recovered from several other Wenlock localities in the Mackenzie Mountains and Arctic Archipelago.

Very small specimens (cranidium and hypostome) have a prosopon of fine pits as well as granules. One of us (B. D. E. C.) has noted, in work on Middle Ordovician trilobite ontogenies, that this is often expressed in the early growth stages of cheirurids; and is particularly well shown in species of *Sphaerocoryphe*, the genus that is the probable ancestor of *Deiphon*. This ancestral relationship was suggested by Lane (1971) based upon stratigraphic range and gross morphologic relations.

Subfamily ACANTHOPARYPHINAE Whittington and Evitt, 1954

Genus YOUNGIA Lindström, 1885

Type species. *Cheirurus trispinosus* Young, 1868, from the Llandovery of Great Britain.

Youngia copelandi sp. nov.

Plate 69, figs. 10–28, 32–35; Plate 76, fig. 20

Derivation of name. This species is named after M. J. Copeland of the Geological Survey of Canada.

Holotype. Cranidium UA 2093 from locality 150.

Other figured material. Paratypes UA 2040–2044, 2047 from locality 150; paratypes UA 2045, 2046, 2048–2050 from locality 100. *Y. copelandi* is represented by 11 cranidia, 7 pygidia, 5 free cheeks, and 1 hypostome.

Diagnosis. A *Youngia* species with moderately impressed 1s furrows, very weakly developed 2s and 3s furrows; a short occipital spine and a coarse tuberculate prosopon. The pygidium bears only one clearly differentiated axial ring on the dorsal surface; and has four marginal spines that turn upward sharply distally.

Description. Glabella strongly inflated, subcircular to oval (slightly longer than wide), with maximum width developed at or slightly behind 1s. 1s curves posteromedially, shallows backwards and intersects occipital furrow. 2s and 3s closely spaced (exsag.), shallow adaxially and have a gentle posterior curvature. Deep, U-shaped axial furrows join narrow (sag.) and deep preglabellar furrow. Eye lobe short (exsag.), located opposite anterior half of 1p. Occipital ring longest (sag.) medially, with short, blunt occipital spine. Ornament comprises coarse granulose tubercles (some perforated) of variable diameter. Posterior border of fixigena raised. Short subcylindrical genal spine extends from genal angle. Posterior border furrow curves forward distally to join the proparian facial suture. Early growth stages bear more spinose prosopon, have two additional lateral and anterolaterally directed spines in front of genal spine, and have relatively larger and longer genal spines.

Subtriangular free cheeks expand in an exponential curve from base of large, subhemispherical schizochroal eyes with at least sixty lenses. Middle free cheek body slopes steeply to deep lateral border furrow that is interrupted at its extremities by sutural ridges. Border broad and gently rounded. Doublure evenly incurved. Prosopon of closely spaced small to large perforated tubercles and granules.

Thoracic segments strongly convex, with highly arched axial segment. Inner part of pleura horizontal, outer part flexed steeply down. Lateral margin of pleura curves strongly posteriorly and terminates in a blunt spine. Spine larger and more strongly directed posteriorly in posterior segments. A narrow (exsag.) articulating flange projects from anterior margin of pleura out to fulcrum; and a slightly narrower posterior articulating flange is also present. Articulating half ring narrow (sag.) and separated from axial ring by deep furrow. Prosopon of perforate large tubercles, small tubercles, and granules; with usually one row of tubercles on axis and two rows of smaller tubercles on pleurae.

Hypostome subpentagonal, fused to a very short (sag.), arcuate rostral plate that is nodose, wide, and extends across width of hypostome. Hypostome with narrow, gently arcuate, raised anterior border. Anterior border furrow deep, and very narrow (sag.) medially. Lateral margin indented by prominent antennal notch immediately posterior to anterior border; small anterior wings with wing processes project subdorsally. Posterior to shoulders, lateral border broadens and merges with posterior border, which gradually becomes wider (exsag.) towards sagittal line. Posterior margin is divided by a series of sublongitudinal indentations. Middle body raised to same level as borders only over axial portion. Middle furrows run inward and bifurcate before dying out, opposite shoulders. Doublure broad posteriorly. Prosopon of fine granules and a few larger pustules.

Pygidium with four short, posteriorly directed and tapering border spines, outer pair slightly longer than inner pair. Axis with short (sag.) articulating half ring, prominent axial ring and a terminal piece. Outer pair of border spines slightly longer and broader than medial pair; tips of border spines curve dorsally and end in vertical faces. Doublure of moderate width, slightly raised near border spine bases. Doublure ornament of fine granules. Dorsal prosopon of fine to coarse, perforate tubercles interspersed with fine granules. One row of tubercles on axial segment, two to three rows on border spines.

Discussion. Y. copelandi is the only species of *Youngia* in our collections from the eastern Mackenzie Mountains; and is not associated with a form that has a very prominent occipital spine, strongly inflated 1p lobes, deeper 1s furrows, and more prominent second axial ring on the pygidium. In collections of Wenlock age from the western Mackenzie Mountains and Arctic Archipelago two species of *Youngia* occur (one with a prominent occipital spine, another lacking a prominent occipital spine).

Y. copelandi sp. nov. is very similar to the form described by Perry and Chatterton (1977) as *Youngia* sp. 2, but differs from that form in having a pygidium with marginal spines whose tips turn upward sharply distally. The latter form occurs in Wenlock strata of both the Arctic and the western Mackenzie Mountains.

Youngia pygidia closely resemble those of the probable ancestor *Acanthoparypha* (see Perry and Chatterton 1977). *Youngia* is a common taxon in facies transitional between platform carbonates and basinal graptolitic shales at several Wenlock localities in north-western and Arctic Canada.

The hypostome described with this taxon is doubtfully included in it. It is included here for the following reasons: it occurs in a horizon that contains a number of specimens of *Y. copelandi*; the hypostome and the attached rostral plate are similar in outline to those of *Acanthoparypha* (see Whittington and Evitt 1954; Chatterton and Ludvigsen 1976); and we have also found this type of hypostome associated with *Youngia* in the western Mackenzie Mountains and the Canadian Arctic. The only other contender for this hypostome is an odontopleurid such as *Acidaspis* which also occurs in these collections. In our opinion, no hypostomes of odontopleurids that have been described to date are quite as close to this unusual type of hypostome as those of some acanthoparypines (see Přibyl and Vaněk 1973). The highly segmented posterior border of the hypostome has not, to our knowledge, been previously described in either of these groups of trilobites.

Family ENCRINURIDAE Angelin, 1854
Subfamily ENCRINURINAE Angelin, 1854
Genus ENCRINURUS Emmrich, 1844

Type species. Entomostracites punctatus Wahlenberg, 1821, from the Wenlock of Gotland.

Encrinurus sp.

Plate 73, figs. 19-28, Plate 74, figs. 15-17, 24-29

Figured material. Encrinurus sp. is represented by pygidia, hypostomes, and thoracic segments of which UA 2149, 2151 are from locality 100 and UA 2147, 2150, 2161, 2162, 2167 are from locality 150.

Discussion. No cranidium could be assigned to this species in our collections. The pygidia are similar to those of *E. ornatus* Hall and Whitfield, illustrated by Best (1961), from the Wenlock Lockport Formation of Dundas, Ontario. Although the axial tubercle distribution cannot be determined in detail for the population because of a paucity of mature pygidia, there does appear to be a tendency for the tubercles to be present on every fourth axial ring of the pygidium (as in *E. ornatus*). Best (1961) suggested that there was a significantly different distribution of tubercles on the axial rings of the pygidium of forms from carbonates when compared with forms from shales at the same locality; and he considered this to be the result of 'the conditioning influence of environment', and the fact that these tubercles were probably light sensitive organs. We consider, however, that using Occam's razor, an hypothesis of geographic races replacing one another with the changes in facies is a simpler and more parsimonious explanation for these differences.

The Mackenzie Mountains taxon also bears close affinity to the pygidia of the *E. punctatus* (Wahlenberg) species group described by Tripp (1962). The hypostome included in this taxon is similar in its long tongue-like posterior border to those of this species group figured by Tripp (1962, pl. 67). Of the species of this group, the pygidium of *Encrinurus* sp. is probably most similar to that of *E. tuberculatus* (Buckland), which also has a thoracic segment with a stout axial spine (if such thoracic segments are correctly assigned to *Encrinurus* sp., since *E. dimitrovi* sp. nov. may also have had axial thoracic spines). *Encrinurus* sp. differs from *E. punctatus* by having fewer axial tubercles on the pygidium, and an anteromedian lobe on the hypostome that does not project beyond the anterior border.

