SILURIAN TRILOBITES FROM THE ANNASCAUL INLIER, DINGLE PENINSULA, IRELAND

by DEREK J. SIVETER

ABSTRACT. The richest and best-preserved Silurian trilobite fauna to have been discovered from Ireland, from two localities in the Annascaul inlier, County Kerry, is described. The specimens belong to eight families, thirteen genera, and sixteen species. Five species are new: *Interproetus galvani*, *Conoparia hollandi*, *Calymene endemopsis*, *Primaspis mendica*, and *Leonaspis parkini*. The precise age of the two limestone lenses which yielded the material is uncertain, but it is likely that they fall within a mid-Wedlock to mid-Ludlow time interval, with several faunal elements indicating a late Wenlock age. The restricted fauna from one of the localities is typical of the illaenid–cheirurid assemblage which typifies shallow water, nearshore carbonate environments; the much richer fauna from the second locality may have inhabited a slightly more offshore, open water position. At the generic level the fauna is cosmopolitan; at the specific level links are evident with the Welsh Borderland (in particular), Bohemia, and Scandinavia.

THE Silurian of Ireland is dominated both in terms of thickness and areal extent by deep water, turbidite, and graptolite facies. Shallow water facies and associated shelly faunas are largely confined to the Galway, Connemara, and Roscommon areas in the north-west, and to the Dingle Peninsula, County Kerry, in the south-west. Since the mid-nineteenth century various trilobites have been recorded from these areas but, apart from the early studies of M'Coy (1846, 1849) and the recent discussions of Whittington and Campbell (1967) and Thomas and Owens (1978) of *Harpidella megalops* (M'Coy, 1849) and Owens (1973) of *Proetus* (s.l.) *latifrons* (M'Coy, 1846), they have received little attention. The taxa described here from the Annascaul inlier represent by far the richest and best-preserved Silurian trilobite fauna to have been described from Ireland.

THE LOCALITIES AND COLLECTIONS

All the specimens come from the western slopes of Caherconree mountain, from two small exposures separated by just over a kilometre of largely unexposed ground (text-fig. 1; Table 1). These exposures were discovered in the last century by officers of the Geological Survey and dubbed by Jukes and Du Noyer (1863, p. 12) the 'dove coloured limestone' and 'gray crystaline limestone' localities. The outcrops were subsequently relocated by Dr John Parkin (1976, figs. 4 and 5) who mapped the area and included them as part of his Ballynane Member within the Annascaul Formation, Dunquin Group, and designated them his shelly fossil localities numbers 28 and 36, respectively. The original Geological Survey material is extant: it comprises nine specimens (GSI F00749–757) from locality 28, referred in Jukes and Du Noyer (1863) to *Cheirurus bimucronatus*, *Encrinurus sexcostatus*, and *Illaenus bowmanni*, and fourteen specimens (GSI F00758–771) from locality 36, referred in the same paper to *Acidaspis jamesii*. Subsequent collections by the present author together with Parkin and Dr Colin Harris, and by Parkin and Mr Phillip Doughty, produced over seven hundred specimens; a few odontopleurids from this material were figured by Siveter *in* Holland (1981, fig. 51). All these more recently collected specimens are now housed in Trinity College, Dublin (TCD) and the Ulster Museum, Belfast (UM). Other material listed in the present work includes specimens from the Museum of the British Geological Survey (GSM), the British Museum (Nat. Hist.) (BM), the Humboldt-Universität, East Berlin (HU), and the Geological Survey of Canada (GSC).

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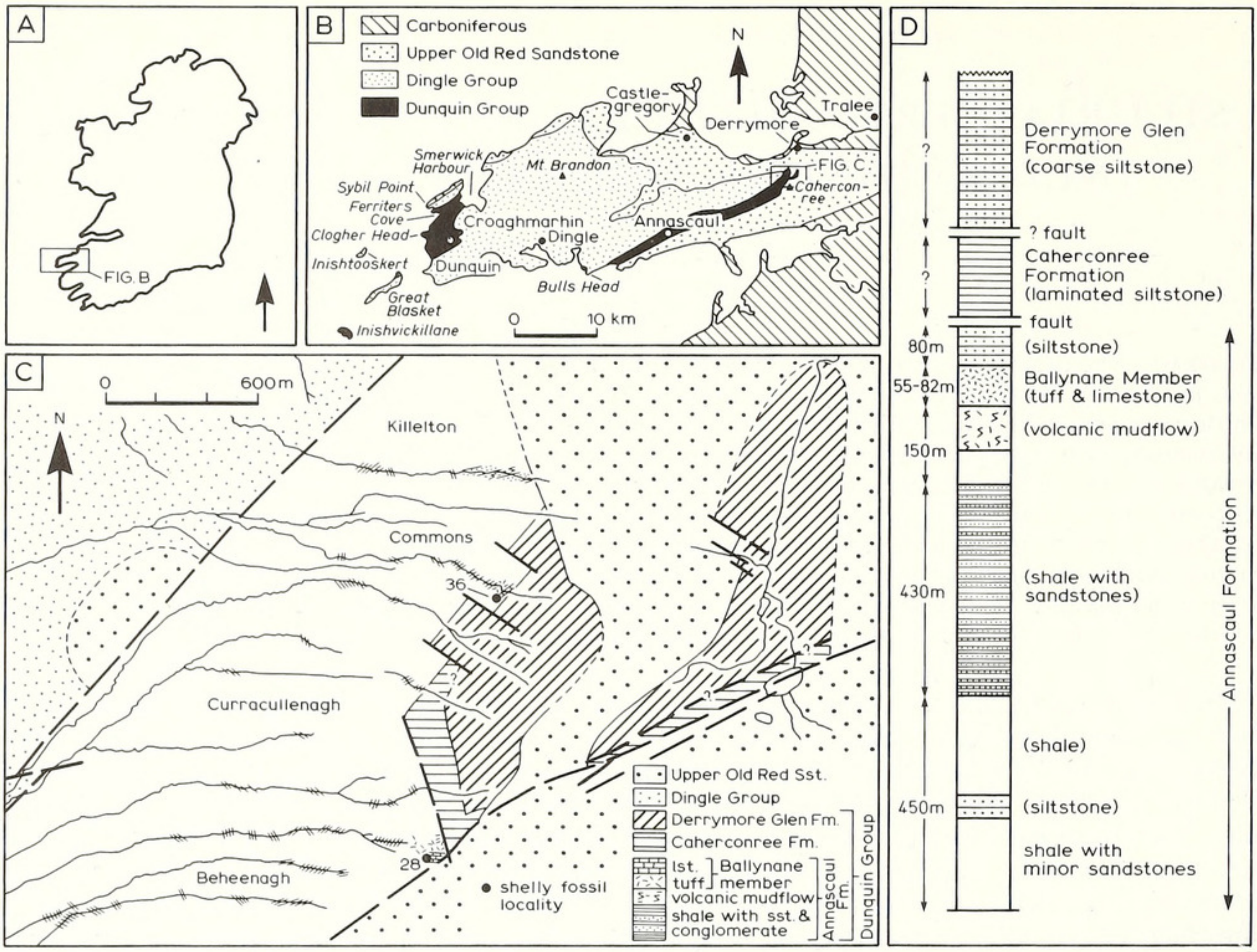


TEXT-FIG. 1. Locality map. A, Ireland with inset of the Dingle Peninsula. B, geological map of the Dingle Peninsula (after Holland 1981, fig. 48). C, geological map of the Carherconree–Derrymore Glen area, with the two fossil localities (28 and 36) which have yielded the trilobites described herein (simplified from Parkin 1976, fig. 4). D, stratigraphical section through the Dunquin Group, Bull's Head, Annascaul, and Derrymore Glen inliers (after Parkin 1976, fig. 5 and Holland 1981, fig. 49).

FAUNAL COMPOSITION

The fauna (Table 1) comprises eight families, thirteen genera, and sixteen species, of which five are new. Locality 28 has yielded three genera and three species, locality 36 eleven genera and thirteen species. The Proetidae, Phacopidae, Calymenidae, and Cheiruridae are represented by one genus, the Styginidae, Aulacopleuridae and Lichidae by two, and the Odontopleuridae by three. *Cheirurus*, *Calymene*, and *Leonaspis* have two species, other genera have one. The fauna is dominated both in terms of species and specimen numbers by the odontopleurids which total some 46% of the cranidia or cephala identified. Of the odontopleurids, *Odontopleura* (*Odontopleura*) *ovata* is by far the commonest species, and the most abundant in the fauna as a whole, comprising almost 31% of the cranidia or cephala. *Interproetus galvani* sp. nov. and *Ananaspis* aff. *stokesii* are the second and third most common species, totalling 24% and 20% respectively of the recovered cranidia or cephala, with the rest of the species each having less than 10%, *Kosovopeltis* aff. *allaarti*, *Trochurus*? sp. indet. and the indeterminate styginid species being represented by a single cranidium or pygidium.

TABLE 1. Occurrence of trilobite fauna in localities 28 and 36 and abundance of exoskeletal parts for each species as identified from bulk collections. Only *Ananaspis* is represented by cephala, the other species being represented by cranidia.

	Locality		Cephala/ cranidia				
	28	36	No.	%	Free cheeks	Hypostomata	Pygidia
Styginid gen. et sp. indet.	•						1
Kosovopeltis aff. *allaarti*		•	1	0·3			
Interproetus galvani		•	83	24·0	40	10	46
Conoparia hollandi		•	7	2·1	3		1
Scharyia sp.		•	2	0·6			
Cheirurus sp. nov.?		•	5	1·5		4	6
Cheirurus sp.	•		2	0·6		1	1
Calymene endemopsis		•	9	2·6			5
Calymene sp.		•	5	1·5	1	1	1
Ananaspis aff. *stokesii*		•	70	20·3		3	20
Odontopleura (*O.*) *ovata*		•	106	30·7	97	28	88
Primaspis mendica		•	21	6·1	10	15	15
Leonaspis coronata coronata		•	11	3·1	4	2	2
L. parkini		•	19	5·5	5		3
Dicranopeltis salteri?		•	3	0·9			2
Trochurus? sp. indet.	•		1	0·3			
Total			345		160	64	190

AGE

Parkin (1976, p. 593) considered that the Ballynane Member was most likely to be of upper Wenlock age, citing in particular the brachiopod evidence. He noted that this member may extend into the Ludlow, but not to any great extent as its upper limit was constrained by the overlying Caherconree Formation which he believed to be of *C. scanicus* Biozone (middle Gorstian) age. Aldridge (1980, pp. 130–131) concluded from the conodonts that the fauna from locality 28 was most likely of Wenlock age but that it was not possible to be more specific, and that the locality 36 fauna suggested a Ludlow age; the balance of evidence indicated to him that the strata at each of the two outcrops were deposited at different times, but that an ecological control may also have operated.

The trilobite faunas of the two localities are mutually exclusive at the specific level and *Cheirurus* is the only genus common to both. Of the taxa from locality 28 the unnamed *Cheirurus* species, which is related to *C. insignis* and *C. centralis*, suggests a Wenlock age, but the very similar and incompletely known *C. strux* comes from lower Ludlow strata; the relationships of the other two species from here are indeterminate. All of the species from locality 36 are best compared with Wenlock or Ludlow forms elsewhere, but some in particular give a better indication of its age. The *Ananaspis* species seems to lie on a morphological gradient between the early Wenlock *Acernaspis rubicundula* and late Wenlock material assigned to *Ananaspis stokesii*, though it is clearly much closer to the latter; *L. coronata coronata* has a late Wenlock to earliest Ludlow range; the new *Leonaspis* species is most closely related to a mid to late Wenlock form; *Dicranopeltis salteri*? may be the same species as that occurring in the British late Wenlock Much Wenlock Limestone Formation. Thus the best trilobite evidence suggests a mid/late Wenlock to earliest Ludlow age for locality 36. The differences between the trilobite faunas of the two localities could easily be a reflection of their somewhat different carbonate facies (see below), and possible different palaeoslope positions, but it is not possible to discern an age difference also on the basis of trilobites. Thomas (1980; *in* Thomas *et al.* 1984, pp. 54, 55) has already noted the lithofacies control on many British Wenlock trilobite genera, and also the difficulty in determining the Wenlock–Ludlow boundary on trilobites, as many Wenlock species range into the early Ludlow.

Limestone development of any note is uncommon in the British Silurian: it is almost absent from the Llandovery,, with the few good examples occurring at the base and particularly the top of the Wenlock and in the middle Ludlow. There is even less limestone in the Irish Silurian. The faunal and lithological evidence combined suggests that the Caherconree limestones may represent an Irish age equivalent of the Much Wenlock Limestone Formation. This was a time when carbonates were well developed throughout western and northern Europe, for example in the Welsh Borderland, Gotland, and the East Baltic. Even in areas subject to slightly deeper water deposition throughout much of the Silurian, for instance the Lake District and the Long Mountain, carbonate horizons formed in the late Wenlock (Rickards 1978; Palmer 1970).

SYSTEMATIC PALAEONTOLOGY

Family STYGINIDAE Vogdes, 1980

Discussion. For the most recent appraisal of this family, see Lane and Thomas 1983, p. 156.

styginid gen. et sp. indet.

Plate 15, figs. 7 and 8

1863 *Illaenus Bowmanni*; Baily *in* Jukes and Du Noyer, p. 12.
1878 *Illaenus Bowmanni*; Baily *in* Kinahan, p. 40.
1976 illaenid; Siveter *in* Parkin, p. 595, table 1 (*pars*).
1984 illaenimorph; Siveter *in* Thomas, Owens, and Rushton, p. 55.

Material. Two thoracic segments, one pygidium.

Occurrence. Annascaul Formation, locality 28 of Parkin 1976, p. 587, fig. 4, Annascaul inlier.

Discussion. These rare, fragmentary illaenimorph specimens have been regarded as styginids rather than illaenids (both families *sensu* Lane and Thomas 1983) because, even though very incomplete, the pygidium does not appear to possess a prominent median arch as diagnosed for the latter family. The nature of the material and the lack of a cephalon precludes even a tentative generic or specific assignment, especially considering the number of new illaenimorph genera introduced in recent years (see, for example, Lane and Thomas 1983; Lane and Owens 1982; Lane and Thomas *in* Thomas 1978, Howells 1982).

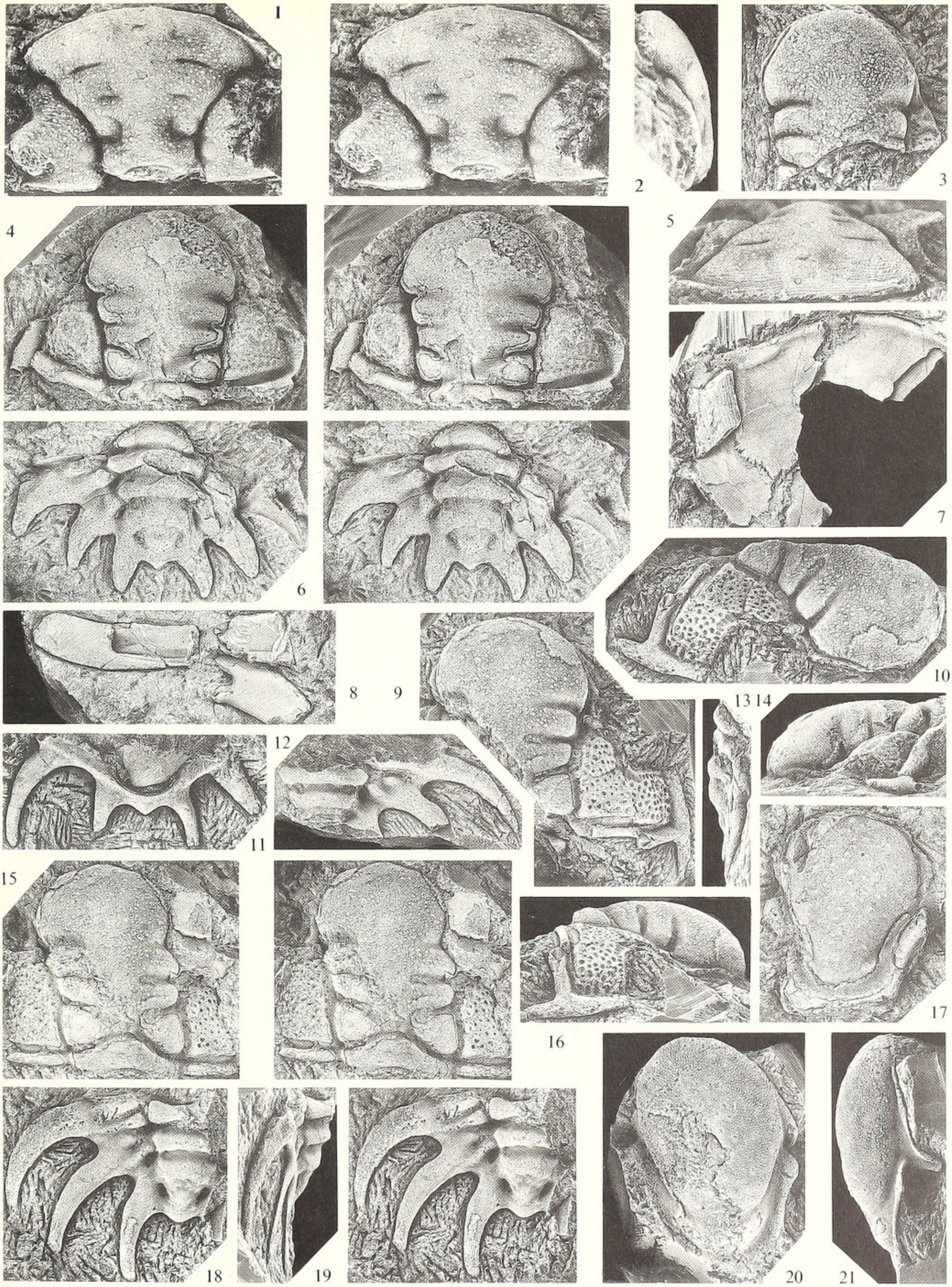
EXPLANATION OF PLATE 15

Figs. 1, 2, 5. *Kosovopeltis* sp. aff. *K. allaarti* Lane, 1984. Cranidium, GSI F00758, Annascaul Formation, locality 36; dorsal stereo-pair, lateral, frontal views, ×5·5.

Figs. 3, 9–12, 15, 16, 18–21. *Cheirurus* sp. nov.? All specimens are from the Annascaul Formation, locality 36. 3, cranidium, internal mould, TCD 12091; dorsal view, ×1. 9, 10, 15, 16, cranidium, largely internal mould, and silicone rubber cast of external mould; dorsal, oblique, lateral views (internal mould), dorsal stereo-pair (cast), ×1. 11, pygidium, TCD 12074; ventral view, ×1·5. 12, pygidium, internal mould, TCD 12073; dorsal view, ×1·5. 18 and 19, pygidium, internal mould, TCD 12078; dorsal stereo-pair, lateral view, ×1·25. 20 and 21, hypostoma, TCD 12631; ventral, lateral views, ×1·25.

Figs. 4, 6, 13, 14, 17. *Cheirurus* sp. All specimens are from the Annascaul Formation, locality 28. 4 and 14, cranidium, internal mould, GSI F00756; dorsal stereo-pair, lateral view, ×2. 6 and 13, pygidium, internal mould, GSI F00753; dorsal stereo-pair, lateral view, ×1·5. 17, hypostoma, largely internal mould, GSI F00754; ventral view, ×1·5.

Figs. 7 and 8. Styginid gen. et sp. indet. Both specimens are from the Annascaul Formation, locality 28. 7, pygidium, GSI F00751; ventral view, ×1. 8, two thoracic segments, GSI F00750, ventral view, ×1·5.



SIVETER, Silurian trilobites

Genus KOSOVOPELTIS Šnajdr, 1958

Type species. Kosovopeltis svobodai Šnajdr, 1958, p. 178; from the Kopanina Formation (Ludlow) of Kosov, near Králův Dvur, Czechoslovakia. By original designation.

Kosovopeltis sp. aff. *K. allaarti* Lane, 1984

Plate 15, figs. 1, 2, 5

? 1863 *Acidaspis Jamesii*; Baily (*pars*) *in* Jukes and Du Noyer, p. 12.
? 1878 *Acidaspis Jamesii*; Baily (*pars*) *in* Kinahan, p. 40.
1976 scutelluid; Siveter *in* Parkin, p. 595, table 1.
1984 scutelluid; Siveter *in* Thomas, Owens, and Rushton, p. 55.

Material. One cranidium.

Occurrence. Annascaul Formation, locality 36 of Parkin 1976, p. 587, fig 4, Annascaul inlier.

Description. Glabella gently convex (sag. and tr.) and 1·3 times as wide (tr.) as long (sag.) across frontal lobe excluding occipital ring which is missing. Medial section of occipital furrow is convex forwards, abaxially occipital furrow is not preserved. Lateral lobe 1p is subrectangular in outline. Lateral furrow 1p narrow (exs.) and clearly impressed at axial furrow, runs inward and becomes wider (exs.) and shallow, not reaching one-third the glabellar width then turning quite sharply forward for a short distance before finally swinging abaxially and dying out on dorsal glabellar surface, though it reappears as a very shallow impression on adaxial side of axial furrow, thus enclosing a moderately sized and inflated lobe. Furrow 2p narrow (exs.) and slit-like, distinct, more or less transversely directed, about as wide (tr.) as posterior section of 1p furrow, isolated on dorsal glabellar surface by a distance from axial furrow equal to its own width (tr.), reaches as far adaxially as 1p furrow. Lobe 2p about as long as 1p and 3p lobes. Furrow 3p distinct and slit-like, adaxially is directed slightly forwards, is slightly deeper than, about twice as wide as, and does not reach as far adaxially as 2p furrow, is connected abaxially to axial furrow by very weak depression. Frontal lobe expanded abaxially, 2·3 times as wide (tr.) as glabella at 1p lobes, moderately strongly convex forward in dorsal outline.

Axial furrow at 1p lobe moderately deep, is directed forward and very slightly inward, at 1p furrow becomes slightly narrower (tr.) and turns sharply outward at an angle of about 40° to the sagittal line, is slightly abaxially convex at 2p lobe before continuing forward and slightly more outward to then widen (tr.) and curve very sharply inward around side of frontal lobe to merge with preglabellar furrow. The latter becomes progressively more finely marked adaxially and fades out at about one-third the width of the frontal lobe inward from axial furrow (Pl. 15, fig. 5). Anterior border short (exs.) abaxially in front of axial furrow, runs inward below frontal lobe as a progressively more slender rim, is obsolete as an anteriorly projecting feature anterior to central glabellar area but its position here is indicated by change in lateral profile of cranidium (Pl. 15, fig. 2). Outer face of anterior border subvertical, deepest medially, decreases gradually in height abaxially. Rounded, smooth lateral muscle impression is independently convex of fixed cheek and sited opposite anterior part of lobe 1p, and is slightly smaller than inflation enclosed within 1p furrow. Anterior part of fixed cheek flat, slopes downward and forward. Eye ridge distinct, runs inward and forward from anterior part of palpebral lobe to meet axial furrow at mid-length of 3p lobe. Palpebral lobe extends (exs.) posteriorly from a point oposite most anterior part of furrow 1p to a point opposite posterior margin of lateral muscle impression. Width of fixed cheek at palpebral lobe very slightly less than that of glabella at 1p lobe. Other cranidial parts not preserved. Free cheek, hypostoma, thorax, and pygidium unknown.

Cranidial surface exclusive of all furrows and lateral muscle impressions has small to medium sized, moderately densely scattered granules together with very fine terrace ridges, the latter becoming slightly more conspicuous and subparallel on anterior part of frontal lobe and subvertical face of anterior border.

Discussion. The distinct, slit-like 2p and 3p lateral glabellar furrows distinguish this Kerry cranidium from all species assigned to *Kosovopeltis* except *K. tchernychevae* Šnajdr, 1960 (pl. 36, fig. 7) from rocks of possible Ludlow age from the Urals, and *K. allaarti* Lane, 1984 (pl. 1, figs. 9–16) of possible Wenlock age from north Greenland. These three species also appear to differ from other congeneric species in having a rather narrower (tr.) anterior part to the fixed cheek in front of the palpebral lobe, a convex forward occipital furrow behind the central glabellar area, and a more clearly outlined frontal lobe abaxially. The Kerry and Urals species are, however, known from only one specimen.

The Irish cranidium differs from *allaarti* in having a combination of dominantly granular and subsidiary terrace ridge, rather than solely terrace ridge, type of sculpture (though small specimens of *allaarti* have a granular sculpture), and a longer palpebral lobe reaching posteriorly to opposite the posterior margin of, not the mid-length of, the lateral muscle impression. It differs from *tchernychevae* in having granular sculpture and a preglabellar furrow present abaxially; the Russian species appears to have only terrace ridges (though much of the glabella is in the form of an internal mould), and as Lane (1984, p. 57) has already noted it seems to lack a preglabellar furrow, even laterally.

Family PROETIDAE Salter, 1864
Subfamily CORNUPROETINAE Richter and Richter, 1956
Genus INTERPROETUS Šnajdr, 1977

Type Species. *Proetus intermedius* Barrande, 1846, p. 63; from the Kopanina Formation (Ludlow) of Dlouhá hora, Prague district, Czechoslovakia. By original designation.

Discussion. Following the comments of Owens (1973, pp. 40 and 83), Thomas (1978, p. 42) generically assigned a group of seven Silurian cornuproetine species to *Cornuproetus* (s.l.). All were previously assigned to *Cornuproetus* (s.s.) but where the thorax was known it was claimed (Owens 1973; Thomas 1978) that they differed from the type of *Cornuproetus*, *Gerastos cornutus* Goldfuss, 1843, in lacking a preannulus. This group, which included *P. intermedius*, together with seven new species or subspecies, were all placed by Šnajdr (1977, 1980) in his new taxon *Interproetus*, a genus he (1980, p. 223) claimed to be ancestral to *Cornuproetus* and which he diagnosed in part as having 'a very narrow, lowered preannulus'. Šnajdr (1980, p. 224) specifically described *P. intermedius* as having a preannulus, though it is not apparent on the complete holotype (Šnajdr 1980, pl. 45, fig. 17) due to the overlapping nature of the thoracic segments. This character is in need of further investigation in *Interproetus*. In addition the preglabellar field and the pygidial doublure in *Interproetus* species do not appear particularly 'narrow', as diagnosed (see Šnajdr 1980, p. 223, pl. 49, figs. 3 and 7; pl. 44, fig. 20), especially as in discussion Šnajdr (1980, p. 223) distinguished the preglabellar field of *Interproetus* from that of *Cornuproetus* by being 'wider', and he described the pygidial doublure of *Interproetus numvertus* Šnajdr, 1980 (p. 229) as 'very wide'. Whether *Interproetus* merits full generic separation from *Cornuproetus* is open to question (cf. Šnajdr 1980, text-figs. 58 and 64A–C).

