THE ORDOVICIAN TRILOBITE FAUNA OF THE SHOLESHOOK LIMESTONE FORMATION SOUTH WALES

by DAVID PRICE

ABSTRACT. This paper gives a complete account of the historically important trilobite fauna of the Sholeshook Limestone; it comprises 50 species here placed in 40 genera and representing 23 families. Three new species, *Harpidella (H.) lacrymosa, Platylichas noctua*, and *Primaspis llandowrorensis* are included. Species of *Liocnemis* and *Whittingtonia* occur in laterally equivalent parts of the Slade and Redhill Mudstone Formation; the former genus is described for the first time from British strata. *Proceratocephala* is described for the first time from Wales. The rostral plate of *Stenopareia bowmanni* (Salter) is described, and a free cheek figured. A pygidium is described for a form tentatively referred to *Panderia edita* Bruton. Well-preserved topotype specimens of *Pseudosphaerexochus juvenis* (Salter) give a better characterization of the species than Salter's original syntypes. A thorax is illustrated for *Duftonia geniculata* Ingham, and a distinctive hypostoma is described for a form tentatively referred to *Platylichas angulatus* Warburg. Ranges and abundances are charted. The Sholeshook Limestone was deposited in an environment intermediate between deep-slope mudstones and shelf-edge carbonates, and has elements of its trilobite fauna in common with both facies types.

THE Sholeshook Limestone Formation is a lithologically variable thickness of mudstones, sandstones and (predominantly) siltstones of calcareous type developed between the Mydrim Shale Formation and the Slade and Redhill Mudstone Formation at Sholeshook and Prendergast, Haverfordwest, south-west Dyfed (type development), and in the area around Llandowror about 30 km further east. It is present between the type Robeston Wathen Limestone and the Slade and Redhill Mudstones at Robeston Wathen, about 13 km east of Haverfordwest. Further details of stratigraphy were given in an earlier account (Price 1973*a*) which showed the formation to have a diachronous base and to overlie the Mydrim Shales unconformably. The base of the normally succeeding Slade and Redhill Mudstones was also diachronous, so that to the north and west of Haverfordwest this formation contains strata laterally equivalent to the type Sholeshook Limestone. At that time the age of the Sholeshook Limestone was considered to range from the upper part of Zone 1 to probably Zone 3 of the Cautleyan Stage. Since then, largely as a result of re-examining the trilobite fauna during the preparation of this paper, aided by recent descriptions of Ashgill trilobites by other authors, it has been found necessary to revise the younger of these age limits and the formation is now considered to range upwards into Zone 5 of the Rawtheyan Stage (Price 1980).

Both the Sholeshook Limestone and its trilobite fauna have played an important part in the development of knowledge and concepts concerning upper Ordovician stratigraphy (see Price 1973*a*, p. 226; 1973*b*, p. 535; 1974, p. 841). The present paper deals with the trilobite fauna as a whole. The trilobites of the basal Slade and Redhill Mudstones are also mentioned since these beds are partly correlatives of the Sholeshook Limestone and, with the exception of two forms, all their species are common to both formations. Occurrences of Sholeshook species in the higher Slade and Redhill Mudstones are also noted.

The trilobite fauna of these horizons is a rich and varied one, comprising some 52 species representing 42 genera and 23 families. Its treatment within a single relatively short paper is possible because some of its elements have already been described in detail elsewhere (e.g. Price 1974, 1977), and because recent descriptions of Ashgill trilobites have been given by such workers as Kielan (1960), Whittington (1962–8), Ingham (1970–7), Dean (1971–8), and McNamara (1979*a*).

[Palaeontology, Vol. 23, Part 4, 1980, pp. 839–887, pls. 107–114.]

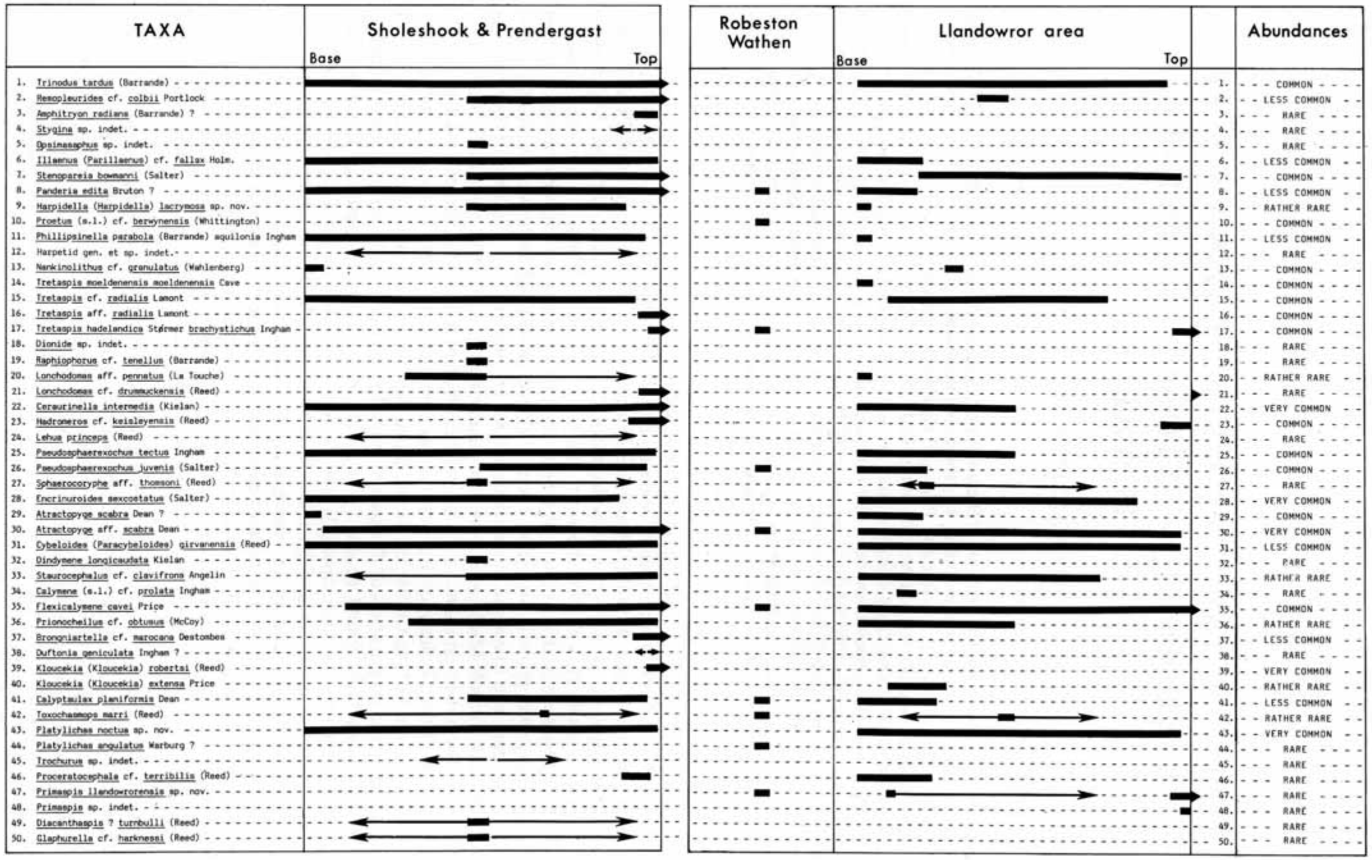


TABLE 1. Ranges and abundances of trilobite species in the Sholeshook Limestone Formation. Bold solid bars where short indicate actual occurrences, where longer show known ranges. Solid black arrow-heads show which forms range up into the overlying Slade and Redhill Mudstones at Haverfordwest and Llandowror. Lighter bars with arrow-heads indicate the possible range of occurrence of ill-localized material.

Accordingly, the complete fauna is given in an annotated list below and only forms meriting further comment are given systematic descriptions. The composition of the fauna is discussed in a final section. The trilobites dealt with here largely come from outcrops of naturally decalcified rock and are normally preserved as internal and external moulds; material representing the exoskeleton is only rarely present. The vast majority of specimens are disarticulated exoskeletal parts of which a high proportion are fragmentary or incomplete. Nevertheless a few complete or partly articulated specimens are known, and seventeen of the Sholeshook species are represented by at least one such specimen. Most material is somewhat distorted.

Terminology. For the purposes of description, measurement, and illustration, specimens have been viewed in the standard orientations described by Temple (1975); for isolated exoskeletal parts the horizontal plane is generally defined by the (maximized) sagittal length. An exception is made in the case of trinucleid cephala which, following Hughes, Ingham, and Addison (1975) are oriented with the anterior and posterior fossulae in the horizontal plane. All references to shape and proportions, unless otherwise stated, refer to dorsal views. The term glabella is used to include the occipital ring and glabellar lobes and furrows are numbered from the rear. The term 'bullar lobes' (Temple 1972) is used for the structures formerly designated 'composite' or 'bicomposite' lobes in the lichid genus *Trochurus*. Several of the forms described here have lengthy synonomies; where these are available in earlier references they are not repeated herein.

Repositories and localities. Material is housed in the following museums: British Museum (Natural History) (BM), Hunterian Museum, Glasgow (HM), Institute of Geological Sciences (GSM), National Museum of Wales (NMW), and the Sedgwick Museum, Cambridge (SM). The determinations and descriptions in this paper are based on all available material in these collections which for most forms is too numerous to be listed separately. Maps and tables showing precise localities for specimens collected by the author and for other well-localized material have been given previously (Price 1973*a*) and it is to these that locality numbers cited in the text refer. Occurrences within the Sholeshook Limestone are shown graphically in Table 1.

ANNOTATED LIST OF COMPLETE TRILOBITE FAUNA

The forms marked with an asterisk are treated in the Systematic Account. Those based on type material from the Sholeshook Limestone or basal Slade and Redhill Mudstones are marked thus †

Trinodus tardus (Barrande). Pl. 107, figs. 1–3. See also Dean's illustrations (1971, pl. 1, figs. 1, 2) of the syntypes of *Agnostus tardus*, var. *β convexus* Salter, 1848 from the Sholeshook Limestone

Remopleurides cf. *colbii* Portlock*

Amphitryon radians (Barrande)? Pl. 107, fig. 9; Pl. 108, fig. 9. Rare; 2 cranidia from basal Slade and Redhill Mudstones (locs. 3, 4), 2 from high Sholeshook Limestone (locs. 8b, 8c) of Prendergast

Stygina sp. indet.*

Opsimasaphus sp. indet.*

Illaenus (*Parillaenus*) cf. *fallax* Holm*

Stenopareia bowmanni (Salter)†. Pl. 107, fig. 15; Pl. 108, fig. 15. For description of topotype material see Price 1974, p. 842, pl. 112, figs. 1–8, ?9. Rostral plate since recognized and figured here together with free cheek not previously figured

Panderia edita Bruton?*

Harpidella (*Harpidella*) *lacrymosa* sp. nov.*

Proetus (s.l.) cf. *berwynensis* (Whittington)*

Phillipsinella parabola (Barrande) *aquilonia* Ingham. Pl. 108, fig. 16

Harpetid gen et sp. indet. Not figured. See Reed 1905*a*, p. 97, pl. 4, fig. 1, and Whittington 1950*b*, p. 32

Nankinolithus cf. *granulatus* (Wahlenberg)*

Tretaspis moeldenensis moeldenensis Cave† }
T. cf. *radialis* Lamont } See Price 1977
T. aff. *radialis* Lamont }
T. hadelandica Størmer *brachystichus* Ingham }