Encrinurus dimitrovi sp. nov.

Plate 72, figs. 1-3; Plate 73, figs. 1-17, 29-31; Plate 74, figs. 1-14, 18-23, 30-35

?*Encrinurus* (*Fragiscutum*) sp. Perry and Chatterton, 1977, p. 300, pl. 4, figs. 1-14, 25-26.

Derivation of name. This species is named after Frank Dimitrov of the University of Alberta.

Holotype. Cranidium UA 2152 from locality 150.

Other figured material. Paratypes UA 2086, 2087 from locality 495; UA 2138, 2142, 2153-2157, 2159, 2160, 2163-2166 from locality 150; UA 2140, 2141, 2146, 2158 from locality 450; UA 2143-2145, 2148 from locality 100. *E. dimitrovi* is represented by 76 cranidia, 62 pygidia, 15 hypostomes, and 25 free cheeks.

Diagnosis. A species with reduced glabellar segmentation; with a glabellar tubercle pattern I–1; ii–0, II–1, 2; iii–0, III–1, 2; iv–0, 1, IV–1, 2, 3; with 9–12 axial rings, a shallow sagittal groove, and 7–9 pleural ribs on a non-mucronate pygidium.

Description. Glabella widens to about one and one-half times posterior width (tr.) near anterior margin. Prosopon of large perforated granulose tubercles separated by microgranules. Microgranules absent on occipital and axial furrows. Glabellar furrows indistinct on dorsal surface, only differentiated on ventral surface by four pairs of apodemes marking the occipital, 1s, 2s, and 3s furrows. Occipital ring slightly longer (sag.) medially. Furrow 3s situated opposite front of eye lobe. Occipital ring bears four or more weakly developed tubercles. Tubercles on glabella of relatively large size and can be labelled according to Tripp's system (1957, 1962). Tubercles pattern on UA 2141 (Pl. 73, fig. 7) I–1; ii–0, II–1, 2; iii–0, III–1, 2; iv–0, 1, IV–1, 2, 3. There are usually ten tubercles along the anterior margin of the cranidium. Axial furrows deep, of moderate width (tr.). Two tubercles placed in a row between eye and axial furrow. Five to six tubercles present on fixed cheek along axial furrow. Palpebral lobes raised, bear granular prosopon. Genal spine reduced to a posteriorly directed, rounded knob in large specimens, prominent genal spines in early growth stages.

Free cheek bears large, subspherical eye. Posterior branch of suture extends posterolaterally; anterior branch extends anterolaterally or anteriorly to axial furrow, whereupon it curves inward and forward. Doublure strongly incurved; widens slightly posteriorly, bears granular prosopon. Subtrapezoidal shaped rostral plate connecting expanded anterior segments of free cheeks inferred although not available in collections. Faint vincular furrow preserved along ventrolateral edge of doublure of free cheek (Pl. 74, figs. 21, 34).

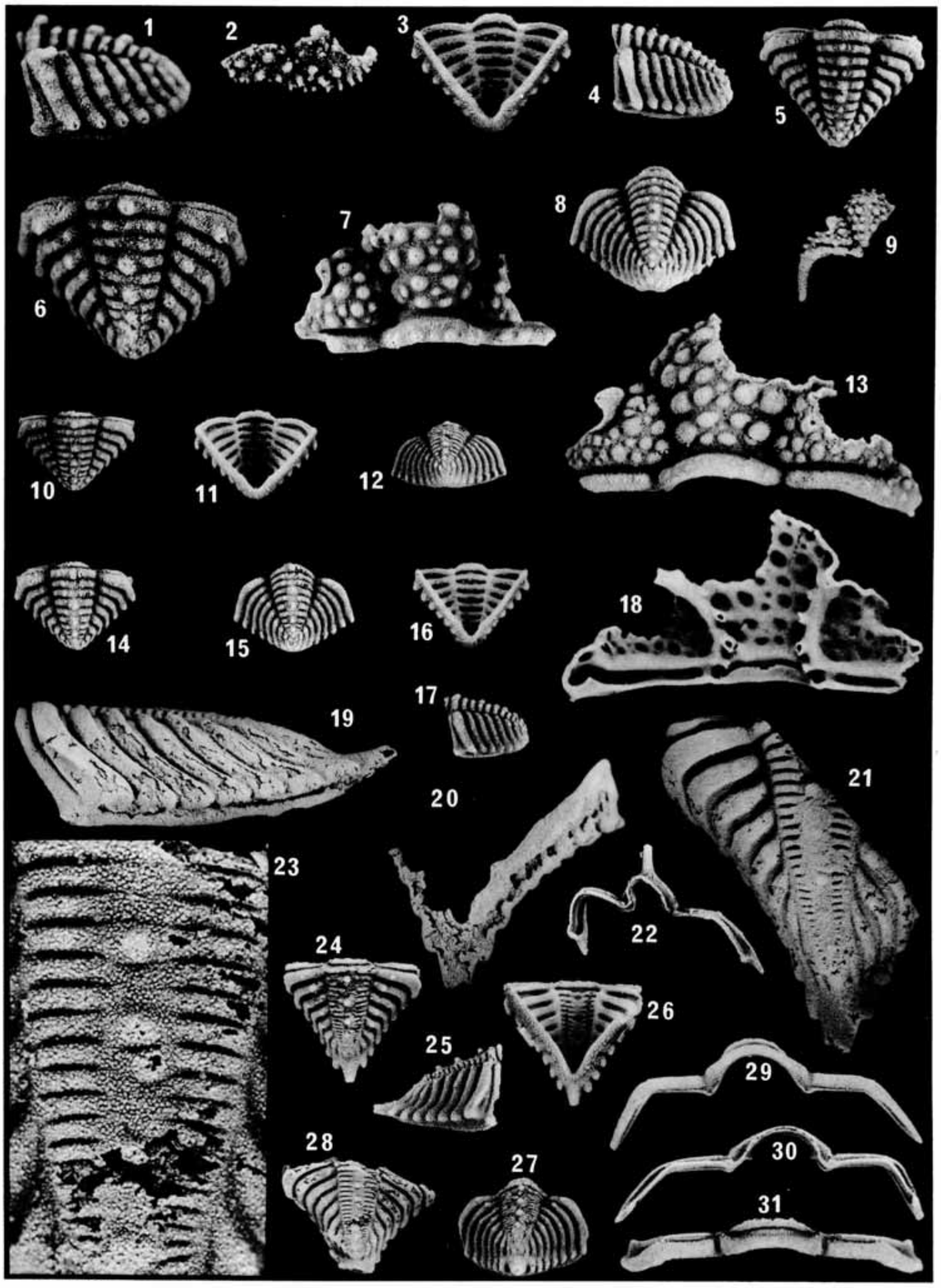
Hypostome longer than wide, elongate suboval shaped. Middle body strongly inflated with anterior lobe pinched medially into a pronounced, narrow anterior median lobe, which extends over the anterior border furrow. Furrows bounding median lobe flare posteriorly and shallow markedly opposite anterior wings. Anterior border narrow, convex forward, and turned ventrally; separated from middle body by deep, narrow border furrow. Posterolateral border widens posteriorly; separated from middle body by deep furrow. Tongue-like posterior border longest (sag.) medially. Macula in form of narrow (exsag.) swelling situated along posterolateral margin of middle body. Prosopon of very fine granules. Anterior wing folded sharply dorsally and processes twisted outward. Doublure narrows rapidly forward from antennal notch; posterior doublure strongly incurved, of moderate width, with posterior wings behind antennal notch.

Number of thoracic segments uncertain. Axis one-quarter total width. Some segments of greater relief than others, possibly due to preservation. Apodemes curve inward and downward from a point a short distance medial to axial furrow. Prominent anterior flange on pleurae narrows at break in slope, then widens distally. Pleurae flat toward axial segment, slope steeply ventrally distally; and terminate in a blunt spine at posterolateral margin.