Interproetus is known almost exclusively from Czechoslovakia. *Cornuproetus peraticus* Owens, 1973 from the early Wenlock of the Welsh Borderland, which was assigned with slight doubt by Šnajdr (1980) to his new genus, must be placed there with certainty now that Thomas (1978, p. 43) has identified the correct pygidium for this species. *Cornuproetus* (*Cornuproetus*?) *walliseri* Alberti, 1967 from the lower Ludlow of Morocco was not discussed by Šnajdr (1977, 1980), after the remarks of Owens (1973, p. 40), but it also fits in *Interproetus*.

Interproetus galvani sp. nov.

Plate 16, figs. 1–15, 17–29; Plate 17, figs. 16–25

1863 *Acidaspis Jamesii*; Baily (*pars*) *in* Jukes and Du Noyer, p. 12.
1878 *Acidaspis Jamesii*; Baily (*pars*) *in* Kinahan, p. 40.
1976 *Decoroproetus* sp.; Siveter *in* Parkin, p. 595, table 1.
1984 *Cornuproetus* sp.; Siveter *in* Thomas, Owens, and Rushton, p. 55.

Derivation of name. After Mr C. Galvan, nineteenth-century fossil collector for the Geological Survey of Ireland and discoverer of the trilobite-rich limestone of shelly fossil locality 36.

Holotype. Cranidium, TCD 12107; Plate 16, figs. 1, 2, 4.

Type horizon and locality. Annascaul Formation, locality 36 of Parkin 1976, p. 587, fig. 4, Annascaul inlier.

Additional material. Eighty-two cranidia, forty free cheeks, ten hypostomata, forty-six pygidia, isolated thoracic segments.

Diagnosis. A species of *Interproetus* with a relatively long preglabellar area, 0·25 to 0·3 times as long as glabella. Anterior border is very gently convex (sag.), slightly longer than preglabellar field; anterior border furrow contains weak ridge centrally. Glabella is low, rises gently from axial and preglabellar furrows, is weakly convex (tr. and sag.); lateral glabellar furrows weak or lacking, crossed by surface sculpture. Pygidium has four (?five) axial rings and three pleural ribs.

Description. Cranidium is about as wide (tr.) as long (sag.). Glabella is generally 0·8 times as wide as long (sag.) including occipital ring, and 0·9 to 1·0 times as wide excluding occipital ring; in one specimen (Pl. 16, fig. 11) these ratios are 1·0 and 1·1. Occipital ring is from 3·2 to 3·7 times as wide (tr.) as long (sag.) in all specimens except one (Pl. 16, fig. 11) where it is 4·5 times as wide, it forms the widest part of the glabella, is longest behind central glabellar area, and narrows (exs.) slightly abaxially; in profile it is almost flat (Pl. 16, fig. 5) to very gently convex (Pl. 16, fig. 2). Two specimens (Pl. 16, figs. 19 and 21) have a very shallow furrow abaxially on occipital ring, running adaxially from axial furrow to define a very weak occipital lobe. A small, slightly anteriorly positioned median occipital granule is present (Pl. 16, figs. 3 and 10). Occipital furrow well defined, moderately deep, its posterior slope is longer and more gently sloping than anterior slope which is short (sag. and exs.) and steep. Shallow, broad occipital impression present on posterior slope of occipital furrow, behind abaxial part of 1p furrow. Preoccipital part of glabella weakly convex (sag. and tr.), rises gently from axial and preglabellar furrows (Pl. 16, figs. 2 and 4). Lateral glabellar furrows weak (Pl. 16, figs. 1, 8, 11) to imperceptible (Pl. 16, fig. 3; Pl. 17, figs. 21 and 24); where present they are crossed by glabellar sculpture. Furrow 1p runs inward and backward from axial furrow opposite a point about midway between α and δ, expands slightly before bending a little more strongly backward to fade out before occipital furrow. A small, rounded auxiliary impression is sited a short distance adaxially from expanded part of furrow 1p. Furrow 2p trends inward and very slightly backward from γ; furrow 3p is short, does not reach axial furrow, is transverse or trends slightly inward and forward, lies opposite a point about one-third of the distance between γ and β.

Axial furrow sharply impressed, runs forward from posterior cranidial margin beside posterior half of occipital ring, then turns sharply inward to meet occipital furrow, anterior to which it is gently abaxially convex inside palpebral lobe, becoming very gently adaxially convex at γ and thereafter running forward and slightly inward into sharply defined preglabellar furrow. Preglabellar area 0·25 to 0·3 times as long as glabella including occipital ring. Preglabellar field slightly shorter than anterior border and gently convex (sag.), becomes gradually longer (exs.) abaxially. Anterior border furrow much broader (exs.) than preglabellar or axial furrows, centrally it contains a very gently raised weakly anteriorly convex ridge. Anterior border very weakly convex (sag.), projects forward and gently upward (Pl. 16, figs. 2 and 5), is about 0·6 times the length

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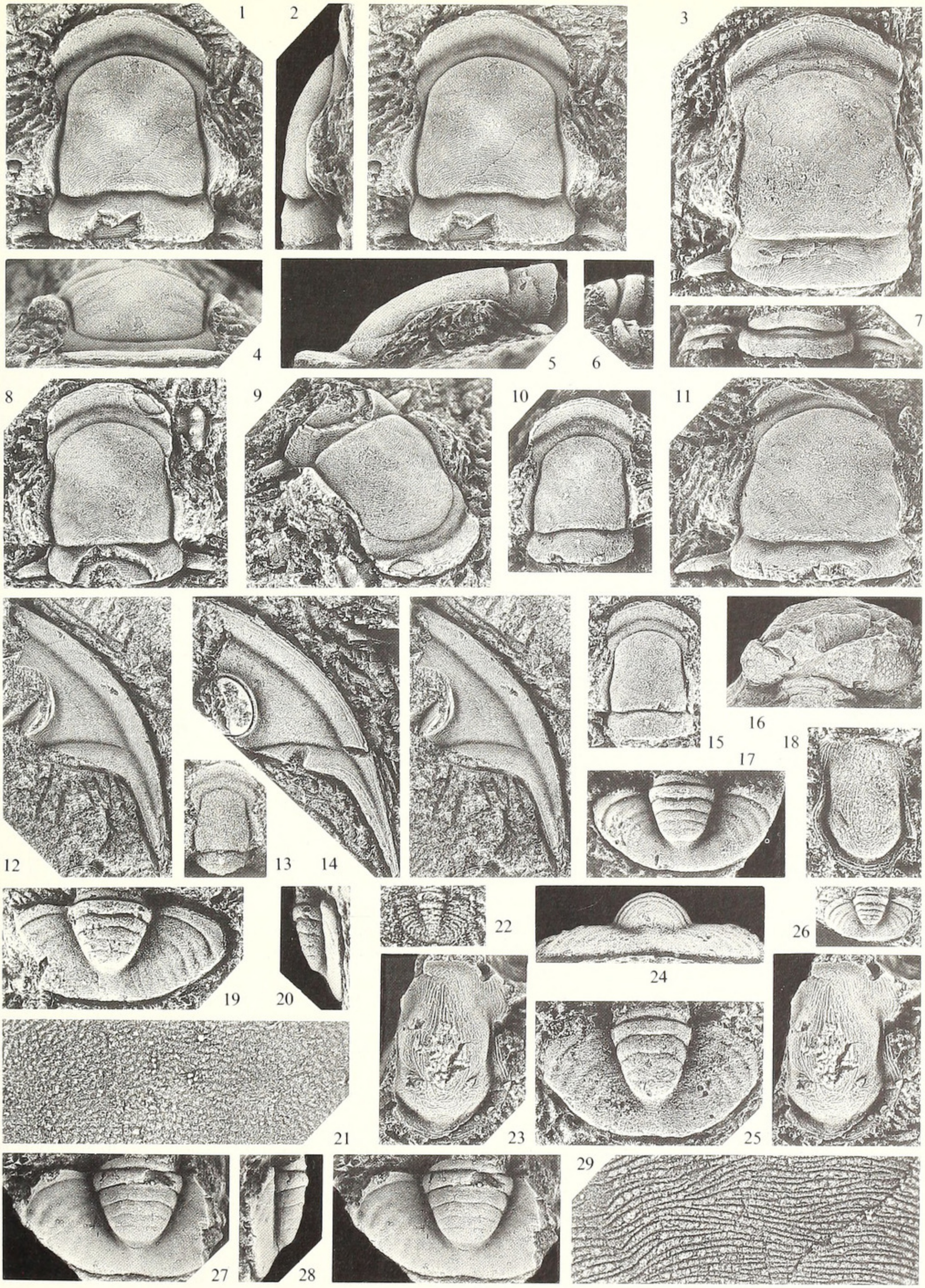
EXPLANATION OF PLATE 16

Figs. 1–15, 17–29. *Interproetus galvani* sp. nov. All specimens are from the Annascaul Formation, locality 36. 1, 2, 4, 29, holotype, cranidium, TCD 12107; dorsal stereo-pair, lateral, frontal views, ×5, sculpture, central, posterior part of glabella, ×22. 3 and 5, cranidium, TCD 12537; dorsal, lateral views, ×5. 6 and 7, thoracic segment, UM K2824; lateral, dorsal views, ×6. 8 and 9, cranidium, TCD 12018; dorsal, oblique views, ×5. 10, cranidium, TCD 12558; dorsal view, ×5. 11, cranidium, TCD 12015; dorsal view, ×5. 12, free cheek, TCD 12014; 'dorsal' stereo-pair, ×4. 13, cranidium, TCD 12611; dorsal view, ×10. 14, free cheek, TCD 12118; 'dorsal' view, ×4. 15, cranidium, TCD 12001; dorsal view, ×5. 17, pygidium, TCD 12564; dorsal view, ×5. 18, hypostoma, TCD 12050*a*; ventral view, ×9. 19 and 20, pygidium, TCD 12132; dorsal, lateral views, ×5. 21, sculpture, central, posterior part of glabella, TCD 12189; dorsal view, ×22; see also Plate 17, figs. 19, 23, 24. 22, meraspis pygidium and one thoracic segment, silicone rubber cast of external mould, TCD 12589*a*; dorsal view, ×10. 23, hypostoma, TCD 12554; ventral stereo-pair, ×7. 24 and 25, pygidium, TCD 11981; posterior, dorsal views, ×5. 26, pygidium, TCD 12113; dorsal stereo-pair, lateral view, ×5. 27 and 28, pygidium, TCD 12113, dorsal stereo-pair, lateral view, ×5.

Fig. 16. *Trochurus*? sp. indet. Cranidium, internal mould, GSI F00749, Annascaul Formation, locality 28; dorsal view, ×2.



SIVETER, Silurian trilobites

of the preglabellar area. Anterior cranidial margin evenly curved forward (Pl. 16, fig. 8; Pl. 17, fig. 21) or slightly angular medially (Pl. 16, fig. 10; Pl. 17, fig. 24).

Postocular part of fixed cheek is about as wide (tr.) as occipital ring is long (sag.). Palpebral lobe moderately narrow (tr.), extends anteriorly from occipital furrow to a point slightly in front of glabellar mid-length excluding occipital ring, slopes adaxially initially gently and then very steeply into axial furrow. Between α and γ anterior branch of facial suture is slightly less abaxially convex than its moderately convex outline between γ and ϵ around palpebral lobe; posterior branch between ϵ and ζ runs parallel to outward and backwardly directed section of axial furrow around anterior part of occipital ring, at ζ it swings sharply outward to genal angle. At γ and between ϵ and ζ fixed cheek is exceedingly narrow.

Lateral margin of free cheek (Pl. 16, figs. 12 and 14; Pl. 17, fig. 17) broadly and evenly convex abaxially; lateral border moderately convex (tr.) anteriorly, becoming gradually less so posteriorly, at junction of lateral and posterior border furrows it is only very slightly less wide than at anterior branch of facial suture, posteriorly from this junction it narrows more sharply along genal spine. Lateral border furrow is distinct, continuous, and moderately deep and broad (tr.). Posterior border more gently convex (exs.) than lateral border. Posterior border furrow slightly narrower (exs.) and more sharply defined than lateral border furrow. Main field of free cheek gently to moderately inflated (tr. and exs.), slopes gently into lateral border furrow, descends more steeply and suddenly into posterior border furrow. Eye socle very narrow, separated from posterior border furrow by a moderately narrow adaxial extension of main field; visual surface bears numerous small facets.

Rostral plate unknown. Hypostoma (Pl. 16, figs. 18 and 23) subrectangular in outline with a strongly convex (sag. and tr.) middle body. Anterior border is a narrow, sharply upturned rim; lateral border moderately convex (tr.); posterior and posterolateral border behind lateral shoulder flattened. Maculae weakly indicated; median furrow is absent between maculae, and very weak running forwards abaxially to merge with lateral border furrow. Anterior wings moderately large. A pair of very small spines present on posterior margin.

Isolated thoracic segments (Pl. 16, figs. 6 and 7) have a low preannulus about half as long (sag.) as articulating half-ring. Articulating furrow sharply defined, intra-annular furrow much less so and longer (sag. and exs.). Articulating half-ring and axial ring extremely weakly convex and of about equal length (sag.). Axial and pleural furrows distinctly impressed, the latter with steeper anterior than posterior slope. Anterior pleural band convex (exs.), higher than forward and gently downward sloping posterior band.

Pygidium is from 1·8 (Pl. 16, fig. 25) to 2·25 (Pl. 16, fig. 19) times as wide as long. Posterior outline varies from being evenly convex backwards (Pl. 16, fig. 17) to being medially more transverse (Pl. 16, fig. 25) or slightly forwardly convex (Pl. 16, fig. 27). Axis is strongly convex (tr.), 0·9 to 1·1 times as wide as long, about 0·7 times as long as pygidial length and 0·33 to 0·4 times as long as pygidial width, bears four distinct rings (Pl. 16, fig. 27), sometimes the suggestion of a fifth (Pl. 17, fig. 18), and a terminal piece. First axial ring gently to moderately convex (Pl. 16, figs. 20 and 28; Pl. 17, fig. 16), more posterior ones more or less flat. Medially, posterior margins of first two or three axial rings are projected slightly backwards. Ring furrows sharply defined, become successively weaker and fail to reach axial furrows posteriorly. Axial furrow distinct but shallow, essentially marked by sharp break in slope between flat inner part of pleural area and sharply rising side of axis, fades posteriorly around terminal piece due to short postaxial ridge (Pl. 17, fig. 18). Pleural region comprises an inner and an outer part which are marked off by the inner margin of the doublure reflected on the dorsal surface of the cuticle, this margin running forward and outward from immediately behind the axis (Pl. 16, fig. 17; Pl. 17, fig. 18). Outer part of pleural region descends very gently towards pygidial margin. There are three pleural ribs. First pleural furrow is sharply defined, curves outward and backward, more strongly backward at inner edge of doublure; successively posterior pleural furrows are much less distinct. Interpleural furrows are more weakly marked than pleural furrows and are most distinct abaxially above doublure. Rib profile is of the imbricate type.

Dominant sculpture on most specimens is striae (Pl. 16, figs. 1–5, 17, 19, 20, 24–29), which on cranidium and free cheek comprises fine, moderately continuous ridges. On glabella the ridges are convex forward, on anterior border they are subparallel with anterior margin, on preglabellar field they are directed inward and slightly forward. On posterior part of glabella (Pl. 16, fig. 29) some ridges are broken up into small, scale-like granules. On palpebral lobe ridges run forward and slightly abaxially, on blade-like postocular part of fixed cheek they are transverse. Ridges on lateral border of free cheek run approximately exsagittally into border furrow where they turn sharply to join those directed into this furrow from main field; ridges on posterior border directed transversely. Anterior part of anterior border, outer part of lateral border, and adaxial side of genal spine have two or three terrace lines which are also present on doublure of occipital ring (Pl. 16, figs. 1 and 8). Hypostoma has terrace lines on anterior and posterior lobes of middle body, anterior wing, lateral and posterior borders. On anterior lobe they diverge posteriorly, converging again between maculae; on posterior lobe they anastomose; they run on and parallel with lateral and posterior borders. Axial ring and preannulus have forwardly convex fine ridges, pleurae with transverse ridges; articulating half-ring lacks ridges. Pygidium covered with ridges which appear finer than those on cranidium or free cheek.

Some less common cranidia, free cheeks, and pygidia (Pl. 16, fig. 21; Pl. 17, figs. 16–25) have a sculpture which is dominantly more granular than linear in appearance, though on glabellar side including occipital ring and on main field of free cheek fine, short ridges are formed by merger of granules.

Discussion. The Kerry taxon conforms on the whole to Šnajdr's diagnosis of *Interproetus*, but with the following differences: the cranidial anterior border is only gently convex sagittally, there are no anterior pits or suggestions thereof in the preglabellar furrow, and the preglabellar field and pygidial doublure are not particularly narrow (Pl. 16, figs. 1, 2, 27). At least the last two of these distinctions also apply to some of the species originally referred to *Interproetus* (see generic discussion), and the first two alone seem to carry little generic significance. I have interpreted the sculptural variation as intraspecific in nature in the Irish *Interproetus* specimens (see description): in these there is a common form with a linear sculpture (Pl. 16, figs. 1–15, 17, 19, 20, 24–29) and a rarer morphotype with a more granular sculpture (Pl. 16, fig. 21; Pl. 17, figs. 16–25); the uncommon form also has an additional difference—a weak furrow abaxially on the occipital ring (Pl. 17, figs. 19–21). Silurian proetid specimens from elswhere showing similar sculptural differences have been accommodated within a single species by other authors: see, for example, *Interproetus soncobrinus* Šnajdr, 1980 (pl. 49, figs. 2 and 3), *I. walliseri* (Alberti 1969, pl. 1, fig. 9; 1981, pl. 2, fig. 16), or *Decoroproetus anaglyptus* Holloway, 1980 (p. 21). Also, unusually wide specimens in the Kerry population (Pl. 16, figs. 11 and 19) are regarded as conspecific.

Some of the many *Interproetus* species described by Šnajdr (1980) have been distinguished on the basis of very fine morphological details, and they come from similar or the same horizons and localities; recognition of all of them as independent species seems questionable. This aside, of the species he recognized *I. galvani* appears closest to the Bohemian *I. vertumnus* (Prantl and Vaněk, 1958) from the Liteň Formation, *M. flexilis* Biozone (mid-Wenlock), to *I. numvertus* Šnajdr, 1980 from the boundary beds of the Liteň and Kopanina formations (late Wenlock to early Ludlow), and to *I. venustus* (Barrande, 1846) from the Kopanina Formation, *Ananaspis fecunda* horizon (mid to late Ludlow). *I. vertumnus* (a cast of the holotype of which I have examined) has a more raised glabella and a shorter preglabellar area (from 0·2 to 0·25 times its glabellar length; Šnajdr 1980, pl. 47, figs. 14 and 15); *I. numvertus* and *I. venustus* differ in having a shorter preglabellar area, of the same ratio to their glabellae as that in *vertumnus* (Šnajdr 1980, pl. 47, figs. 18–20; pl. 48, fig. 8), and *venustus* also has wider palpebral lobes (Šnajdr 1980, text-fig. 64c).

Morphologically the closest species to *I. galvani* appears to be *I. walliseri* (casts of the type specimens of which I have examined); in particular both have a rather long preglabellar area. The Irish and Moroccan material have been considered different because in *walliseri* the glabella stands more proudly, rising more abruptly from the axial furrow, and the glabellar furrows are better marked, especially 1p furrow across which the sculpture is effaced. In the geographically close *I. peraticus* the preglabellar area is shorter (0·2 times its glabellar length), the preglabellar field relatively shorter and anterior border relatively longer and more convex sagittally, the glabellar furrows seem better developed and lack sculpture, and there is apparently no ridge-like feature in the anterior border furrow (cf. Pl. 16, figs. 1, 2, 4 with Thomas 1978, pl. 11, fig. 7*a–c*).

Occurrence. Known only from the type horizon and locality.

Family AULACOPLEURIDAE Angelin, 1854

Discussion. Thomas and Owens (1978) reviewed this family which they regarded as comprising the Scharyiinae Osmólska, 1957 in addition to the nominate subfamily and, following Bergström (1973) and Fortey and Owens (1975), they considered the Otarionidae Richter and Richter, 1926 to be a junior synonym. Owen and Bruton (1980), Holloway (1980), and Chatterton and Wright (1986) subsequently agreed with this synonymy but Přibyl and Vaněk (1981) have used the junior name Otarionidae to encompass the Aulacopleurinae Angelin, 1854, the Cyphaspidinae Přibyl, 1947, the Brachymetopinae Prantl and Přibyl, 1950, and the nominate subfamily. Přibyl and Vaněk (1981) did not comment on the earlier work of Thomas and Owens (1978). The phylogeny of the Aulacopleuridae (= Otarionidae) and recognition of its constituent genera and subgenera are also considerably different as portrayed by Thomas and Owens (1978, text-fig. 1) and Přibyl and Vaněk (1981, text-fig. 1). An assessment of such discrepancies lies outside the scope of the present paper, in which I have preferred to adopt in general the outline higher classification of the former authors.

Subfamily AULACOPLEURINAE Angelin, 1854
Genus CONOPARIA Hawle and Corda, 1847

Type species. Conoparia convexa Hawle and Corda, 1847, p. 83; from the Devonian (Pragian) of Czechoslovakia. By subsequent designation of Přibyl and Vaněk 1981, pp. 173–174.

Discussion. The 1978 work of Thomas and Owens attempted, as far as was possible, to revise aulacopleurine genera and subgenera; of these, *Otarion* (*Otarion*) Zenker, 1833 and their *Cyphaspis* s.l. best potentially embrace the new aulacopleurine species described below.

Přibyl and Vaněk (1981), as similarly advocated by Thomas and Owens (1978), restricted the formerly widely conceived Siluro-Devonian *Otarion* (*Otarion*) to species corresponding closely to *O.* (*O.*) *diffractum* Zenker, 1833, the type species. They regarded *Cyphaspis* Burmeister, 1843 as a subgenus of *Otarion*, and resurrected *Conoparia* Hawle and Corda, 1847 as a subgenus of *Otarion* for numerous Ordovician to Devonian species previously placed mainly in *Otarion* or *Cyphaspis*.

Thomas and Owens (1978, p. 11) considered that there is a group of Ordovician to Devonian species related to *Cyphaspis* which possibly comprises several undifferentiated genera or subgenera. It was such species that they referred to *Cyphaspis* s.l. until they became better known. It now seems that *Conoparia* is the available name for at least some of these species. Přibyl and Vaněk (1981, pp. 174–175) included in *Conoparia: O.* (*Otarion*) *horani* Chatterton, 1971, *O.* (*Otarion*) n. sp. of Chatterton 1971, and *Otarion tridens* Ingham, 1970. The first two of these species were placed in *Cyphaspis* s.l. by either Thomas and Owens (1978, pp. 71, 76–78) or Thomas (1978, p. 31; the new species left unnamed by Chatterton being established therein as *C.* (s.l.) *elachopos*), and *tridens* was implied by them to fall within this group or to be a precursor of it.

Conoparia hollandi sp. nov.

Plate 17, figs. 1–15

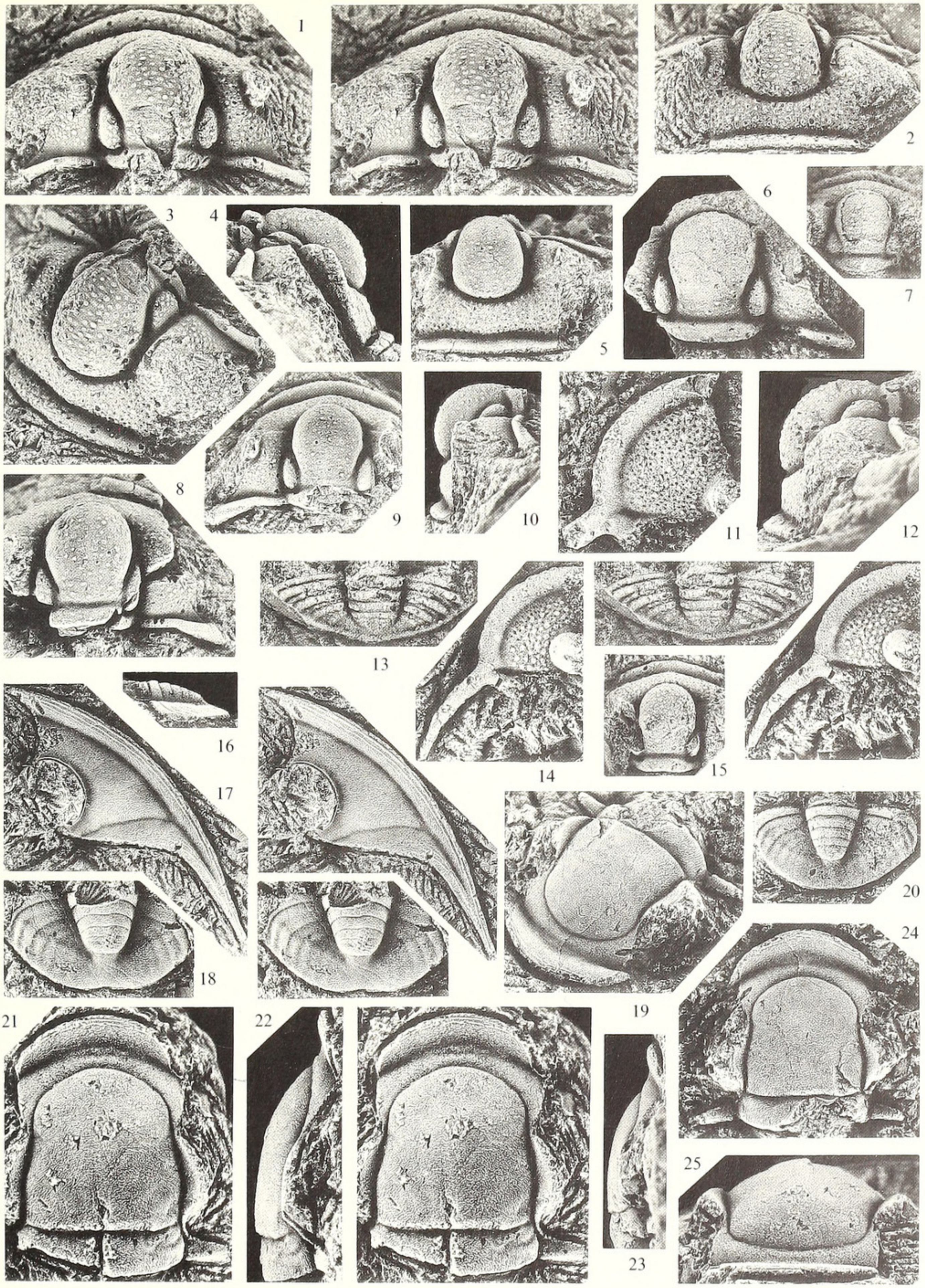
1976 *Otarion* sp.; Siveter *in* Parkin, p. 595, table 1 (*pars*).
1984 *Cyphaspis* (s.l.) sp.; Siveter *in* Thomas, Owens, and Rushton, p. 55.