Dionide sp. indet.*

Raphiophorus cf. *tenellus* (Barrande)*

Lonchodomas aff. *pennatus* (La Touche)*

L. cf. *drummuckensis* (Reed)*
Ceraurinella intermedia (Kielan). Pl. 110, figs. 7, 8.
Hadromeros cf. *keisleyensis* (Reed). Not figured. See Lane 1971, p. 20, pl. 3, figs. 8–11, pl. 4, figs. 1–4.
Lehua princeps (Reed)†. Not figured. Now that both cranidium (Lane 1971, p. 36, pl. 7, figs. 17*a*, *b*) and pygidium (Price 1974, p. 848, pl. 113, fig. 12) have been described, the species is placed firmly in genus *Lehua*
Pseudosphaerexochus tectus Ingham. Pl. 110, figs. 9–11. Previously listed in Sholeshook faunal lists as *P. octolobatus* (McCoy)
P. juvenis (Salter)†*
Sphaerocoryphe aff. *thomsoni* Reed*
Encrinuroides sexcostatus (Salter)†. Not figured. See Whittington 1950*a*, p. 535, pl. 68, figs. 7–16, text-fig. 2 and Price 1974, p. 856, pl. 115, figs. 1–8
Atractopyge scabra Dean? Pl. 110, fig. 17. See discussion of *A.* aff. *scabra*
Atractopyge aff. *scabra* Dean*
Cybeloides (*Paracybeloides*) *girvanensis* (Reed). Pl. 110, fig. 16; Pl. 111, fig. 5
Dindymene longicaudata Kielan*
Staurocephalus cf. *clavifrons* Angelin*
Calymene (s.l.) cf. *prolata* Ingham*
Flexicalymene cavei Price†*
Prionocheilus cf. *obtusus* (McCoy)*
Brongniartella cf. *marocana* Destombes*
Duftonia geniculata Ingham?*
Kloucekia (*Kloucekia*) *robertsi* (Reed)† }
K. (*Kloucekia*) *extensa* Price† } Not figured. See Price 1974, p. 857, pl. 115, figs. 9–14; pl. 116, figs. 1, 2 and p. 862; text-fig. 2*a–k*
Liocnemis recurvus (Linnarsson)*
Calyptaulax planiformis Dean*
Toxochasmops marri (Reed). Pl. 112, figs. 16, 17. See also Reed 1904, pl. 12, fig. 3 and Cocks and Price 1975, pl. 81, fig. 4
Platylichas noctua sp. nov.†*
P. angulatus Warburg?*
Trochurus sp. indet.*
Whittingtonia whittingtoni Kielan*
Proceratocephala cf. *terribilis* (Reed)*
Primaspis llandowrorensis sp. nov.†*
P. sp. indet.*
Diacanthaspis? *turnbulli* (Reed)†. Not figured. See Price 1974, p. 864, pl. 116, figs. 3–5
Glaphurella cf. *harknessi* (Reed)*

SYSTEMATIC DESCRIPTIONS

Family REMOPLEURIDAE Hawle and Corda, 1847
Genus REMOPLEURIDES Portlock, 1843

Type species. Remopleurides colbii Portlock, 1843.

Remopleurides cf. *colbii* Portlock, 1843

Plate 107, figs. 4–8

1885 *Remopleurides longicostatus*, Portl.; Marr and Roberts, faunal list p. 481.
1885 *Remopleurides dorso-spinifer*, Portl.; Marr and Roberts, faunal list p. 481.
1905*a* *Remopleurides Salteri*, Reed, var. *girvanensis*; Reed, p. 98, pl. 4, fig. 3.
1914 *Remopleurides longicostatus* Portl.; Strahan, Cantrill, Dixon, Thomas, and Jones, table p. 64.
1914 *Remopleurides colbii* Portl.; Strahan *et al.* (*pars*), list p. 71.
1914 *Remopleurides salteri* Reed; Strahan *et al.*, p. 75.
1966 *Remopleurides* cf. *colbii* Portlock; Whittington (*pars*), p. 75, pl. 22, figs. 5, 6, 9.
?1966 *Remopleurides* cf. *colbii* Portlock; Whittington (*pars*), p. 75, pl. 22, fig. 7; pl. 23, figs. 1–6.
1973*a* *Remopleurides* aff. *colbii* Portlock; Price, tables 1–3.
1975 *Remopleurides* sp.; Cocks and Price, p. 705, pl. 81, fig. 5.

Horizons and localities. Apart from the occurrences shown in Table 1, ranges through the Slade and Redhill Mudstone Formation around Haverfordwest (to locality I of Cocks and Price 1975) and is known also from the high Slade and Redhill Mudstones just south of Little Clerkenhill, 9 km further east (Grid ref. SN 045 150).

Description. Cranidium about as wide (tr.) as long (sag.) and moderately convex transversely. In lateral profile (Pl. 107, fig. 4) just less than posterior three-fifths of length straight, rest curved evenly through about 90°. Glabellar width (tr.) immediately in front of occipital furrow slightly over half maximum width achieved just behind mid-length. Anterior tongue of similar width (tr.) posteriorly, tapers very slightly forwards. Lateral glabellar furrows (Pl. 107, fig. 7) faint, evenly spaced (exsag.). 1p and 2p sub-parallel, gently convex anteriorly; separated longitudinally by about 15% of sagittal cranidial length and mesially by about 30% of maximum glabellar width; not reaching axial furrows. 3p furrows short (tr.), their adaxial ends slightly further apart than those of the 1p and 2p. Occipital furrow straight, deep, and narrow. Occipital ring strongly arched transversely, broad (sag. and exsag.) mesially; convex posterior margin bears row of (?eighteen) prominent, backwardly directed tubercles. Palpebral lobes narrow (tr.) anteriorly, broaden posteriorly, and indent pre-occipital part of glabella. Librigenae (see Whittington 1966, pl. 22, figs. 5, 9) narrow (tr.) anteriorly, widening posteriorly and produced into long, gently curved, stout genal spines; no sub-genal notch. Visual surface of eye surrounded by broad furrow and prominent external rim. Ventral surface of doublure with strong, sub-parallel ridges separated by broad grooves which are themselves striated. Hypostoma not known. Thorax incompletely known; axis strongly convex, rings broad (sag. and exsag.), dorsally flat, slightly expanded abaxially, separated by broad articulating furrows. Pleurae narrow (tr.), strongly bent-down, antero-laterally rounded, postero-laterally drawn into short spines; inner anterior corners bear large articulating bosses fitting sockets in previous segments. Pleural doublure bears strong longitudinal grooves. One partial thorax, SM A30963, from the high Slade and Redhill Mudstones, bears a long median spine but the specimen does not show clearly which ring this is on.

Pygidium (Pl. 107, fig. 8 and Cocks and Price 1975, pl. 81, fig. 5) sub-triangular. First axial ring narrow (sag. and exsag.) mesially but much expanded at tips; second ring represented by pair of elongated, postero-laterally directed lobes separated by longitudinal furrow. Faint, narrow (tr.) posteriorly tapering post-axial ridge. Margin with two pairs of spines, anterior pair slender, thorn-like, gently curved adaxially, posterior pair broad-based and much larger. Doublure broad with fine transverse terrace-lines arranged in posteriorly convex arc.

Discussion. The Sholeshook specimens are similar to the holotype of *R. colbii* as redescribed by Whittington (1950*a*, p. 540, pl. 70, figs. 1, 4, 5) though that specimen is too incomplete to show either the form of the posterior pygidial spines or whether a short 3p lateral glabellar furrow is present. Similar also to *R. colbii* and the South Welsh specimens is the species described by Whittington (1966, p. 75, pl. 22, fig. 7; pl. 23, figs. 1–6) from the Rhiwlas Limestone—though it is not well enough known for detailed comparison. A pygidium with similarly large posterior spines to those of the South Welsh form is seen in the species described by Ingham (1970, p. 13, pl. 1, figs. 22–25, ?17–21) from the Cautley Mudstones as *Remopleurides* sp. B. That form, however, has a large sub-genal notch and appears to bear a surface Bertillon pattern of fine ridges.

Family SCUTELLUIDAE Richter and Richter, 1925
Genus STYGINA Salter, 1853

Type species. Asaphus latifrons Portlock, 1843.

Stygina sp. indet.

Plate 107, fig. 12

1885 *Stygina*; Marr and Roberts, list p. 480 (*pars*).
1973*a Stygina*? sp. indet.; Price, table 2.

Material. SM A31595, internal mould of incomplete pygidium and posterior-most part of thorax (enrolled), from the high Sholeshook Limestone Formation of Prendergast Place, Haverfordwest (locality 8b, 8c, or 8d).

Discussion. In features such as the broad, concave border, the fine sub-parallel terrace-lines on the ventral mould of the doublure, the long, gradually tapering axis only weakly defined posteriorly, and the post-axial ridge, the specimen shows much similarity with the pygidia of the lectotype and other topotype specimens of *S. latifrons* figured by Whittington (1950, pl. 72, figs. 2, 3, 6, 9). The axial furrows are shallow and the pygidium thus differs from that of the form figured by Whittington (1966, pl. 21, figs. 13–15) from the Rhiwlas Limestone of North Wales where they are deeply incised. In addition the axis of the Rhiwlas form appears to be narrower (tr.) anteriorly and to taper less rapidly back than in either *S. latifrons* or the Sholeshook form.

Family ASAPHIDAE Burmeister, 1843
Subfamily ASAPHINAE Burmeister, 1843
Genus OPSIMASAPHUS Kielan, 1960

Type species. Opsimasaphus jaanussoni Kielan, 1960.

Opsimasaphus sp. indet.

Plate 107, figs. 10–11

1914 *Asaphus*?; Strahan *et al*., p. 76.
1973*a* *Opsimasaphus*? sp. indet.; Price, tables 1, 2, 7.

Material. BM It9257, internal mould of incomplete hypostoma from near middle of Sholeshook Limestone Formation, locality 9e, Sholeshook. A poorly preserved pygidium, GSM H.T. 480, from the basal Slade and Redhill Mudstones near Clarbeston Road Station (locality 6a) probably also belongs here.

Description. Hypostoma with convex, sub-ovoid central body. Lateral border broadest (tr.) opposite posterior margin of central body, extended back, ornamented with faint, gently sinuous terrace-lines, and bifurcate posteriorly where it is excavated by a deep, anteriorly expanded notch. Lateral border furrow deepest and broadest posteriorly; transverse furrow wide (sag. and exsag.) and shallow. A small, faint median tubercle is present at the posterior margin of the central body and maculae are developed behind the abaxial ends of the transverse furrow.

EXPLANATION OF PLATE 107

Figs. 1–3. *Trinodus tardus* (Barrande). 1, SM A31383, internal mould of pygidium from basal Slade and Redhill Mudstones of Pelcomb Cross (locality 2), dorsal view. 2, SM A77583a, internal mould of cephalon from basal Sholeshook Limestone of Pentre-howell road section (locality 17), left lateral view. 3, SM A31378, internal mould of cephalon from Sholeshook Limestone of Sholeshook railway cutting, dorsal view. All ×8.

Figs. 4–8. *Remopleurides* cf. *colbii* Portlock. 4–6, SM A77953, internal mould of cranidium from high Sholeshook Limestone of Prendergast (locality 8c), left lateral, dorsal, and anterior views, ×4. 7, SM A30721, internal mould of cranidium showing lateral glabellar furrows, Slade and Redhill Mudstones of Upper Slade, Haverfordwest, dorsal view, ×4. 8, SM A98065, internal mould of pygidium from high Sholeshook Limestone (topmost locality 8d), Prendergast, dorsal view, ×6.

Fig. 9. *Amphitryon radians* (Barrande)? BM In54167a, internal mould of incomplete cranidium from basal Slade and Redhill Mudstones of Rudbaxton (locality 4), dorsal view, ×6.