EXPLANATION OF PLATE 73

Figs. 1–18, 29–31. *Encrinurus dimitrovi* sp. nov. 1, 6, paratype UA 2138, lateral and dorsal views of pygidium, loc. 150, × 9·1. 2, paratype UA 2139, outer view of small left free cheek, loc. 450, × 15·0. 3–5, 8, paratype UA 2140, ventral, lateral, dorsal, and posterodorsal views of pygidium, loc. 450, × 5·6. 7, paratype UA 2141, dorsal view of cranidium fragment, loc. 450, × 5·6. 9, paratype UA 2142, dorsal view of small cranidium, loc. 150, × 10·0. 10–12, paratype 2143, dorsal, ventral, and posterior views of pygidium, loc. 100, × 6·1. 13, 18, paratype UA 2144, dorsal and ventral views of cranidium, loc. 100, × 5·5. 14, 15, paratype UA 2145, dorsal and posterodorsal views of pygidium, loc. 100, × 6·1. 16, 17, paratype UA 2146, ventral and lateral views of pygidium, loc. 450, × 6·1. 29–31, paratype UA 2148, posterior, anterior, and dorsal views of thoracic segment without axial spine, loc. 100, × 6·1.

Figs. 19–28. *Encrinurus* sp. 19–21, UA 2149, lateral, ventral, and dorsal views of large pygidium, loc. 100, × 3·4. 22, UA 2147, anterior view of thoracic segment with axial spine, loc. 150, × 6·1. 23, 28, UA 2150, enlargement of axial pygidial ornament and dorsal view of pygidium, loc. 150, × 15·5 and × 2·6 respectively. 24–27, UA 2151, dorsal, lateral, ventral, and posterior views of pygidium, loc. 100, × 6·1.



PERRY and CHATTERTON, Wenlock trilobites

Pygidium triangular in outline with width/length/height ratio of approximately 5/4/2·5. Axis semicircular in transverse profile. Axis narrows posteriorly until it disappears near point of strong ventral geniculation. Nine to twelve axial rings separated by deep axial furrows. Slightly depressed, narrow central band evident along axis beginning at second axial ring. Axial tubercles variable but most commonly on axial rings 1, 4, 7, 9. Less prominent set of tubercles developed on pleurae before ventral geniculation. Commonly one or two less pleural segment than axial segment. Axial furrows deep, shallower, and narrower (tr.) posteriorly. Axis terminates in front of and above posterior margin; no posterior spine. Doublure sharply recurved narrows slightly about axis posteriorly, forming a distinct cleft. Doublure and dorsal surface ornament of very fine granules. Transitory pygidia with more prominent axial spines, one to two rows of pleural spines and with distal ends of pleurae extended into spines.

Discussion. Encrinurus dimitrovi sp. nov. is similar to both species belonging to the subgenus *Fragiscutum* Whittington and Campbell and those belonging to the *E. variolaris* species group (Tripp *et al.* 1977). We do not believe that the character that separates *Fragiscutum* from the *E. variolaris* species group (ten instead of eleven thoracic segments) is significant enough to warrant separation of these groups at the generic level. Whittington and Campbell (1967) suggested that *Fragiscutum* may also be separated from the *E. variolaris* species group by the presence of a median band on the axis of the pygidium (since shown to occur in the *E. variolaris* species group by Tripp *et al.* 1977); and the presence of the glabellar tubercles I–1 in the *E. variolaris* group, but their absence in *Fragiscutum*. In our opinion, the posteriormost pair of tubercles that is present in most species of the *E. variolaris* group (labelled I–1 by Tripp *et al.* 1977) is homologous with the posteriormost pair of spines on the glabella of species of *Fragiscutum* (labelled ii–1 by Whittington and Campbell 1967). Whether this pair of tubercles should be labelled I–1 or ii–1 depends upon whether the 1s furrows run anteromedially or posteromedially in these species, since Tripp (1957, p. 61) in describing his original system of numbering these tubercles stated 'Rows I, II and III are opposite the posterior, middle and anterior lateral glabellar lobes respectively'. This implies to us that tubercle pair I–1 should be on the 1p lobe. Since, where they can be clearly seen in most species of *Encrinurus*, the 1s furrows run anteromedially, this spine pair should probably be labelled I–1 in both *Fragiscutum* and

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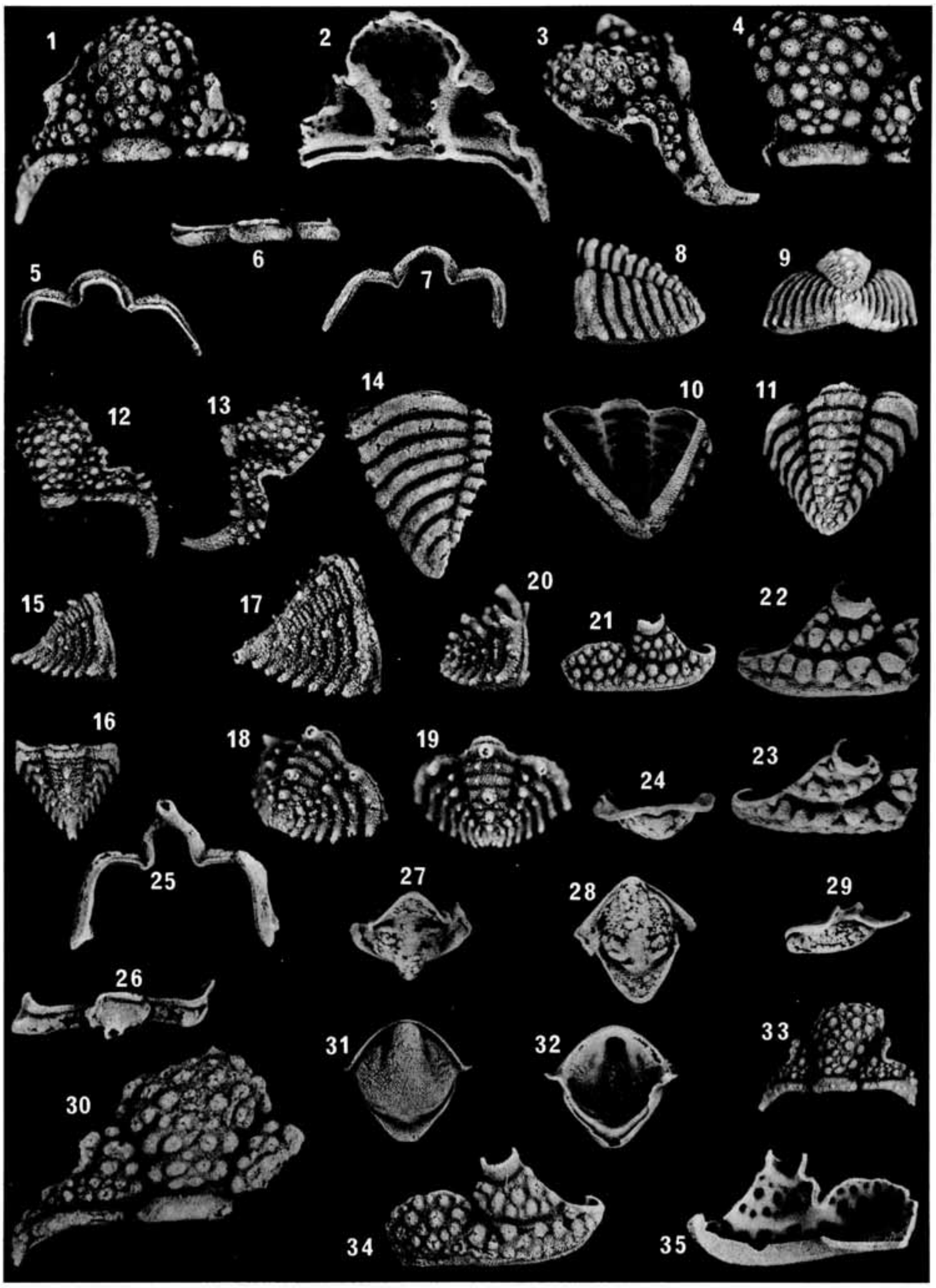
EXPLANATION OF PLATE 74

Figs. 1–14, 18–23, 30–35. *Encrinurus dimitrovi* sp. nov. 1–3, holotype UA 2152, dorsal, ventral, and dorsolateral views of cranidium, loc. 150, ×8·0. 4, paratype UA 2153, dorsal view of cranidium fragment, loc. 150, ×8·0. 5–7, paratype UA 2154, anterior, dorsal, and posterior views of thoracic segment without axial spine, loc. 150, ×8·0. 8–11, paratype UA 2155, lateral, posterior, ventral, and dorsal views of pygidium, loc. 150, ×8·0. 12, 13, paratype UA 2156, dorsal and oblique lateral views of small cranidium, loc. 150, ×8·0. 14, paratype UA 2157, outer view of pygidial pleurae, loc. 150, ×8·0. 18–20, paratype UA 2158, posterolateral, dorsal, and lateral views of small pygidium, loc. 450, ×15·0. 21, paratype UA 2159, dorsolateral view of left free cheek, loc. 150, ×6·1. 22, 23, paratype UA 2160, dorsolateral and dorsal views of right free cheek, loc. 150, ×5·8. 30, paratype UA 2163, dorsal view of cranidium, loc. 150, ×6·1. 31, 32, paratype UA 2164, ventral and dorsal views of hypostome, loc. 150, ×6·3. 33, paratype UA 2165, dorsal view of cranidium, loc. 150, ×5·8. 34, 35, paratype UA 2166, dorsolateral and ventrolateral views of left free cheek, loc. 150, ×5·8.