Derivation of name. For Professor C. H. Holland, student of the Silurian geology of Ireland.

EXPLANATION OF PLATE 17

Figs. 1–15. *Conoparia hollandi* sp. nov. All specimens are from the Annascaul Formation, locality 36. 1–3, 12, holotype, cranidium, TCD 12587; dorsal stereo-pair, oblique, lateral views, ×5, frontal view, ×4. 4 and 8, cranidium, TCD 12529; lateral, dorsal views, ×5. 5, 9, 10, cranidium, TCD 12586; frontal, dorsal, lateral views, ×5. 6, cranidium, TCD 12526; dorsal view, ×5. 7, cranidium, TCD 12527; dorsal view, ×10. 11, free cheek, TCD 12531; 'dorsal' view, ×7. 13, pygidium, UM K2816; dorsal stereo-pair, ×7. 14, free cheek, TCD 12627; 'dorsal' stereo-pair, ×7. 15, cranidium, TCD 12528; dorsal view, ×5.

Figs. 16–25. *Interproetus galvani* sp. nov. All specimens are from the Annascaul Formation, locality 36. 16 and 20, pygidium, TCD 12191; lateral view, dorsal stereo-pair, ×5. 17, free cheek, TCD 12141; 'dorsal' stereo-pair, ×4. 18, pygidium, TCD 11980; dorsal stereo-pair, ×5. 19, 23, 24, cranidium, TCD 12189; oblique, lateral, dorsal views, ×5; see also Plate 16, fig. 21. 21, 22, 25, cranidium TCD 12117; dorsal stereo-pair, lateral, frontal views, ×5.



SIVETER, Silurian trilobites

Holotype. Cranidium, TCD 12587; Pl. 17, figs. 1–3, 12.

Type horizon and locality. Annascaul Formation, locality 36 of Parkin 1976, p. 587, fig. 4, Annascaul inlier.

Additional material. Six cranidia, three free cheeks, one pygidium.

Diagnosis. A *Conoparia* species with a relatively large basal glabellar lobe which is about one-third as long as the strongly convex (sag. and tr.) glabella; mid-length of palpebral lobe opposite mid-length of 2p lobe; preglabellar field very steeply to vertically sloping, very short (sag.) in dorsal view, moderately high in frontal view. Pygidium has five or ?six axial rings, four or five pleural ribs and a well-defined border furrow. Sculpture of small to medium-sized granules and small pits on main field of free cheek and preglabellar field.

Description. Cranidium is about 1·9 times as wide as long. Glabella is about 0·9 times as wide as long and 0·4 times as wide as cranidium; it is strongly convex (sag. and tr.) and subparabolic in outline. Occipital ring bears an extremely weak median tubercle in some specimens (Pl. 17, fig. 7), is of more or less constant width (sag. and exs.) behind central glabellar area; in small specimens (Pl. 17, figs. 7 and 15) it is wider (sag.) than anterior border, in larger specimens (Pl. 17, figs. 1 and 8) they are more subequal in width. Behind basal glabellar lobe occipital ring narrows (exs.) slightly and turns forward a little. Occipital furrow well defined and moderately deep behind central glabellar area, deeper abaxially behind basal glabellar lobe. The latter is well inflated, about one-third as long as glabella, tear-shaped. Furrow 1p is moderately deep at axial furrow, trends acutely backward and inward becoming shallower, is still distinctly impressed across neck of lobe 1p to occipital furrow, 'Lobe' 2p indicated by the slightest abaxial convexity of glabellar outline in dorsal view (Pl. 17, figs. 1, 6–9) and an exceedingly weak furrow 2p which is confined to the lower side of glabella (Pl. 17, fig. 3). Frontal glabellar lobe is well rounded in dorsal outline, strongly convex (tr. and sag.). In lateral profile dorsal surface of glabella runs forwards for a short distance from occipital furrow before descending in a strongly, evenly convex arc to preglabellar furrow which it slightly overhangs (Pl. 17, figs. 4, 10, 12).

Axial furrow wide (tr.) beside occiptal ring, slightly narrower (tr.) and deeper around lobe 1p, is deepest in front of lobe 1p. Sagittally, preglabellar furrow is about as wide as occipital furrow, but is deeper here, being sharply incised and undercutting the frontal glabellar lobe. Preglabellar area is just less than 0·25 times as long as glabella in dorsal view (Pl. 17, fig. 1). Preglabellar field is very short in dorsal view, about one-fifteenth to one-twentieth as long as glabella and always shorter than the length of the occipital ring; in frontal view (Pl. 17, figs. 2 and 5) it is moderately high and in lateral profile slopes very steeply (Pl. 17, fig. 4) to almost vertically (Pl. 17, figs. 10 and 12) to anterior border furrow. Abaxially the preglabellar field merges imperceptibly into anterior part of fixed cheek (Pl. 17, fig. 3). Anterior border furrow is clearly defined. In dorsal view anterior border is shorter (sag.) than preglabellar field in small specimens (Pl. 17, figs. 7 and 15) and longer than preglabellar field in largest specimens (Pl. 17, figs. 1 and 8), is flat to slightly convex in profile and projects forward and very slightly downward from preglabellar field. Anterior margin broadly convex (Pl. 17, fig. 9) to weakly angular (Pl. 17, fig. 15) in dorsal outline.

Posterior border of fixed cheek narrow (exs.) and moderately convex at axial furrow, widens gradually and becomes more strongly convex (exs.) abaxially to facial suture. Posterior border furrow broad (exs.) and moderately deep, rises less steeply anteriorly than posteriorly. Posterior part of fixed cheek gently convex (exs.), anterior part descends very steeply forwards into preglabellar field. Adaxially from palpebral lobe, fixed cheek is moderately convex and falls steeply into axial furrow. Palpebral lobe rises steeply from fixed cheek, its mid-length lies oposite mid-length of 2p 'lobe', its posterior margin is opposite anterior abaxial end of furrow 1p, and anterior margin opposite furrow 2p. Weak, narrow eye ridge present on some specimens (Pl. 17, figs. 5 and 9). Shallow but distinct palpebral furrow present. Posterior branch of facial suture descends from palpebral lobe to run very slightly sinuously outward and strongly backward to meet posterior margin at an acute angle; anterior branch trends forward and very gently outward to anterior margin.

Rostral plate, hypostoma and thorax unknown. Visual surface of eye is semiglobular and high (Pl. 17, fig. 14). Main field of free cheek is gently convex, descends into shallow lateral border furrow which is wider and most distinct anteriorly, weakest posteriorly. A short (tr.) section of the posterior border furrow runs into base of genal spine on free cheek. Lateral border rises quite sharply from border furrow, is tightly convex (tr.). Lateral margin of free cheek moderately (Pl. 17, fig. 14) to strongly (Pl. 17, fig. 11) abaxially convex. Genal spine deflected sharply outwards from curve of lateral margin, is slender, gently arched, and about as long as main field of cheek, subcircular in section.

Pygidium (Pl. 17, fig. 13) is bow-shaped in outline, about 3·0 times as wide as long. Axis is 0·3 times as wide as pygidium, it is moderately convex (tr.), has five or possibly six axial rings (preservation imperfect in this region on the one known pygidium) and a tiny terminal piece. Ring furrows become weaker posteriorly, are complete across axis. Axial furrow most distinctly impressed and widest anteriorly, becomes narrower and shallower posteriorly, scarcely continues behind terminal piece. Pleural region is 1·2 times as wide as axis and has at least four pairs of ribs, anterior pleural band of each rib is narrower (exs.) than posterior band, both pleural and interpleural furrows reach clearly marked border furrow inside narrow border.

Cranidium has medium to large sized, moderately closely (Pl. 17, fig. 1) to sparsely (Pl. 17, fig. 6) distributed granules; posterior and anterior borders have fewer granules than other parts of the cranidium; granules lacking in all furrows. Preglabellar field also covered with small pits which are slightly smaller and more densely distributed than adjacent granules. Main field of free cheek has similar distribution and size of pits and granules as preglabellar field. Very rare, small granules on lateral border and genal spine. Pygidium has small granules along anterior and posterior pleural bands and axial rings.

Discussion. The generic assignment of this new species is somewhat equivocal as ideas on the phylogeny, classification, and definition of aulacopleurid genera are in a state of flux. Species of the Devonian *Cyphaspis* as defined by Thomas and Owens (1978, pp. 67, 70–71), whilst being not far removed from the Kerry form, can be generically separated by their even more strongly swollen glabella which markedly overhangs the preglabellar field and their wider pygidial axis which is anteriorly as wide as the pleural region.

On the available morphology the new species (thorax unknown) shows quite a strong similarity to species of *Otarion* (*Otarion*) as restricted by Thomas and Owens (1978, pp. 66–68). However, in *Otarion* (*Otarion*) the inner edge of the articulating facet is diagnosed as being about two-thirds of the pleural width abaxially from the axial furrow, but in the Irish taxon, based on the position of the fulcrum on the posterior cephalic margin, it is only two-fifths abaxially from the axial furrow (Pl. 17, figs. 1, 8, 9). Although the pygidium of the new species is generally similar to that of *O.* (*O.*) *diffractum* (very wide and short, with a moderately large number of axial rings—five or six and five to eight respectively—and a clearly marked narrow border and border furrow), in the latter the pygidial pleural region anteriorly is about 1·5 times the width of the anterior part of the pygidial axis, whereas in the former it is about 1·2 times as wide. In this respect the new species stands approximately midway between *Otarion* (*Otarion*) and *Cyphaspis* (cf. Pl. 17, fig. 13 with Thomas and Owens 1978, pl. 7, figs. 3 and 4*b*). Certain cephalic features of the Kerry species are also different from those of *O.* (*O.*) *diffractum* and from this subgenus as diagnosed by Přibyl and Vaněk (1981), which typically has a more slender glabella particularly in front of the basal lobes, and a longer, deeper preglabellar field with numerous distinct genal cacae. Acceptance of the phylogeny proposed by Thomas and Owens (1978, text-fig. 1), together with a Wenlock or earliest Ludlow age for the Irish species, makes it seem even more unlikely that it belongs in *Otarion* (*Otarion*). It would be the earliest member of the subgenus, and this would not fit in well with their postulated derivation of *Otarion* (*Otarion*) from *Otarion* (*Aulacopleura*), as especially in its glabella and preglabellar field the Irish species is not very close to *O.* (*Aulacopleura*) and it is unlikely to stand phylogenetically between the latter (Ordovician to Devonian) and undoubted species of the nominate subfamily (all being no older than mid-Ludlow in age), such as *O.* (*O.*) *diffractum* (cf. Pl. 17, fig. 1 with Thomas and Owens 1978, pl. 7, figs. 2*a* and 9).

Cyphaspis s.l. was not characterized by Thomas and Owens (1978), nor by Thomas (1978), other than to say that it embraced species which differed in 'various details' from *Cyphaspis* s.s. However, the morphology represented in this informal grouping can be gauged from that of *C.* (s.l.) *elachopos* Thomas, 1978 (pl. 7, figs. 5, 8–13) from the Wenlock of the Welsh Borderland. I am unable generically to divide the Kerry species from *elachopos* which now appears best placed in *Conoparia*, as assigned by Přibyl and Vaněk (1981). In slight variance to the diagnosis of *Conoparia* of the latter authors, the pygidium of *hollandi* and of *elachopos* is not narrower than that of *Otarion* (*Otarion*), and at least in *hollandi* there is a well-defined (not slight) pygidial border furrow. Whether *Conoparia* becomes re-established as a useful genus or subgenus depends on future revision of many of the species placed therein by Přibyl and Vaněk (1981).

The most obvious specific differences of *Conoparia elachopos* from *C. hollandi* include it having fewer pygidial axial rings (two to three) and pleural ribs (two). *Otarion brauni* Perry and Chatterton, 1979 from the Wenlock of north-west Canada is similar to the Irish species in gross morphology and in particular both have a combination of pits and granular sculpture on the field of the free cheek. The Canadian species differs because it has a straighter genal spine, only three to four pygidial axial rings, three pairs of pygidial pleural ribs, and a much weaker pygidial border furrow. Of the several aulacopleurid species described in recent years from the Siluro-Devonian of Australia, the poorly known *Otarion bowningensis* (Etheridge and Mitchell, 1893) from the Devonian and possibly Ludlow of New South Wales, redescribed by Chatterton (1971, p. 9, pl. 24, figs. 8–10), seems nearest to the Kerry species, but it has four pygidial axial rings, a more weakly defined pygidial border furrow and a gently abaxially convex lateral margin to the free cheek from which the genal spine is apparently only weakly deflexed laterally. *Otarion* (*Conoparia*) *inculpatum* Přibyl and Vaněk, 1981 (p. 195, pl. 8, figs. 7–8, pl. 9, fig. 5) from the Wenlock of Bohemia may be close to *C. hollandi*, but detailed comparison is precluded on account of the poor steinkern preservation of the three specimens belonging to the type suite, and Šnajdr (1984*e*, p. 287) has subsequently questioned the validity and type horizon of this species, though this claim has been repudiated by Přibyl, Vaněk and Hörbinger (1985, p. 242). The complete steinkern figured by Šnajdr (1984*e*, pl. 2, fig. 8) as *C.* cf. *inculpatum* (Přibyl and Vaněk), which was assigned with certainty to this species by Přibyl, Vaněk and Horbinger (1985, p. 243), appears to differ from the Irish species by its relatively longer preglabellar field.

Subfamily SCHARYIINAE Osmólska, 1957
Genus SCHARYIA Přibyl, 1946

Type species. Proetus micropygus Hawle and Corda, 1847, p. 78; from the Kopanina Formation (Ludlow), Czechoslovakia. By original designation.

Scharyia sp.

Plate 22, figs. 14, 17, 19

1976 *Scharyia* sp.; Siveter *in* Parkin, p. 595, table 1.
1984 *Scharyia* sp.; Siveter *in* Thomas, Owens, and Rushton, p. 55.

Material. Two cranidia.

Occurrence. Annascaul Formation, locality 36 of Parkin 1976, p. 587, fig. 4, Annascaul inlier.

Description. Glabella subparabolic in outline, about 0·9 times as wide as long (sag.) including occipital ring. Occipital ring has slight median swelling, which may represent an occipital tubercle (preservation imperfect), sited closer to posterior margin than to occipital furrow. No trace of lateral glabellar furrows or lobes. Glabella gently convex (sag.), in profile descends evenly anteriorly from occipital to preglabellar furrow (Pl. 22, fig. 17).

Axial furrow shallow and widest beside occipital ring, narrows and becomes deeper at posterior one-third of glabella exclusive of occipital ring, anteriorly it shallows before running into the preglabellar furrow where it deepens a little. Preglabellar area is about 0·45 times as long as glabella and 0·3 times as long as cranidium; preglabellar field very gently convex (sag.), one-third as long as glabella. Anterior border is about 0·25 times as long (sag.) as preglabellar area, rises quite steeply from border furrow which is moderately deep and wider (sag. and exs.) than axial, preglabellar, or occipital furrows. Anterior cranidial margin is broadly convex forwards. Anterior branch of facial suture diverges forward and outward to abaxial part of preglabellar furrow at an angle of about 30° to the sagittal line, course thereafter uncertain.

Discussion. This *Scharyia* material does not fit that of any described species and the features displayed by the best preserved cranidium (Pl. 22, figs. 17 and 19) suggest that a new species could be established if this morphology were found to be constant in any future collections. The combination of a relatively short preglabellar field, rather weakly diverging anterior branches of the facial suture, and a relatively short anterior border (sag.) is distinctive. Both *S. micropya*

(Hawle and Corda, 1847) *wenlockiana* Přibyl, 1967 from the late Wenlock of Bohemia (see Owens 1974, pl. 98, fig. 13; Šnajdr 1980, pl. 30, figs. 6–10) and *S. siceripotrix* Owens, 1974 (pl. 98, figs. 1–9, text-figs. 1A, C and 3) from the lowest Ludlow of Shropshire are not too dissimilar from the Kerry species, but are immediately distinguished by having a shorter preglabellar field and more widely anteriorly diverging facial sutures. The *Scharyia*? sp. of Lane (1972, p. 352, pl. 61, fig. 12) from the Wenlock (?Llandovery; see Perry and Chatterton 1979, p. 570) of Greenland also has a moderately short preglabellar field and, if anything, even less diverging facial sutures anteriorly than the Irish form, but here the preglabellar area is transversely narrower, it has a very large occipital tubercle, a longer, sagittally convex anterior border with terrace lines, and a coarser granular sculpture.

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

Type species. *Cheirurus insignis* Beyrich, 1845, p. 12; from the Liteň Formation (Wenlock) of Czechoslovakia. By subsequent designation of Barton 1916, p. 129.

Cheirurus sp. nov.?

Plate 15, figs. 3, 9–12, 15, 16, 18–21

1976 *Cheirurus* sp.; Siveter *in* Parkin, p. 595, table 1 (*pars*).
1984 *Cheirurus* sp.; Siveter *in* Thomas, Owens, and Rushton, p. 55.

Material. Five cranidia, four hypostomata, six pygidia.

Occurrence. Annascaul Formation, locality 36 of Parkin 1976, p. 587, fig. 4, Annascaul inlier.

Description. Cranidium (Pl. 15, fig. 9) estimated at 1·6 times as wide as long (sag.). Glabella (Pl. 15, figs. 9 and 15) about 0·7 times as wide at frontal lobe as long (sag.), and 1·1 to 1·2 times as wide at frontal lobe than at basal lobes, appearing to widen (tr.) only weakly anteriorly. Occipital ring (Pl. 15, fig. 15) longest (sag.) medially where it is convex and slopes quite strongly downwards into occipital furrow; laterally it has a flatter dorsal surface and narrows (exs.) sharply to axial furrow where it is about half its sagittal length. Occipital furrow strongly convex forwards behind central glabellar area where it is moderately deep, becomes deeper trending backwards abaxially. Lobe 1p subtriangular, slightly greater than one-third the glabellar width at this point. Furrow 1p is moderately deep, curves gently posteriorly from axial furrow to meet occipital furrow in medially depressed area which is narrower (tr.) than basal lobe. Lobe 2p transversely elongate, longer (exs.) adaxially than at axial furrow. Furrow 2p more or less transverse or is very gently convex forwards, is deepest at axial furrow, reaches about one-third across glabella. Lobe 3p subrectangular; furrow 3p very gently curved forwards, directed transversely overall, deepest at axial furrow where it meets anterior pit, adaxially falls just short of inner point of furrow 2p. Frontal lobe about 0·4 times as long as glabella including occipital ring, with strongly rounded outline (Pl. 15, fig. 9) or with anterolateral margins obliquely flattened (Pl. 15, fig. 3), falls anteriorly in a steeply convex arch (Pl. 15, fig. 16), is strongly convex transversely. Axial furrow narrow and moderately deep at 1p lobe anterior to which it becomes slightly wider and shallower except at very deep anterior pit. Anterolaterally, preglabellar furrow is shallow but distinct and merges with axial furrow; adaxially it becomes gradually narrower and more weakly impressed, not reaching sagittal line. Anterior border is a narrow, tightly convex rim below anterolateral part of glabella, becomes gradually finer and much less prominent adaxially.

Posterior border of fixed cheek (Pl. 15, figs. 9, 10, 16) narrow (exs.) and tightly convex (exs.) adaxially, widens slightly abaxially; border furrow narrow and rille-like, narrowest at genal angle, moderately deep. Lateral border of fixed cheek tightly convex (tr.), widens (tr.) slightly posteriorly and is produced into a short genal spine which on available material appears slightly incomplete but is about as long (exs.) as lobe 1p or one-fifth to one-sixth as long as glabella, and is directed more or less exsagittally. Outer, Posterior part of fixed cheek descends steeply to shallow lateral border furrow; preocular part of fixed cheek is small and narrow (tr.), bears a palpebral ridge which trends inward and slightly forward and at axial furrow protrudes towards anterior pit as a short, sharply rounded projection. Palpebral lobe sited slightly less than half-way across fixed cheek, posterior margin lies about opposite mid-length of lobe 2p, length and form unknown; traces of palpebral furrow preserved. Posterior branch of facial suture runs outward and very slightly forward abaxially before turning sharply backward for a short distance on lateral border to meet lateral margin opposite about anterior part of lobe 1p. Free cheek, rostral plate, and thorax unknown.

Hypostoma (Pl. 15, figs. 20 and 21) estimated at about 0·75 to 0·8 times as wide as long (sag.) with maximum width at lateral shoulder. Anterior lobe of middle body very strongly convex (sag. and tr.), roughly pear-shaped in outline, about 0·75 times as wide as long with a very strongly forwardly convex anterior margin. Median furrow weak laterally, runs forward and outward from large, ovate, convex maculae to meet lateral border furrow at anterior margin of lateral shoulder. Posterior lobe crescentic in outline, independently convex (sag. and exs.) of and 0·2 times as long as anterior lobe, produced anterolaterally into long, gradually and finely tapering extensions which end at lateral shoulder. Anterior border is extremely narrow and low medially, not visible medially in ventral view due to highly convex anterior lobe, gradually widens (tr.) posterolaterally and centrally contains a shallow furrow. Anterior border furrow medially is a shallow nick, becomes broader posterolaterally where it runs into lateral border furrow. Lateral border at shoulder, posterior to well-developed notch, is gently convex (tr.) and moderately wide (tr.), narrows rapidly posteriorly before broadening again towards posterior border; border furrow is shallow and wide (tr.). Lateral margin posterior to shoulder is broadly concave abaxially. Posterior border furrow shallow and wide (sag.); posterior border flat, posterior extent unknown.

Dorsal morphology of pygidia known essentially from internal moulds only (Pl. 15, figs. 12, 18, 19), ventral morphology from one incomplete specimen with cuticle remaining (Pl. 15, fig. 11). Axis has three rings and a terminal piece. First ring imperfectly preserved, narrows adaxially, abaxial margin directed exsagittally. Second ring has abaxial margin obliquely directed forward and slightly outward, narrows adaxially, has ankylosed half-ring. Third ring apparently longer (sag. and exs.) than first two with what seems to be a weak, ankylosed half-ring. Terminal piece is strongly convex, forms a half-cone with a shorter, more steeply posteriorly descending anterior part. Postaxial sector is drawn posteriorly into a short, obtusely pointed mucronation. Axial furrow distinct and narrow beside first two axial rings, shallower and broader beside third ring; beside each ring furrow is a deep pit. First pleural furrow distinctly impressed, narrow, runs obliquely outward and backward to divide two small, transversely elongate, boss-like dorsal projections of the first pleura which represent the anterior and posterior pleural bands; anterior band is the larger and the more prominent and expands (exs.) abaxially, posterior band expands adaxially. First interpleural furrow distinct at axial furrow, shallows abaxially. Second pleural furrow shallower, shorter (tr.), and runs more obliquely backwards than the first, divides a lower anterior from posterior pleural band. Second interpleural furrow broader and shorter than first. Third pleural furrow lacking; shallow depression which represents third interpleural furrow separates base of third marginal spine from median mucronation. Marginal spines are slender, each is in the form of a flat ellipse in section, they taper gradually distally and are radially disposed. First spine curves outward to opposite (tr.) posterior part of terminal piece, and moderately (Pl. 15, fig. 12) to strongly (Pl. 15, fig. 18) backward, at its base it is distinctly swollen; second spine slightly less wide, of about the same length (the tips of all three spines in Pl. 15, fig. 18 are missing), extends just behind median mucronation, curves more backward than outward; third spine only slightly narrower than the second, curves strongly backward. Between third pair of spines, along a posteriorly convex, median embayment, doublure (Pl. 15, fig. 11) is acutely reflexed dorsally from ventral facing part of pygidial 'border', this reflex forming a sharp ridge. This ridge continues abaxially but at second spine is obtusely angled, the doublure here being horizontal.

Glabella covered with small to medium sized, moderately densely scattered granules which become more sparsely distributed on abaxial parts of lateral glabellar lobes. Fixed cheek has scattered large pits with a row of pits alongside proximal part of posterior branch of facial suture. Hypostoma has anterior lobe and lateral and posterior border with very closely spaced small granules; one or two larger, low granules present near centre of anterior lobe. Border furrows and median furrow with very small sparser granules. Sculpture of pygidium largely unknown; a few very small granules on ventral surface of second and third marginal spines and doublure.

Discussion. Specimens of this species are incomplete and many are mainly in the form of internal moulds. It is characterized by its glabella which apparently expands forwards relatively weakly compared with other species, and by its slender pygidial marginal spines. The latter invite comparison with those of *Cheirurus infensus* Campbell, 1967 from the late Wenlock to early Ludlow

Henryhouse Formation of Oklahoma but in *infensus* the spines, particularly the second and third, are directed distinctly upwards posteriorly, they have a more nearly circular outline in section and the first spine curves slightly forwards proximally before swinging backwards. Additionally in *infensus* the glabella expands more rapidly forwards, having a ratio of glabellar width across the frontal to basal lobes of 1·3 to 1·4 : 1·0 (own measurements based on the figures of Campbell), compared with that estimated for the Irish species of 1·1 to 1·2 : 1·0; the genal spine is longer; the glabellar granules are generally finer; the hypostoma is slightly wider relative to its length and it has better developed anterior wings which project well beyond the lateral shoulder, a wider lateral border, a less anteriorly extending lateral part to the crescentic posterior lobe, weaker maculae, and even finer granulation over most of the middle body.