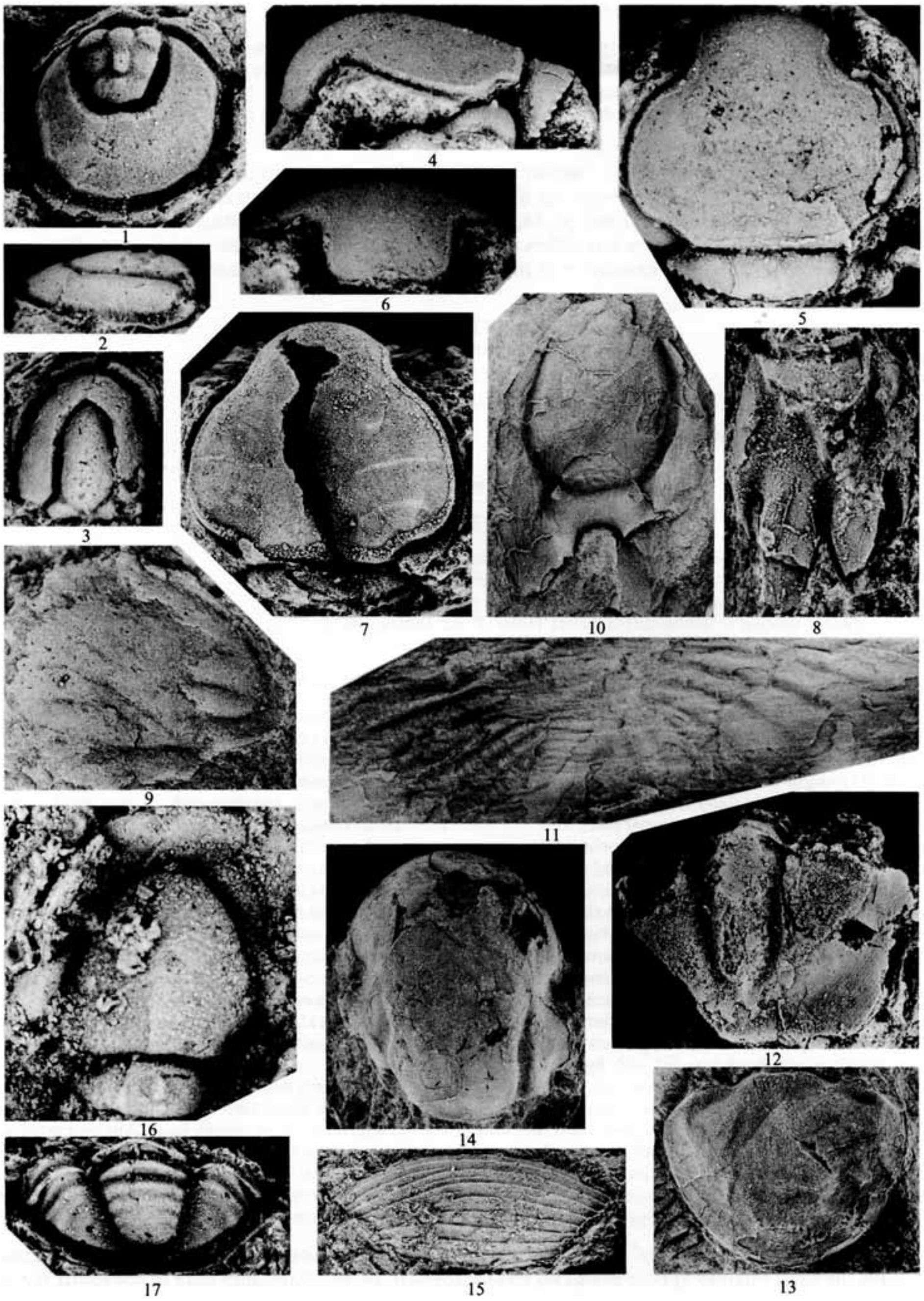
Figs. 10, 11. *Opsimasaphus* sp. indet. 10, BM It9257, internal mould of incomplete hypostoma, middle Sholeshook Limestone, locality 9e, Sholeshook, ventral view. 11, GSM H.T. 480, flattened and sheared internal mould of pygidium from basal Slade and Redhill Mudstones of Clarbeston Road Station (locality 6a), dorsal view. Both ×1½.

Fig. 12. *Stygina* sp. indet. SM A31595, internal mould of pygidium and posterior part of thorax (enrolled) from the high Sholeshook Limestone of Prendergast (locality 8b, c, or d), pygidium in dorsal view, ×3.

Figs. 13, 14. *Illaenus* (*Parillaenus*) cf. *fallax* Holm. 13, BM In54706, internal mould of pygidium from Craig-y-deilo quarry, Llandowror, dorsal view, ×1. 14, BM In54464, internal mould of cranidium from high Sholeshook Limestone (locality 8b), Prendergast, dorsal view, ×1½.

Fig. 15. *Stenopareia bowmanni* (Salter). SM A99092b, cast from external mould of rostral plate, high Sholeshook Limestone (locality 8d) of Prendergast, ventral view, ×2½.

Figs. 16, 17. *Proetus* (s.l.) cf. *berwynensis* (Whittington). 16, SM A77821, cast from external mould of incomplete cranidium, Sholeshook Limestone horizon, Robeston Wathen (locality 10a), dorsal view, ×8. 17, SM A99093, internal mould of pygidium, same horizon and locality, dorsal view, ×6.



PRICE, Sholeshook trilobites

Pygidium with long (sag.), narrow, gradually tapering axis and abaxially expanding, unfurrowed pleural ribs separated by strong furrows. At least seven axial rings are present and there is room for several more on the anteriorly damaged portion of the axis; there appear to be eight inter-pleural furrows. Although the ventral mould of the doublure is not completely exposed, a broad band of concentric terrace-lines is visible postero-laterally.

Discussion. The hypostoma is very similar to that of *O. jaanussoni* originally figured by Barrande (1852, pl. 31, fig. 6; pl. 32, fig. 6) from the Králův Dvůr Formation of Bohemia. That of *O. radiatus* Salter figured by Whittington (1966, pl. 24, fig. 6) from the Crugan Mudstone Formation of north Wales is similar in over-all form but differs in that the posterior notch is sub-angular anteriorly and not with a rounded anterior expansion as in the south Welsh and Bohemian forms.

Family ILLAENIDAE Hawle and Corda, 1847
Subfamily ILLAENINAE Hawle and Corda, 1847
Genus ILLAENUS Dalman, 1827
Subgenus PARILLAENUS Jaanusson, 1954

Type species. *Illaenus fallax* Holm, 1882.

Illaenus (*Parillaenus*) cf. *fallax* Holm, 1882

Plate 107, figs. 13–14; Plate 108, figs. 1–2

1885 *Illaenus Bowmanni*, Salt.; Marr & Roberts (*pars*), pp. 480–481.
1914 *Illaenus davisi* Salter; Strahan *et al.*, table p. 63.
1933 *Illaenus bowmanni* Salter; Reed (*pars*), pp. 124–125.
1973*a* *Illaenus* (*Parillaenus*) cf. *fallax* Holm; Price, tables 1–4.
1974 *Illaenus* (*Parillaenus*) cf. *fallax* Holm; Price, p. 844 (top).

Horizons and localities as in Table 1. Not known from Slade and Redhill Mudstone Formation.

Description. Entire exoskeleton sub-oval in outline (Pl. 108, fig. 1), almost $1\frac{3}{4}$ times as long (sag.) as wide (tr.); isopygous. Cephalon sub-semicircular in outline, moderately and evenly convex (sag., tr.). Axial furrows broad and shallow, extending forwards to about half cephalic length from posterior margin; rear sections sub-parallel with very slight abaxially convex curvatures, then, from about mid-level of palpebral lobes, furrows curve sigmoidally first adaxially and then outwards before dying out opposite anterior ends of palpebral lobes. Maximum width (tr.) between axial furrows about three-fifths of maximum width of cranidium; latter achieved on mid-level of palpebral lobes. Palpebral lobes long (exsag.) and crescentic, occupying about one-quarter of total cephalic length (sag.) and situated at about two-thirds of their own length (exsag.) from posterior margin. Posterior branches of facial sutures directed straight back from palpebral lobes; anterior branches curve at first gently outwards but then converge as they approach the anterior margin and become confluent on the ventral surface. Free cheeks thus sub-triangular in form, declined very steeply outwards, with rounded genal angles.

Thorax of ten segments, with shallow but broad and distinct axial furrows. Convex axis occupies over half total thoracic width anteriorly, remains sub-parallel over anterior-most five or six segments then tapers gradually back. Axial rings flat in lateral view. Pleurae simple; flat and horizontal adaxially, deflected postero-ventrally at fulcrum in gentle, posteriorly convex curves; abaxial extremities truncated antero-laterally; indistinctly separated articulating facets developed. Horizontal adaxial sections of pleurae become broader (tr.) posteriorly along the thorax (Pl. 108, fig. 1).

Pygidium about $1\frac{1}{4}$ times as broad (tr.) as long (sag.), convex transversely and in lateral profile rather flat over most of length but dropping steeply posteriorly. Axis anteriorly occupies about two-fifths of total width (tr.), is moderately convex, and bounded by shallow, ill-defined furrows which converge rapidly back. Anterior margins of pleural lobes transverse adaxially for length equivalent to about one-third of axial width then deflected gently back. Behind, shallow but broad and distinct furrows run obliquely back from anterior ends of axial furrows diverging at about 130°. Doublure of even width around margin and posteriorly occupying about one-quarter of total pygidial length (sag.); bearing rather widely spaced concentric terrace-lines.

Discussion. Holm's material of *I. fallax* awaits modern redescription, but to judge from his original figures the axial furrows appear to extend less far forward on the cranidium than in the south Welsh material. This difference also applies to cranidia figured by Ingham (1970, p. 19, pl. 2, figs. 10–20) from the high Caradoc and the Pusgillian and Cautleyan Stages at Cautley, and here there appear to be slight differences in cephalic proportions also—though much of the material from both south Wales and Cautley is distorted. In those pygidia figured by Holm which are most like the Sholeshook specimens (e.g. 1882, pl. 2, figs. 15, 18) the doublure appears to be narrower antero-laterally. *I.* (*P.*) *davisi* Salter, from the Rhiwlas Limestone of north Wales (see Whittington 1966, p. 67, pl. 20, figs. 16–23; pl. 21, figs. 1–4, 6–9) differs in having a pygidium which is strongly humped medially and has a much broader doublure.

Subfamily PANDERIINAE Bruton, 1968
Genus PANDERIA Volborth, 1863

Type species. *Panderia triquetra* Volborth, 1863.

Panderia edita Bruton, 1968?

Plate 108, figs. 3–8

1973*a* *Panderia* aff. *edita* Bruton; Price, pp. 233, 243, tables 1–4.

Horizons and localities. Apart from the Sholeshook Limestone occurrences shown in Table 1, the species ranges into the basal Slade and Redhill Mudstones at Prendergast (locality 8a) and is known also from the 'Bala Limestone' outcrop near Trefanty, 4 km south-east of St. Clears (Strahan, Cantrill, Dixon, and Thomas 1909, p. 56; Price 1973*a*, p. 243).

Description. Cephalon strongly convex (tr. and sag.); sub-semicircular in lateral profile (Pl. 108, fig. 5). Glabella about 1¼ times as long (sag.) as wide (tr.) with maximum width on mid-level of palpebral lobes. At this level also is a small median tubercle. Broad, shallow occipital furrow present only faintly mesially but deep occipital pits are developed where it meets the axial furrows. Latter deep and broad posteriorly where they outline small but distinct postero-lateral swellings of glabella (Pl. 108, fig. 4) then run forwards shallowing, at first straight and slightly divergent as viewed normally to the occipital region ('dorsally' *sensu* Bruton 1968) but opposite palpebral lobes are bowed outwards in distinctive geniculations and then deflected again abaxially to meet facial sutures just in front of palpebral lobes. Latter broad (tr.) and crescentic, occupying almost two-fifths of total glabellar length and situated at about two-thirds their own length from posterior margin. Short posterior branches of facial suture postero-mesially convex. Anterior branches converge for short distance and then gradually diverge and again converge in gentle curves to define an anterior glabellar area which is sub-rectangular with broadly rounded antero-lateral margins and attains a maximum width (tr.) of about nine-tenths the maximum glabellar width. Free cheeks in lateral view with broad concave embayments along antero-lateral margins—probably to accommodate edge of pygidium during enrolment (cf. Bruton 1968, p. 26, pl. 9, fig. 5). Eye lobes surrounded by prominent broad furrows.

Pygidium sub-semicircular in outline. Moderately convex, well-defined axis occupies one-third of total width anteriorly and tapers only gradually back reaching to two-thirds pygidial length, its posterior end rounded. Axial furrows broad and shallow. Anterior margins of pleural lobes transverse adaxially but about half-way out from axial furrows deflected gently posteriorly (Pl. 108, fig. 8). Broad, gently down-turned triangular facets are developed antero-laterally. Doublure narrow, occupying only 10–15% total pygidial length at posterior margin and narrowing antero-laterally.

Discussion. The south Welsh cranidia show much similarity with those of *P. edita* Bruton (1968, p. 25, pl. 9, figs. 3–8; pl. 10, figs. 1–3, 8) from the Boda Limestone (Harju Series) of the Siljan district, Sweden. While the anterior part of the glabella in the Welsh specimens is by no means as long (sag. and exsag.) as in one of the specimens figured by Bruton (pl. 10, fig. 2) it is of similar length to that of the holotype (Bruton 1968, pl. 9, fig. 7). The geniculation in the course of the axial furrows in the Welsh form, however, appears to be more prominent than in the Swedish material. No pygidium is known for *P. edita*. The form described by Dean (1977, p. 108, pl. 51, figs. 7, 8; pl. 52, figs. 1–14, 16, 17) from the Chair of Kildare Limestone as *P.* cf. *edita* differs from the south Welsh species in having anterior branches to the facial suture which converge in even curves and define a relatively shorter (sag.), frontally narrower (tr.) anterior glabellar area, in having free cheeks which are broadest further anteriorly and in having a pygidium with a relatively broader axis and much wider doublure. *P. megalophthalma* Linnarsson (Bruton 1968, p. 26, pl. 10, figs. 5, 6, 9; pl. 11, figs. 1, 5–10) differs in having a relatively shorter (sag.) and broader glabella lacking the postero-lateral swellings, in having broader (tr.) free cheeks, straighter posterior branches to the facial sutures and a much wider pygidial doublure. The north Welsh form *P. lewisi* (Salter), known only from the holotype (Bruton 1968, p. 28, pl. 10, fig. 7; pl. 11, figs. 2–4), also has proportionally broader (tr.) free cheeks than the south Welsh species. Examination of the holotype shows that in frontal view the anterior branches of the facial sutures converge evenly forwards and are not sinuous.