Figs. 15–17, 24–29. *Encrinurus* sp. 15–17, UA 2167, posterolateral, dorsal, and oblique lateral views of small pygidium, loc. 150, ×10·0 and ×15·0 respectively. 24, 27–29, UA 2161, posterior, posteroventral, ventral, and lateral views of hypostome, loc. 150, ×3·1. 25, 26, UA 2162, posterior and dorsal views of thoracic segment with axial spine, loc. 150, ×5·8.

PLATE 74



PERRY and CHATTERTON, Wenlock trilobites

the *E. variolaris* species group; and we have labelled *E. dimitrovi* on this basis. It should be noted that this pair of tubercles is absent from some of the cranidia of the type species of *Fragiscutum*, *E.* (*F.*) *rhytium* illustrated by Whittington and Campbell (1967, pl. 12, figs. 8, 15). Thus, since the only character that can be used to distinguish between *Fragiscutum* and the *E. variolaris* species group is the number of segments in the thorax (Tripp *et al.* 1977, p. 855, also noted only this difference), and the number of thoracic segments is not known for *E. dimitrovi*, it is not possible to state whether or not this species belongs to *Fragiscutum*.

E. dimitrovi lacks the distinctive posterior constriction of the glabella, wide axial furrows, and large eyes of *E.* (*F.*) *glebalis* (Campbell). The hypostome and free cheeks of *E. dimitrovi* are very similar to those of *E.* (*F.*) *rhytium* (Whittington and Campbell), but *E. dimitrovi* differs from that species in having distinctly fewer axial rings on the pygidium, more numerous tubercles on the fixed cheeks, and a more distinct pair of apodemes under 3s.

In comparison to species of the *E. variolaris* species group, *E. dimitrovi* has the following characters (these characters were used by Tripp *et al.* 1977 to compare species within the *E. variolaris* group in their Table 5): moderate convexity of the glabella, moderate sized tubercles I-1, and small tubercle iii-0; 2 tubercles between the palpebral lobe and the axial furrow; 5 (sometimes 6) tubercles along the axial furrow on the fixigena; 7-10 tubercles on the field of the free cheek; a small fixigenal spine; a trapezoidal shaped rostrum; 10-12 axial rings, 7-9 pleural ribs, a weak sagittal groove, and axial tubercles modally placed on axial rings 1, 4, 7, 9, on the pygidium. On the basis of these characters, *E. dimitrovi* is most similar to *E. diabolus* Tripp, Temple and Gass, but differs from that form in the tubercle formula, more tuberculate free cheek field, and fewer pygidial axial rings.

E. hyperboreus Thomas and Narbonne, 1979, a species of the *E. variolaris* group from the Ludlow Read Bay Formation of Cornwallis Island, Arctic Canada, differs from *E. dimitrovi* in having a more densely tuberculose cephalic surface (smaller gaps between tubercles), a distinct pair of glabellar tubercles I-2, a more rounded postero-medial pygidial outline, with less ornamented and steeply sloping pygidial pleurae.

Family CALYMENIDAE Burmeister, 1843
Subfamily CALYMENINAE Burmeister, 1843
Genus CALYMENE Brongniart, 1822

Type species. *Calymene blumenbachii* Brongniart, 1822 from the Wenlock Limestone of Great Britain.

Calymene sp.

Plate 75, figs. 16-23

Figured material. Fragmental cranidia, hypostomes, and rostral plate include UA 2113, 2116 from locality 150; and UA 2114, 2115, 2137 from locality 100.

Discussion. The material at hand is too fragmentary for detailed comparison, although the cranidium is quite similar to *Calymene clavicula* Campbell from the Wenlock-Ludlow Henryhouse Formation of Oklahoma in that the glabellar and axial furrows are much the same. The anterior lobe of the middle body of the hypostome of the Mackenzie Mountains *Calymene* does not bear as prominent a protuberance as that of *C. clavicula*. The specimens of *Calymene* illustrated by Perry and Chatterton (1977) from the Wenlockian of the Arctic Archipelago has an ornament of perforated tubercles, more isolated 2p lobes, a straighter-sided glabellar outline, and a shorter anterior border than *Calymene* sp.

Calymene is represented in a number of Wenlock collections available from north-western or Arctic Canada.

Family LICHIDAE Hawle and Corda, 1847
Subfamily CERATARGINAE Tripp, 1957
Genus HEMIARGES Gürich, 1901

Type species. Lichas wesenbergensis Schmidt, 1885, from the Upper Ordovician of Estonia.

Hemiarges sp.

Plate 76, figs. 25–30

Figured material. Only fragmental cranidia hypostomes and free cheeks are available of which UA 2133, 2134, 2136 from locality 450 and UA 2135 from locality 495 are illustrated.

Discussion. Characters of the cranidium are generally conservative within this genus, but *Hemiarges* sp. could well belong to a species close to *H. mikulici* or *H. rohri*, described from the Wenlock of the Arctic Archipelago by Perry and Chatterton (1977), with the prominent separation of anterolateral and posterolateral lobes by 1s and the subparallel longitudinal glabellar furrows. The apparent bimodality of ornament and the broad free cheeks suggests a possible affinity with *H. mikulici* Perry and Chatterton. Although not always abundant, *Hemiarges* is a widely dispersed genus in north-western and Arctic Canada Wenlock and Ludlow faunas of both platform and basin-edge facies.

Family ODONTOPLEURIDAE Burmeister, 1843
Subfamily ODONTOPLEURINAE Burmeister, 1843
Genus ACIDASPIS Murchison, 1839

Type species. Acidaspis brightii Murchison, 1839, from the Wenlock Limestone of Great Britian.

Acidaspis jessi sp. nov.

Plate 76, figs. 1–19, 21–24

Derivation of name. This species is named after J. G. (Jess) Johnson of Oregon State University.

Holotype. UA 2118, from locality 150.

Other figured material. Paratypes UA 2117, 2119–2121, 2123–2129, 2131 from locality 150, UA 2122 from locality 100 and UA2132 from locality 450. *A. jessi* is represented by 17 cranidia, 7 pygidia, and 2 free cheeks.

Diagnosis. Acidaspis with an axial spine as long as the cephalon and of moderate diameter, prominent 1p and 2p lobes, but small to insignificant 3p lobes; long posterolaterally directed and backwardly curving genal spines; and six pairs of border spines on the pygidium, with the fourth pair being distinctly larger.

Description. Occipital furrow very weakly developed medially, deep behind 1p lobes. Occipital ring with long, stout posterodorsally directed spine whose base occupies whole occipital ring. One prominent tubercle located medially just in front of spine; prosopon on spine of small spinose tubercles and granules. Two pairs of lateral glabellar lobes separated from median lobe by strongly impressed longitudinal furrow. 1p lobe elongate (exsag.) oval shaped, about twice as large as 2p. 2p subspherical. 1p and 2p completely surrounded by deep furrows. Median lobe of glabella strongly convex in profile, subparallel sided and slightly overhangs narrow anterior border furrow. Axial furrow separates 1p and 2p from narrow (exsag.), elongate fixigenal areas which curve and narrow (exsag.) anteromedially. Palpebral furrow separates prominent eye ridge from rest of fixigena posteromedially. Subspherical eye somewhat elevated lateral to 1p lobe. Eye ridge extends from anteromedial corner of eye to front of glabella. Facial suture fused in mature specimens and not obvious. All elevated areas of cephalon with prominent tubercles. Prominent tubercles arranged in pairs (four to five prominent pairs) on median lobe of glabella.