The pygidial marginal spines of *Cheirurus phollikodes* Holloway, 1980 from the Wenlock of Arkansas and Oklahoma are in some specimens (Holloway 1980, pl. 6, fig. 22; pl. 7, fig. 21) as slender as those of the Irish species, though there are other pygidial, cranidial, and hypostomal differences, too numerous to list, between the two. *Cheirurus prolixus* Holloway, 1980 from the same general provenance and horizon is equally distinct, most obviously in its widely diverging genal spines.

Cheirurus tarquinius Billings, 1869 from the West Point Formation (Ludlow) of Gaspé remains essentially unrevised in modern terms, although it has been commented on by Raymond (1916), Campbell (1967), Lane (1971), and Holloway (1980), and re-illustrated by Northrop (1939) and Kindle (1945). Billings (1869, pl. 3, fig. 22; see also Northrop 1939, pl. 27, fig. 3) depicted the eye in his line-drawing of the lectotype (Raymond 1916, p. 38) as being wholly opposite the 3p lobe and he regarded this as an important specific character. My examination of the lectotype (GSC 3081) confirms that the illustration of Billings is accurate, and the one other syntype cranidium with the eye preserved (GSC 3081*d*) has it in a similar position, as does one well-preserved cranidium figured by Kindle (1945, pl. 68, fig. 3; right cheek). This feature separates *tarquinius* and its genal spine seems longer and more outwardly directed, and its pygidium to have more broadly based border spines and a longer, more acutely pointed terminal mucronation (Northrop 1939, pl. 27, figs. 1 and 2; pl. 28, figs. 3–5; Kindle 1945, pl. 68, fig. 5).

Cheirurus centralis Salter, 1853 and the closely related *C. insignis* from the Wenlock of the Anglo-Welsh area and Czechoslovakia respectively, have at least more anteriorly expanded glabellae and broader, shorter pygidial spines (see Lane 1971, pl. 1, figs. 1–6; text-fig. 3; Přibyl, Vaněk and Pek 1985, pl. 6, figs. 1 and 2). The low Wenlock *C.* cf. *centralis* of Thomas (1981, p. 57, pl. 15, figs. 3, 4, 7) has slender pygidial spines, but in this material a distinct second pleural furrow is lacking and the glabella widens strongly at the frontal lobe as in *centralis*. Incidentally, the neotype selected for *insignis* by Prantl and Vaněk *in* Horný *et al.* (1958) from Barrande's Collection is invalid; Dr H. Jaeger (Humboldt-Universität, Berlin) has commented that Beyrich's type of *C. insignis* 'is well preserved in our collection' (pers. comm. 29 Dec. 1976; this contradicts Přibyl and Vaněk 1975, p. 48).

The eye ridge on the Irish material is similar to that on *Cheirurus postremus* Lane, 1971 from the Ludlow of the Lake District, which its author claimed was unique for a *Cheirurus* species. But often such features are more prominent on internal moulds, like the only two known specimens of *postremus* and the Irish cranidia, and the same albeit more subdued feature appears to be present on other *Cheirurus* species known from testiferous specimens, such as *C. infensus* (see Campbell 1967, p. 18, pl. 6, fig. 4; pl. 7, fig. 1), or *C. phollikodes* (see Holloway 1980, pl. 7, figs. 1 and 8). The usefulness of this feature as the main diagnostic character of *postremus* would seem in doubt, but the British species appears to be distinct from the Irish in its more anteriorly widening glabella (1·3 to 1·4 times as wide at the frontal compared with basal glabellar lobes: own measurements).

The Irish *Cheirurus* species appears to be new, but I hesitate formally to establish it because of the incomplete nature of the material.

Cheirurus sp.

Plate 15, figs. 4, 6, 13, 14, 17

1863 *Cheirurus bimucronatus*; Baily *in* Jukes and Du Noyer, p. 12.
1878 *Cheirurus bimucronatus*; Baily *in* Kinahan, p. 40.
1976 *Cheirurus* sp.; Siveter *in* Parkin, p. 595, table 1 (*pars*).
1984 *Cheirurus* sp.; Siveter *in* Thomas, Owens, and Rushton, p. 55.

Material. Two cranidia, one hypostoma, one pygidium.

Occurrence. Annascaul Formation, locality 28 of Parkin 1976, p. 587, fig. 4, Annascaul inlier.

Discussion. This *Cheirurus* material can easily be distinguished from *Cheirurus* sp. nov.? by, amongst other features, its much shorter, broader pygidial spines, more weakly transversely and sagittally convex middle body of the hypostoma and, apparently, more anteriorly expanding glabella which is slightly less than 1·3 times as wide at the frontal lobe than at 1p lobe. It belongs within the Wenlock–lower Ludlow group which includes *C. insignis*, *C. centralis*, and the Moroccan *C. strux* Alberti, 1970, but without knowledge of its variation its specific identity remains uncertain. The cranidia of all these are very similar. The pygidial spines of the Kerry form are similar to those of *centralis* but in the latter the spine tips appear to lie on a more posteriorly gentle arc, as the first spine extends backwards beyond and the second spine well beyond the median mucronation, with the tips of the second and third spines being more nearly transversely in line (Lane 1971, pl. 1, figs. 2, 6–8, 11, 12; Thomas 1981, pl. 15, fig. 2*b*). In *insignis* the pygidial spines appear generally slimmer than in the Irish specimen, though in both the tips seem more strongly radially disposed than in *centralis* (see Prantl and Vaněk *in* Horný *et al.* 1958, pl. 7, fig. 2; Horný and Bastl 1970, pl. 14, fig. 5; Lane 1971, p. 15, text-fig. 3*d*, *h*; Přibyl, Vaněk and Pek 1985, pl. 6, fig. 2). The pygidium of *C. strux* is unknown.

Family CALYMENIDAE Milne Edwards, 1840
Subfamily CALYMENINAE Milne Edwards, 1840
Genus CALYMENE Brongniart *in* Brongniart and Desmarest, 1822

Type species. Calymene blumenbachii Brongniart *in* Desmarest, 1817, p. 517; from the Much Wenlock Limestone Formation, Homerian Stage, Wenlock Series, Dudley, West Midlands, UK. By subsequent designation of Milne Edwards *in* Cuvier 1844, pl. 80, fig. 1*a*, *b*. Siveter (1986, p. 785) and Whittington and Siveter (1986, pp. 105–106) thought Shirley (1933) was the first author to validly designate the type species of *Calymene*, but Dr L. B. Holthuis (Rijksmuseum van Natuurlitke Historie, Leiden, The Netherlands) subsequently informed (June 1986) the International Commission on Zoological Nomenclature that Milne Edwards was the first. The prior designation by Milne Edwards, together with the central nomenclatural proposals of Whittington (1983) and Whittington and Siveter (1986) regarding *Calymene*, have now been accepted by the ICZN (1987).

Calymene endemopsis sp. nov.

Plate 18, figs. 1–7, 15–17, 20, 21, 23

1976 *Calymene* sp.; Siveter *in* Parkin, p. 595, table 1 (*pars*).
1984 *Calymene* sp.; Siveter *in* Thomas, Owens, and Rushton, p. 55.

Derivation of name. From the Greek, *endemos*, living in, and *apopsis*, a lofty spot that gives a commanding view. Alluding to its locality high on the flank of Caherconree.

Holotype. Incomplete cranidium, TCD 12095; Pl. 18, figs. 1–3.

Type horizon and locality. Annascaul Formation, locality 36 of Parkin 1976, p. 587, fig. 4, Annascaul inlier.

Additional material. Eight cranidia, five pygidia.

Diagnosis. A species of *Calymene* with a very strongly bell-shaped glabella which becomes distinctly narrower in front of lobe 2p; frontal lobe 0·6 times as wide as glabella at lobe 1p; 3p lobe small. Axial furrow narrow around 1p lobe, wide beside 3p and frontal lobe. Preglabellar area relatively long (sag.), estimated at 0·25 to almost 0·3 times the glabellar length (including occipital ring). Moderately long (sag.), deep preglabellar furrow and subequally long, high anterior border, Pygidium with eight axial rings and five pleural furrows. The latter are deeply impressed and wide over inner pleural region and abruptly die out well before lateral margin; interpleural furrows very much weaker and longer than pleural furrows, sharply and narrowly defined at axial furrow, scarcely impressed on inner pleural region, clearly and finely impressed on outer pleural region.

Description. Glabella very strongly bell-shaped, about 0·8 (Pl. 18, fig. 7) to 1·0 times (Pl. 18, fig. 1) as long as wide. Occipital ring (Pl. 18, fig. 7) longest (sag. and exs.) behind central glabellar area, narrows gradually abaxially. Occipital furrow longest and shallowest behind central glabellar area, deep and slit-like abaxially. Lobe 1p large, well inflated, subquadrate in outline with abaxial anterolateral corner obtusely pointed, joined by a rather narrow (exs.), slightly depressed neck to central glabellar area. Furrow 2p is deep and narrow at axial furrow, runs inward and backward, forks at anterolateral corner of lobe 1p, posterior branch directed more sharply backwards then curves more or less transversely inwards for a short distance and fades out, anterior branch trends forward and inward; within this fork is a distinct intermediate lobe. Glabellar lobe 2p elongate (tr.), trends slightly forward abaxially, divorced from central glabellar area by moderately shallow, broad (tr.) furrow; 2p furrow short (tr.), confined largely to side of glabella. Lobe 3p gently to moderately inflated, small in comparison to 2p lobe, confined to dorsolateral surface of glabella, marked anteriorly by narrow, shallow 3p furrow (Pl. 18, fig. 3). Frontal lobe 0·6 times as wide as glabellar width at 1p lobes, moderately convex forward anterior outline, well-rounded anterolateral corners, falls very steeply to and is slightly undercut by preglabellar and axial furrows (Pl. 18, figs. 2 and 6), projects well in front of anterior part of fixed cheek.

Axial furrow shallow beside occipital ring, is narrow and becomes progressively deeper anteriorly around 1p lobe, runs under bridge of lobe 2p and buttress from fixed cheek, is deep and becomes very much wider (tr.) in front of 2p lobe due to glabella becoming distinctively narrower (tr.); at 2p lobe the base and lower abaxial side of axial furrow is interrupted by a ridge. Anterior pit well marked, sited on adaxial side of base of axial furrow at about mid-length of frontal lobe. Preglabellar area relatively long, estimated at 0·25 to almost 0·3 times as long as glabella. Preglabellar furrow is very deep, moderately long, anteriorly it curves very steeply upwards or upwards and slightly backwards and runs into inner face of anterior border; it extends laterally to separate anterior border from fixed cheek where it is slightly less deep. Dorsal surface of anterior border is slightly shorter than or is about the same length (sag.) as preglabellar furrow, of more or less constant length (exs.) abaxially until shortening near facial suture, reaches high up the face of frontal lobe, has a moderately to strongly convex surface which curves over anteriorly into a near vertical anterior face that trends downward then slightly backward (Pl. 18, figs. 2, 6, 16).

Posterior border of fixed cheek imperfectly preserved, lengthens (exs.) abaxially to fulcrum; border lens-like with shallower anterior slope. Moderately sloping palpebral lobe is about as long or slightly longer than lobe 2p, mid-length just anterior to mid-length of lobe 2p. Width of cranidium at posterior margin of palpebral lobe about 1·7 times that of glabella at lobe 2p. Anterior part of fixed cheek is quite strongly convex (exs.) and descends steeply forwards. Posterior branch of facial suture runs outward and slightly backward from eye, then bends more sharply backwards to run to and across lateral border furrow after which it turns sharply more exsagittally; course thereafter uncertain. Anterior branch runs forward and very slightly inward to anterior border, very sharply inward on outer face of anterior border towards broadly arched rostral suture (Pl. 18, fig. 16). Free cheek, hypostoma, rostral plate, and thorax unknown.

Pygidial axis has seven distinct and one indistinct axial rings and a terminal axial piece (Pl. 18, figs. 17, 20, 21, 23); the eighth axial ring is marked posteriorly by a very weak ring furrow. Axial furrow well marked beside axis, shallow anteriorly, deepest posteriorly abaxial to terminal piece, shallowest behind terminal piece. Inner part of pleural region descends relatively steeply, outer part very steeply, to pygidial margin. The five pleural furrows are very well incised and abaxially become rather wide (exs.) across inner pleural region, they abruptly become very weak and narrow and fade out rapidly on outer part of pleural region. Interpleural furrows distinct immediately adjacent to axial furrow, very narrow and weak adaxially on inner pleural region, becoming gradually slightly more distinct abaxially across inner pleural region, are best developed on outer pleural region where they extend well beyond pleural furrows, but do not reach pygidial margin.

Anterior pleural band behind fifth interpleural furrow very slightly raised, forms abaxial margin of posterior sector.

At least the glabella and inner part of fixed cheek have small to large granules, moderately densely scattered; on dorsal and outer face of anterior border, and abaxial part of fixed cheek, the larger granules appear to be absent. Preglabellar and axial furrows smooth. Posterior border furrow with fine granules. Pygidium with small granules close together on central part of axis, more loosely scattered on inner pleural region, very densely distributed fine granules on outer pleural region and border roll.

Discussion. This new taxon is closest to Wenlock and Ludlow species of the *C. blumenbachii* plexus, and certain of its diagnostic characters are similar also to those of some other Llandovery and Přídolí *Calymene* species. However, in particular its very strongly bell-shaped glabella which is wide across the basal glabellar lobes and narrows sharply in front of the 2p lobes, its relatively long and deep preglabellar furrow and subequally long, high anterior border, the disparity in definition of its pleural and interpleural furrows, and its style of sculpture all combine to make it different. The Wenlock age *C. blumenbachii blumenbachii*, *C. blumenbachii neotuberculata* Schrank, 1970, and *C. blumenbachii* subsp. nov. of Siveter 1980 all have a similar type of sculpture, but they are immediately distinguished by their shorter preglabellar furrow and preglabellar area, and they have the anterior border slightly swollen opposite the axial furrow (Pl. 17, fig. 1, cf. Schrank 1970*a*, pl. 8, fig. 1; Siveter 1980, pl. 100, fig. 12; 1986, pl. 90, fig. 1, pl. 91, figs. 3 and 6). Also in *blumenbachii* and its subspecies there is not such a marked difference between the depth of the pleural and interpleural furrows, and the pleural furrows are longer (Pl. 18, fig. 23, cf. Siveter 1980, pl. 100, figs. 11 and 16; 1986, pl. 90, fig. 5; pl. 91, figs. 4 and 5). Some of the varieties of *C. tentaculata* (Schlotheim, 1820) from the Přídolí of the Baltic area figured by Schrank (1970*a*, *b*) appear similar to the new Irish species in the form of their preglabellar area, but all of them have, amongst other differences, a less variably sized, finer, and more closely-knit glabellar granulation and a slightly abaxially convex outline to the pygidial axial furrow.

Of the large number of Llandovery to Přídolí age East Baltic *Calymene* species described by Männil (1977, 1983), the Wenlock age *C. restevensis* Balashova, 1968 (= senior synonym of *C. mimaspera livonica* Männil, 1977; *pers. comm.* Dr Reet Männil, 1985; see also Männil 1982, 1986) shows some similarity in the form of its preglabellar area to *C. endemopsis*, though in *restevensis* the glabella has a more evenly tapering glabellar outline and lacks a strong intermediate lobe and it has a relatively wider axial furrow beside the basal glabellar lobe. *Calymene flabellata* Männil, 1983 (pl. 1, figs. 1–7) from the Ludlow age Kuressaare Stage has a glabellar outline reminiscent of the Irish species, but it has a shorter preglabellar area and preglabellar furrow, four lateral glabellar lobes, and longer, narrower pleural furrows.

Calymene planicurvata Shirley, 1936 from the Llandovery Aeronian Stage of the Shelve area, Welsh Borderland, resembles *C. endemopsis* in its relatively long preglabellar area but in this older species the preglabellar furrow is shallower, the glabella tapers more evenly and has a better

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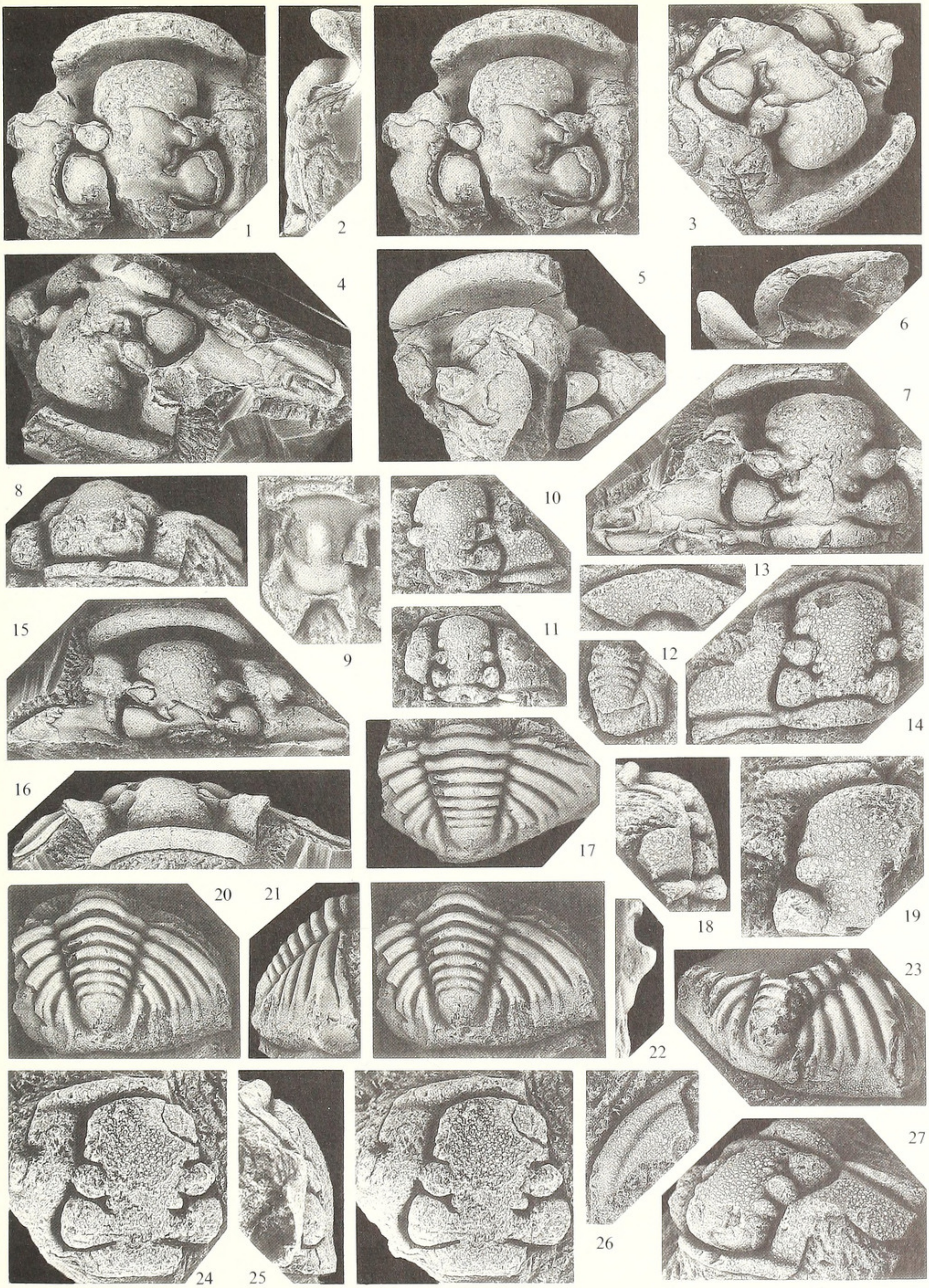
EXPLANATION OF PLATE 18

Figs. 1–7, 15–17, 20, 21, 23, *Calymene endemopsis* sp. nov. All specimens are from the Annascaul Formation, locality 36. 1–3, holotype, cranidium, TCD 12095; dorsal stereo-pair, lateral, oblique views, ×1·25. 4 and 7, cranidium, TCD 12093; oblique, dorsal views, ×1·25. 5 and 6, cranidium, TCD 12071; dorsal, lateral views, ×1·25. 15 and 16, cranidium TCD 12094*a*; dorsal, frontal views, ×1·25. 17, 20, 21, pygidium, TCD 12067; dorsal view, posterior stereo-pair, lateral view, ×1·25. 23, pygidium, TCD 12064; oblique view, ×1·25.

Figs. 8–14, 18, 19, 22, 24–27. *Calymene* sp. All specimens are from the Annascaul Formation, locality 36. 8, 14, 18, 27, cranidium, UM K2819; frontal, dorsal, lateral, oblique views, ×4. 9 and 22, hypostoma, TCD 12629; ventral, lateral views, ×7. 10, cranidium, TCD 12627; dorsal view, ×4. 11, cranidium, UM K2820; dorsal view, ×4. 12, pygidium, UM K2818; posterior view, ×4. 13, rostral plate, UM K2817; ventral view, ×7. 19, cranidium, TCD 12626; dorsal view, ×4. 24 and 25, cranidium, UM K2803; dorsal stereo-pair, lateral view, ×3. 26, free cheek, TCD 12625; 'dorsal' view, ×4.



SIVETER, Silurian trilobites

developed 3p lobe, a 4p lobe, and no intermediate lobe. The cranidium of *Calymene kokbaitalensis* Maksimova, 1968 (pl. 8, figs. 1 and 2) from the Devonian of Kazakhstan looks very like that of the Irish species as far as can be determined from the internal moulds of the Russian form, but the much longer pygidial pleural furrows of *kokbaitalensis* immediately distinguish it (Maksimova 1968, pl. 8, figs. 2-4, 6, 7).

Occurrence. Known only from the type horizon and locality.

Calymene sp.

Plate 18, figs. 8-14, 18, 19, 22, 24-27

1976 *Calymene* sp.; Siveter *in* Parkin, p. 595, table 1 (*pars*).
1984 *Calymene* sp.; Siveter *in* Thomas, Owens, and Rushton, p. 55.

Material. Five cranidia, one free cheek, one rostral plate, one hypostoma, one pygidium.

Occurrence. Annascaul Formation, locality 36 of Parkin 1976, p. 587, fig. 4, Annascaul inlier.

Discussion. The material of this second species of *Calymene* is mostly small in size, rather incomplete, and one of the cranidia (Pl. 18, figs. 24 and 25) has apparently suffered vertical compaction. The morphology of the cranidium figured on Plate 18, fig. 14 is probably the closest to that of the original form. This species is easily separated from *C. endemopsis* sp. nov. by its much shorter preglabellar area, more evenly tapering glabella, relatively larger 3p lobe, the presence of a 4p lobe, and the slightly denser, relatively smaller granular sculpture. The size of all the material ascribed to *Calymene* sp. is much smaller than that of *C. endemposis* but the length and form of preglabellar area are so different between the two groups of specimens that their morphological differences are not thought to be ontogenetic in nature.

The short preglabellar area of *Calymene* sp., with its short, shallow preglabellar furrow and short anterior border, invites comparison with such species as *C. blumenbachii*, *C. minimarginata* Schrank, 1970, and *C. tuberculosa* Dalman, 1827 from the Wenlock of the Anglo-Baltic area, and the Přídolí *C. chica* Šnajdr, 1982 from Czechoslovakia. Of these both *minimarginata*, which has palpebral lobes wider apart compared with its glabellar width at 2p lobes together with other differences, and *tuberculosa*, which has a subconical (not elongate) protuberance on the middle body of the hypostoma (Siveter, in prep.), a more rounded outline to the frontal glabellar lobe, and which lacks an intermediate lobe within the fork of 1p furrow (Schrank 1970*a*), are clearly different; *blumenbachii* also appears distinct in having a deeper preglabellar furrow and more upturned anterior border. The poorly defined *C. chica*, which may be synonymous with *C. nabrici* Šnajdr, 1982 also from the Přídolí of Bohemia, is not well known though the age difference between this species and the Irish *Calymene* material suggests that they are unlikely to be conspecific. Further comparison is unwarranted on the basis of the present material from Kerry.

Family PHACOPIDAE Hawle and Corda, 1847
Subfamily PHACOPIDAE Hawle and Corda, 1847
Genus ANANASPIS Campbell, 1967

Type species. Phacops fecundus Barrande, 1846, p. 46; from the Kopanina Formation (Ludlow), Koledník near Beroun, Czechoslovakia. By original designation.

Discussion. In establishing *Acernaspis* (mainly Llandovery in age) and *Ananaspis* (mainly Ludlow to Přídolí in age), Campbell (1967; see also 1977) recognized that there were transitional (Wenlock) species in the evolutionary plexus between the two genera; these species could be expected to show differential rates of development of the features characterizing typical members of each genus and they would therefore be difficult to unequivocally assign generically. Ramsköld (1985) has subsequently highlighted such a gradual transformation from typical *Acernaspis* to typical *Ananaspis* species showing, for example, that his new Gotland species *Acernaspis rubicundula* has, albeit much more weakly developed, the type of glabellar granulation that has been regarded as characteristic of *Ananaspis*. The Irish phacopid described below has glabellar sculpture which is similar to that of *A. rubicundula* but is more primitive than that in late Wenlock specimens of *A. stokesii* (Milne Edwards, 1840), the latter being regarded by Ramsköld as the first definite *Ananaspis*. I agree with Ramsköld that to put all the *Acernaspis* and *Ananaspis* species into a single genus is too unwieldy and so have retained them as separate. The Irish phacopid has been placed in *Ananaspis* mainly on account of its distinct lateral border furrow, which seems to me one of the most reliable ways of distinguishing between the groups of species assigned to each genus. On the latest Llandovery to latest Wenlock morphological series indentified by Ramsköld (1985, p. 13), *Acernaspis sororia* Ramsköld, 1985–*A. rubicundula*–*A. stokesii*–*Ananaspis amelangi* Ramsköld, 1985, the Irish species fits best between *rubicundula* and *stokesii*.

Ananaspis sp. aff. *A. stokesii* (Milne Edwards, 1840)

Plate 19, figs. 1–27; Plate 20, figs. 8–10

1976 phacopids; Siveter *in* Parkin, p. 595, table 1 (*pars*).
1984 *Ananaspis* sp.; Siveter *in* Thomas, Owens, and Rushton, p. 55.

Material. Seventy cephala, three hypostomata, twenty pygidia.

Occurrence. Annascaul Formation, locality 36 of Parkin 1976, p. 587, fig. 4, Annascaul inlier.