Family AULACOPLEURIDAE Angelin, 1854
Subfamily AULACOPLEURINAE Angelin, 1854
Genus HARPIDELLA McCoy, 1849
Subgenus HARPIDELLA McCoy, 1849

Type species. Harpes? *megalops* McCoy, 1846.

Remarks. For diagnosis of genus and subgenus, discussion, and renewed separation of *Harpidella* from genus *Otarion* see Thomas and Owens 1978, p. 71.

Harpidella (*Harpidella*) *lacrymosa* sp. nov.

Plate 108, figs. 10–14

1885 *Cyphaspis megalops*, M'Coy; Marr and Roberts, list p. 481.
1914 *Cyphaspis megalops* (McCoy); Strahan *et al.*, table p. 63.
1973*a* *Otarion* aff. *tenuis* Kielan; Price, tables 1–4.

Holotype. SM A31471 (Pl. 108, fig. 10), incomplete internal mould of exoskeleton from Sholeshook Limestone of Sholeshook railway cutting.

Horizons and localities. See Table 1.

Diagnosis. Species of *Harpidella* (*Harpidella*) with elongate, pear-shaped medio-frontal glabellar lobe, drop-shaped basal lateral lobes, very small 2p lobes; large eye-lobes reaching almost to posterior border furrow; free cheeks with shallow lateral border furrows, broad convex borders, and concave lateral margins near bases of

EXPLANATION OF PLATE 108

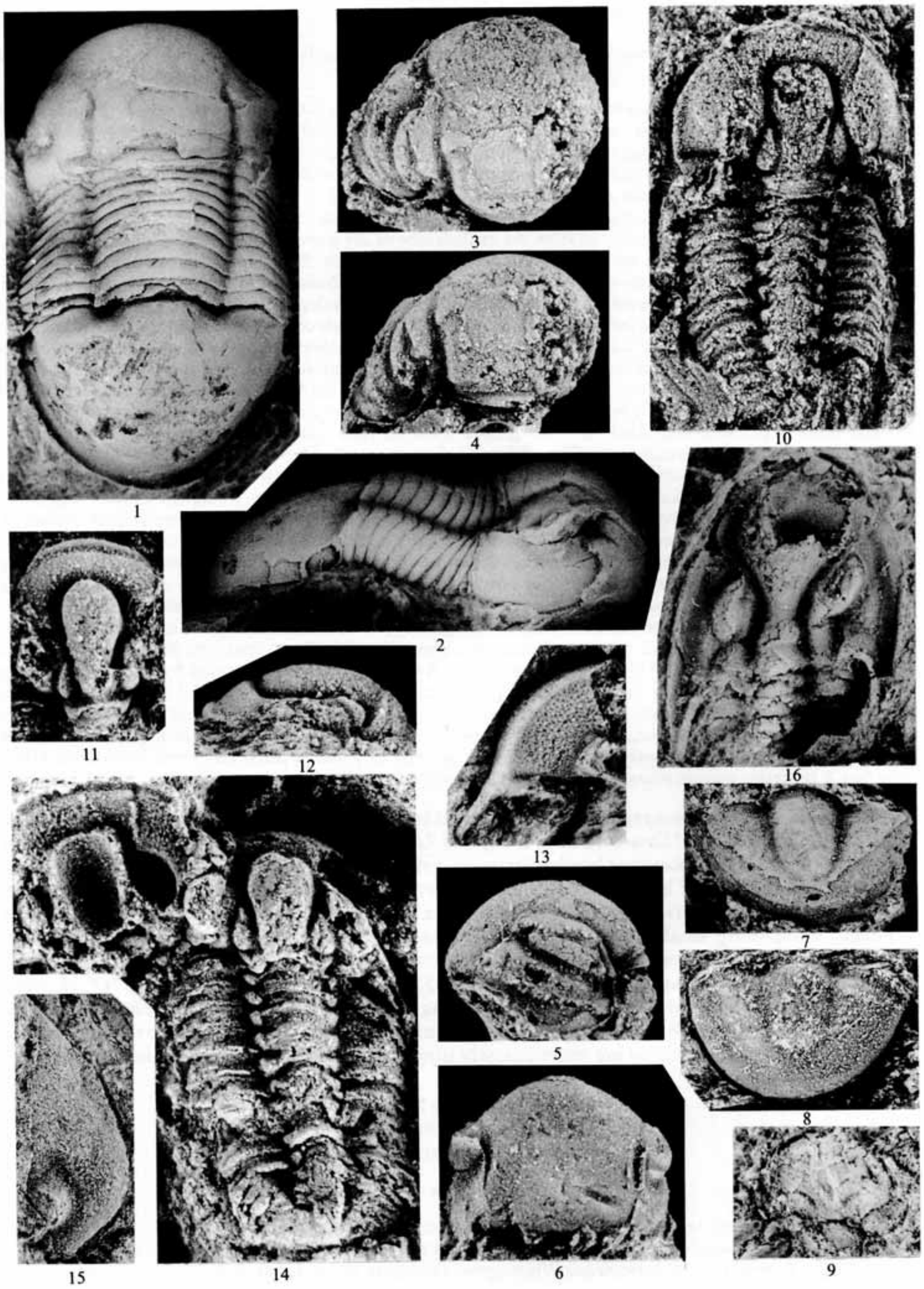
Figs. 1, 2. *Illaenus* (*Parillaenus*) cf. *fallax* Holm. SM A31500, internal mould of entire articulated specimen from the Sholeshook Limestone of Sholeshook, dorsal and right lateral views, ×1½.

Figs. 3–8. *Panderia edita* Bruton? 3, 4, HM A9572a, internal mould of incomplete cephalon from the 'Bala Limestone' of Trefanty, 4 km south-east of St. Clears, dorsal view as used herein and 'dorsal' view sensu Bruton 1968 (normal to occipital region), ×8. 5, 6, SM A31503, internal mould of cephalon from Sholeshook Limestone of Sholeshook railway cutting, left lateral and anterior views, ×6. 7, BM It9290, internal mould of pygidium from Sholeshook Limestone horizon at Robeston Wathen (locality 10a), dorsal view, ×4. 8, SM A99096, internal mould of pygidium from high Sholeshook Limestone (locality 8c) of Prendergast, dorsal view, ×6.

Fig. 9. *Amphitryon radians* (Barrande)? SM A77947, internal mould of small, incomplete cranidium from high Sholeshook Limestone of Prendergast (locality 8b or 8c), dorsal view, ×8.

Figs. 10–14. *Harpidella* (*Harpidella*) *lacrymosa* sp. nov. 10, SM A31471, HOLOTYPE, internal mould of incomplete articulated cephalon and thorax from Sholeshook Limestone of Sholeshook railway cutting, dorsal view, ×8. 11, 12, SM A77536, internal mould of incomplete cranidium, middle Sholeshook Limestone, locality 9e, Sholeshook, dorsal and left lateral views, ×8. 13, SM A77592b, cast from external mould of left free cheek, horizon and locality as for figs. 11, 12, dorsal view, ×8. 14, SM A31470, internal mould of incomplete articulated exoskeleton and SM A104833, external mould of incomplete cephalon, Sholeshook Limestone of Sholeshook railway cutting, A31470 in dorsal view, ×8.

Fig. 15. *Stenopareia bowmanni* (Salter). HM A10397, internal mould of right free cheek, middle Sholeshook Limestone, Lan-y-gaer (locality 16b), Llandowror, dorsal view, ×2.



PRICE, Sholeshook trilobites

short, slender genal spines; subdued cephalic ornament of fine granules, free cheeks in addition pitted, borders and genal spines smooth.

Description. Cephalon semicircular in outline and moderately convex (tr.). Glabella sub-parabolic, broadest (tr.) posteriorly where occupies about one-third of total cephalic width. Median and frontal lobes together form distinctive pear-shaped unit, strongly convex (tr.) and narrowest posteriorly. Anterior part of this unit defined by deep, broad axial furrows which anteriorly contain shallow antero-lateral pits and by the broad but shallower pre-glabellar furrow. Rear portion defined by posteriorly convergent 1p lateral glabellar furrows which are broad and deep and form continuations of the anterior parts of the axial furrows; they run back to the occipital furrow and isolate the basal lateral lobes from the median lobe of the glabella. Basal lateral lobes drop-shaped, strongly convex (tr.), occupying about one-third total glabellar length. Basal lobes defined abaxially by rear portions of axial furrows; these posteriorly divergent, narrower, and shallower than either anterior portions or 1p lateral furrows. 2p furrows never clearly seen but appear to be developed faintly on at least two specimens (SM A77950, not figured, and the holotype) just in front of anterior ends of 1p furrows and thus delimiting very small 2p lateral lobes. Occipital furrow broad and shallow; ring rather narrow (sag. and exsag.), mesially transverse and sub-parallel sided but abaxially narrowing and curving forwards towards axial furrows. Pre-glabellar field drops in steep, convex slope to broad, shallow anterior border furrow. Anterior border of about same width as furrow, moderately convex and sloping forward less steeply than pre-glabellar field (Pl. 108, fig. 12). Eye-lobes large, occupying almost one-third cephalic length; their mid-lengths occur slightly in front of the basal lateral lobes and they reach posteriorly almost to the posterior border furrow. Palpebral lobes also large but form not clearly seen. Anterior branches of facial sutures diverge at 40–50° until reaching anterior border where they are deflected adaxially and run obliquely across border leaving narrow, triangular anterior tongues to free cheeks (Pl. 108, fig. 13). Posterior branches curve out and gently back. Free cheeks drop steeply to shallow lateral border furrows and broad, convex borders and are extended postero-laterally as relatively short, slender genal spines which carry a faint median furrow. Outer margins of genal spines and lateral borders merge in abaxially concave curves. Transverse posterior border furrows broad and deep; borders narrow and strongly convex adaxially but much broader and more gently convex towards genal angles. Cephalic surface bears fine, rather subdued granulation; free cheeks in addition irregularly pitted; borders and genal spines smooth.

Thorax poorly preserved and number of segments uncertain, though at least ten. Strongly convex axis occupies just over one-third total width (tr.) anteriorly. Axial rings convex, separated by strong articulating furrows which abaxially deepen to apodemal slots separating prominent rounded axial lobes. Axial furrows broad but shallow. Inner portions of pleurae transverse and horizontal, then bent down and deflected posteriorly at fulcrum; divided roughly along median line by broad, shallow pleural furrows which gradually narrow outwards; distal extremities bluntly terminated. Pygidium only very poorly preserved; much broader (tr.) than long (sag.), posterior margin rounded and axis well defined anteriorly.

Discussion. H. (*H.*) *lacrymosa* sp. nov. is most similar to '*Otarion*' *tenue* Kielan (1960, p. 63, pl. 2, figs. 1–2; text-fig. 15) from the '*Staurocephalus clavifrons* Zone' of Poland but differs as follows: eye-lobes larger and set closer to posterior border furrows; genal spines slenderer, narrower-based, and not carrying continuations of lateral and posterior border furrows; lateral border wide and prominent, border furrow weak; anterior border furrow not wider than anterior border; cephalic ornament more subdued, comprising smaller and more closely spaced granules, borders and genal spines not ornamented; anterior thoracic pleurae not sharply pointed. Cranidia from the Irish Chair of Kildare Limestone figured by Dean (1974, p. 68, pl. 28, figs. 5, 8, 10, 12, 13; pl. 29, figs. 3, 5) as '*O*', cf. *tenue* differ from both Polish and Welsh specimens in having more divergent anterior branches to the facial sutures and in possessing broader (sag. and exsag.) anterior borders which are more strongly arched anteriorly. The Irish specimens are more coarsely ornamented than those from Wales.