Free cheeks with long, stout, curved genal spine which extends posterolaterally proximally and recurves slightly posteromedially distally. Border furrow shallow; separates raised genal spine and border from depressed area. Eleven cylindrical spines extend downward and outward from border; spines closely spaced, increase in length toward genal spine. Prosopon of coarse granules to fine tubercles on genal spine and lateral border, and of finer granules on free cheek area. Doublure narrow, moderately incurved.

Number of thoracic segments uncertain. Pleurae divided by furrow into a gently convex anterior band and a raised, strongly convex, stouter, posterior band. Narrow (exsag.) posterior articulating flange. Posterior band curves backward distally (degree depending on position of segment in thorax) into a long barbed pleural spine. Anterior band terminates in a shorter, slightly curved, barbed spine. Anterior pleural spine usually more ventrally directed than posterior pleural spine. Posterior band with prosopon of prominent spinules, especially on pleural spine. Anterior band with prosopon of finer spinules.

Pygidium approximately three to four times wider than long (without marginal spines). One prominent axial ring whose pleural extensions terminate at the base of the fourth pair of border spines. Six pairs of border spines present, of which forth pair of major border spines is greatly swollen and elongated, and situated slightly above the plane of the other spines (partially overlaps fifth pair). Second axial ring marked by a slight elevation and a pair of tubercles, merges insensibly into small terminal piece. Axial furrow very shallow on first segment, deep and broad beside second axial ring and terminal piece, and very shallow to absent posteromedially. Anterior and lateral borders elevated. Doublure moderately wide and evenly enrolled. Dorsal prosopon of fine granules and a few coarser tubercles on body of pygidium and on border spines, with spinose tubercles more prominent on marginal spines.

Discussion. A. jessi sp. nov. has a narrower median glabellar lobe with a more rectangular anterior margin, that is not separated from the occipital lobe, than the Wenlock *A. brightii* Murchison (see Whittington 1956); and the pygidium bears only six pairs of border spines, as compared to seven in the type species. *A. grayi* Barrande

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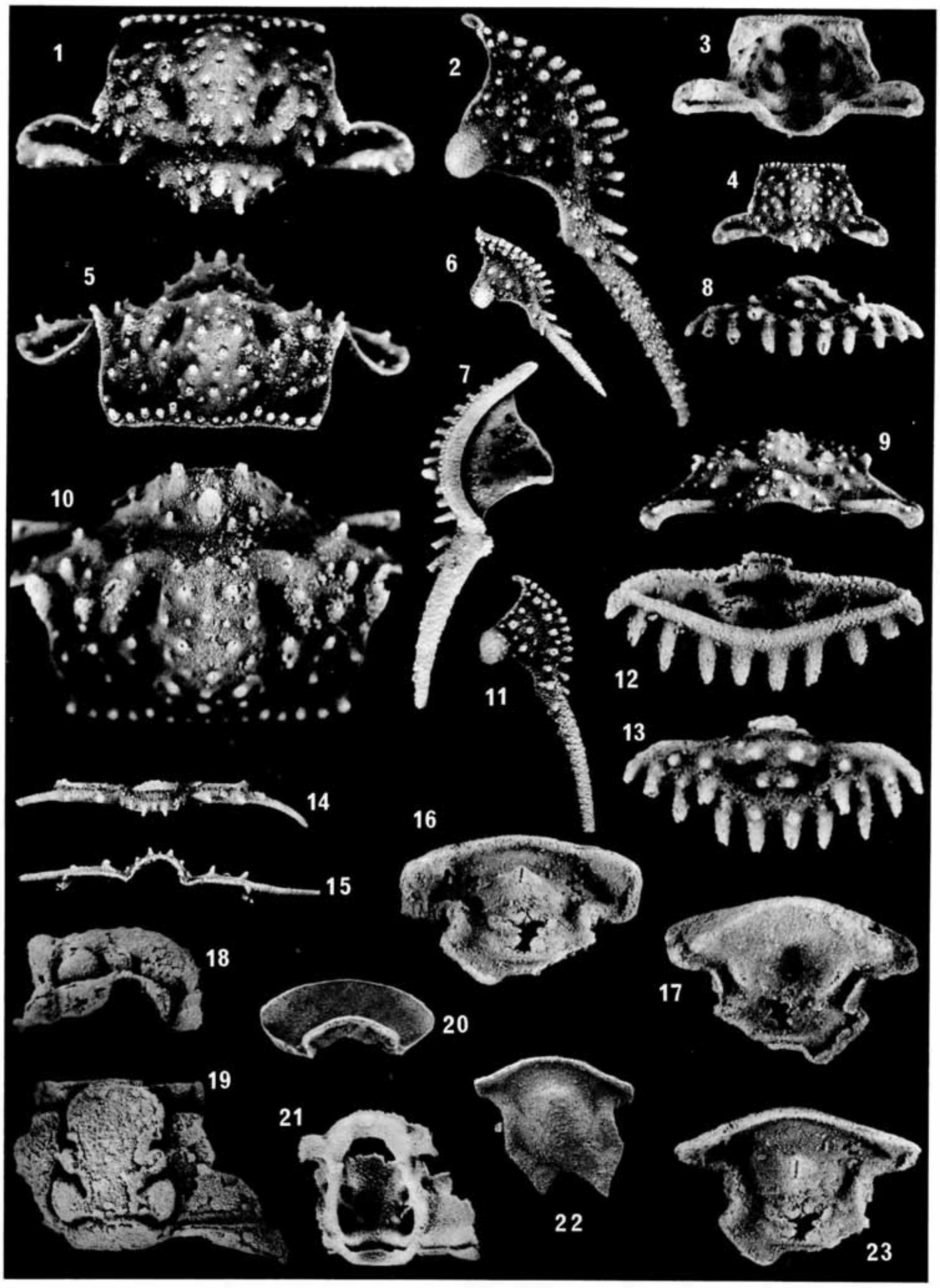
EXPLANATION OF PLATE 75

Figs. 1–15. *Diacanthaspis* (*Acanthalomina*) *thorsteinssoni* sp. nov. 1, 3, 5, 9, 10, holotype UA 2105, dorsal, ventral, anterodorsal, posterodorsal, and enlargement of anterodorsal view of cranidium, loc. 450, ×10·0, ×6·6, ×10·1, ×7·3, and ×15·0, respectively. 2, paratype UA 2106, outer view of right free cheek, loc. 450, ×15·0. 4, paratype UA 2107, dorsal view of cranidium, loc. 450, ×5·8. 6, paratype UA 2108, outer view of right free cheek, loc. 450, ×5·8. 7, paratype UA 2109, inner view of right free cheek, loc. 450, ×10·0. 8, 12, 13, paratype UA 2110, posterior, ventral, and dorsal views of pygidium, loc. 450, ×11 and ×14·0. 11, paratype UA 2111, outer view of right free cheek, loc. 150, ×10·0. 14, 15, paratype UA 2112, dorsal and posterior views of thoracic segment, loc. 450, ×6·0.

Figs. 16–23. *Calymene* sp. 16, 17, 23, UA 2113, posteroventral, dorsal, and ventral views of hypostome, loc. 150, ×7·1. 18, 19, UA 2114, lateral and dorsal views of cranidium, loc. 100, ×5·4. 20, UA 2137, posterodorsal view of rostral plate, loc. 100, ×4·1. 21, UA 2115, ventral view of cranidium, loc. 100, ×5·4. 22, UA 2116, SEM ventral view of small hypostome, loc. 150, ×17·5.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from the Wenlock of Bohemia (see Bruton 1968) has a more inflated occipital spine than *A. jessi*, and bears a more distinct pair of 3p lobes.

Whittington (1956, p. 232) provided a diagnosis for *Acidaspis*, stating 'Pygidium with seven pairs of border spines, fifth the major'. *A. jessi* has only six pairs of border spines with the fourth pair being the major pair. Thus the generic diagnosis of *Acidaspis* should be emended to read pygidium with six or seven pairs of border spines, fourth or fifth the major.