Description of small-eyed dimorph. Cephalon 1·8 (Pl. 19, fig. 9) to 2·25 (Pl. 19, fig. 1) times as wide as long. Glabella 0·9 (Pl. 19, fig. 7) to 1·2 (Pl. 19, fig. 1) times as wide across frontal lobe as long. Occipital ring moderately convex (Pl. 19, fig. 24) to flat-topped (Pl. 19, fig. 6) in profile, descends moderately to strongly anteriorly into occipital furrow, abaxially behind lobe 1p it bends gently forward and is slightly greater than half its sagittal length. Occipital furrow distinct, shallowest medially, deepest abaxially, with a very short, subsidiary posterior notch which indents anterolateral margin of occipital ring posterior to inner margin of lobe 1p. The latter is discrete, swollen, transversely elongate, and clearly marked off from intercalating ring by a distinct furrow. Furrow 1p deepest in front of 1p lobe, becomes shallower adaxially where it runs parallel with occipital furrow (Pl. 19, fig. 25) or swings more strongly forward (Pl. 19, fig. 16); the two 1p furrows join medially to form an intercalating ring. On most small to medium sized specimens furrows 2p and 3p are well marked (Pl. 19, figs. 1 and 9), on large specimens they are weak (Pl. 19, figs. 7, 14, 16). Furrow 2p gently (Pl. 19, fig. 9) to moderately (Pl. 19, fig. 1) arched forward, isolated from axial furrow. Posterior section of furrow 3p weakly convex forward, is of about the same definition or is slightly less well defined than furrow 2p; straighter anterior section trends forward and outward towards axial furrow, fades out high on glabellar side about opposite anterior margin of palpebral lobe. 'Lobe' 3p slightly longer than 'lobe' 2p. Frontal glabellar lobe broadly convex to subangular in anterior outline (Pl. 19, figs. 7 and 22), extends slightly anterolaterally. In lateral profile glabella is moderately convex dorsally from occipital furrow to anterior face of frontal lobe where it curves relatively sharply to descend vertically to preglabellar furrow.

Axial furrow weakest beside occipital ring, becomes a little deeper and more sharply defined around lobe 1p, at furrow 1p turns sharply outwards at an angle of about 30° (Pl. 19, fig. 7) to 35° (Pl. 19, fig. 1) to the sagittal line and is shallow to moderately deep from here anteriorly to anterior margin of palpebral lobe where it becomes slightly deeper before merging with lateral border furrow. Preglabellar furrow shallow but sharply defined, in frontal view it dips slightly ventrally medially. Anterior border is a very narrow, exceedingly short rim.

Posterior border narrow and tightly convex (exs.) to fulcrum, widens and becomes gradually less convex from fulcrum to genal angle; border furrow very narrow and rille-like throughout its length (tr.). Length of fixed cheek between posterior border furrow and posterior margin of palpebral lobe is equal to or slightly less than length of 1p lobe. Palpebral lobe strongly abaxially convex, in dorsal view trends overall obliquely forward and inward and in lateral and frontal views slopes forward and downward; palpebral furrow is subparallel and well marked, Just adaxial to outer margin of palpebral lobe there is a shallow, parallel furrow which confines a very narrow, abaxial border to palpebral lobe; this furrow pinches out anteriorly and posteriorly at visual surface of eye. Facial suture ankylosed, posterior branch well marked, running moderately strongly forward to lateral border furrow, very faintly present in some specimens on dorsal part of lateral border (Pl. 19, fig. 6); anterior branch cuts across axial furrow and anterolateral corner of frontal lobe to run along lower side of this lobe. Eye moderately large in medium and large sized holaspides, visual surface has from seventeen lens files with a total of eighty-six lenses (Pl. 19, fig. 10) to twenty files and ninety-two lenses (Pl. 19, fig. 1), the maximum number of lenses in any file being six. A small holaspid (Pl. 19, fig. 5; glabellar length 3·7 mm) has seventeen files with a total of fifty-seven lenses; maximum number of lenses in any file is, exceptionally, five, normal complement is four. Beneath visual surface some specimens show a very narrow, weakly defined eye socle from below which the narrow, posteriorly expanding main field of the cheek descends more or less vertically to lateral border furrow. The latter is shallow anteriorly, becomes slightly less so and a little wider towards junction with facial suture posterior to which it becomes narrower and more sharply defined to posterior border furrow. Below anterior part of eye lateral border is gently to moderately convex (tr.) and relatively wide, gradually expands in width posteriorly to genal angle (Pl. 19, fig. 10).

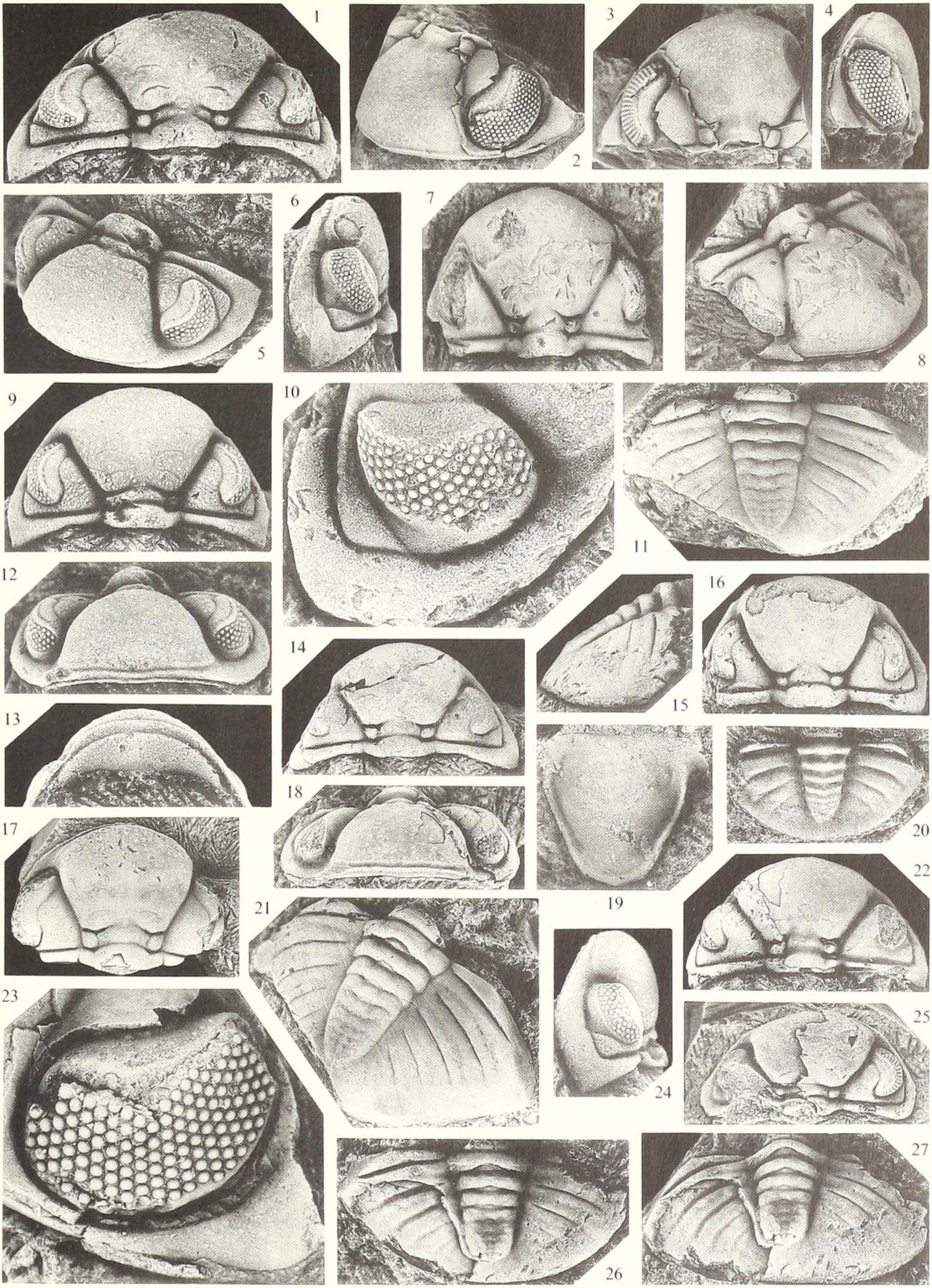
Vincular furrow continuous and shallow medially, more deeply notched laterally (Pl. 19, fig. 13). Medially, doublure is wide (sag.) and hypostomal suture extremely weakly convex posteriorly. Hypostoma known completely only in internal mould form, is shield-shaped and about 0·9 times as wide as long exclusive of anterior wings. Convex middle body falls steeply abaxially and posteriorly to border furrows. Lateral border narrow (tr.), posterior border only slightly wider (sag.). At junction of lateral and posterior margins and sagittally the hypostomal outline is angular, but without evidence on the internal mould material available of discrete spines. Lateral and posterior border furrows shallow and narrow.

Thorax unknown. Pygidium (Pl. 19, figs. 15, 26, 27) is about 2·1 times as wide as long with a subrounded, bow-like posterior outline. Axis about 1·3 times as long as wide and about 0·25 times as wide and 0·85 times as long as pygidium, contains seven to eight rings. Axis is moderately convex (tr.) anteriorly, progressively less so posteriorly where the axial rings are flat-topped. At least the second to sixth axial rings have ankylosed half-rings. First axial ring moderately convex (sag.), narrowest medially, at axial furrow lengthens to about double its sagittal length; difference in length between sagittal and abaxial parts of axial rings becomes less marked posteriorly. More posterior ring furrows fail to reach axial furrow. Terminal axial piece is extremely short (sag.) and bluntly rounded. Axial furrow very broad and shallow at first ring, becomes slightly narrower and better marked from second axial ring to terminal piece around which it becomes shallower and weaker again. Wide pleural region descends away from axial furrow in an even, moderately strong, dorsally convex curve. There are five, finely incised pleural furrows which become progressively shorter and weaker posteriorly; first furrow ends abruptly on reaching the well-developed articulating facet. Interpleural furrows are much broader than pleural furrows and are extremely shallow. Both pleural and interpleural furrows stop well short of pygidial margin to leave a wide, smooth 'border' around outer part of pleural region.

Glabella and palpebral area have very subdued, scattered, medium-sized granules which themselves are composed of several minute granules (Pl. 19, figs. 1 and 12); in large specimens the medium-sized granules are less frequent and of exceedingly weak relief. On the palpebral area of some of the larger cephala there are a few very shallow 'pits'. Internal moulds of glabellae show a suboval arrangement of raised auxiliary muscle impressions medially on the frontal lobe (Pl. 19, fig. 18). Internal moulds of hypostoma have a few dispersed medium-sized granules on anterior and central part of middle body. Pygidium has no obvious granulation.

EXPLANATION OF PLATE 19

Figs. 1–27. *Ananaspis* sp. aff. *A. stokesii* (Milne Edwards, 1840). All specimens are from the Annascaul Formation, locality 36. 1, 5–10, 12–16, 18–20, 22, 24–27, small-eyed dimorph. 1 and 6, cephalon, UM K2800*a*; dorsal, lateral views, ×4. 5, 9, 12, 13, 24, cephalon, TCD 12175; oblique, dorsal, frontal, ventral, lateral views, ×6. 7 and 8, cephalon, UM K2827; dorsal, oblique views, ×2. 10 and 25, cephalon, partial internal mould, TCD 12061; oblique view of cheek, ×7, dorsal view, ×2. 14, cephalon, TCD 12166; dorsal view, ×2. 15, 26, 27, pygidium, TCD 12179; lateral, dorsal, posterior views, ×3. 16, cephalon, TCD 12169; dorsal view, ×3. 18 and 22, cephalon, largely internal mould, TCD 12633; frontal, dorsal views, ×2. 19, hypostoma, internal mould, TCD 12146; ventral view, ×5. 20, pygidium, internal mould, TCD 12185; dorsal view, ×3. 2–4, 17, 23, ?11, ?21, large-eyed dimorph. 2–4, 23, cephalon, largely internal mould except for palpebral area and visual surface of eye, UM K2826; oblique, dorsal, lateral views, ×2, eye and cheek, ×7. 17, cephalon, TCD 12156; dorsal view, ×2. 11 and 21, pygidium, UM K2802*a*; dorsal, oblique views, ×3.



SIVETER, Silurian trilobites

Description of the large-eyed dimorph. This takes the form of a differential comparison with the small-eyed morph (cf. Pl. 19, figs. 2, 3, 7, 8, 10, 17, 23). The large-eyed morph differs in having: 1, an eye with at least twenty-one lens files and on the one specimen of this dimorph with the eye preserved (Pl. 19, fig. 23) there is room on the incompletely preserved visual area for an extra file, making the probable total twenty-two. The maximum number of lenses in any file is nine and the estimated total number of lenses is 165–170; 2, a much shorter postocular section on the cheek, the eye almost reaching the posterior border furrow; 3, a narrow cheek field which below the visual surface descends very strongly inward to a very narrow, deep, slit-like lateral border furrow; 4, a lateral border which below the anterior part of the visual surface is much narrower, and expands in width posteriorly at a much greater rate.

One large phacopid pygidium (Pl. 19, figs. 11 and 21) differs from the others in having: 1, a straighter, obliquely directed lateral margin; 2, one more (9) axial ring; 3, one more (6) pleural furrow; 4, a more pointed posterior outline to the terminal axial piece; 5, a pleural region which has a more abrupt change in slope between its inner and outer parts descending abaxially from the axial furrow, so that the transversely wider outer part falls a little more steeply towards the lateral margin. This pygidium may represent that of the large-eyed morph.

Discussion. Two distinct forms have been identified in the Caherconree phacopid material; they are distinguished essentially on the morphology of the eye and associated characters of the cheek, though there may be pygidial differences also (see description). Of the fifteen prepared phacopid cephala two specimens (Pl. 19, figs. 2–4, 17, 23) are of the large-eyed morph which, following the work of Eldredge (1973), Campbell (1977), and others on this family, I have interpreted as a sexually dimorphic form. Sexual dimorphism has been increasingly invoked in the literature as a feature of Devonian phacopids; it has not been recognized hitherto in *Ananaspis* with the exception of the suggestion of Holloway (1980) that the co-existing *A. fecunda fecunda* and *A. fecunda aspera* from the Ludlow of Czechoslovakia, which differ in the size of their eyes and in other features (see Chlupáč 1977), are probably sexual dimorphs. Non-dimorphic variability in the Kerry material which is considered to be intraspecific includes the definition of the 2p and 3p glabellar furrows, the degree of divergence of the axial furrows, and the distinctness of the larger glabellar granules (see description). The latter, at least, may be ontogenetic in nature with the larger specimens having the weaker sculpture, though this variability may be controlled by specimen preservation as may that of the lateral glabellar furrow definition.

The Kerry taxon is most clearly related both to *A. amelangi* from the latest Wenlock Mulde Beds of Gotland, and to similarly aged British specimens that I have examined which have been referred to the unrevised *A. stokesii*, a species established on the basis of material from England, Bohemia, and the United States. *A. amelangi* differs from the small-eyed dimorph of the Irish species in having from one to four less lens files (sixteen) in equivalent, adult-sized holaspides, and from the large-eyed dimorph it has at least five files less; it also has a prominent median node on the occipital ring, more conspicuous glabellar granules, a 2p furrow positioned closer to 1p furrow thus forming an exsagittally shorter 1p lobe (cf. Pl. 19, figs. 1 and 9 with Ramsköld 1985, pl. 4, figs. 2*a* and 3*b*), and less definite eighth and ninth ring furrows (cf. Pl. 19, figs. 11 and 26 with Ramsköld 1985, p. 20, pl. 4, fig. 9) though this difference may be due to the *amelangi* pygidia being smaller. Also in the Swedish form the lateral border furrow runs immediately below the eye, contrasting at least with the small-eyed dimorph of the Irish species which has a narrow but definite strip of the cheek field separating this furrow from the eye base (cf. Pl. 19, fig. 6 with Ramsköld 1985, pl. 4, fig. 2*b*); in the large-eyed dimorph of the Irish form the border furrow runs very close to the eye base similar to that in *amelangi*, but the latter still differs in not having a sharply inwardly descending narrow strip of the cheek field below the eye together with having a much shallower lateral border furrow.

A. stokesii has not received attention since Salter (1864, p. 21); a revision is being prepared by Dr A. Thomas but meanwhile the nature of the type material, horizon, and locality and the variability within the species remains either unknown or imprecisely defined. Ramsköld (1985, pl. 4, fig. 7*a*, *b*) has figured a specimen attributed to *stokesii* from the Much Wenlock Limestone Formation of the Malverns and I have looked at material assigned to *stokesii*, housed in the British

Museum (Nat. Hist.) from the same formation of the Dudley area, the latter occurrence forming one of the type localities of Milne Edwards in his account of this species. Comparison of the Kerry phacopid with *stokesii* is based on these Dudley and Malverns specimens. The British species appears slightly closer than *amelangi* to the Irish forms, but differs in its slightly stronger glabellar granulation, deeper cephalic axial furrow, and exsagittally shorter 2p lobe; additionally, comparing *stokesii* to equal-sized specimens of the small-eyed Irish dimoph, the cheek field below the eye is narrower and falls sharply inward to a deep lateral border furrow which undercuts the base of the eye, allied to which the anterior part of the lateral border is narrower, the border expands in width more rapidly posteriorly and is more tightly convex. These differences are well exhibited on comparing UM K2800*a* (Pl. 19, figs. 1 and 6) with BM 59043 and BM I310 (one of two specimens with this number, the other being *Eophacops musheni*). Undercutting of the base of the eye by the lateral border furrow is common to both *stokesii* and the large-eyed Kerry dimorph, but in the former this furrow is less sharply incised and very much wider, and the eye is much smaller having at least three fewer lens files (seventeen to eighteen). There are at least seven axial rings and five pleural furrows in the pygidium of *stokesii*. Pending a full revision of the British species I prefer to refer to the Irish material as aff. *stokesii*.

Family ODONTOPLEURIDAE Burmeister, 1843
Subfamily ODONTOPLEURINAE Burmeister, 1843
Genus ODONTOPLEURA Emmrich, 1839

Discussion. The concept of *Odontopleura* and the number of species it contained (two) remained stable up to and including the work of Thomas (1981), except for the brief note of Šnajdr (1979) resurrecting *O. prevosti* Barrande, 1846. Subsequently, Chatterton and Perry (1983) erected from the early Wenlock of north-west Canada *O. brevigena* which, like the long established *O. ovata* Emmrich, 1839 and *O. dufrenoyi* Barrande, 1846, also has paired occipital spines. They further introduced four new Llandovery species which in overall morphology fitted best in *Odontopleura*, but differed from other taxa formerly placed therein in lacking paired occipital spines; additionally they allied *Taemasaspis llandoveryiana* Šnajdr, 1975 (see also Šnajdr 1978) from the Llandovery of Bohemia to the latter group and placed it, also, in *Odontopleura*. I agree with Chatterton and Perry (1983) that the Canadian and Bohemian Llandovery forms lacking paired occipital spines are best regarded, if somewhat uneasily, as early representatives of *Odontopleura*. Ramsköld (1984, p. 249) independently proposed that *T. llandoveryiana* is morphologically (and stratigraphically) intermediate between *Primaspis* and *Odontopleura* (see also Chatterton and Perry 1983, p. 23), whilst Přibyl *et al.* (1986, p. 268) have most recently suggested that the material Šnajdr (1975, 1978) placed in *llandoveryiana* belongs to both *Primaspis* (*Meadowtownella*) Přibyl and Vaněk, 1965 and to *Odontopleura*.

Šnajdr (1979, 1984*a*, *b*, *c*) re-examined Bohemian *Odontopleura* specimens in combination with his review of the type material of Hawle and Corda (1847), and he recognized thirteen species or subspecies (see species discussion below), all with occipital spines, ranging in age from the late Aeronian *sedgwickii* Zone of the Llandovery to the lower Ludlow *nilssoni* Zone. A new genus was set up, *Ivanopleura*, containing the Wenlock *flexilis* Zone *O. dufrenoyi*, type species, together with *Miraspis rarissima* Šnajdr, 1975 from the *sedgwickii* Zone. The monotypic *Borkopleura* was also introduced, based on a new late Wenlock species *B. gorella*.

Whereas *O. dufrenoyi* and *M. rarissima* differ collectively from *Odontopleura* in the characters listed in the remarks of Šnajdr (1984*a*, p. 49), it seems to me that in these two species the overall form of the cephalon, thorax, and pygidium is so like that of *Odontopleura* that a division at the subgeneric level is more appropriate. Přibyl *et al.* (1986, p. 267) also believed *M. rarissima* belonged to *Odontopleura*. Thus in Bohemia early (Llandovery) species of *Odontopleura* seem to have occipital morphologies which range from lacking paired occipital spines, to possessing either short- or long-paired occipital spines, these different types being represented by *O.* (*Odontopleura*) *llandoveryiana*, *O*. (*Odontopleura*) *perpeta* Šnajdr, 1984*b*, and *O*. (*Ivanopleura*) *rarissima* respectively, all from the *sedgwickii Zone* of the Hyskov area.

Subgenus ODONTOPLEURA (ODONTOPLEURA) Emmrich, 1839

Type species. *Odontopleura ovata* Emmrich, 1839, p. 53; from a late Wenlock to lower Ludlow age Graptolithengestein glacial erratic of Niederkunzendorf, Silesia. By monotypy.

Odontopleura (*Odontopleura*) *ovata* Emmrich, 1839

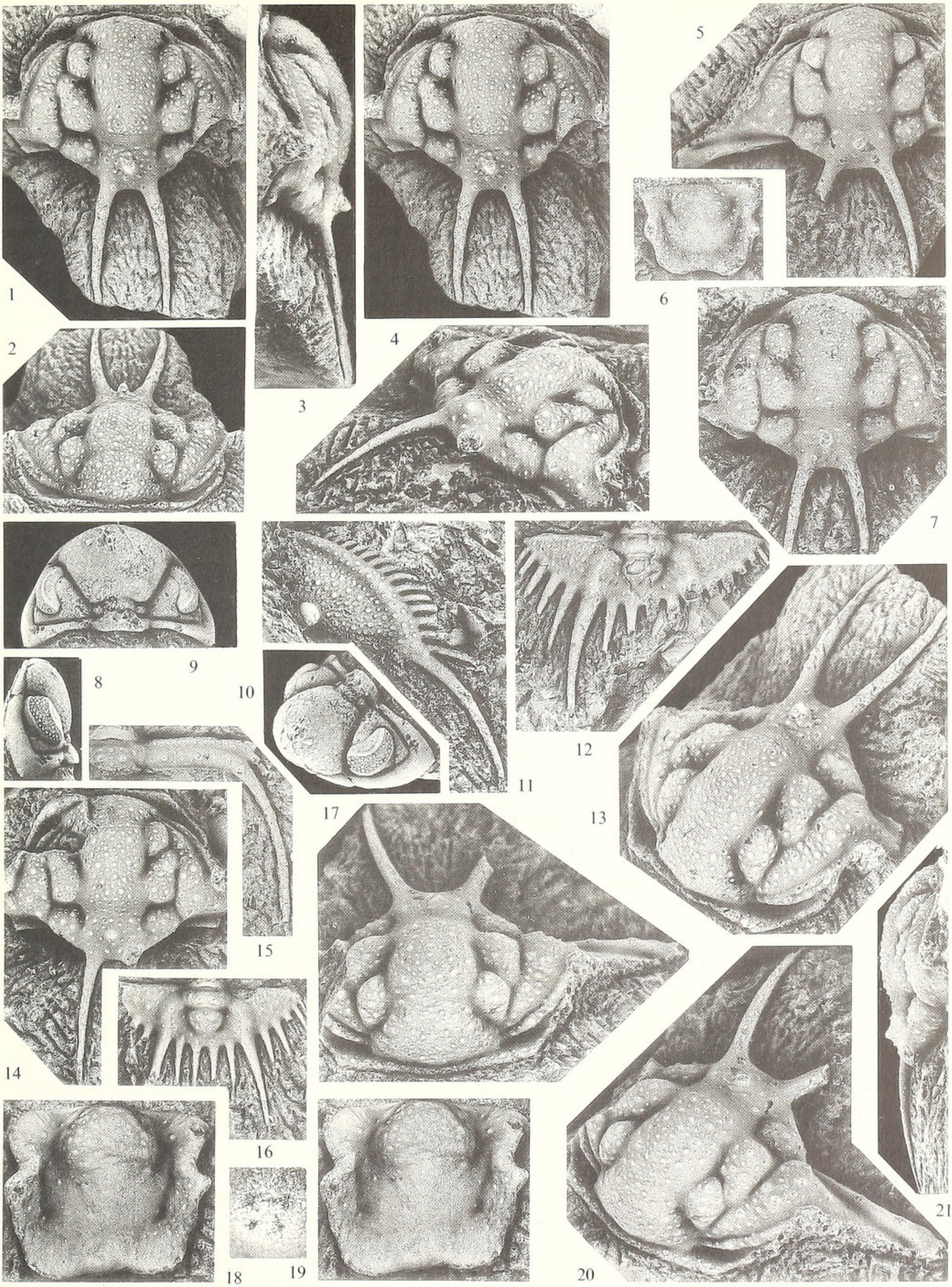
Plate 20, figs. 1–7, 11–21; Plate 21, figs 1, 3, 4, 8

1839 *Odontopleura ovata* Emmrich, p. 53, pl. 1, fig. 3.
1847 *Odontopleura Siemangii* Hawle et Corda; Hawle and Corda, p. 147.
1847 *Odontopleura Neumanni* Hawle et Corda; Hawle and Corda, p. 151.
1847 *Odontopleura tenuicornis* Hawle et Corda; Hawle and Corda, p. 155.
1863 *Acidaspis Jamesii*; Baily (*pars*) *in* Jukes and Du Noyer, p. 12.
1878 *Acidaspis Jamesii*; Baily (*pars*) *in* Kinahan, p. 40.
? 1930 *Ceratocephala* (*Acidaspis*) *ovata* Emmrich; Gaertner, p. 196, pl. 24, fig. 11.
1966 *Odontopleura ovata* Emmrich, 1839; Přibyl and Vaněk, p. 294, pl. 6, fig. 5; ?pl. 9, figs. 2–4.
1967 *Odontopleura ovata* Emmrich, 1839; Bruton, p. 216, pl. 30, fig. 1 (with synonymy).
1967 *Odontopleura ovata* (Emmrich, 1834); Hucke and Voigt, pl. 28, figs. 13 and 14.
1968 *Odontopleura ovata* Emmrich, 1839; Bruton, p. 8, pl. 1, figs. 1–4, 6, 7.
1969 *Odontopleura ovata* Emmrich, 1839; Schrank, p. 707, pl. 1, figs. 1–7; pl. 2, figs 1–5.
1970 *Odontopleura ovata* Emmrich, 1839; Alberti, p. 129, pl. 19, figs. 1–5.
1972 *Odontopleura ovata*; Schrank, p. 7.
1973 *Odontopleura ovata* Emmrich, 1839; Přibyl and Vaněk, p. 302, text-fig. 1-1.
1973 *Odontopleura ovata* Emmrich, 1839; Neben and Kreuger, pl. 103, figs. 1–4.
1976 *Odontopleura ovata* Emmrich; Siveter *in* Parkin, p. 595, table 1.
1979 *Odontopleura ovata* Emmrich, 1839; Šnajdr, p. 171.
? 1979 *Odontopleura prevosti* Barrande, 1846; Šnajdr, p. 171, pl. 1, fig. 1.
1981 *Odontopleura ovata* Emmrich, 1839; Thomas, p. 80, pl. 22, figs. 1–3 (with synonymy).
1981 *Odontopleura ovata* Emmrich, 1839; Siveter *in* Holland, p. 78, fig. 51.2, 4, 5.
? 1983 *Odontopleura ovata* Emmrich, 1839; Chatterton and Perry, p. 18.
1984*a* *Odontopleura ovata* Emmrich; Šnajdr, p. 50.
? 1984*b* *Odontopleura prevosti prevosti* Barrande, 1846; Šnajdr, p. 97, pl. 4, figs. 1–4.
1984*b* *Odontopleura prevosti tenuicornis* Hawle et Corda, 1847; Šnajdr, p. 98, pl. 4, figs. 5 and 6.
1984*b* *Odontopleura prevosti adriana* subsp. nov.; Šnajdr, p. 99, pl. 4, figs. 7 and 8.
? 1984*b* *Odontopleura salma* sp. nov.; Šnajdr, p. 99, pl. 3, figs. 8 and 9.
1984*b* *Odontopleura siemangi* Hawle et Corda, 1847; Šnajdr, p. 100, pl. 2, figs. 5–8.
1984*b* *Odontopleura omega omega* subsp. nov.; Šnajdr, p. 100, pl. 1, figs. 1–5.
1984*b* *Odontopleura omega kalidasa* subsp. nov.; Šnajdr, p. 101, pl. 2, fig. 9.