Family PROETIDAE Salter, 1864
Genus PROETUS Steininger, 1831
Proetus (s.l.) cf. *berwynensis* (Whittington, 1966)

Plate 107, figs. 16–17

1909 *Proetus* cf. *brachypygus* Marr and Nicholson; Strahan *et al.*, table p. 58.
1973*a* *Astroproetus* aff. *berwynensis* Whittington; Price, pp. 233, 243.
1973 *Proetus* (s.l.) cf. *berwynensis* Whittington; Owens, p. 20, pl. 1, figs. 2–7.

Horizons and localities. Relatively abundant in the Sholeshook Limestone horizon at Robeston Wathen (locality 10a). Also occurs in the 'Bala Limestones' of Trewern Quarry 3 km north-west of Whitland (Strahan *et al.* 1914, p. 56) and Bron-haul about 2·5 km east-south-east of Llandowror (Strahan *et al.* 1909, p. 56).

Discussion. Owens (1973, see synonomy), who illustrated several specimens of this form, pointed out the close similarity to *P. berwynensis* (Whittington), a species known only from a single specimen (Whittington 1966, pl. 25, figs. 14–16; Owens 1973, pl. 1, fig. 1) from the Ashgill Dolhir Beds of Cynwyd, 3 km south-west of Corwen, Clwyd. This holotype of *P. berwynensis* has the genal angles poorly preserved and it is uncertain whether or not genal spines are developed as in the South Welsh specimens (Owens 1973, pl. 1, figs. 2, 5).

One of the specimens figured here, a cast from an incomplete external mould of the cranidium (Pl. 107, fig. 16) shows the short (sag. and exsag.) pre-glabellar field, a glabellar surface ornamentation of scattered granules of 0·075–0·1 mm and a prominent occipital tubercle. The other specimen is the internal mould of a pygidium (Pl. 107, fig. 17). The axis comprises, in addition to the half-ring, four axial rings and a short terminal piece; the doublure extends mesially almost to the tip of the axis.

Family TRINUCLEIDAE Hawle and Corda, 1847
Subfamily TRINUCLEINAE Hawle and Corda, 1847
Genus NANKINOLITHUS Lu, 1954

Type species. *Nankinolithus nankinensis* Lu, 1954.

Remarks. Ingham (1970, p. 44) in his discussion of genus *Tretaspis* McCoy referred to and briefly characterized a species-group typified by *T. granulata* (Wahlenberg) and *T. portrainensis* Lamont. Such forms have subsequently been removed from *Tretaspis* and placed in genus *Nankinolithus* Lu (Hughes *et al.*, 1975, pp. 558–559, see p. 558 for diagnosis).

Nankinolithus cf. *granulatus* (Wahlenberg, 1818)

Plate 109, figs. 1–10

1885 *Trinucleus seticornis*, var. *Bucklandi*, Barr.; Marr and Roberts, pp. 480, 481.
1914 *Trinucleus seticornis* (His.); Strahan *et al.* (*pars*), table p. 64, faunal lists p. 76.
1914 *Trinucleus seticornis* (His.), var. *bucklandi* Barr.; Strahan *et al.*, table p. 64.
1916 *Trinucleus seticornis* (His.). var. *bucklandi* Barr.; Cantrill *et al.*, faunal list p. 50.
1973*a* *Tretaspis* cf. *granulata* (Wahlenberg); Price, pp. 229, 234, 241, tables 1–3, 7.

Horizons and localities. Abundant in basal 2 or 3 m of Sholeshook Limestone at Sholeshook but rarer in low Sholeshook Limestone around Llandowror (locality 19); also abundant in basal Slade and Redhill Mudstones between Pelcomb and Clarbeston Road Station (localities 1–6).

Description. Cephalon almost as broad (tr.) as long. Occipital ring moderately arched transversely, longitudinally narrow, and not strongly convex, almost straight in dorsal view; furrow abaxially containing deep, ovoid apodemal slots. 1p apodemal slots converge anteriorly at about 110°. 2p furrows in form of large ovoid pits diverging anteriorly at 110–120°. 3p lateral furrows usually visible, even in internal moulds, as shallow ovoid pits near mid-length of pseudofrontal lobe. Anterior fossulae only developed as very shallow depressions, not always visible. Genal lobes moderately convex (tr. and exsag.), steeply declined antero-laterally but not overhanging fringe; not bearing lateral tubercles or eye-ridges. Both pseudofrontal glabellar lobe and genal lobes smooth. Posterior border furrows shallow, abaxially containing large posterior fossulae. Posterior border narrow and only weakly convex. Upper lamella of fringe anteriorly comprises steep, slightly concave genal roll merging into narrow horizontal brim; laterally drops outwards in smooth, gently concave curve. Genal prolongations reach almost as far back as posterior margin of pygidium (Pl. 109, fig. 2). Long slender genal spines produced beyond these (Pl. 109, fig. 10) have strong ventral ridges continuous with girder. Pits of E_2, E_1, and I_1 arcs radially in line. Frontally and antero-laterally on upper lamella exist as clearly separate pits (Pl. 109, fig. 8), but on genal prolongations E_1 and I_1 tend to be contained in short radial sulci (Pl. 109, fig. 10) and occasionally these may contain of E_2 also; E_1 and E_2 gradually merge posteriorly but usually remain present as separable pits in all but posterior-most two or three radii. On a few specimens the E arcs are most closely merged antero-laterally and become slightly more separated posteriorly (Pl. 109, fig. 10). Lower lamella has more distinct change of slope between genal roll and brim and a broad girder is present (Pl. 109, figs. 2, 6); E_1 and E_2 pits gradually merge posteriorly and are present beyond R12 or R13 as conjunct pit-pairs (Pl. 109, figs. 2, 5-6), though merging completely only in posterior-most two or three radii. Number of pits in E_1 (half-fringe) ranges from 28 (2 specimens), through 29 to 32 (1 specimen in each case). On all specimens the pits of the innermost two I arcs (I_n and that adjacent) are radially in line (Pl. 109, figs. 3, 4, 8) but pits of the arcs between these and I_1 are arranged very irregularly and difficult to count (see Pl. 109, fig. 6). Usually there are 4 I arcs frontally (I_{1-3}, I_n) and antero-laterally 5 or 6 (i.e. I_4 or I_4 and I_5 also present); at least 1 specimen (SM A77527 from Sholeshook) appears to have 7 I arcs (I_{1-6}, I_n) antero-laterally. The number of I arcs increases by intercalation on the genal prolongations until there are 13 (4 specimens), 14 (2 specimens), 15 (1 specimen), 16 (4 specimens), or 17 (3 specimens) pits in the posterior row. Two specimens differ from description so far given. One, a fringe fragment shown in Pl. 109, fig. 7 is unique in showing well-developed sulci containing pits of the E_2, E_1, and I_1 arcs. The other, the cephalon seen in Pl. 109, figs. 3, 4, is unique in that while two E arcs are developed frontally on the upper lamella only one E arc is present laterally from about R16.

Axis of thorax strongly convex, occupying one-fifth of total width anteriorly; rings broadest (sag. and exsag.) mesially where gently arched forward, narrow and curved forwards abaxially; dorsal surfaces flat in lateral profile. Axial furrows broad and prominent. Pleural lobes flat. Pleurae transverse and horizontal for most of length but deflected ventrally and slightly posteriorly at distal ends. Pleural furrows adaxially narrow, commence near inner anterior corners of pleurae and run slightly obliquely, broadening outwards and separating narrow anterior and broad, strongly convex posterior pleural bands.

Pygidium about 2½ times as wide as long, with convex postero-lateral margins. Gently convex axis, anterior occupies one-quarter of total width and tapers back at 35°. Mesially broad articulating furrows become elongated apodemal pits abaxially; eight such pairs of pits developed. Flat pleural regions crossed by five broad (exsag.), abaxially expanding pleural bands increasingly faintly defined posteriorly. Anterior-most bands carry narrow, faint pleural furrows and are separated by broad interpleural furrows. Strong sub-marginal rim. Slightly bevelled posterior margin carries faint, irregular terrace-lines.

Discussion. Material, including the holotype, of '*Tretaspis*' *granulata* described by Kielan (1960, p. 171, pl. 32, figs. 1-3; pl. 34, figs. 1, 2; pl. 35, figs. 1, 2; pl. 36, fig. 6; text-fig. 49) from the upper Ordovician of Poland, Sweden, and Bohemia differs mainly in the presence (both frontally and laterally on the fringe upper lamella) of well-developed sulci containing the E_2, E_1, and I_1 pits.

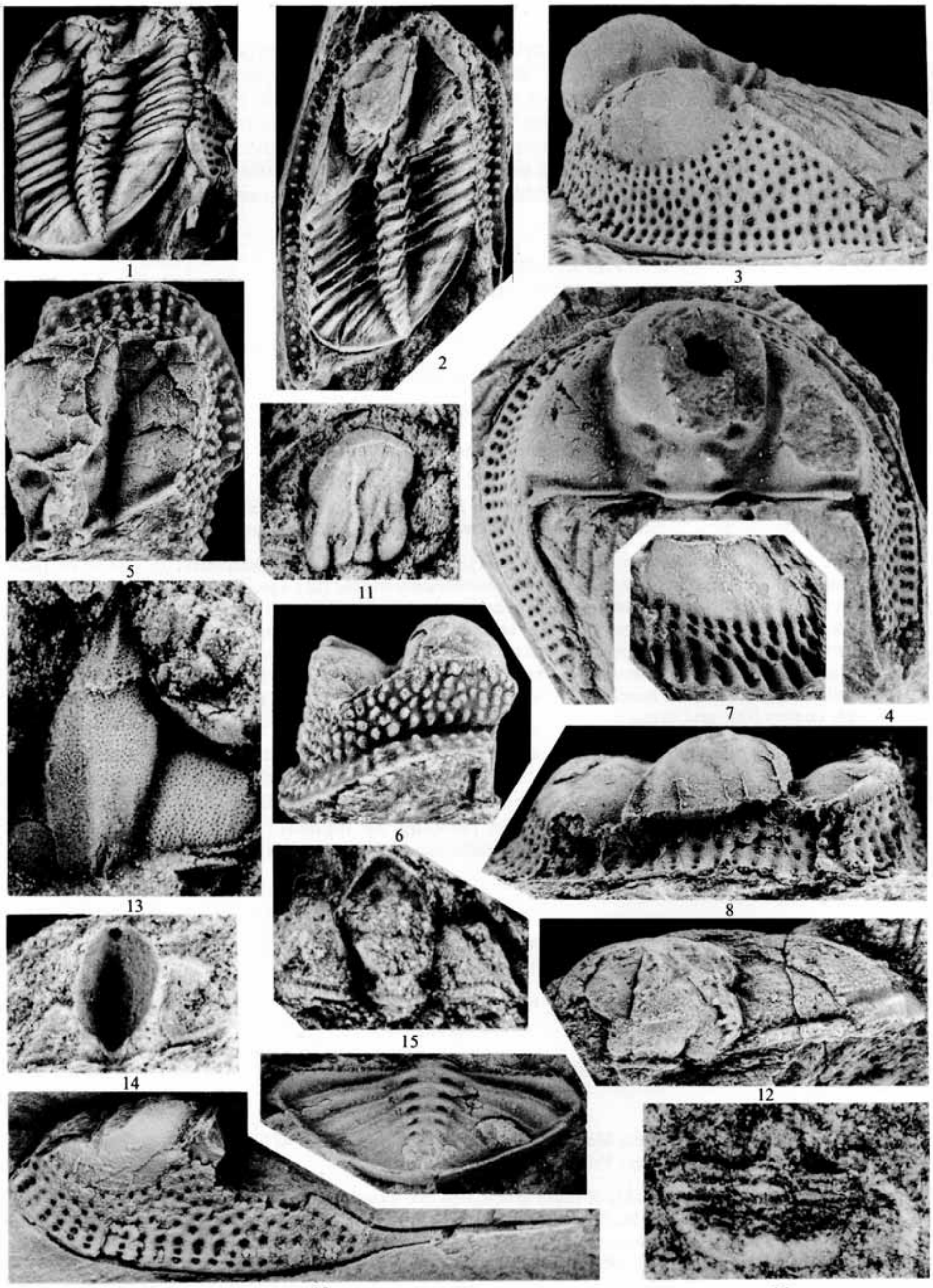
EXPLANATION OF PLATE 109

Figs. 1-10. *Nankinolithus* cf. *granulatus* (Wahlenberg). 1, 2, SM A31606b, a, cast from external mould and internal mould of articulated exoskeleton from low horizon in Slade and Redhill Mudstones near Pelcomb Cross (locality 2), dorsal views, ×3. 3, 4, GSM TCC. 1736, internal mould of large, well-preserved cephalon from low(?) horizon in Slade and Redhill Mudstones, quarry south of Marlsborough, 7 km west-north-west of Haverfordwest, left-lateral and dorsal views, ×3. 5, 6, SM A77526, internal mould of incomplete cephalon from basal Sholeshook Limestone, south end of Sholeshook railway cutting, dorsal and anterior views, ×3. 7, SM A77675a, fragment of upper lamella of fringe with E_2, E_1, and I_1 pits in well-developed sulci, basal Slade and Redhill Mudstones south-west of Knock (locality 3), oblique view, ×4. 8, SM A31616, slightly distorted internal mould of cephalon, horizon, and locality as for figs. 5, 6, anterior view, ×4. 9, GSM TCC. 1178, cast from external mould of pygidium, horizon, and locality as figs. 5, 6, dorsal view, ×3. 10, SM A77700, left genal area and prolongation of fringe upper lamella and genal spine, basal Slade and Redhill Mudstones of Withy Hedge (locality 5), oblique view, ×3.