Acidaspis is a common taxon in carbonate platform-basin edge carbonate facies of Wenlock age in north-western and Arctic Canada.

Genus DIACANTHASPIS Whittington, 1941
Subgenus ACANTHALOMINA Prantl and Přibyl, 1949

Type species. Odontopleura minuta Barrande 1846, from the lower Budňany (Ludlow) of Czechoslovakia.

Discussion. Four closely similar taxa that can be assigned to *Acanthalomina* are the type species, *Diacanthaspis* (*Acanthalomina*) *minuta* (Barrande), *D.* (*A.*) *parvissima* (Etheridge and Mitchell), *D.* (*A.*) *thorsteinssoni* sp. nov., and possibly *Diacanthaspis* (*Acanthalomina*) sp. nov. from California (illustrated as *D.* (*A.*) *minuta* by Churkin (1961). Specimens of this subgenus, very close to or conspecific with *D.* (*A.*) *thorsteinssoni*, have been obtained by us from Wenlock strata of the Canadian Arctic. The characteristic pygidium of this subgenus, with major border spines that are little larger than the other border spines on the pygidium, is very similar to that of *Diacanthaspis*. The Wenlock species of this subgenus, *D.* (*A.*) *thorsteinssoni*, has anterior thoracic pleural spines that consist of a single short spine (barbed in early growth stages), sometimes with a secondary smaller lobed spine, that is more similar to the

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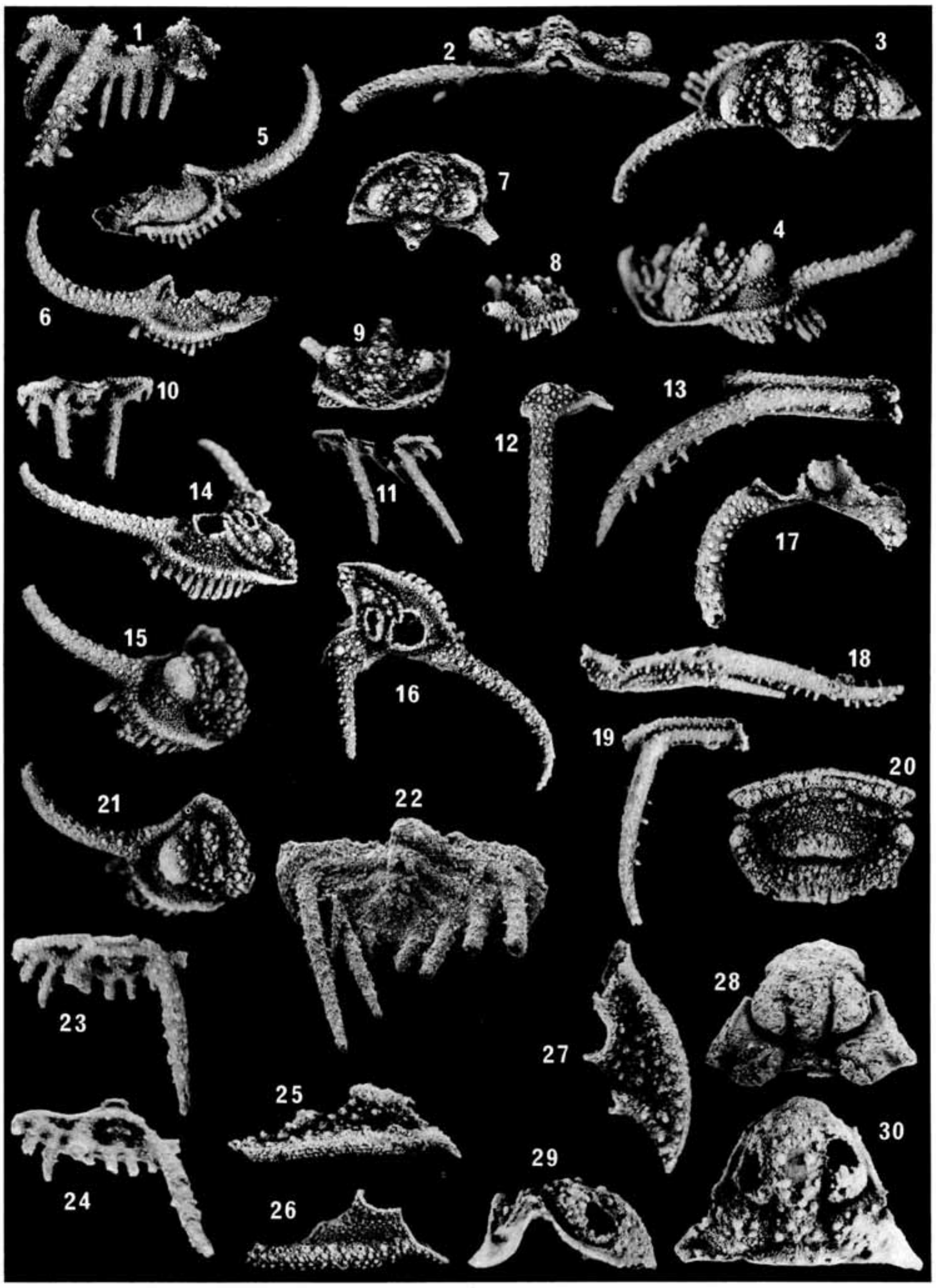
EXPLANATION OF PLATE 76

Figs. 1–19, 21–24. *Acidaspis jessi* sp. nov. 1, paratype UA 2117, dorsal view of pygidium fragment, loc. 150, ×8·0. 2–4, holotype UA 2118, posterodorsal, dorsal, and dorsolateral views of cephalon, loc. 150, ×15·0. 5, 6, paratype UA 2119, ventral and dorsal views of fragment of right side of a cephalon, loc. 150, ×8·0. 7–9, paratype UA 2120, dorsal, lateral, and anterodorsal views of small cephalon, loc. 150, ×15·0. 10, paratype UA 2121, dorsal view of small pygidium, loc. 150, ×15·0. 11, paratype UA 2122, dorsal view of broken, tectonically distorted pygidium, loc. 100, ×6·0. 12, paratype UA 2123, dorsal view of occipital spine, note occipital organ at base of spine, loc. 150, ×6·0. 13, paratype UA 2124, dorsal view of left thoracic pleura, loc. 150, ×15·0. 14, 16, paratype UA 2125, anterolateral and dorsal views of cephalon fragment, loc. 150, ×15·0. 15, 21, paratype UA 2126, anterolateral and dorsal views of cephalon fragment, loc. 150, ×15·0. 17, paratype UA 2127, dorsal view of large cranidial fragment, loc. 150, ×6·0. 18, paratype UA 2128, anterodorsal view of left thoracic pleura, loc. 150, ×4·1. 19, paratype UA 2129, dorsal view of part of thoracic segment, loc. 150, ×15·0. 22, paratype UA 2131, SEM dorsal view of transitory pygidium, loc. 150, ×30·0. 23, 24, paratype UA 2132, dorsal and posterodorsal views of pygidium, loc. 450, ×10·2.

Fig. 20. *Youngia copelandi* sp. nov. Paratype UA 2130, ventral view of hypostome with rostral plate attached, loc. 150, ×15·0.

Figs. 25–30. *Hemiarges* sp. 25, 27, UA 2133, lateral and dorsal views of right free cheek, loc. 450, ×9·5. 26, UA 2134, dorsolateral view of small right free cheek, posterior broken, loc. 450, ×15·0. 28, UA 2135, dorsal view of internal mould of cranidium, loc. 495, ×3·8. 29–30, UA 2136, lateral and dorsal views of cranidium, loc. 450, ×5·0.



PERRY and CHATTERTON, Wenlock trilobites

situation in *Diacanthaspis* than it is to that in *Leonaspis*. *D.* (*A.*) *thorsteinssoni* is, in our opinion, more similar to *Diacanthaspis* than it is to *Leonaspis*, but it occurs at an horizon where distinctive species of *Leonaspis* have already evolved. Thus, although later species of *Acanthalomina*, such as *D.* (*A.*) *parvissima* and *Diacanthaspis* (*Acanthalomina*) sp. nov., may have subdivided anterior thoracic pleural spines, more like those of *Leonaspis s.s.*, we believe that they are independently derived from species of *Diacanthaspis*, and that it is more logical to include these forms as a subgenus of *Diacanthaspis* than it is to place them in synonymy with *Leonaspis* (as was done by Whittington 1956; Bruton 1968). *Leonaspis* and *Acanthalomina* probably had common ancestry in some species of *Diacanthaspis* during the Late Ordovician or Early Silurian; and following an initial period of divergence, convergent evolution in the details of the thoracic pleurae and, to a lesser extent, the pygidium took place.