EXPLANATION OF PLATE 20

Figs. 1–7, 11–21. *Odontopleura* (*Odontopleura*) *ovata* Emmrich, 1839. All specimens are from the Annascaul Formation, locality 36. 1–3, 13, cranidium, TCD 12245; dorsal stereo-pair, frontal view, ×3, lateral, oblique views, ×4; figured Siveter *in* Holland 1981, fig. 51.4 as *O. ovata*. 4, 14, 19, 21, cranidium, TCD 12217; posterior oblique view, ×3·5, dorsal view, ×3, occipital organ, ×30, lateral view, ×3. 5, 17, 20, cranidium, TCD 12048; dorsal view, ×3, frontal, oblique views, ×4. 6, hypostoma, TCD 12320; ventral view, ×8. 7, cranidium, TCD 12592; dorsal view, ×4. 11, free cheek, TCD 12328; 'dorsal' view, ×4; figured Siveter *in* Holland 1981, fig. 51.2 as *O. ovata*. 12, pygidium, TCD 12362; dorsal view, ×3. 15, thoracic segment, TCD 12202; dorsal view, ×4. 16, pygidium, TCD 12543; dorsal view, ×3. 18, hypostoma, TCD 12243; ventral stereo-pair, ×5.

Figs. 8–10. *Ananaspis* sp. aff. *A. stokesii* (Milne Edwards, 1840). Small-eyed dimorph, cephalon, UM K2801, Annascaul Formation, locality 36; lateral, dorsal, oblique views, ×4.



SIVETER, Silurian trilobites

1984*b* *Odontopleura betina* sp. nov.; Šnajdr, p. 101, pl. 3, figs. 5–7.
1984*b* *Odontopleura rataji* sp. nov.; Šnajdr, p. 102, pl. 3, figs. 2–4.
1984*b* *Odontopleura* cf. *ovata* Emmrich, 1839; Šnajdr, p. 103, pl. 2, figs. 3 and 4.
1984*c* *Odontopleura prevosti tenuicornis* Hawle et Corda, 1847; Šnajdr, p. 198, pl. 8, fig. 3.
1984*c* *Odontopleura prevosti neumanni* Hawle et Corda, 1847; Šnajdr, p. 175, pl. 6, fig. 7.
1984*c* *Odontopleura siemangii* Hawle et Corda, 1847; Šnajdr, p. 192, pl. 12, fig. 1.
1984 *Odontopleura* sp.; Siveter *in* Thomas, Owens, and Rushton, p. 55.

Holotype. Articulated specimen comprising incomplete cephalon, partial thorax and pygidium, HU K162; figured Emmrich 1839, pl. 1, fig. 3; Bruton 1967, pl. 30, fig. 1; Hucke and Voigt 1967, pl. 28, fig. 13; Schrank 1969, pl. 1, fig. 1; Neben and Krueger 1973, pl. 103, fig. 1.

Type horizon and locality. As for type species. See Schrank 1969, p. 726.

Material. 106 cranidia, 97 free cheeks, 28 hypostomata, 88 pygidia, isolated thoracic segments.

Description. See Bruton 1967, p. 217; Schrank 1969, p. 707.

Discussion. The type specimen of *O*. (*O*.) *ovata* has the shortcomings of occurring in a glacial erratic, having each paired occipital spine broken off at its base and, it seems from the illustrations, having its glabellar sculpture somewhat abraded. With the considerable increase recently of species assigned to *O*. (*Odontopleura*) (see generic discussion), it has become more important to recognize the amount of variation within *ovata*, a task made difficult by the lack of assignable topotype material. Therefore, for practical purposes, the extra Graptolithengestein erratic material of *O*. (*Odontopleura*) assigned to *ovata* by Schrank (1969) from northern Germany assumes greater significance; I agree with this assignment and have used this material to assess the likely range of variation in the species.

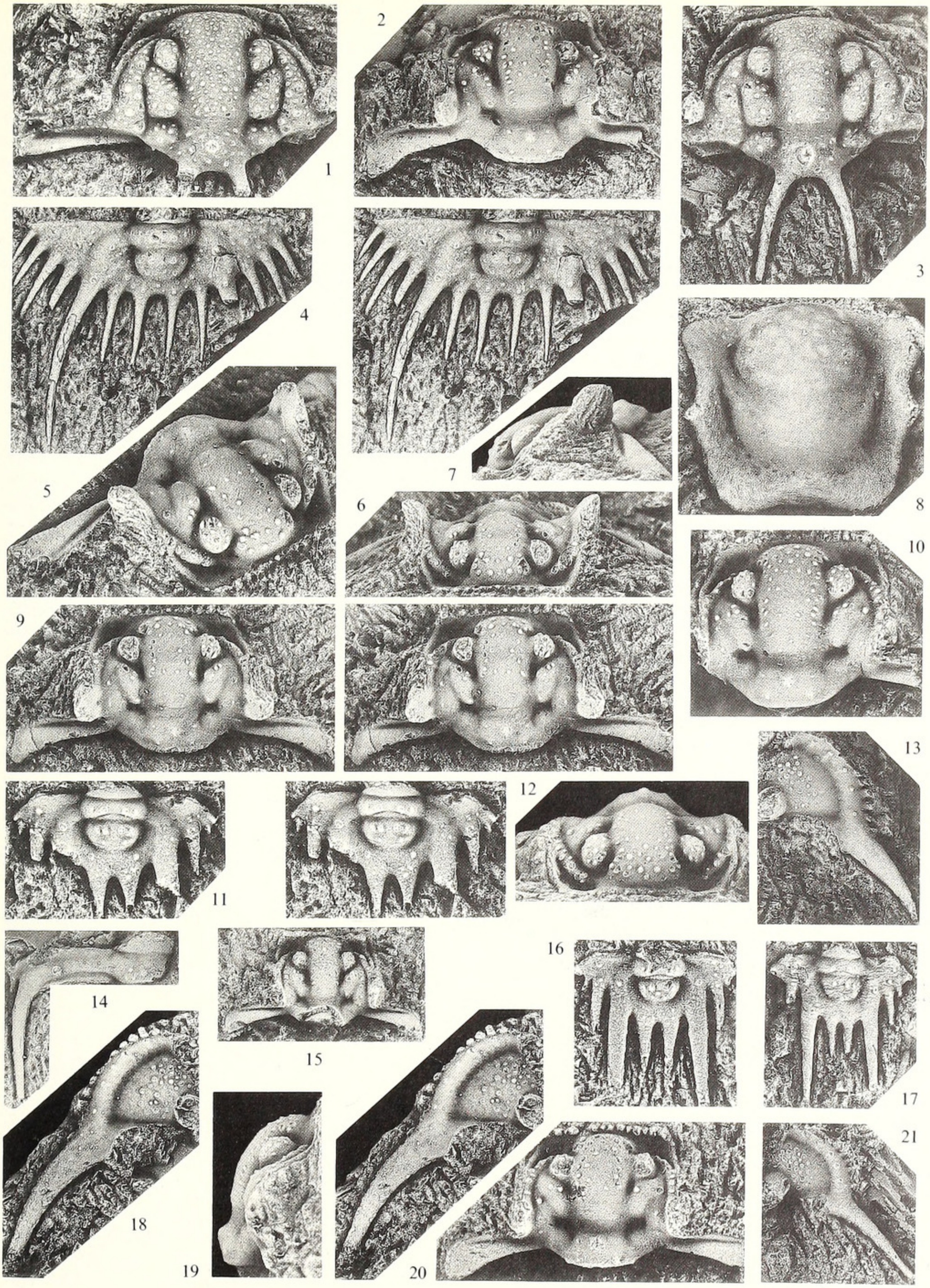
The Kerry *O*. (*Odontopleura*) material shows clear variation in the following features (all considered to be intraspecific and the material to belong to *ovata*): the angle of divergence of the paired occipital spines (Pl. 20, figs. 5 and 14), the single or bicomposite eye ridge (Pl. 20, figs. 13 and 20), the density and size of cranidial granules (pl. 20, fig. 7; Pl. 21, fig. 1), the number (four or five) of subsidiary pygidial spines external to the major border spines (Pl. 20, fig. 12; Pl. 21, fig. 4).

The synonymy above reflects the extent to which I have accepted, at least on the basis of the present evidence, that the many Bohemian *O*. (*Odontopleura*) species introduced or rehabilitated by Šnajdr (1984*b*) deserve separate recognition from *ovata*. Many of these have been exceedingly finely drawn, very often being based largely on minute sculptural differences, and have similar or the same occurrences. In contrast, Šnajdr (1984*b*), who did not refer to Schrank's (1969) work, did not identify *ovata* with certainty in Bohemia. *O*. (*O*.) *prevosti prevosti* Barrande, 1846 and *O*. (*O*.)

EXPLANATION OF PLATE 21

Figs. 1, 3, 4, 8. *Odontopleura* (*Odontopleura*) *ovata* Emmrich, 1839. All specimens are from the Annascaul Formation, locality 36. 1, cranidium, TCD 12252*a*; dorsal view, ×4. 3, cranidium, TCD 12219; dorsal view, ×4. 4, pygidium, TCD 12050*a*; dorsal stereo-pair, ×3; figured Siveter *in* Holland 1981, fig. 51.5 as *O. ovata*. 8, hypostoma, UM K2813*a*; ventral view, ×8.

Figs. 2, 5–7, 9–21. *Leonaspis parkini* sp. nov. All specimens are from the Annascaul Formation, locality 36. 2, cranidium, TCD 12275; dorsal view, ×5. 5–7, 9, holotype, cranidium, TCD 12207; oblique view, ×6, frontal, lateral views, dorsal stereo-pair, ×5. 10, 12, 19, dorsal view, TCD 12624; dorsal, frontal, lateral views, ×6. 11, pygidium, TCD 12203; dorsal stereo-pair, ×6. 13, free cheek, TCD 12576; 'dorsal' view, ×4. 14, thoracic segment, UM K2822; dorsal view, ×4. 15, cranidium, TCD 12206; dorsal view, ×5. 16, pygidium, TCD 12599; dorsal view, ×6. 17, pygidium, UM K2809; dorsal view, ×6. 18, free cheek, TCD 12327; 'dorsal' stereo-pair, ×4. 20, cranidium, TCD 12202; dorsal view, ×6. 21, free cheek, TCD 12301; 'dorsal' view, ×6.



SIVETER, Silurian trilobites

salma Šnajdr, 1984*b* (see also Šnajdr 1979, pl. 1, fig. 1) may differ from *ovata* but both are based on compressed mould specimens and are questionably put in synonymy. Both *prevosti prevosti* and *salma* occur in the *testis* Biozone at the same localities and seem to me synonyms; *prevosti prevosti* was considered a junior synonym of *ovata* by Prantl and Přibyl (1949), Bruton (1967, 1968), and subsequent authors until Šnajdr (1984*b*) resurrected it. The general lack of glabellar granules except for the larger paired granules in the lower Ludlow *O.* (*O.*) *palava* Šnajdr, 1984*b*, and the genuinely short occipital spines of *O.* (*O.*) *brevigena* and *O.* (*O.*) *perpeta* distinguish these from *ovata*. Incidentally, *O.* (*O.*) *perpeta* may be a junior synonym of *brevigena*, but the nature of the Bohemian material makes comparison with the excellent Canadian specimens difficult.

In some of the Irish *ovata* specimens (Pl. 20, figs. 1, 5, 13, 20) the 1p glabellar lobe is somewhat composite in nature due to the presence anteriorly of two secondary furrows. These originate from the 1p furrow just either side of the point at which it turns more sharply backward at the median glabellar lobe, and they run outward and backward to almost circumscribe a small raised area on the anterolateral, adaxial part of the 1p lobe. These furrows are also clearly present on the Bohemian *ovata* cranidium figured by Bruton (1968, pl. 1, fig. 1), and a similar morphology was noted by Whittard (1961, p. 200, pl. 27, fig. 1) in *Primaspis whitei*, which shows (at least) a single, secondary subtransverse furrow on the basal lobe. These secondary furrows are probably atavistic features. Bruton (1983, p. 882, text-fig. 2) has recently suggested that a likely Cambrian ancestor of the Odontopleurinae, of which *Odontopleura* is a relatively late representative and *Primaspis* a root stock, is *Acidaspides* Lermontova, 1951. *Acidaspides precurrens*, Lermontova, 1951, the type species, appears to show such furrows invading the 1p lobe (see Bruton 1983, pl. 88, figs. 12 and 15).

Occurrence. Annascaul Formation, locality 36 of Parkin 1976, p. 587, fig. 4, Annascaul inlier. Also from the Wenlock to lower Ludlow of Czechoslovakia (Bruton 1968; Šnajdr 1984*b*, *c*), Poland (Tomczykowa 1957), German Democratic Republic (Schrank 1969, 1972), German Federal Republic (Alberti 1970), and Anglo-Welsh area (Thomas 1981). Possibly from the late Wenlock of the southern Urals (Bruton 1968), the late Wenlock to lower Ludlow of north-west Canada (Chatterton and Perry 1983), and the Silurian of the Carnic Alps (Gaertner 1930).

Genus PRIMASPIS Richter and Richter, 1917

Type species. *Odontopleura primordialis* Barrande, 1846, p. 29; from the middle Ordovician, Děd near Beroun, Czechoslovakia. By original designation. Bruton (1968, p. 12) gives the type horizon as the Liben Formation, whereas Horný and Bastl (1970, p. 249) and Šnajdr (1984*d*, p. 50) give it as the Letná Formation.

Discussion. Since *Primaspis* was established a subdivision of it has been attempted by Přibyl and Vaněk (1965) who proposed *P.* (*Meadowtownella*), Chatterton (1971) who set up *P.* (*Taemasaspis*), and Šnajdr (1984*d*) who erected *P.* (*Bojokoralaspis*). Bruton (1968) rejected *P.* (*Meadowtownella*) and subsequently this subgenus has not been formally used by other authors, though Ramsköld (1984) has recently suggested that it is a coherent group. *P.* (*Taemasaspis*) was synonymized by Thomas (1981) with *Dudleyaspis*, a procedure accepted by Ramsköld (1984), by the present author, and also, at least on present knowledge, by Chatterton and Perry (1983, p. 45) and by Chatterton and Wright (1986, p. 293). Of the characters listed by Šnajdr (1984*d*, p. 54) differentiating *P.* (*Bojokoralaspis*) from *P.* (*Primaspis*), it seems to me from his figures that only the absence of paired occipital spines in his new subgenus is a potentially usable character and, in any case, if a subgeneric distinction is made on this basis, *P.* (*Bojokoralaspis*) is really best regarded as a junior synonym of *P.* (*Meadowtownella*), type species *P. whitei* Whittard, 1961.

The validity of separating odontopleurid subgenera on the basis of posterior occipital or cephalic spines is debatable. Spinose and non-spinose species have, for example, been placed in the nominate subgenera of *Odontopleura* (see generic discussion above), *Diacanthaspis* (Chatterton and Perry 1979, pp. 1333–1334) and *Dudleyaspis* (Chatterton and Perry 1983, p. 44); also Whittington (1956*a*), Bruton (1968), and others have considered the paired occipital spines in the type species of *Primaspis* to be of no greater than specific value, though admittedly in *Primaspis* only the type species of the genus was then known to have this feature, and in his recent work Šnajdr (1984*d*) assigned to the nominate subgenus three other species with such spines. For the present I take a similar view about *Primaspis* as did Chatterton and Perry (1983) and Chatterton and Wright (1986) with respect to the *Taemasaspis–Dudleyaspis* situation; unless the spinose and non-spinose forms of *Primaspis* can be shown to belong to separate lineages, which can then be considered distinct subgenera or even genera, I prefer to regard all as belonging to *Primaspis* (*Primaspis*). It appears to me, in conjunction, that there is difficulty in recognizing as specifically distinct at least two of the four species Šnajdr (1984*d*) placed in *Primaspis* (*Primaspis*), namely *P. propriofan* and *P. oxitron*, both described by him as new. Acceptance of the non-spinose *Primaspis* species as a distinct higher taxon would be made easier if this were not the case.

Primaspis mendica sp. nov.

Plate 22, figs. 1–13, 15, 16, 18, 21

1863 *Acidaspis Jamesii*; Baily (*pars*) *in* Jukes and Du Noyer, p. 12.
1878 *Acidaspis Jamesii*; Baily (*pars*) *in* Kinahan, p. 40.
1976 *Primaspis* sp.; Siveter *in* Parkin, p. 595, table 1.
1981 *Primaspis* sp.; Siveter *in* Holland, p. 78, figs. 51. 1, 3, 6.
1984 *Primaspis* sp.; Siveter *in* Thomas, Owens, and Rushton, p. 55.

Derivation of name. From the Latin, *mendicus*, beggarly, reflecting the coarse appearance of the cuticular sculpture.

Holotype. Cranidium lacking outer part of left fixed cheek, TCD 12254; Plate 22, figs. 1, 2, 5, 11.

Type horizon and locality. Annascaul Formation, locality 36 of Parkin 1976, p. 587, fig. 4, Annascaul inlier.

Additional material. 20 cranidia, 10 free cheeks, 15 hypostomata, 15 pygidia, isolated thoracic segments.

Diagnosis. A species of *Primaspis* with glabellar outline subparabolic to horseshoe shaped. Preglabellar area extremely short (sag.). Cranidium with mid-length of palpebral lobe opposite a point slightly anterior to the mid-length of basal glabellar lobe. Median occipital spine sited anteriorly, two-thirds of the length from posterior margin to occipital furrow. Four internal and two external secondary spines on pygidium; inner spine adjacent to major spine is not fused to it at its base. Sculpture of cranidium, free cheek, thoracic segments, and pygidium dominated by large, moderately to densely distributed granules; main field of free cheek has pitting.

Description. Cranidium 1·9 to 2·0 times as wide as long. Glabella including occipital ring 0·8 to 0·9 times as wide across basal lobes as long (sag.), subparabolic to horseshoe shaped in outline, very convex (sag. and tr.), in dorsal view projects anteriorly fractionally in front of anterior cranidial margin (Pl. 22, fig. 1). Occipital ring 3·5 times as wide as long (sag.) with median occipital spine sited anteriorly two-thirds of the distance between posterior margin and occipital furrow. Lateral occipital lobe defined anterolaterally by short furrow extending posteriorly one-third the length (exs.) of occipital ring from opposite inner margin of 1p lobe.

Occipital furrow widest (sag. and exs.) and shallowest behind central glabellar area, posterior to 1p lobe it narrows and deepens sharply. Lobe 1p slightly less than one-third as wide as glabellar width, cat's-ear shaped, drawn out and pointed anterolaterally with its anterior, abaxial margin being slightly sinuous, has independent inflation to central glabellar area from which it is completely separated by shallow, broad posterior extension of 1p furrow. The latter is moderately deep at axial furrow, trends gently backward and becomes deeper adaxially between 1p and 2p lobes, turns sharply backward and shallows at central glabellar area. Lobe 2p subquadrate in dorsal view (Pl. 22, fig. 1) and cat's-ear shaped in oblique view (Pl. 22, fig. 5), about two-thirds the size of 1p, strongly convex (exs. and tr.), clearly divorced from central glabellar area by shallow, broad furrow connecting furrows 1p and 2p. Furrow 2p well defined, moderately deep, curves inward and backward. Lobe 3p very small compared with lobe 2p, clearly delimited anteriorly by sharply incised, short 3p furrow which runs into 2p furrow on side of glabella (Pl. 22, figs. 5 and 11). Frontal glabellar lobe quite strongly convex in outline, falls steeply anteriorly. Central glabellar area widest between 1p furrows.

Axial furrow broad and shallow and trends forward and inward at side of occipital ring, is slightly deeper and narrower curving around base of lobe 1p and running sinuously forward, shallowing slightly at anterolateral part of lobe 1p, becomes slightly deeper around 2p lobe before trending inward below frontal lobe to meet preglabellar furrow. Preglabellar area extremely short sagittally, lengthens (exs.) toward facial suture. Preglabellar furrow is clearly defined. Anterior cranidial margin very broadly convex forward.

Outer part of fixed cheek about 0·8 times as wide as occipital ring. Posterior border narrow and tightly convex adaxially, gradually expands in width (exs.) abaxially; border furrow widest (exs.) about midway between axial furrow and facial suture, moderately deep. Fixed cheek adaxial to eye is strongly convex (exs. and tr.), about as wide as lobe 1p, anteriorly it is drawn inward, narrows rapidly, and falls steeply. Very strong eye ridge curves inward to meet axial furrow just in front of base of 2p furrow. Small, sunken subtriangular area between anterior margin, suture, and eye ridge. Low, steeply raised palpebral lobe is about one-third as long as 1p lobe, it is positioned half-way or slightly less across fixed cheek abaxially from axial furrow and its mid-length lies opposite a point just anterior to the mid-length of 1p lobe; palpebral furrow distinct. Anterior branch of facial suture runs forward and inward to cranidial margin; posterior branch trends outward and backward from eye, turns exsagittally at genal angle to meet posterior border; both branches run on a weak sutural ridge.

Lateral border of free cheek (Pl. 22, figs. 6 and 15) moderately convex, broadens posteriorly. Lateral margin has an estimated twelve to fourteen fringing marginal spines (the remains of at least eleven are present) that increase in length gradually posteriorly until the last one, sited on base of genal spine, which is slightly shorter than the penultimate spine. Genal spine short, about one-third the length of the rest of the free cheek; it is more or less straight (Pl. 22, fig. 6) or at most is extremely gently curved (Pl. 22, fig. 15). Lateral border furrow broad, slightly deeper anteriorly than posteriorly. Main field of cheek relatively wide and broadly convex; eye socle very narrow. Visual surface kidney-shaped with numerous small lenses.

Hypostoma (Pl. 22, figs. 3 and 16) subrectangular in outline, about 1·4 times as wide as long. Anterior border lacking medially, widens (exs.) quickly abaxially; laterally, border widens (tr.) gradually posteriorly, is moderately convex and falls steeply into border furrow; posterior border gently convex (sag. and exs.). Notch and shoulder strongly developed on lateral margin, posterior margin transversely directed, anterior margin broadly convex forwards. Anterior border furrow scarcely present sagittally, broadens and deepens towards anterior wing; lateral border furrow deepest, well marked along its whole length; posterior border furrow weak medially, becomes better defined abaxially. Middle body moderately convex (tr. and sag.); anterior lobe oval (tr.), posterior lobe crescentic; finely incised median furrow trends backward and inward for a short distance before fading out. Maculae small, oval, weakly inflated, positioned close together on projected adaxial path of median furrow just either side of median line.

Isolated thoracic segments (Pl. 22, figs. 7–9) show moderately convex axial ring. Articulating furrow divided into two medially by a narrow, gently raised strip which lenses out either side the sagittal line towards the weak axial furrow. Articulating half-ring well developed. Pleural furrow narrow (exs.), well incised. Posterior pleural band about three times as wide (exs.) as anterior band, developed abaxially into relatively short, stout spine; form of anterior pleural spine unknown. Very narrow facet behind posterior band.