Figs. 11, 12. *Dionide* sp. indet. 11, SM A31619, internal mould of partial cephalon, horizon, and locality as for figs. 1, 2, dorsal view, ×6. 12, SM A77534, internal mould of incomplete cephalon from middle Sholeshook Limestone, locality 9e, Sholeshook.

Fig. 13. *Lonchodomas* aff. *pennatus* (La Touche). SM A77629, cast from incomplete external mould of cranidium, horizon, and locality as for fig. 7, dorsal view, ×10.

Figs. 14-16. *Raphiophorus* cf. *tenellus* (Barrande). 14, 15, BM It8101b, a, external mould showing base of frontal spine and internal mould of cranidium, horizon, and locality as for fig. 12, dorsal views, ×10. BM It8091a, internal mould of small incomplete articulated exoskeleton, same horizon and locality, dorsal view, ×10.



PRICE, Sholeshook trilobites

Although the species is described as having two E arcs present anteriorly and only one developed laterally (Kielan 1960, p. 172), several of the illustrated specimens show separate E_1 and E_2 arcs present in all but the posterior-most two or three radii of the fringe as in the south Welsh material. The south Welsh specimens appear to have similar numbers of pit arcs frontally on the fringe but rather more in the posterior row (cf. Kielan's fig. 49). Kielan does not give figures for the number of E_1 pits in the half-fringe but, to judge from the illustrations and a few Polish specimens in the collections of the British Museum (Natural History), the number ranges from around twenty-seven to around thirty-one.

Family DIONIDIDAE Gürich, 1907
Genus DIONIDE Barrande, 1847

Type species. Dionide formosa Barrande, 1846.

Dionide sp. indet.

Plate 109, figs. 11, 12

1885 *Illaenus* (young); Marr and Roberts, faunal list p. 481.
1973*a* *Dionide* sp. indet.; Price, tables 1, 2.

Material. Two internal moulds of incomplete cephala; SM A31619 from basal Slade and Redhill Mudstones near Pelcomb Cross (locality 2) and SM A77534 from middle Sholeshook Limestone, locality 9e, Sholeshook.

Description. Cephalon much wider (tr.) than long (sag.). Glabella sub-quadrate, narrowest (tr.) across occipital ring and narrowing again just in front of mid-length; moderately convex (tr.). Occipital ring narrow and convex (sag. and exsag.), occipital furrow narrow; both gently arched forward. Deep 1p lateral glabellar furrows run forward from occipital furrow diverging slightly and reaching to about one-quarter of total glabellar length. Genal lobes sub-quadrant shaped, apparently pitted (Pl. 109, fig. 11), and one specimen (Pl. 109, fig. 12) shows traces of what appear to be genal caecae. This same specimen also clearly shows the inner margin of the fringe and a ventral mould of the lower lamella with tuberculation reflecting the fringe pitting. Posterior border broad and strongly convex (sag. and exsag.).

Discussion. The incompleteness of these specimens does not permit very useful comparison with other dionidid species. It may be noted, however, that the narrowing (tr.) of the glabellar around its mid-length is an unusual feature though it may be seen also in specimens of *D. richardsoni* Reed from the upper Whitehouse Beds of Girvan (Reed 1903, pl. 4, fig. 3). Ingham (1974, p. 64) has noted that specimens of Reed's species from the upper Whitehouse Beds and those from the upper Drummuck Group represent distinct forms.

Family RAPHIOPHORIDAE Angelin, 1854
Genus RAPHIOPHORUS Angelin, 1854

Type species. Raphiophorus setirostris Angelin, 1854.

Raphiophorus cf. *tenellus* (Barrande, 1872)

Plate 109, figs. 14–16

1885 *Ampyx tumidus* Forbes; Marr and Roberts (*pars*), lower list p. 481.
1973*a* *Raphiophorus* sp. indet.; Price, tables 1, 2.

Material. Internal and external moulds of small articulated exoskeleton (Pl. 109, fig. 16) and of cranidium (Pl. 109, figs. 14, 15) both from locality 9e, Sholeshook, and two internal moulds of cranidia (SM A31384–5) from the basal Slade and Redhill Mudstones of Pelcomb Cross (locality 2). A partial cranidial external mould (SM A99477) from the basal Slade and Redhill Mudstones south-west of Knock (locality 3) probably also belongs here.

Description. Ovoid glabella strongly convex transversely, moderately so longitudinally; anteriorly bluntly pointed and projecting well beyond fixed cheeks, posteriorly contracts (tr.) rapidly between broad triangular depressions confluent with axial and occipital furrows. Latter furrow narrow, shallow mesially. Sub-triangular fixed cheeks strongly declined antero-laterally. Posterior border furrows strong, set slightly oblique, deepening abaxially; borders broad and prominent. Occipital ring narrow (sag. and exsag.), gently arched dorsally. Cranidial external moulds show position of circular-sectioned frontal spine, also apparent lack of surface ornamentation. The articulated Sholeshook specimen appears foreshortened due to folding between the thoracic segments and the absence of the anterior part of the glabella but shows the course of the genal spine and the relatively large pygidium with its broad border.

Discussion. The South Welsh specimens are most like *R. tenellus* from the Ashgill of Sweden, Poland, and Bohemia (Kielan 1960, p. 165, pl. 35, fig. 6; Whittington 1968, p. 94, text-fig. 6). *R. tenellus* is like *R. setirostris* in general form but the type species appears to have a relatively shorter (sag.) and wider glabella projecting less far beyond the fixed cheeks and with a shorter constricted posterior section. *R. acus* (Troedsson) from the Ashgill of Poland (Kielan 1960, p. 168, pl. 32, fig. 4; pl. 35, fig. 7) and the high Rawtheyan of the southern Lake District (McNamara 1979*b*, table 2) has a glabella which projects less far forward than in either *R. tenellus* or *R. setirostris* and which is broadly rounded anteriorly; it also has relatively longer (exsag.) and narrower fixed cheeks which are strongly convex antero-laterally and a smaller pygidium.

Genus LONCHODOMAS Angelin, 1854

Type species. Ampyx rostratus Sars, 1835.

Lonchodomas aff. *pennatus* (La Touche, 1884)

Plate 109, fig. 13; Plate 110, figs. 1–3

1885 *Ampyx tumidus* Forbes; Marr and Roberts (*pars*), higher list p. 481.
1914 *Ampyx tumidus* Forbes; Strahan *et al.*, table p. 63.
1973*a* *Lonchodomas tumidus* (Forbes); Price (*pars*), tables 1–3, 7.

Horizons and localities. Apart from occurrences shown in Table 1, also abundant in basal Slade and Redhill Mudstones to north and west of Haverfordwest (localities 2, 3, 5).

Description. Cranidium broadly triangular with sagittal length (excluding frontal spine) about four-fifths the maximum width. Glabella about twice as long (sag.) as wide (tr.) with maximum width just in front of mid-length; strongly convex (tr.), standing high above fixigenae, frequently carinated; produced anteriorly into long, slender frontal spine (Pl. 110, fig. 1) which is sub-square in cross-section. Broad, shallow axial furrows separated by one-fifth of cranidial width posteriorly, diverging forwards at about 40°, containing deep, slot-like fossulae anteriorly. Fixigenae about as long (exsag.) as posteriorly wide (tr.); only gently convex. Occipital furrow continuous with posterior border furrows, both broad and shallow, latter contain small, deep, round pits abaxially. Occipital ring very narrow (sag. and exsag.), gently arched posteriorly, continuous laterally with very narrow but convex posterior borders. External moulds show cranidial surface covered with small pits of about 0·03 mm diameter (Pl. 109, fig. 13).

Pygidium more than twice as wide (tr.) as long (sag.) and broadly rounded posteriorly. Axis moderately convex (tr.) and raised above pleural lobes, occupies one-third total width anteriorly and tapers back at 30°. On internal moulds only articulating furrow on axis are clearly visible but there are faint indications behind of several paired pits. A pydium with some of the exoskeleton preserved (SM A77766) shows eight pairs of raised muscle scars on the axis. Axial furrows shallow and indistinct. Pleural lobes only gently convex, with steeply declined wide borders; only one pair of pleural furrows is clearly visible though there appear to be faint traces of two or three pairs of ribs behind.

Discussion. The South Welsh cranidia are similar in outline and proportions to cranidia of the high Caradoc–low Ashgill form *L. pennatus* (see Dean 1960, pl. 11, figs. 2, 5, 8–12; 1962, pl. 6, figs. 1, 3–5, 9, 12) but differ in the pitting of the cranidial surface and the much shallower posterior border furrows. In these features they are like cranidia of the form described by Ingham (1974, p. 65, pl. 11, figs. 6–14) as *L.* aff. *pennatus* from Zones 1 and 2 (and possibly 4) of the Cautley Mudstones. None of the south

Welsh pygidia, however, show clearly the development of the two or more pleural furrows seen in the Cautley form. Ingham noted the similarity between the Cautley form he described and a specimen, probably from the Dolhir Beds near Corwen, referred by Whittington (1968, pl. 30, figs. 13, 15, 18-20) to *L. tumidus* (Forbes). As in the south Welsh specimens, the pygidium of this form shows only one clear pair of pleural furrows.

Lonchodomas cf. *drummuckensis* (Reed, 1903)

Plate 110, figs. 4-6

1914 *Ampyx drummuckensis* Reed; Strahan *et al.*, table p. 63.
1973*a* *Lonchodomas tumidus* (Forbes); Price (*pars*), tables 1-3.
?1974 *Lonchodomas* aff. *portlocki* (Barrande); Ingham, pp. 65-66, pl. 12, figs. 1-13.

Material. Articulated pygidium and incomplete thorax, three pygidia and one small, incomplete cranidium, all from either the top 4 m of the Sholeshook Limestone or the base of the overlying Slade and Redhill Mudstones (localities topmost 8d to basal 8a) at Prendergast Place. A few distorted or incomplete larger cranidia from the same localities probably belong here too (e.g. SM A31158), and an incomplete cranidium (HM A9656) from the basal Slade and Redhill Mudstones of Clog-y-fran (locality 15) near Llandowror.

Description. Most complete and undistorted cranidium very small (Pl. 110, fig. 6); broadly triangular with sagittal length just over four-fifths maximum width. Glabella, excluding frontal spine, over twice as long (sag.) as wide (tr.) with maximum width at about two-fifths its length from posterior margin; only moderately convex (tr.), slightly carinate anteriorly. Axial furrows shallow and indistinct, diverging forwards at about 50°, with

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EXPLANATION OF PLATE 110

Figs. 1-3. *Lonchodomas* aff. *pennatus* (La Touche). 1, SM A77701, internal mould of partial cranidium showing form of frontal spine, basal Slade and Redhill Mudstones of Withy Hedge (locality 5), dorsal view, ×2. 2, SM A77632, poorly preserved internal mould of pygidium from same locality, dorsal view, ×6. 3, SM A77684a, internal mould of incomplete cranidium from basal Slade and Redhill Mudstones south-west of Knock (locality 3), dorsal view, ×8.