Diacanthaspis (*Acanthalomina*) *thorsteinssoni* sp. nov.

Plate 75, figs. 1–15

Derivation of name. This species is named after R. Thorsteinsson of the Geological Survey of Canada.

Holotype. UA 2105, from locality 450.

Other figured material. Paratypes UA 2106–2110, 2112 from locality 450; and paratype UA 2111 from locality 150. *D.* (*A.*) *thorsteinssoni* is represented by 2 cranidia, 1 pygidium, and 13 free cheeks.

Diagnosis. A small *Diacanthaspis* with an ornament of coarse spinose tubercles; with a prominent occipital tubercle (1) and slightly less prominent pair of occipital tubercles (0p); without a distinct sagittal row of fine tubercles; with two to three prominent spinose tubercles on the inner portion of the pleura of each thoracic segment; with a pronounced pair of spinose tubercles in each axial somite; and with fourteen to fifteen marginal spines on the free cheeks.

Description. Cranidium subtrapezoidal in outline; ornament of coarse spinose tubercles. Larger spinose tubercles organized in paired fashion, with distinctly larger occipital tubercle (1) and a recognizable pair of occipital tubercles (0p). 1p and 2p lobes distinct, with 2p being much smaller. They are separated from median lobe by sublongitudinal furrows that are moderately impressed opposite lateral glabellar lobes and deeply impressed at median ends of posterolaterally directed and firmly impressed 1s and 2s furrows. Axial furrows shallow, and they curve slightly outward and forward from posterior margin before curving inward towards front of glabella. Low eye ridge runs in a straight line from front of palpebral lobe to front of glabella. Moderate sized, subspherical, holochroal eyes are raised almost to height of median lobe of glabella; and are situated opposite the anterior halves of the 1p lobes; eyes with at least twenty-one files of lenses containing up to fifteen lenses per file (clearly visible on ventral surface). Posterior border furrow firmly impressed and interrupted distally by a well-developed sutural ridge. Sutural ridge also present along anterior branch of facial suture. Facial sutures converge weakly in a straight line in front of eyes, and diverge strongly behind eyes before curving sharply backward opposite posterior border. A distinct row of fine tubercles runs along narrow (sag.) anterior border.

Free cheek with large, slightly posterolaterally curved genal spine. Lateral margin curved, and forms obtuse angled junction with genal spine. Numerous (fourteen to fifteen) fine cylindrical marginal spines project posterolaterally from lateral margin and anterolateral margin of genal spine. They increase in length backward. A second row of fine spines (tubercles) extends along dorsolateral edge of free cheek. A moderately impressed border furrow is interrupted at each end by a sutural ridge. Prosopon on upper surface of gena and anterior portion of genal spine consists of a few coarse spinose tubercles and some interspersed finer tubercles. Doublure of moderate width, with a row of granules just inside marginal spines.

Hypostome and rostral plate not recovered.

Number of segments in thorax not known. Pleurae end distally in long tubular posterior pleural spines and short subventrally directed anterior pleural spines. Ornament on axial ring consists of a pair of prominent spinose tubercles and several slightly smaller tubercles. Prosopon on inner portion of pleura consists of two to three prominent spinose tubercles. Inner portion of pleura divided into a broad posterior band and a narrow anterior band by a firmly impressed pleural furrow.

Pygidium broad, with five subequal pairs of border spines. Axis consists of a single axial ring and a terminal piece; is ornamented by a pair of coarse spinose tubercles on each of first axial ring and terminal piece, but axial ring has additional smaller tubercles. A very low and poorly defined ridge bearing two pairs of tubercles runs from axial ring towards third pair of border spines, which is not noticeably larger than other pairs of border spines. One pair of spinose tubercles situated near base of second pair of border spines, another pair at base of fifth pair of border spines, and a larger posteriorly directed pair placed opposite terminal piece in front of gap between third and fourth pairs of border spines. Axial furrows moderately impressed. Very fine tubercles present on proximal dorsal surfaces of border spines. Doublure gently curved.

Discussion. D. (*A.*) *thorsteinssoni* sp. nov. is similar to the other three species of the subgenus *Acanthalomina*. These four species appear to form a tight species group. They range in age from Wenlock (*D.* (*A.*) *thorsteinssoni*) to the Ludlow (*D.* (*A.*) *minuta* and *D.* (*A.*) *parvissima*). The age of the Californian form is not known with certainty.

D. (*A.*) *thorsteinssoni* differs from the type species, *D.* (*A.*) *minuta* in having fewer spinose tubercles on, and in having a distinctly larger pair of tubercles on each segment of, the axis; and in having a smaller number of marginal spines on the free cheek (14–15 as opposed to 16–17).

D. (*A.*) *thorsteinssoni* differs from *D.* (*A.*) *parvissima* in that it has a more prominent occipital (1) and a pair of occipital tubercles; it lacks as distinct a row of small tubercles running down the sagittal line; it has a distinctly larger pair of spinose tubercles on each axial somite; and it has five rather than four pairs of somewhat shorter and fatter border spines on the pygidium.

D. (*A.*) *thorsteinssoni* differs from *Diacanthaspis* (*Acanthalomina*) sp. nov., the species from California, in having less distinct major border spines on the pygidium.

Genus XANIONURUS Whittington and Campbell, 1967

Type species. Xanionurus boucoti Whittington and Campbell, 1967, from the Wenlock–Ludlow of Maine, north-eastern United States.

?*Xanionurus* sp.

Plate 69, figs. 29, 30, ?31

Figured material. Pygidia and a fragmental cranidium from locality 150, UA 2051–2053.

Discussion. This is the first reported occurrence of *Xanionurus* in Western or Arctic North America. Other than the type locality in Maine, the genus is known from Emsian beds of New South Wales (*X. bispinosus* Chatterton, 1971) and from the Wenlock of Czechoslovakia (*X. formosa* (Prantl and Vaněk) *fide* Whittington and Campbell (1967)). Kříž and Pek (1974) reassigned *X. formosa* to *Radiaspis*, and discussed the relationships between *Radiaspis*, *Xanionurus*, and *Diacanthaspis*.

The lateral glabellar lobes are not as clearly differentiated as in *Xanionurus boucoti* Whittington and Campbell. The similar number and shape of pygidial border spines, the termination of the pleural ridge at the base of the fifth border spine and the pustulose prosopon appear to support the assignment to *Xanionurus*.

Phylum BRACHIOPODA
Family SOWERBYELLIDAE Öpik, 1930
Subfamily AEGIROMENINAE Havlíček, 1961
Genus AEGIRIA Öpik, 1933

Type species. Aegiria norvegica Öpik, 1933, from the Llandovery of the Oslo region, Norway.

Discussion. An articulated limonitized internal mould of *Aegira* from locality 100 appears close to *A. grayi* (Davidson), as illustrated by Bassett (1974). *A. grayi* is also known from the Wenlock of Britain and Gotland (Bassett and Cocks 1974). This genus has only been recently recognized in North America by Lenz (1977) who reported it from Wenlock Ludlow, and Pridoli strata.

Family CHILIDIOPSIDAE Boucot, 1957
Genus MORINORHYNCHUS Havlíček, 1965

Type species. Morinorhynchus dalmanelliformis Havlíček, 1965, from the Ludlow of Bohemia.

Morinorhynchus sp.

Plate 72, figs. 4, 6–8

Figured material. Morinorhynchus sp. is represented by specimens UA 2088–2089 and several more silicified juvenile specimens from locality 450.

Discussion. The shells in question are clearly closely allied to the Chilidiopsidae as interpreted by Bassett (1974). The shells have a large ventral pseudodeltidium and a small dorsal chilidium. The genus *Coolinia* has a small ventral pseudodeltidium and a large dorsal chilidium. *Fardenia* has small discrete chilidial plates (Bassett 1974). The shells assigned to ?*Fardenia* sp. by Lenz (1977, pl. 2, figs. 20–23) from the Wenlock of the western Mackenzie Mountains probably belong to *Morinorhynchus*. The genus has been previously reported from the Pridoli of central Nevada in western North America (Johnson *et al.* 1973).