Pygidium (Pl. 22, figs. 4, 12, 21) 3·4 to 3·7 times as wide as long excluding articulating half-ring; posterior margin excluding spines is saucer-shaped. Axis has two rings and a very short terminal piece. Second axial

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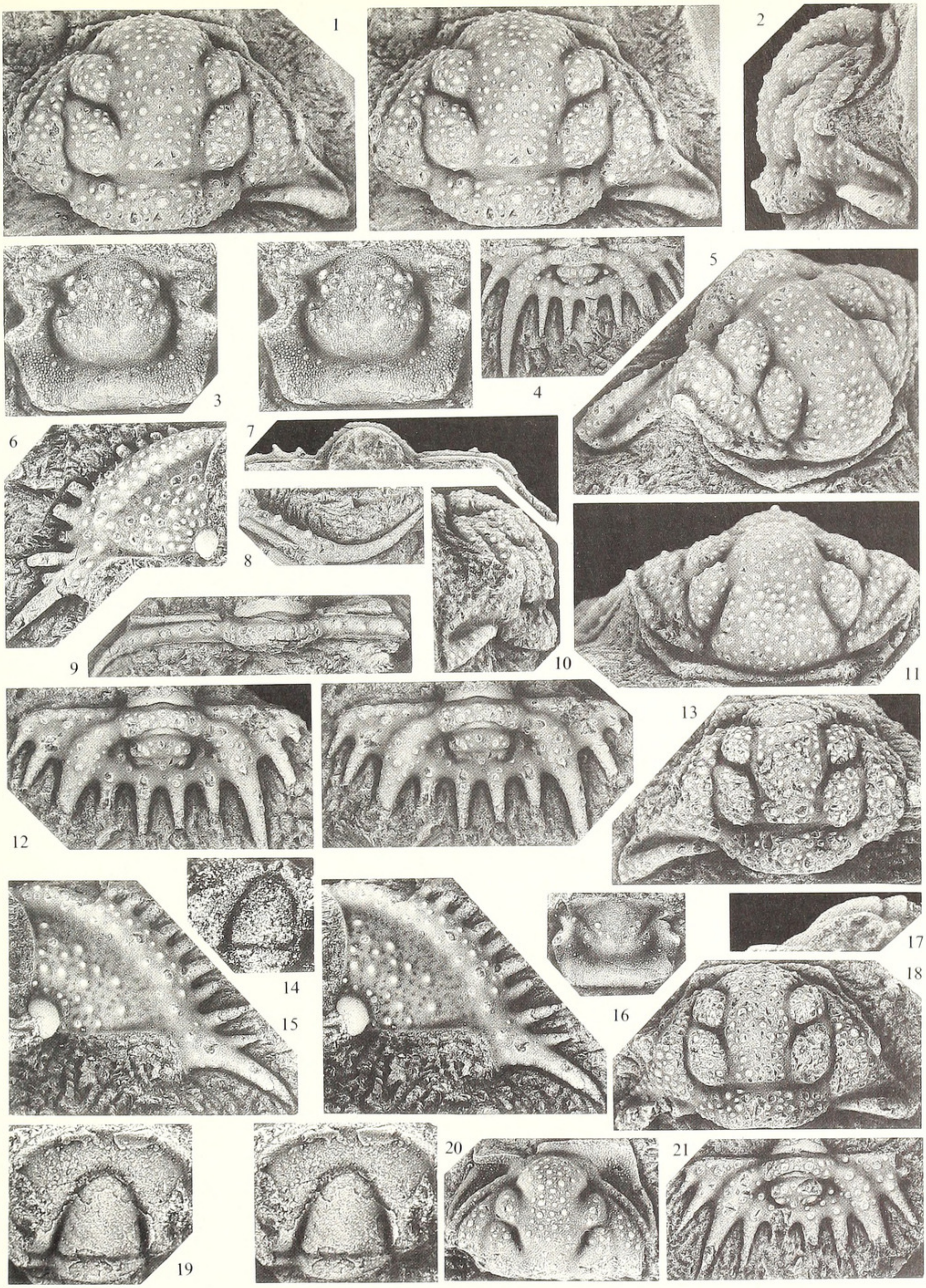
EXPLANATION OF PLATE 22

Figs. 1–13, 15, 16, 18, 21. *Primaspis mendica* sp. nov. All specimens are from the Annascaul Formation, locality 36. 1, 2, 5, 11, holotype, cranidium, TCD 12254; dorsal stereo-pair, lateral, oblique, frontal views, ×4; figured Siveter *in* Holland 1981, fig. 51.1 as *Primaspis* sp. 3, hypostoma, TCD 12318; ventral stereo-pair, ×8. 4, pygidium, TCD 12211; dorsal view, ×5. 6, free cheek, UM K2807; 'dorsal' view, ×4. 7 and 9, thoracic segment, TCD 12309; frontal, dorsal views, ×4. 8, thoracic segment, TCD 12650; oblique view, ×4. 10 and 13, cranidium, TCD 12622; lateral, dorsal views, ×4. 12, pygidium, TCD 12202; dorsal stereo-pair, ×5; figured Siveter *in* Holland 1981, fig. 51.6 as *Primaspis* sp. 15, free cheek, TCD 12596; 'dorsal' stereo-pair, ×5; figured Siveter *in* Holland 1981, fig. 51.3 as *Primaspis* sp. 16, hypostoma, TCD 12331; ventral view, ×8. 18, cranidium, TCD 12255; dorsal view, ×4. 21, pygidium, TCD 12210; dorsal view, ×5.

Figs. 14, 17, 19. *Scharyia* sp. Both specimens are from the Annacaul Formation, locality 36. 14, cranidium, TCD 12145; dorsal view, ×10. 17 and 19, cranidium, TCD 12144; lateral view, dorsal stereo-pair, ×10.

Fig. 20. *Leonaspis coronata coronata* (Salter, 1853). Cranidium, TCD 12197, Annascaul Formation, locality 36; dorsal view, ×5.



SIVETER, Silurian trilobites

ring has ankylosed half-ring. First axial ring is narrowest sagittally, becomes wider (exs.) abaxially. Axial furrow weakly developed beside first axial ring and centrally behind terminal piece, best defined beside articulating half-ring, second axial ring, and the side of terminal piece. Pleural area sunken beside second axial ring and terminal piece, dominated by strongly convex (tr.) ridge which gradually expands (tr.) abaxially from first axial ring and is most swollen just inside posterior margin; this ridge then narrows gradually into gently curved, stout, major border spine. Very slight ridge runs obliquely backward and outward across pleural area to connect with first secondary spine outside major spine; a second external secondary spine is also present. There are two pairs of inner secondary spines, estimated to be about half as long as major spines. Indistinct posterior border present between major spines, becomes lost abaxially to them.

Cranidium, excluding all furrows and to a lesser extent anterior border and subtriangular area, covered with large to medium sized granules which are moderately loosely (Pl. 22, fig. 1) to densely distributed (Pl. 22, figs. 13 and 18). Whole cranidium has a very finely granulated groundmass. Cranidial sculpture thus essentially bimodal. Free cheek has medium to large granules moderately widely to loosely scattered on main field, lateral border, and base of genal spine. Main field and lateral border furrow also has moderately to loosely distributed pits. All the free cheek has a fine, granulate groundmass. Hypostoma has large to medium sized granules on central body either side of median furrow, medium granules on centre of anterior lobe and inner part of posterior border near border furrow, and a dense overall covering of fine granules except for the border furrows. Axial ring and posterior pleural band have large to medium granules; anterior pleural band, articulating half-ring and furrow lack coarse granules; posterior pleural spine (Pl. 22, fig. 8) has small granules. Pygidial axial rings excluding half-rings, terminal piece, pleural ridges, and outer pleural area inside margin have large to medium sized granules; large granule on each spine base; large, paired granules on adaxial part of major pleural ridge and axial rings. Pygidial spines have small granules. Whole pygidium finely granulated.

Discussion. This new species appears to be the youngest member of the genus. The combination of the characters given in the diagnosis, particularly the anterior position of the eye, easily distinguish it from other *Primaspis* species, of which there are very few recorded or generally agreed upon from the Silurian. *P. mackenziensis* Chatterton and Perry, 1983 (pl. 5, figs. 1–24) from the early Llandovery of the Mackenzie Mountains, north-west Canada has, amongst other things, the eye placed opposite the occipital furrow and basal part of lobe 1p, a more sharply tapering glabellar outline, a relatively longer, posteriorly extended occipital ring, and longer genal and major pygidial spines.

Primaspis kreugeri Schrank, 1969 from the Baltic Graptolithengestein glacial erratics can easily be distinguished from the Irish species and in any case belongs to *Anacaenaspis*, as Thomas (1981) and Ramsköld (1984) have noted. *P. mendica*, though being clearly specifically distinct from Ordovician *Primaspis* species, has a reasonably similar glabella to several of the earliest of them, all of middle Ordovician age, for example *P. whitei* and *P. rorringtonensis* Whittard, 1961 from the Shelve inlier, *P. ascitus* Whittington, 1956*a* from Virginia, *P. koral* Šnajdr, 1984*d* from Czechoslovakia, and *P. multispinosa* Bruton, 1965 from Norway.

Occurrence. Known only from the type horizon and locality.

Genus LEONASPIS Richter and Richter, 1917

Type species. Odontopleura leonhardi Barrande, 1846, p. 58; from the Kopanina Formation (Ludlow), Koledník, Beroun district, Czechoslovakia. By original designation.

Discussion. Over the past thirty years there have been many comments in the literature on the origin of *Leonaspis* and how clearly to distinguish it from *Primaspis*. Investigation of such problems requires examination of all Silurian and Ordovician species of both genera. Comparison of the *Leonaspis* and *Primaspis* species described in this paper endorses the need for such a study.

Prantl and Přibyl (1949, p. 146), as commented on by Whittington (1956*a*, p. 506; 1956*b*, p. 199), noted the *Primaspis*-like features displayed by *Leonaspis coronata* (Salter, 1853) and *Leonaspis deflexa* (Lake, 1896). Whittington (1956*b*) maintained both these species in *Leonaspis*, which he suggested was derived from *Primaspis*, and he provided new diagnoses for both genera. Bruton (1968, p. 11) later said that the most reliable way of distinguishing the two was the presence in *Primaspis* of a 3p lobe, other features having proved to be less useful. Chatterton and Perry (1979) claimed that *Leonaspis* was derived from *Diacanthaspis* and they later (1983) suggested that *Leonaspis* might be diphyletic, those species with two secondary pygidial spines between the major border spines having come from *Diacanthaspis*, and those with four inner secondary spines having their origin in *Primaspis*. The two-spined forms are overwhelmingly the most common type in North America, only *L. churkini* Chatterton and Perry (1979) from California having four, but they occur also in Europe, Asia, and Australia; the four-spined forms are abundant in Europe and include the type species, *L. leonhardi*. This dichotomy of *Leonaspis* taxa had earlier been commented on by Campbell (1977, p. 113).

The overall morphology of the *L. coronata coronata* specimens figured in this study, particularly the form of the glabella and 1p lobe, seems closer to that of *Primaspis mendica* sp. nov. and other *Primaspis* species such as the late Ordovician *P. bacculenta* McNamara, 1979 (see Owen 1981, pl. 17, figs. 6–13), rather than to *Leonaspis parkini* sp. nov. and many other *Leonaspis* species, for example *L. williamsi* Whittington, 1956 (see Campbell 1977, pl. 32). The Kerry *coronata* material lacks a 3p lobe and I have assigned it to *Leonaspis* (cf. Pl. 21, fig. 5; Pl. 22, fig. 5; Pl. 23, fig. 9), though it seems questionable to place generic emphasis on such a small feature, whose presence is sometimes difficult to determine unequivocally. Thomas (1981) does not describe a third lobe in English material of *coronata*, though there appears the suggestion of one on one of his figured specimens (pl. 23, fig. 17*b*).

Leonaspis coronata coronata (Salter, 1853)

Plate 22, fig. 20; Plate 23, figs. 9–23

1976 *Leonaspis* sp.; Siveter *in* Parkin, p. 595, table 1 (*pars*).
1981 *Leonaspis coronata* (Salter, 1853); Thomas, p. 88, pl. 23, figs. 10, 12–14, 16–18, 20, 22–26 (with full synonymy).
1984 *Leonaspis coronata* (Salter); Thomas *in* Thomas, Owens, and Rushton, p. 53.
1984 *Leonaspis* sp.; Siveter *in* Thomas, Owens, and Rushton, p. 55 (*pars*).
1984 *Leonaspis coronata coronata*; Ramsköld, p. 257.

Lectotype. Selected Whittard 1938, p. 109, internal mould of incomplete cephalon, GSM 36734; see Thomas 1981, p. 88, pl. 23, fig. 13.

Type horizon and locality. Ludlow Series, lower Gorstian Stage, Vinnal Hill, Ludlow district, Shropshire.

Material. Eleven cranidia, four free cheeks, two hypostomata, two pygidia, isolated thoracic segments.

Description. Thomas (1981) has given a full description of this subspecies, which can apply in general to the present Irish material, apart from the points raised below.

Discussion. The Kerry material clearly belongs to the late Wenlock–early Ludlow *L. coronata*. In addition to the nominate subspecies Ramsköld (1984) has recently introduced *L. coronata bufo* from the late Wenlock of Gotland and he regarded the coeval *L. marklini* (Angelin, 1854), which was also based on Gotland material, as a *nomen dubium*. Given that it is impossible to re-collect topotype material of *marklini* I agree with this action, but it is unfortunate because *marklini* has become entrenched in the literature for over a century and it is quite possible, if not probable, that *coronata bufo* is its junior synonym. Certainly *coronata bufo* is of a similar morphology to that ascribed over the years to *marklini*, as is evidenced by Ramsköld placing in the synonymy list of *coronata bufo* the late Wenlock Graptolithengestein erratic material from the Baltic described by Schrank (1969, pl. 4, figs. 9 and 10; pl. 5, figs. 1–6; pl. 6, figs. 1, 2, 4–7) under the name of Angelin's species.

There appears little variation in the Kerry material, the most obvious being the sparseness of larger granules on one of the specimens (Pl. 23, figs. 9, 22, 23), but this could be preservational, and in any case should be considered intraspecific. From comparing *coronata coronata* (see Thomas 1981, p. 88, pl. 23, figs. 10, 12–14, 16–18, 20, 22–26; Whittington 1956*a*, pl. 59, fig. 12) with *coronata bufo* (Ramsköld 1984, p. 257, pl. 30, figs. 6, 14–16, pl. 31, figs. 1–6; Schrank 1969) the following differences separate the subspecies. The genal spine is longer in *coronata bufo* and reaches back to about the seventh thoracic segment, whereas in *coronata coronata* it extends back to the fourth. In *coronata bufo* the posterior pleural spines are slender and pointed, longest on the sixth segment, short on the anterior three segments, but distinctly shorter only on the first segment; in *coronata coronata* the posterior pleural bands are extended into thick pleural spines which on the anterior four segments are short, but on the posterior six segments are long. The major pygidial border spines of *coronata bufo* are diagnosed as being directed exsagittally, or are slightly divergent posteriorly; in the nominate subspecies they incurve posteriorly.

The length of the genal spine of the Irish material (Pl. 23, figs. 19 and 20) seems closer to that of *coronata coronata*, though I have no articulated material to assess its posterior extension alongside the thorax; isolated thoracic segments (Pl. 23, fig. 14) also seem to be of the less slender *coronata coronata* type. Only two Irish pygidia (Pl. 23, figs. 15 and 16) are known, and only one of these has a single, complete major border spine, which is directed more or less exsagittally. It is questionable which subspecies this single specimen most resembles, especially as in one figured specimen (Schrank 1969, pl. 6, fig. 1) put (Ramsköld, 1984) in synonymy of *coronata bufo* one of the major spines is slightly incurved, and in another (Schrank 1969, pl. 6, fig. 2) the spines also appear inwardly directed.

In both *coronata coronata* and *coronata bufo* three prominent granules at the base of each major border spine are described and a single one at the base of each inner secondary spine. One of the Irish pygidia (Pl. 23, fig. 16) apparently shows just one larger granule at the base of the only major border spine preserved on this specimen, and lacks a larger granule inside the base of each of the innermost pair of secondary spines, though one topotype specimen of *coronata bufo* (Ramsköld 1984, pl. 31, fig. 2) appears the same in this latter respect. The second Irish pygidium (Pl. 23, fig. 15) may have the three larger granules at the major spine base, but they are only slightly larger (not distinctly larger as in typical *coronata coronata* or *coronata bufo*) than the fine, dense, background granulation. Also in both *coronata coronata* and *coronata bufo* there is a prominent granule at the fulcrum of each thoracic segment and one half-way across each pleura. The first of these, though again somewhat less prominent, is present in the Irish material (Pl. 23, fig. 14), yet the second one appears absent. Thomas (1981) did not describe any pitting which might represent rudimentary genal cecae on the free cheek of *coronata coronata*; this feature is present in the Irish specimens, but Thomas's illustrations of free cheeks are small and these structures are not easily picked out if present. However, they do exist in *coronata bufo* (Ramsköld 1984, pl. 30, fig. 6*a*, *b*). Also Thomas (1981) described, but did not figure, the hypostoma of *coronata coronata*. The Irish hypostoma fits his description except it (Pl. 23, figs. 10 and 21) has a slightly posteriorly convex posterior margin, not 'weakly bifurcate' as described for the English material. The Irish specimens agree entirely with those figured by Ramsköld (1984, pl. 30, figs. 15 and 16) for *coronata bufo*.

Both the English and Baltic material of *coronata* seem to have a better defined contact of the lateral and posterior border furrows on the free cheek inside the genal spine base, and a slightly better impressed lateral border furrow than is the case in the Irish free cheek, but these minor differences appear to be the only non-sculptural distinctions setting the non-Irish material (collectively) apart.

Because of the form of its genal spine and thoracic segments, the Irish material appears to be excluded from *coronata bufo*. I have, considering the sample size, not placed too much weight on the slight differences of the Irish examples from the English specimens of *coronata coronata*, and on balance placed them without qualification in this subspecies. Closely related species include *L. mutica* (Emmrich, 1844), *L. muldensis* Bruton, 1967, and *L. varbolensis* Bruton, 1967 (see Bruton 1967; Schrank 1969; Temple 1970; Thomas 1981; Howells 1982; Ramsköld 1984).

Occurrence. Annascaul Formation, locality 36 of Parkin 1976, p. 587, fig. 4; late Wenlock part of the Coalbrookdale Formation, Dudley, West Midlands, England; Much Wenlock Limestone Formation of the West Midlands and Welsh Borderland; the late Wenlock of South Wales; the Ludlow, lower Gorstian Stage, of the Welsh Borderland (see Thomas 1981, p. 88).

Leonaspis parkini sp. nov.

Plate 21, figs. 2, 5–7, 9–21

1863 *Acidaspis Jamesii*; Baily (*pars*) *in* Jukes and Du Noyer, p. 12.
1878 *Acidaspis Jamesii*; Baily (*pars*) *in* Kinahan, p. 40.
1976 *Leonaspis* sp.; Siveter *in* Parkin, p. 595, table 1 (*pars*).
1984 *Leonaspis* sp.; Siveter *in* Thomas, Owens, and Rushton, p. 55 (*pars*).

Derivation of name. For Dr John Parkin, geological mapper of the Annascaul inlier.

Holotype. A complete cranidium, TCD 12207; Plate 21, figs. 5–7, 9.

Type horizon and locality. Annascaul Formation, locality 36 of Parkin 1976, p. 587, fig. 4, Annascaul inlier.

Additional material. Eighteen cranidia, five free cheeks, three pygidia, isolated thoracic segments.

Diagnosis. A species of *Leonaspis* with obliquely elongate 1p lobe; axial furrow at anterolateral corner of this lobe extremely weak or lacking, so that here 1p lobe tends to merge with inner part of fixed cheek which is weakly developed or pinched out by convergence of the lobe and eye ridge. Lateral and posterior border furrow on free cheek well developed; genal spine about as long or slightly longer than main part of free cheek. Pygidium with two inner secondary spines less than half as long as major border spines; one external secondary spine of about the same or slightly shorter length plus a second very small external secondary spine. Whole dorsal surface of exoskeleton extremely finely and densely granulate. Anterior part of glabella, 2p lobe, eye ridge, anterior cranidial margin, and inner part of main field of free cheek with medium sized, moderately densely distributed granules; posterior part of glabella has a few, very widely scattered small to medium granules; granules sparse on central glabellar area. Occipital ring has median organ with four symmetrically arranged pits, and two granule pairs, the posterior pair of which is the larger. Lateral border of free cheek with a single row of five, isolated medium sized granules. Two granule pairs on each pygidial axial ring, the inner pair of each the larger.

Description. Cranidium 2·0 (Pl. 21, fig. 15) to 2·3 times (Pl. 21, fig. 9) as wide as long. Glabella including occipital ring 0·8 to 0·9 times as wide as long (sag.), bell-shaped in outline, in sagittal profile gently to moderately convex from occipital furrow to frontal lobe, falls more steeply to preglabellar furrow. Occipital ring extended posteriorly behind central glabellar area so that here it is longest (sag. and exs.), becomes shorter (exsag.) behind 1p lobe due to sharp forward flexure of posterior margin; median occipital organ with four subquadrately arranged pits is sited slightly anteriorly (Pl. 21, figs. 2 and 10); abaxially, occipital ring has a weakly inflated occipital lobe which is outlined anterolaterally by short, broad posterior extension of longitudinal glabellar furrow. Occipital furrow is very broad (sag.) and shallow behind central glabellar area, deeper and narrower behind 1p lobe which is very elongate and trends forward and outward, becoming more or less confluent with fixed cheek anteriorly (Pl. 21, fig. 20), separated from central glabellar area by a broad (tr.), shallower part of the longitudinal furrow. Furrow 2p deep, runs inward and backward. Lobe 2p subcircular and strongly convex (tr. and exs.), very clearly separated from central gabellar area by distinct furrow. Frontal lobe moderately convex in dorsal outline.

Axial furrow extremely broad and shallow and runs inward from posterior cranidial margin to occipital furrow, becomes narrower and slightly better defined as it trends outward alongside lobe 1p, shallows and more or less disappears at anterolateral margin of this lobe (Pl. 21, fig. 5), is well defined around 2p lobe where it merges with anterior extension of furrow which runs inward from palpebral furrow on the inside of eye ridge. Preglabellar furrow shallow; preglabellar area short (sag.), lengthens (exs.) abaxially. Anterior cranidial margin straight (tr.) (Pl. 21, fig. 9) to extremely gently convex forwards (Pl. 21, fig. 20).

Outer part of fixed cheek 0·9 times as wide as occipital ring, very narrow (exs.); posterior border quite strongly convex and narrow adaxially, becomes flatter and very much wider (exs.) near facial suture; posterior border furrow is long, narrow, rille-like, fades abaxially. Inner part of fixed cheek adaxially from eye is about as wide or slightly wider that 1p lobe, it falls steeply posteriorly, less so anteriorly, narrows rapidly forwards alongside lobe 1p just anterior to which it pinches out. Palpebral lobe is high (Pl. 21, fig. 6), rises up almost vertically from fixed cheek before becoming less steeply inclined towards its outer margin; mid-length of lobe is opposite posterior margin of lobe 1p or outer part of occipital furrow; length of lobe is about two-thirds to three-quarters that of 1p lobe. Eye ridge is pronounced, curves strongly forward and inward in front of lobe 2p. Relatively large subtriangular area between facial suture, anterior cranidial margin, and eye ridge. Anterior branch of facial suture runs forwards for a short distance before turning inward to anterior margin; posterior branch trends transversely from eye then curves broadly backward to posterior margin (Pl. 21, figs. 5 and 6).

Main field of free cheek (Pl. 21, fig. 18) relatively small in area, moderately strongly convex from visual surface to lateral border furrow, which is well developed and moderately wide (tr.) from anterior branch of facial suture posteriorly to transversely directed, equally deep posterior border furrow. Lateral border becomes slightly more convex (tr.) posteriorly. Fringing border spines incomplete in one small specimen (Pl. 21, fig. 21) where they are relatively short; at least eleven present with the most posterior spine sited at or a short distance posteriorly from base of genal spine. The latter is moderately broadly based, gently (Pl. 21, figs. 13 and 21) to moderately (Pl. 21, fig. 18) curved, about as long (Pl. 21, fig. 13) or slightly longer than (Pl. 21, fig. 18) main part of free cheek from which it bends outwards and downwards.

Hypostoma unknown. Isolated thoracic segments (Pl. 21, fig. 11) show wide (sag.) axial ring and articulating half-ring. Articulating furrow weak. Axial furrow and pleural furrow very weak. Anterior pleural band slender, weakly convex, produced abaxially into short, posteriorly directed spine; posterior band wider (exs.) and more prominent, swollen slightly at fulcrum, extended into long, exsagittally directed pleural spine. Relatively wide (exs.), flat, facet behind posterior pleural band.

Pygidium 2·35 (Pl. 21, fig. 17) to 2·5 (Pl. 21, fig 11) times as wide as long (sag.) excluding articulating half-ring. Axis has two rings and a short (sag.), bluntly rounded terminal piece. Second axial ring has half-ring fused to first axial ring. Ring furrow between second axial ring and terminal piece is incomplete. Axial furrow weakest beside first axial ring and behind terminal piece, strongest beside second axial ring and side of terminal piece. Pleural area small. Pleural ridge runs outward and almost immediately backwards from first axial ring, expands in width near posterior margin and is extended into major spine which in lateral profile bends gently upward posteriorly. Two inner secondary spines are less than half the length of major spines (Pl. 21, fig. 17); first secondary spine outside major spine about as long or slightly shorter than internal secondary spines, a second very much shorter external secondary spine present. Anterolateral pygidial margin with an obliquely directed articulating facet.

Frontal glabellar lobe and 2p lobe have moderately densely distributed medium sized granules which are also present but much more loosely scattered on central glabellar area between 1p and 2p furrows, and are present though somewhat more concentrated on eye ridge and anterior cranidial margin. Posterior part of central glabellar area with extremely sparse, small to medium granules or lacking in granules. On occipital ring are two small to medium sized granule pairs arranged either side of the pitted median occipital organ; the anterior pair are more nearly in transverse line with the median tubercle and tend to be slightly smaller and wider apart than the posterior pair (Pl. 21, figs. 9 and 10). Small to medium sized granules present on posterior and adaxial, anterolateral angle of 1p lobe, two or three more concentrated on anterior part of this lobe and two or three widely dispersed in a line (exs.) on fixed cheek between palpebral lobe and axial furrow. Whole of the cranidial surface is extremely finely and densely granulate, as is that of free cheek, thoracic segments, and pygidium. Free cheek has a row of five, widely separated, medium sized granules along lateral border and a moderately dense concentration of these on the inner, mainly anterior, part of main field. Thoracic segments have a medium to large granule on posterior pleural band just inside fulcrum and a few small granules and one medium sized granule (?one of a pair) on axial ring (Pl. 7, fig. 14). Each pygidial axial ring has two pairs of granules, the inner pair medium to large, the outer pair of medium size. Terminal piece shows a single granule pair. Distinct granule on pleural ridge at base of each major spine; less consistent granule at base of each internal secondary spine and on pleural area near base of larger external secondary spine.

Discussion. There are a large number of described *Leonaspis* species, at least fifty on my own records not counting synonyms. A few have unique features, but the majority have been established on the basis of different combinations of characters. *L. parkini* falls into the latter category, and although there are several existing species which are similar to it, I can find none which is exactly the same.