Figs. 4-6. *Lonchodomas* cf. *drummuckensis* (Reed). 4, SM A104835a, internal mould of pygidium and incomplete thorax from basal Slade and Redhill Mudstones of Prendergast (locality 8a), dorsal view, ×2. 5, BM It9249, distorted internal mould of pygidium from highest Sholeshook Limestone of Prendergast (locality 8b), dorsal view, ×3. 6, BM It9247, internal mould of small partial cranidium from the high Sholeshook Limestone (topmost locality 8d) of Prendergast, dorsal view, ×10.

Figs. 7, 8. *Ceraurinella intermedia* (Kielan). 7, SM A31585, internal mould of incomplete pygidium from the Sholeshook Limestone of Sholeshook railway cutting, dorsal view, ×3. 8, BM It9216, internal mould of slightly distorted incomplete cranidium, horizon, and locality as for fig. 4, dorsal view, ×3.

Figs. 9-11. *Pseudosphaerexochus tectus* Ingham. 9, SM A77875, cast from external mould of pygidium from the high Sholeshook Limestone, locality 9g, Sholeshook, dorsal view, ×5. 10, 11, SM A31586, internal mould of cranidium from Sholeshook Limestone of Sholeshook, right lateral view, ×3, and dorsal view, ×2.

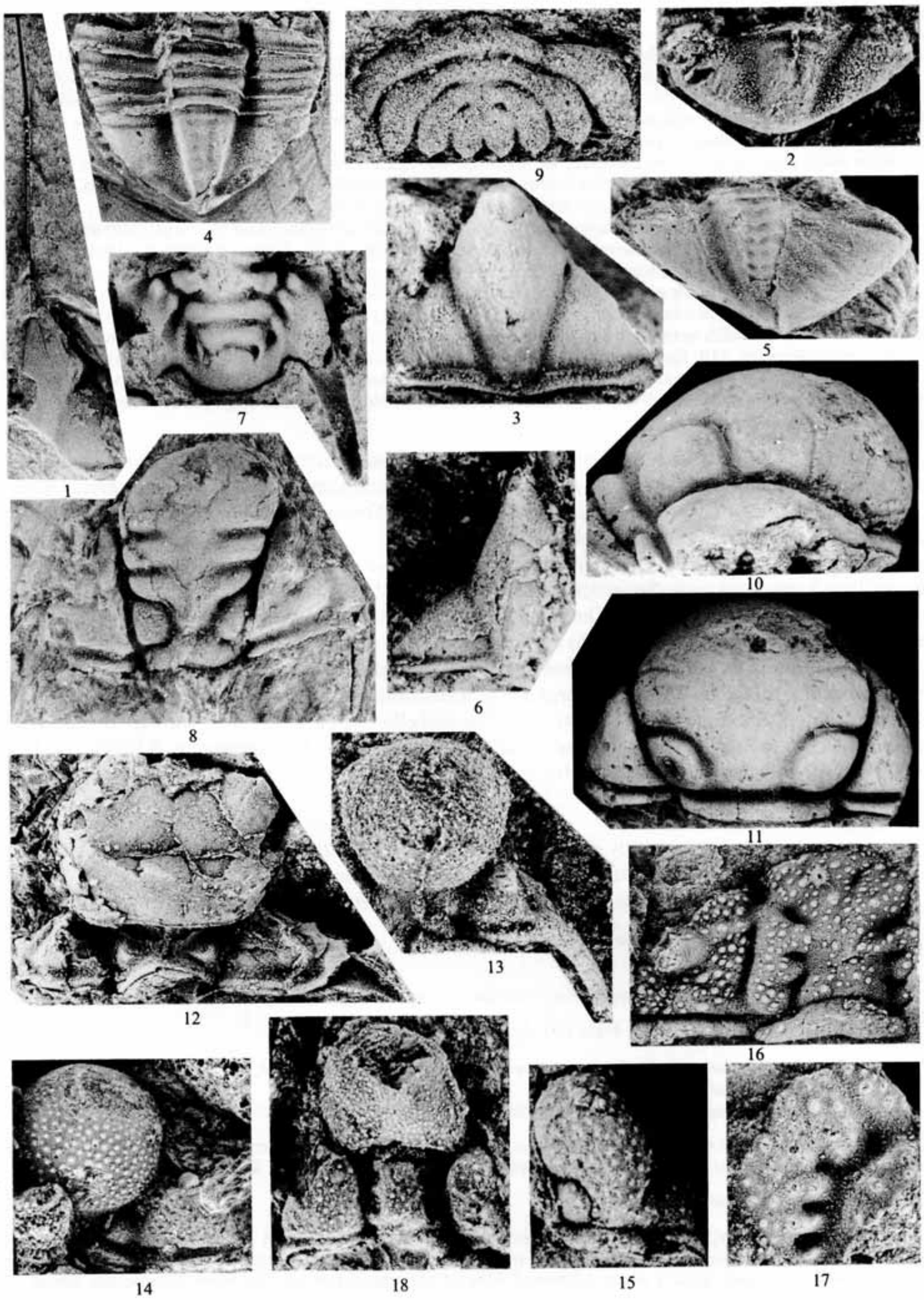
Figs. 12-14. *Sphaerocoryphe* aff. *thomsoni* Reed. 12, HM A9733, internal mould of flattened, incomplete cranidium from the low Sholeshook Limestone, track south of Craig-y-deilo quarry, Llandowror (locality 18d), dorsal view, ×4. 13, BM In54702, cast from external mould of partial cranidium from Sholeshook Limestone of Craig-y-deilo quarry, Llandowror, dorsal view, ×4. 14, BM It9245, cast from external mould of partial cranidium from middle Sholeshook Limestone, locality 9e, Sholeshook, dorsal view, ×4.

Fig. 15. *Pseudosphaerexochus juvenis* (Salter). SM A77887b, cast from external mould of small cranidium from middle Sholeshook Limestone, locality 9e, Sholeshook, dorsal view, ×10.

Fig. 16. *Cybeloides* (*Paracybeloides*) *girvanensis* (Reed). SM A77531, cast from external mould of incomplete cranidium from the Sholeshook Limestone of Sholeshook railway cutting, dorsal view, ×4.

Fig. 17. *Atractopyge scabra* Dean? SM A77971, partial internal mould of cranidium from 9½-10 m above base of Sholeshook Limestone in Mylet road section (locality 24a), Llandowror, dorsal view, ×3.

Fig. 18. *Staurocephalus* cf. *clavifrons* Angelin. HM A9751, internal mould of cranidium, horizon, and locality as for fig. 12, dorsal view, ×6.



PRICE, Sholeshook trilobites

small, slot-like fossulae anteriorly. Fixed cheeks about three-quarters as long (exsag.) as wide (tr.) and gently convex dorsally, though dropping steeply antero-laterally. Posterior border furrows shallow and indistinct adaxially but on internal moulds deepen and widen outwards into broad slots. Occipital furrow shallow and indistinct; ring continuous with posterior borders, gently arched posteriorly. Posterior borders convex (exsag.) and distinct, about as broad as posterior border furrows.

Other much larger cranidia fragmentary or distorted but agree in showing shallow axial furrows, strongly developed posterior borders, and border furrows which are indistinct adaxially but well developed laterally; some show the free anterior part of the glabella to be sub-circular in section.

Thorax known from posterior four segments (Pl. 110, fig. 4). Axis occupies about one-third total width; rings flat (sag. and exsag.) dorsally, ring furrows shallow mesially and laterally but deepened between into paired slots. Axial furrows broad and deep. Pleural furrow on anterior-most segment (second) continuous and transverse but on those behind runs obliquely out and forwards from position about one-third pleural width from axial furrow. Pygidium just less than twice as wide (tr.) as long (sag.) and bluntly pointed posteriorly. Axis occupying just less than one-third total width anteriorly and tapering back at 30°; behind the articulating furrow internal moulds show a series of six (Pl. 110, fig. 4) or seven (Pl. 110, fig. 5) pairs of elongated (tr.) pits. Axial furrows broad and distinct. Pleural lobes with gently convex and steeply declined postero-lateral margins. Single pair of pleural furrows, shallow adaxially but distinct for outer two-thirds of length and curving forwards towards antero-lateral corners of pleural lobes.

Discussion. The South Welsh pygidia closely resemble those of the Rawtheyan form from Cautley described by Ingham (1974) as *L.* aff. *portlocki* (Barrande) and also those of *L. drummuckensis* (Reed 1903, p. 18, pl. 3, figs. 1-5) from the late Rawtheyan upper Drummuck Group of Girvan. The Polish and Bohemian Ashgill species *L. portlocki* (see Kielan 1960, pl. 33, fig. 8; pl. 35, fig. 4) has a pygidium which is relatively much shorter (sag.). The specimens figured by Kielan are small but even on a much larger Polish specimen in the Sedgwick Museum (A44183) the pygidium is three times as wide as long and posteriorly broadly rounded. The small Sholeshook cranidium strikingly resembles a small one figured by Ingham (1974, pl. 12, fig. 5) as *L.* aff. *portlocki* but differs from his larger cranidia. These are said to differ from cranidia of *L. drummuckensis* in having a relatively shorter, less inflated, and less well-defined glabella. The lack of large south Welsh cranidia makes similar comparisons difficult. From the small Sholeshook cranidium alone the glabella does appear to be similar to that of *L. drummuckensis* to judge from specimens of the latter in the Sedgwick Museum (e.g. A10918, A11103, A52598), though these differ slightly from the South Welsh form in possessing narrower (exsag.) posterior borders.

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

Type species. Sphaerexochus hemicranium Kutorga, 1854.

Pseudosphaerexochus juvenis (Salter, 1848)

Plate 110, fig. 15; Plate 111, figs. 8-11

1974 *Pseudosphaerexochus* (*Pseudosphaerexochus*) *juvenis* (Salter); Price, pp. 849-850, pl. 113, figs. 5-9. Includes full synonomy.

?1974 *Pseudosphaerexochus conformis* (Angelin); Ingham, pp. 70-71, pl. 14, figs. 6-12.

Lectotype. Subsequently designated Whittington 1965, p. 40; GSM 24534, internal mould of cranidium from Sholeshook Limestone of Sholeshook; figured Whittington 1965, pl. 12, figs. 2, 4, 8.

Horizons and localities. See Table 1.

Description. The lectotype and other GSM specimens used by Whittington (1965, see synonomy) in his redescription of *P. juvenis* are all indifferently preserved and most are distorted. Better-preserved topotype cranidia described here, give a much improved idea of the characters of this form. Cranidium about $1\frac{1}{4}$

times as wide (tr.) as long (sag.). Glabella occupies three-fifths total cranidial width; ovoid in outline with parabolic anterior margin; pre-occipital length about four-fifths maximum width, latter on level of 2p lateral lobes; strongly convex (tr. and sag.), in lateral profile greatest convexity is over anterior half, frontal lobe dropping steeply forward (Pl. 111, fig. 10). Basal lateral lobes in dorsal view are obliquely elongated ovoids, each occupying one-fifth of maximum glabellar width (tr.) and separated posteriorly by about 1½ times this width. Basal lateral furrows broad and deep abaxially, gently curved, dying out before reaching occipital furrow. Exsaggital length of 2p lateral lobes about two-thirds that of basal lobes, 3p lobes slightly shorter. 2p and 3p furrows shallower and narrower than 1p and short (tr.) in dorsal view. Occipital furrow broad and deep, ring broad and convex (sag. and exsag.), both arched posteriorly in dorsal view. Axial furrows deep and slot-like, confluent with broad anterior border furrow, containing small round pits just in front of 3p furrows. Convex (tr.) fixed cheeks with concave antero-lateral margins in dorsal view, genal angles broadly rounded, no genal spine seen. Posterior border furrows broad and deep adaxially, shallowing outwards, borders narrow and convex adaxially, broadening and flattening outwards. Palpebral lobes of similar length (exsag.) to 2p lateral glabellar lobes, situated slightly behind them, running obliquely out and back, gently convex antero-laterally; palpebral furrows broad and distinct. Posterior branches of facial sutures meet lateral borders in rounded curves. External surface of glabella covered with scattered large granules or small tubercles (Pl. 111, fig. 11) which are more prominent in small specimens (Pl. 110, fig. 15). On internal moulds the glabella is sometimes finely granulated. Fixigenal surface strongly pitted, pits usually visible on internal moulds.

Librigenae, thorax, and hypostoma unknown. Pygidium known only from incomplete specimens of which the best have been figured previously (Whittington 1968, pl. 31, fig. 17; Price 1974, pl. 113, fig. 9).