Morinorhynchus occurs in nearly all the collections from the Delorme Range Wenlock–?Ludlow. The shells are small 3–4 mm in diameter, with a semicircular outline and slightly ventribiconvex profile. The ornament consists of prominent plicae which are clearly visible internally, with weaker intercalated costae. The hinge teeth are supported by strong anterolaterally divergent dental plates. The inner socket plates meet posteromedially and form the base of a weakly differentiated posteriorly directed bilobed cardinal process.

Family STROPHOMENIDAE King, 1846
Subfamily FURCITELLINAE Williams, 1965
Genus KATASTROPHOMENA Cocks, 1968

Type species. Strophomena antiquata (J. de C. Sowerby) var. *woodlandensis* Reed, 1917, from the Llandovery of Scotland.

Katastrophomena sp.

Plate 70, figs. 28, 29

Figured material. Katastrophomena sp. is represented by UA 2075 from locality 150 and another very small dorsal valve and a pedicle valve fragment.

Discussion. The only other possible citation of *Katastrophomena* from North America is material questionably assigned to the genus by Lenz (1977) from Llandovery age beds of the western Mackenzie Mountains. Comparison of the Delorme Range shells with those of the *K. antiquata* species group shows the dorsal interiors to be virtually identical, and the dorsal external parvicostellate ornament to be similar to that of juvenile shells from the Wenlock Limestone of Great Britain (Bassett 1974, pl. 27, figs. 5*a*, *b*, 8; pl. 28, figs. 1, 4). The interior of the fragmentary ventral valve shows the prominent anteriorly raised muscle field with a prominent median myophragm. It should be noted that Wenlock *Katastrophomena* and *Pentlandina* approach being homoeomorphic although *Pentlandina* appears to have a concentric ornament of more irregular intercostal rugae; and the costae increase more commonly by bifurcation as opposed to intercalation in most *Katastrophomena*. The fragmental dorsal valve illustrated by Lenz (1977, pl. 7, fig. 6) appears to be more similar to *Leptaena* than *Katastrophomena*.

Genus LEPTAENA Dalman, 1828

Type species. Leptaena rugosa Dalman, 1828 from the Ashgill of Sweden.

Leptaena sp.

Plate 72, figs. 5, 9

Figured material. Leptaena is represented by the illustrated specimen UA 2090 from locality 450 and several small brachial valves and a pedicle valve fragment.

Discussion. Leptaena is an ubiquitous taxon in basin edge shelly faunas of Siluro-Devonian age in western North America. These small shells already show the sharp dorsal anterior geniculation, although rugations are weakly developed. The dorsal adductor muscle field is as yet unfortified with shell callus. The ventral orientation of the cardinal process lobes, the anteriorly located dorsal median septum and the prominently pseudopunctate shell interior are characteristic features. These small specimens of *Leptaena* sp. are distinct from previously described taxa by their coarser, less numerous radial ornament which is stronger than the concentric rugae.

Family ANOPLIIDAE Muir-Wood, 1962

Genus SHAGAMELLA Boucot and Harper, 1968

Type species. Shagamella ludloviensis Boucot and Harper, 1968, from the Ludlow of Wales and the Welsh Borderland.

?*Shagamella* sp.

Plate 70, figs. 26–27

Figured material. Only this small, silicified pedicle valve is available (UA 2074), from locality 450.

Discussion. The only previously reported smooth Silurian brachiopods with hinge line spines are *Anoplia* and *Shagamella*. For absolute distinction of the taxon in question from *Anoplia*, the dorsal interior structures need to be observed. Bassett (1977) illustrated poorly preserved *S.* cf. *S. ludloviensis* from the Wenlock Limestone of the Ludlow Anticline. The specimen from the Mackenzie Mountains bears two pairs of spines projecting at 90° to the valve margin, and possesses a weakly developed apical median septum. A small, apical pseudodeltidium is developed, a feature not present in the type species (Boucot and Harper 1968).

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APPENDIX I

Delorme Range Section C47 (62° 46′ N, 125° 15′ W) Trilobite and Brachiopod Faunal List

Abbreviations used include: C—cranidium; P—pygidium; F—free cheek; H—hypostome; RP—rostral plate; BV—brachial valve; PV—pedicle valve; f—fragmental material.

C47-510

Otarion sp. 1Cf, 1Ff; *Encrinurus* sp. aff. *E. dimitrovi* sp. nov. 1Cf, 2Pf, 1Hf.

C47-495

Indeterminate illaenid 2Ff; *Otarion brauni* sp. nov. 21Cf, 4Pf, 26Ff; *Encrinurus dimitrovi* sp. nov. 40Cf, 30Pf, 6Hf; *Calymene* sp. 1Hf; *Hemiarges* sp. 2Cf, 2Hf; *Acidaspis* sp. 5Pf, 1Ff; *Diacanthaspis* sp. 3Ff; *Morinorhynchus* sp. 2Bv, 3Pv.

C47-450

Indeterminate illaenid 1Pf, 1Hf; ?*Schizoproetus* sp. 1P, 8Ff; *Proetus* (*Coniproetus*) sp. 1P, 1Cf; *Otarion brauni* sp. nov. 22Cf, 15P, 55Ff; *Cheirurus* sp. 1C, 1P, 1H, 1F; *Sphaerexochus* sp. 1H; *Encrinurus dimitrovi* sp. nov. 3Cf, 6P, 1Ff; *Hemiarges* sp. 3Cf, 3Ff; *Acidaspis jessi* sp. nov. 4Cf, 1P; *Diacanthaspis* (*Acanthalomina*) *thorsteinssoni* sp. nov. 2C, 1P, 9F; *Leptaena* sp. 6BVf. Indeterminate mesodouvilline 2PVf; *Morinorhynchus* sp. 12BV, 15PV; ?*Shagmella* sp. 1PV.

C47-150

Indeterminate illaenid 3Pf, 6Hf, 5Ff, 12P; Indeterminate proetid 2Hf; *Proetus* (*Coniproetus*) sp. 8C, 7Pf, 3H, 40Ff; *Otarion brauni* sp. nov. 2Cf, 1Pf, 1F; *Otarion* sp. 1Cf; *Scharyia redunzoi* sp. nov. 2Cf, 6Pf, 7Ff; *Cheirurus* sp. 8Cf, 3H; ?*Cheirurus* sp. 2Hf; *Sphaerexochus* sp. 2Cf, 2P, 3Ff; *Deiphon braybrooki* sp. nov. 3Cf, 1H, 2P; *Youngia copelandi* sp. nov. 7Cf, 4P, 2F, 1H; *Encrinurus dimitrovi* sp. nov. 18Cf, 15P, 7Hf, 18Ff; *Encrinurus* sp. 2P, 1H; *Calymene* sp. 2Cf, 3Pf, 2H, 2RP; *Acidaspis jessi* sp. nov. 13Cf, 5Pf; *Diacanthaspis* (*Acanthalomina*) *thorsteinssoni* sp. nov. 1F; *Xanionurus*? 1Cf, 2Pf; Indeterminate mesodouvilline 4PVf, 3BV; neanic shells with prominent pedicle tubes; *Leptaena* sp. 1PVf, 1BVf; *Katastrophomena* sp. 2BV, 1PVf; *Morinorhynchus* sp. 1PV, 1BV.

C47-100

Indeterminate illaenid 1Hf; Indeterminate proetid 1H; *Proetus* (*Coniproetus*) sp. 5Cf, 1P, 2Hf, 11Ff; *Otarion brauni* sp. nov. 2Ff; *Scharyia redunzoi* sp. nov. 2P, 1Ff; *Cheirurus* sp. 1Hf, 2F; *Sphaerexochus* sp. 1Cf; *Deiphon braybrooki* sp. nov. 4Cf, 4Hf; *Youngia copelandi* sp. nov. 4Cf, 3P, 3F; *Encrinurus dimitrovi* sp. nov. 15Cf, 11Pf, 2Hf, 6Ff; *Encrinurus* sp. 2P; *Calymene* sp. 2Cf, 2Pf, 1Hf, 1RP; *Acidaspis jessi* sp. nov. 1Pf, 2Ff; *Morinorhynchus* sp. 1BV; *Aegiria* sp. 1 internal mould.