The closest well-known species to *parkini* is *Leonaspis lenzi* Chatterton and Parry, 1983 from the middle to late Wenlock, of the Mackenzie Mountains, one of eight new *Leonaspis* species described by Chatterton and Perry (1983) on the basis of excellent silicified material from the Llandovery to Ludlow of north-west Canada. Were it not for the fine preservation of the specimens of both species, it would be difficult to separate them. The large number of observed differences, mostly concerning fine detail, is also a reflection of this preservation, rather than a measure of the taxonomic distance between the two, which I would recognize at the subspecific level were it not for distinctions in the glabellar lobation, fixed cheek, and number of pygidial spines. In the cranidium of *lenzi*, the fixed cheek between the anterior part of 1p lobe and the eye ridge is more anteriorly continuous and better developed and the anterolateral part of this lobe is better separated from the cheek by a more distinct axial furrow; the four pits in the median occipital organ are lacking; there are a few more granules on the posterior part of the glabella and small specimens have distinctly paired granules on the central glabellar area, a feature not evident in the only known small specimen of *L. parkini* (Pl. 21, fig. 15) which has a sculpture like that of the more mature Irish cranidia (Pl. 21, figs. 2, 9, 10, 15, 20; cf. Chatterton and Perry 1983, pl. 8, figs. 1, 6, 7, 9, 14, 19; pl. 9, figs. 2–4). The number of granules on the lateral border of the free cheek in *lenzi* is much greater (Pl. 21, figs. 13, 18, 21; cf. Chatterton and Perry 1983, pl. 8, figs. 5, 32, 33, 37, 38). The pygidium of *lenzi* has only one secondary pygidial spine outside the major border spine (in the diagnosis of *lenzi* it says 'one or sometimes two', but not one of the twenty figured pygidia shows a second spine and in their discussion of the closely related *L. jaanusoni*, Chatterton and Perry (1983) cite the lack of a second spine as a feature of *lenzi*), the inner secondary spines are longer than half the length of the major spines (own measurements), and each axial ring has only one pair of granules (Pl. 21, figs. 11, 16, 17; cf. Chatterton and Perry 1983, p. 27, pl. 8, figs. 18, 22–24, 34; pl. 9, fig. 8).

L. crenata crenata (Emmrich, 1844) and *L. crenata angelini* (Prantl and Přibyl, 1949) from Gotland, and *L. crenata brutoni* Thomas, 1981 from Britain, all of late Wenlock age, are the closest named Anglo-Baltic taxa to the Irish species. This group has recently received detailed comparison by Thomas (1981) and by Ramsköld (1984). All of them differ in, for example, having only one secondary pygidial spine external to the major border spine, a much longer and more slender genal spine, a less well-developed lateral border furrow on the free cheek and in the detailed form of the granular sculpture.

Leonaspis is well represented in the Siluro-Devonian of Czechoslovakia, though the range of variation has only been adequately illustrated in a very few species and there is contradiction in the literature over possible synonyms and the status of type material (compare, for example, the *Leonaspis* species in Prantl and Přibyl 1949; Bruton 1968; Horný and Bastl 1970; Šnajdr 1984*c*). My survey of this taxonomic minefield suggests that the middle to late Wenlock *L. dormitzeri* (Hawle and Corda, 1847) (see Bruton 1968, pl. 3, figs. 5 and 10, and Šnajdr 1984*c*, p. 152, pl. 13, fig. 5 for new lectotype selection) is fairly close to *L. parkini* but differs most obviously in having a very long, slender genal spine. The uncertainty over the possible synonymy of *L. leonhardi* with *L. geinitziana* (Hawle and Corda, 1847), both from the Kopanina Formation, remains (see Přibyl and Vaněk 1966, pp. 294–295, pl. 2, fig. 1; pl. 3, figs. 1, 3, 4; Bruton 1968, p. 20, pl. 2, figs. 6–8, 10; Ramsköld 1984, p. 260; Šnajdr 1984*c*, p. 157, pl. 7, fig. 11, new lectotype selected). As far as can be determined, *L. parkini* is similar to the figured cephalic parts of both *leonhardi* and *geinitziana*, which Bruton (1968) regarded as synonyms, though the *leonhardi* material, at least, differs from the Irish species in the nature of its occipital granular sculpture (Bruton 1968, p. 19). *L. leonhardi* is also clearly distinct in having four inner, secondary pygidial spines, whereas the pygidia assigned to *geinitziana* have only two. An articulated specimen of *geinitziana* is needed before closer comparison of the Bohemian and Irish species can be made.

L. clavatus Chatterton, 1971, *L. rattei* (Etheridge and Mitchell, 1896) and *L. wellingtonensis* Chatterton, Johnson and Campbell, 1979 from the Devonian of Australia all show resemblances to *L. parkini*, particularly *clavatus* in its pygidium and *wellingtonensis* in its cranidial sculpture, but all have a different combination of other characters.

Occurrence. Known only from the type horizon and locality.

Family LICHIDAE Hawle and Corda, 1847
Subfamily LICHINAE Hawle and Corda, 1847
Genus DICRANOPELTIS Hawle and Corda, 1847

Type species. Lichas scabra Beyrich, 1845, p. 28; from the Liteň Formation (Wenlock), Svatý Jan pod Skalou, Czechoslovakia. By subsequent designation of Reed 1902, p. 61.

Dicranopeltis salteri? (Fletcher, 1850)

Plate 23, figs. 1–8

1976 lichids; Siveter *in* Parkin, p. 595, table 1 (*pars*).
? 1981 *Dicranopeltis salteri* (Fletcher, 1850); Thomas, p. 68, pl. 19, figs. 4, 5, 9–12, *non* figs. 6–8 (with synonymy).
1984 *Dicranopeltis* sp.; Siveter *in* Thomas, Owens, and Rushton, p. 55.

Material. Three cranidia, two pygidia.

Occurrence. Annascaul Formation, locality 36 of Parkin 1976, p. 581, fig. 4, Annascaul inlier. Possibly also the Wenlock and ?low Ludlow of the Anglo-Welsh area, and the Silurian of ?Scandinavia (see below and Thomas 1981, pp. 68–69).

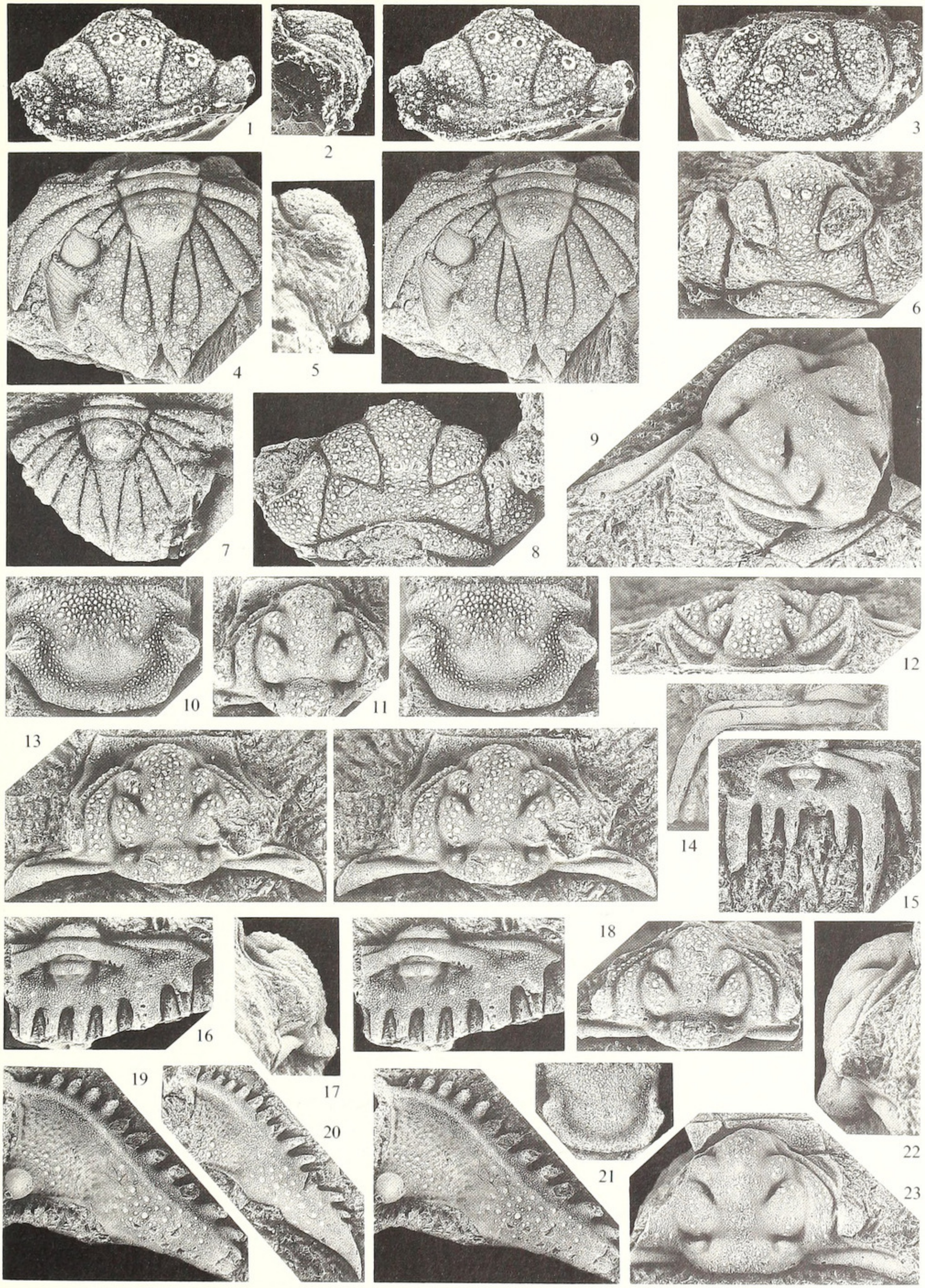
Description. For the cranidium see the description of *D. salteri* by Thomas (1981, p. 69), which largely applies to that of the Irish *Dicranopeltis*, and the discussion below. Free cheek, hypostoma, and thorax unknown.

Pygidium (Pl. 23, figs. 4 and 7) is 1·8 times as wide (tr.) as long sagittally and 1·5 times as wide as pygidial length (exs.) along posterior pygidial spine. Axis is broadly convex anteriorly, has two rings and a terminal piece; it is slightly less than 0·3 times as wide anteriorly as width of pygidium and is 0·4 times as long as pygidial length (sag.). Ring furrows continuous across axis, second furrow weakest. Terminal piece slightly *retroussé* in its medial posterior part, falls steeply posteriorly to shallow, gently backwardly convex posterior section of axial furrow which continues anteriorly to become much more sharply defined along side of terminal piece and axial rings. Postaxial sector slopes very gently posteriorly or is horizontal, narrows (tr.) gradually posteriorly where it is about 0·4 times as wide as anteriorly behind terminal piece. Pleural region horizontal, has three well-marked pleural and interpleural furrows. First pleural furrow curves broadly outward and backwards abaxially, fades on pleural spine, second swings very gently more backwards, distal part unknown; third runs backward and slightly outward, falls well short of pygidial margin. First interpleural furrow swings outward and backward, distal part unknown; second trends gradually backward and slightly outward, swings gently abaxially and becomes much shallower a short distance before reaching lateral margin; third delimits side of postaxial sector, is very weakly present for a short distance on most posterior part of pleural region running backward and slightly inward to posterior margin sagittally. Lateral margin is produced into three pairs of long, sharply pointed, backwardly directed spines between posterior pair of which it is acutely incised. Doublure is wide with subparallel terrace lines.

EXPLANATION OF PLATE 23

Figs. 1–8. *Dicranopeltis salteri*? (Fletcher, 1850). All specimens are from the Annascaul Formation, locality 36. 1–3, cranidium, silicone rubber cast of external mould, TCD 12533; dorsal stereo-pair, lateral, frontal views, ×3. 4, pygidium TCD 12590*a*; dorsal stereo-pair, ×3. 5 and 6, cranidium, TCD 12589*a*; lateral, dorsal views, ×6. 7, pygidium, TCD 12534*a*; dorsal view, ×4. 8, cranidium, TCD 12532; dorsal view, ×4.

Figs. 9–23. *Leonaspis coronata coronata* (Salter, 1853). All specimens are from the Annascual Formation, locality 36. 9, 22, 23, cranidium, TCD 12198; oblique view, ×4, lateral, dorsal views, ×3. 10, hypostoma, TCD 12213; ventral stereo-pair, ×8. 11, cranidium, TCD 19598; dorsal view, ×6. 12, 13, 17, cranidium, TCD 12196; frontal view, dorsal stereo-pair, lateral view, ×6. 14, thoracic segment, TCD 12272; dorsal view, ×4. 15, pygidium, TCD 12209; dorsal view, ×5. 16, pygidium, UM K2808; dorsal stereo-pair, ×4. 18, cranidium, TCD 12201; dorsal view, ×5. 19, free cheek, TCD 12216; 'dorsal' stereo-pair, ×3. 20, free cheek, UM K2806*a*; 'dorsal' view, ×4. 21, hypostoma, UM K2811; ventral view, ×8.



SIVETER, Silurian trilobites

Pygidial sculpture comprises small to medium sized granules over whole pleural region and axis exclusive of furrows. Axis has a pair of medium sized granules on central, posterior part of each axial ring, and one pair on central part of terminal piece about one-third of its length (sag.) posteriorly from second ring furrow.

Discussion. Thomas (1981, p. 68) has recently revised *D. salteri*, his description of the cranidium being based on the type and topotype specimens from the late Wenlock Much Wenlock Limestone Formation of Dudley (Thomas 1981, pl. 19, figs. 4, 11, 12), though the thorax and pygidium were described from non-topotype Malverns' material from the slightly older Coalbrookdale Formation (Thomas 1981, pl. 19, figs. 6–8). Isolated pygidia and thoracic segments of *Dicranopeltis* are known from Dudley but Thomas assigned these to other species of this genus; unlike them the Malverns' material, which includes one specimen with pygidium, thorax, and (partial) cranidium all articulated (Thomas 1981, pl. 19, fig. 6), shows the same paired arrangement of larger granules on the pygidial and thoracic axes and median glabellar lobe as do topotype *salteri* cranidia. In particular, topotype *salteri*, when well preserved (Thomas 1981, pl. 19, fig. 11), show four pairs of larger granules on the median lobe.

The three Kerry *Dicranopeltis* cranidia (Pl. 23, figs. 1–3) appear similar to the cranidium of *salteri* except that on them the 1p glabellar, preglabellar, and axial furrows seem more distinct than those described (Thomas 1981, p. 68) for the English material, but the illustrations of the latter show that the Irish and English specimens cannot be distinguished on these features. However, on the two Irish cranidia which show a complete frontomedian glabellar lobe (Pl. 23, figs. 1–3, 5, 6), there are only three pairs of larger granules. The significance of this is debatable, since the sample size is small and, moreover, four pairs cannot always be confirmed on English specimens due to preservational shortcomings, this apparently applying even to the lectotype and paralectotype (see Thomas 1981, pl. 19, figs. 4 and 12).

The pygidium of the Irish form is certainly distinct from the non-topotype Malverns' material ascribed to *salteri*. The axis is relatively smaller with respect to the size of the pleural region, being only 0·3 times as wide as the pygidial width anteriorly. In the Malverns' material the axis appears to be about 0·4 times as wide; Thomas (1981, p. 69) said about 0·5 times as wide but this figure seems excessive for the two reasonably complete pygidia he figured (1981, pl. 19, figs. 6 and 7). The postaxial sector narrows less rapidly posteriorly. The pygidial spines are much longer. The axis has only two axial rings, though admittedly the two extra incomplete rings in the Malverns' pygidia are only indicated in some specimens (Thomas 1981, p. 69; even though he gave the number of axial rings as a diagnostic character for *salteri*). The paired larger granules on the first axial ring are much less widely separated compared with those on the second ring.

It is clear that there is more than one *Dicranopeltis* taxon exhibiting paired, granular, axial sculpture (see also below) and due to the uncertainties involved I have questionably assigned the Irish material to *salteri*, and consider that the different Malverns' material on present evidence should also be questionably referred to this species. *Dicranopeltis woodwardi* (Reed, 1903) from the Much Wenlock Limestone Formation of Dudley, which is known from pygidia only, differs from the Irish species in showing only one complete axial ring, a subparallel posterior part to the postaxial sector, and the lack of paired granular sculpture.

Paired rows of larger granules have also been indicated in some cranidia attributed to *D. scabra scabra* and *D. scabra propinqua* (Barrande, 1846) from the Wenlock and low Ludlow of Bohemia (Vaněk 1959, text-fig. 13; Prantl and Vaněk *in* Horný *et al.* 1958, p. 271; contrary to the comments of Thomas 1981, p. 69). There is need of careful revision of the *scabra* material and of first-hand comparison of *scabra* and *salteri* specimens to clarify the relationship of the two species.

The synonymy of *Lichas laticeps* Angelin, 1854 from the Silurian of ?Scandinavia with *D. salteri* (see Thomas 1981, pp. 68, 69) seems questionable until the former is revised: it has not been refigured since being established and Angelin's illustration is inadequate for modern comparison.

Subfamily CERATARGINAE Tripp, 1957
Genus TROCHURUS Beyrich, 1845

Type species. Trochurus speciosus Beyrich, 1845, p. 31, unnumbered plate, fig. 14; from the Liteň Formation (Wenlock), Svatý Jan pod Skalou, Czechoslovakia. By monotypy.

Trochurus? sp. indet.

Plate 16, fig. 16

1863 *Encrinurus sexcostatus*; Baily *in* Jukes and Du Noyer, p. 12.
1878 *Encrinurus sexcostatus*; Baily *in* Kinahan, p. 40.
1976 *Primaspis*? sp.; Siveter *in* Parkin, p. 595, table 1.
1984 *Dicranopeltis*? sp.; Siveter *in* Thomas, Owens, and Rushton, p. 55.

Material. One cranidium.

Occurrence. Annascaul Formation, locality 28 of Parkin 1976, p. 587, fig. 4, Annascaul inlier.

Discussion. This fragmentary cranidium is apparently a lichid but is different to the *Dicranopeltis* species described above in having the 1p furrows extended and meeting sagittally to isolate a posterior section of the median lobe, and in having the remnant of what is probably an occipital lobe. Sagittally confluent 1p furrows and a transversely, unequally divided median lobe are present in the specimens of *Trochurus* sp., *Acanthopyge hirsuta* (Fletcher, 1850), and *Hemiarges bucklandii* (Milne Edwards, 1840) recently described from the late Wenlock of Britain by Thomas (1981). However, these *Acanthopyge* and *Hemiarges* taxa do not have an occipital lobe and in *H. bucklandii* the posterior section of the median lobe is much longer than that of the Irish specimen. The remains of the Irish cranidium show no differences to the similarly aged *Trochurus* sp. of Thomas, or to some specimens of *T. speciosus* (see, for example, Vaněk 1959, pl. 9, fig. 1; Přibyl and Vaněk 1975, pl. 1, fig. 6), and I have therefore questionably assigned it to this genus, which is typically a 'middle' Silurian taxon, whereas *Acanthopyge* is typically a Devonian genus.

Watkins (1978, fig. 10A) illustrated a partial cranidium of an unnamed lichid from the upper Wenlock (Homerian Stage) Ferriters Cove Formation in the west of the Dingle Peninsula. This specimen appears to have a transversely continuous 1p furrow as in the Caherconree specimen of *Trochurus*? sp. indet.

PALAEOECOLOGY

The thinly bedded limestone unit at locality 28 may be up to 20 m thick and contains alternations of purer carbonate and more silty horizons; in addition to the trilobites it has yielded about ten species of brachiopods, indeterminate bivalves, fenestellid bryozoans, crinoid ossicles, and is particularly rich in the corals *Coenites repens* Wahlenberg and *Favosites* sp. (Parkin 1976, p. 588, table 1). The trilobites, an illaenimorph, a cheirurid, and a lichid, are sparse in terms of taxa and specimens, and though all these families are of the more robust morphological type, they are represented here by incomplete exoskeletal parts. All the evidence suggests shallow water (see also below).

The limestone of locality 36 is about 3 m thick and consists essentially of small, light-grey coloured carbonate nodules enveloped within generally finer grained sediments (Parkin 1976, p. 588). On sectioning the contact of several nodules with the surrounding sediment, the nodules are found to consist largely of crinoid debris and small trilobite parts in what may be termed a silty crinoidal packstone. Contact with the surrounding sediment, a silty wackestone, is very sharp, with the silt in the wackestone being finer and more abundant. The silty wackestone also contains trilobites, but these are large specimens of *Cheirurus* sp. nov.? and *Calymene endemopsis* sp. nov., whereas the crinoidal packstone contains the other taxa from this locality which are all smaller in size. In addition to the trilobites only athyrid brachiopods and crinoid ossicles were recorded from locality 36 by Parkin (1976, p. 588, table 1). The sedimentological evidence suggests that the crinoidal packstone was already cemented when it was deposited in the finer host-rock wackestone, but this would not necessarily imply a large age difference between the two or that they originated any great distance apart.

The abundant trilobite material from locality 36 as a whole represents a death assemblage, consisting entirely of disarticulated material. Some movement and concentration of the exoskeletal parts with the crinoid debris must have occurred, but the excellent preservation of the trilobites in general and the intact preservation of the odontopleurid spines in particular suggests that any transportation was limited. A lower energy, possibly slightly more offshore and deeper water environment is suggested for this muddier, coral-free limestone with its diverse trilobite fauna, compared to that of locality 28. On a regional basis, in upper Wenlock times Parkin (1976, pp. 602–603) envisaged a palaeoslope dipping approximately east-north-east, away from the Blasket Islands and Dunquin volcanic centres in the west and towards the Bull's Head and Annascaul inliers in the east.

In recent years, Thomas (1980), Männil (1982, 1986), and Chlupáč (1987) have respectively plotted the occurrence of trilobites with respect to lithofacies distribution across the palaeoslope of the Welsh Basin during the Wenlock, the Baltic Basin during the Silurian, and the Barrandian area of Czechoslovakia during the Silurian. The illaenimorph–cheirurid–lichid assemblage from locality 28 includes the same major groups that form part of the fauna inhabiting the nearshore shelf limestone lithofacies of the Welsh Basin during the Wenlock (Thomas 1980, fig. 2); moreover these three groups are typical of shallow water bioclastic limestones from the Ordovician through to the Devonian (Lane 1972; Fortey 1975; Lane and Thomas 1983). The locality 28 fauna can also be compared to part of the *Bumastus–Sphaerexochus–Cheirurus* assemblage occurring in the volcanic-carbonate facies of the Bohemian Wenlock, which also occupies a similar nearshore palaeoslope position (Chlupáč 1987, p. 172, fig. 2).

The trilobite families from locality 36 compare well with those inhabiting the shelf limestone and adjacent offshore shale belt on the Welsh palaeoslope of Wenlock age. The restricted presence there of the Styginidae (= Scutelluidae of Thomas 1980, fig. 2) on the outer part of the shelf limestones, close to where they interfinger with the shale belt, may by analogy suggest a similar position for the Kerry fauna which also contains the styginid *Kosovopeltis*, though only one Irish specimen is known. Consideration of the sedimentological factors outlined above may also suggest a more distal rather than proximal position on the shelf area. At the generic level the fauna from locality 36 does not compare closely with the *Proetus–Warburgella* association or *Dalmanites–Raphiophorus* association which Thomas (1980, fig. 3) used to typify, respectively, the shelf limestone and the shale belt lithofacies of the Welsh Basin. In the Wenlock of Bohemia the *Bumastus–Cheirurus–Sphaerexochus*, the *Miraspis*, and the *Aulacopleura konincki* assemblages, which in total encompass the nearshore volcanic–carbonate to more offshore calcareous and tuffaceous shale facies, all have genera in common with the locality 36 fauna.

A comparison of the Irish trilobite fauna with the Wenlock palaeoslope associations identified by Männil (1982, 1986), shows that the generic diversity of the East Baltic trilobites is much lower and the composition different. There is no species the same, and generically only *Leonaspis* and *Calymene* are common to both areas at this time, the latter genus occurring right across the East Baltic palaeoslope from nearshore to the central part of the 'basin', and the former being found in the slope facies.

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Genera which occur elsewhere in the Annascaul Formation but which are unknown from the two limestone outcrops include *Encrinurus*, *Dalmanites*, and *Proetus* (Siveter, in prep.). The genera described herein are mostly cosmopolitan, with the exception of the relatively newly defined *Interproetus*, which also occurs in Bohemia, Morocco, and England. At the specific level faunal links with several areas are evident. Many of the Annascaul species are closely related to forms in the Welsh Borderland, especially *A.* aff. *stokesii*, *D. salteri*?, and *Cheirurus* sp., whilst *L. coronata coronata* and *O.* (*O.*) *ovata* actually occur there. The Irish species also show some similarity with those from Bohemia: *O.* (*O.*) *ovata*, the most common species in the Irish fauna, occurs there, *Interproetus* species are best represented there, and *D. salteri*? is very close to *D. scabra*, as is *Cheirurus* sp. to *C. insignis*. Species' connections with Scandinavia appear less strong but a subspecies of *L. coronata* occurs in the late Wenlock of Gotland as does *A. amelangi*, a form very close to *A.* aff. *stokesii*. North American species have not been recognized but *L. parkini* shows the closest connection, standing very near to *L. lenzi* from north-west Canada. The Irish *Kosovopeltis* species has affinities with a Greenland form.

Thus species' connections can be made with the Welsh Borderland and Bohemia to the east, where they are strongest, and Scandinavia to the north-east. America, to the west, has some very similar forms without having any species in common. This pattern conforms closely to the triparite origin of Silurian faunal elements in the British Isles, anticipated by Holland (1969*a*, *b*) following the suggestions of Holland and Lawson (1963) and Turner (1935). Bassett (1974), Holland (1969*b*), and others have commented on the Wenlock age rocks that occur under eastern England and their connection with those in central Europe; this indicates there was a possibility for migration between Ireland and Bohemia via the Welsh Borderland. The faunal connection of the Dingle trilobites with those of the Welsh Borderland does not support the idea that these two areas were separated by a southerly extension of the Irish Sea landmass from middle Wenlock to early Ludlow times (Hirst *et al.* 1978, text-figs. 8–10). An alternative migration pathway between Ireland and Bohemia bypassing the Welsh Borderland may have been along the east–west trending Rheic Ocean just to the south, which was the site of the sediments involved in the late Palaeozoic orogeny, but which has been postulated to be in existence at least as early as the late Llandovery (McKerrow and Cocks 1977, text-fig. 1; Cocks and Fortey 1982, text-fig. 5).

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