Discussion. The ovoid glabella with its frontally parabolic outline, its more gently curved basal furrows and relatively narrower basal lobes, and its ornament of scattered large granules clearly differs from that of *P. tectus* Ingham also common in the Sholeshook Limestone (see Pl. 110, figs. 10, 11). In cranidial characters. *P. juvenis* is more like *P. octolobatus* (McCoy) (see Lane 1971, pl. 8) but that form has a glabella which is relatively broader posteriorly, with a shorter (sag. and exsag.), more broadly rounded frontal lobe and less strongly convex anteriorly in lateral profile; also the palpebral lobes are shorter and placed further forward and the ornament includes fine as well as scattered coarse granules.

Cranidia from the Chair of Kildare and Kiesley Limestones figured by Dean (1971, pl. 9, figs. 3, 4, 8; pl. 10, figs. 1–3, 6, 8, 10–12; pl. 11, figs. 4–8, 11, 12) as *P. conformis* Angelin bear prominent genal spines. The glabella of these forms is more broadly rounded frontally than that of *P. juvenis* and more evenly convex in lateral profile with a shorter and less steeply inclined frontal lobe and more prominent surface tubercles. In cranidia from the Chair of Kildare Limestone (e.g. pl. 9, fig. 4) the 3p lateral glabellar lobes are longer than the 2p. Pygidia figured by Ingham (1974, pl. 14, figs. 8–10) as *P. conformis* from Zones 2 and 3 of the Cautley Mudstones are strikingly similar to those from the Sholeshook Limestone here referred to *P. juvenis* (cf. Price 1974, pl. 113, fig. 9), even to the surface perforations. They are not, even the smallest of them, like the small pygidium figured by Dean (1971, pl. 10, figs. 4, 5) from the Chair of Kildare Limestone in which the pleural regions are extremely narrow and the spines longer, slenderer, and directed more strongly posteriorly. The fragmentary and distorted cranidia from Cautley (Ingham 1974, pl. 14, figs. 6, 7, 11, 12) do not allow close comparison with other forms.

Subfamily DEIPHONINAE Raymond, 1913
Genus SPHAEROCORYPHE Angelin, 1854

Type species. Sphaerocoryphe dentata Angelin, 1854.

Sphaerocoryphe aff. *thomsoni* Reed, 1906

Plate 110, figs. 12–14

1973*a Sphaerocoryphe* cf. *thompsoni* Reed; Price, tables 1–3.

Material, horizons, and localities. HM A9733, internal mould of flattened, incomplete cranidium, low Sholeshook Limestone, track south of Craig-y-deilo quarry, Llandowror (locality 18d); BM In54702, external mould of partial cranidium, Sholeshook Limestone, Craig-y-deilo quarry; SM A31590, internal mould of partial cranidium, Sholeshook railway cutting; BM It9245, external mould of partial cranidium, locality 9e, Sholeshook.

Description. Anterior part of glabella sub-spherical, twice as wide (tr.) as central lobe behind and separated by broad, mesially shallow furrow deepening laterally to pair of apodemal pits. Low posterior part of glabella short (sag. and exsag.), broader (tr.) than long (sag.), only moderately convex (tr.). Basal lateral glabellar lobes sub-triangular, small but distinct, strongly convex (exsag.). Occipital furrow shallow and gently arched forward mesially, abaxially deepens to pair of apodemal pits. Occipital ring moderately broad (sag. and exsag.), arched forward mesially and abaxially curving forwards around apodemal pits. Axial furrows broad, posteriorly sub-parallel, containing occipital and 1p apodemal pits but shallow opposite 1p lateral lobes. Sub-triangular fixed cheeks strongly convex, apically bearing pedunculate palpebral lobes; dropping steeply to broad, deep posterior border furrows; posterior borders broad (exsag.) and convex. Broad, convex lateral borders separated from inner parts of cheeks by prominent furrows; bear two short, broad-based pro-fixigenal spines (pl. 110, fig. 12) of which posterior is larger. Lateral and posterior borders produced into long, stout, gradually tapering fixigenal spines. Inflated part of glabella with ornamentation of prominent tubercles and much smaller granules densely scattered between (Pl. 110, fig. 14); tubercles large (0·2–0·25 mm) and widely spaced apically, smaller and more densely packed marginally. Convex surface of cheeks pitted, though not strongly.

Discussion. Lane (1971, p. 64, pl. 13, figs. 1–4, 6–8, 10–18; pl. 15, fig. 9) selected a lectotype from amongst Reed's material and redescribed this and other specimens of *S. thomsoni* from the Starfish Bed of Girvan. The cranidia of that species are similar in over-all form and proportions to those described above and the only major difference appears to be the much coarser glabellar tuberculation in the south Welsh specimens. *S. kingi* Ingham (1974, pp. 71–74, pl. 14, figs. 13–17; text-fig. 22) from the Rawtheyan Stage of the Cautley Mudstones also has a more subdued glabellar ornamentation than the Sholeshook specimens and the fixed cheeks are relatively much broader (tr.). *S. punctata* (Angelin 1854, p. 77, pl. 39, fig. 6; Warburg 1925, pp. 390, 421; pl. 10, figs. 43–49) from the Boda Limestone of Sweden is in need of redescription. A cranidium from the Chair of Kildare Limestone of eastern Ireland referred to this species by Dean (1971, p. 33, pl. 16, figs. 1, 4, 7, 10) has a coarse glabellar tuberculation like the south Welsh form but the inflated anterior glabellar region appears to be proportionally smaller and the fixed cheeks are much more strongly pitted.

Family ENCRINURIDAE Angelin, 1854
Subfamily CYBELINAE Holliday, 1942
Genus ATRACTOPYGE Hawle and Corda, 1847

Type species. Calymene ?verrucosa Dalman, 1827.

Atractopyge aff. *scabra* Dean, 1962

Plate 111, figs. 1–4

1848 *Cybele sexcostata*, Salter, p. 343, pl. 8, figs. 9, 9*a*, 9*b*, *non* 10.
1853 *C.* (*Calym.*) *verrucosa*, Dalman; Salter, Articla 4, p. 4.
1866 *Cybele verrucosa*, Dalm.; Salter, p. 324, pl. 19, fig. 7.
1885 *Cybele verrucosa*, Dalm.; Marr and Roberts, pp. 480, 481.
1909 *Cybele verrucosa* (Dalm.); Strahan *et al.*, table p. 58.
1914 *Cybele verrucosa* (Dalm.); Strahan *et al.*, table p. 63.
1973 *Atractopyge scabra* Dean; Price (*pars*), tables 1–3, list p. 233.
?1974 *Atractopyge* sp.; Ingham, p. 82, pl. 17, figs. 1–6.

Horizons and localities. As in Table 1; not known from Slade and Redhill Mudstones other than at Prendergast (locality 8a).

Description. Clavate glabella strongly convex (tr.); maximum width across frontal lobe less than pre-occipital length. Occipital ring broad and strongly convex (sag. and exsag.), mesially arched forward; abaxially broadened to form forward-curving occipital lobes. Occipital furrow broad and shallow mesially, abaxially dropping to deep, circular pits. Basal lateral lobes sub-triangular, anterior margins set strongly oblique. 1p furrows are deep apodemal slots with triangular outlines and tendency to bifurcate adaxially. 2p and 3p lobes of approximately equal length (exsag.) adaxially, set slightly oblique; 2p lobe narrows outwards, 3p sub-parallel sided. 2p furrows deep, ovoid apodemal pits oblique in same manner as 2p and 3p lobes. 3p slots oblique, posteriorly divergent, broadening (exsag.) inwards and continued adaxially as short, shallow bifurcating branches. Median lobe narrowest on level of 1p lateral furrows, widening only very gently forwards. Glabella expands rapidly in front of 3p lobes to maximum width three times that at 1p furrows. Frontal lobe drops anteriorly in steep, convex slope. Anterior border furrow narrow but distinct, transverse mesially; distally is deflected postero-laterally and broadens; thus has form of three shortest sides of trapezium. Frontal glabellar lobe and anterior border can also have similar outline (Pl. 111, fig. 4) but usually appear more rounded. Axial furrows deep and broad; containing deep circular pits near ends of anterior border furrow. Fixed cheeks much wider (tr.) than long (exsag.), strongly convex (exsag.), dropping steeply to axial furrows; surmounted by palpebral lobes which form parts of long, slender eye-stalks. These opposite 2p furrows and posterior halves of 3p lobes, separated from axial furrows by distance equal to width of median lobe at that level. Eye-ridges run inwards and forwards to positions opposite 3p furrows. Behind these ridges are furrows which are narrow adaxially but expand outwards to form, around the bases of the palpebral lobes, prominent depressed areas granulated and pitted but devoid of the coarse tubercles seen on the rest of the cheek surface. Posterior border furrows broad, deep slots adaxially, borders strongly convex over transverse inner halves then broaden as curve out and back. Free cheeks quadrant-shaped; convex inner portions surmounted by narrow eye-stalks and separated from broad, convex borders by strong furrows; borders produced into narrow anterior 'tongues' whose ends are deflected ventrally. Cranidial surface ornamented with small, closely spaced granules (0·04–0·07 mm); in addition there are numerous much larger (up to 0·75 mm), scattered, apically perforated tubercles, themselves granulated and absent only from the major furrows. On mesial section of anterior border large tubercles form two alternating rows. Many of tubercles on glabella developed in relatively constant symmetrical pattern. Surfaces of fixed cheeks irregularly pitted.

Hypostoma and rostral plate unknown; rostral suture runs along straight margin of mesial section of anterior border, connective sutures along adaxial margins of extreme inner ends of anterior 'tongues' of free cheeks.

Pygidium slightly longer (sag.) than broad (tr.). Axis moderately convex (tr.), tapers posteriorly at 20°; up to twenty rings in well-preserved material. Only first four rings continuous across axis, fifth and subsequent ring furrows fail to reach axial furrows. Posteriorly ring furrows also become increasingly shallower mesially though usually continuous as far back as eighth or ninth after which axis smooth mesially, ring furrows existing as paired apodemal slots. Sharply pointed, convex (tr.) terminal piece merges anteriorly with smooth lateral borders of axis. Four pleural ribs continuous with first four axial rings. First pair curve abaxially to mid-length of pygidium, then gently adaxially, those behind increasingly curved until fourth pair lie sub-parallel to axial furrows. Ribs separated by narrow, depressed anterior pleural bands, terminate in short, free, blunt points arranged *en echelon* with tips of second pair lying level with axial tip.

Discussion. The form described here is closely similar in over-all form to specimens of *A. scabra* Dean recently described by Ingham (1974, p. 79, pl. 16, figs. 2–14; text-fig. 24) from the Pusgillian and low Cautleyan Stages of the Cautley Mudstones but differs in a few features. In *A. scabra* the 2p lateral glabellar lobes are noticeably shorter (exsag.) than the 3p. In Sholeshook material this does appear to be the case in a few cranidia from the basal 14 or 15 m of the formation around Llandowror and the basal 2 or 3 m of Sholeshook railway cutting, and these forms have been herein tentatively referred to *A. scabra* (see Pl. 110, fig. 17). In all other specimens the 2p and 3p lobes are of sub-equal length, the 2p in some cases being slightly longer. The glabellar tuberculation in the south Welsh form differs from that of *A. scabra* in that the paired tubercles are relatively less prominent, the others larger and more numerous. On the pygidium the axial ring furrows appear to be mesially continuous further posteriorly than in *A. scabra* and the pointed ends of the pleurae do not reach so far posteriorly; only the third and fourth spines project beyond the axial tip, the first pair terminate well in front.

The Sholeshook cranidia are more like those referred by Ingham (1974) to *Atractopyge* sp. from Cautleyan Zone 4, though here the 3p lateral glabellar lobes are implied to be consistently shorter than the 2p. The second and third lateral glabellar lobes are approximately the same length in the holotype cranidium of *A. verrucosa* (see Dean 1974, text-fig. 4) but the specimen is much larger than the Sholeshook specimens and the glabella appears to have a relatively much wider (tr.) median lobe and consequently a less clavate outline. *A. verrucosa* is known only from the holotype and topotype specimens are needed before the species can be closely compared with other forms. The form from the

Birdshill Limestone termed *A.* cf. *verrucosa* by Dean (1974, p. 97; 1971, pls. 14, 15) has a less clavate, less convex (tr.) glabella than the Sholeshook form and on the pygidium the pleural spines appear to extend much further posteriorly (Dean 1971, pl. 14, figs. 8, 9).

Subfamily DINDYMENINAE Přibyl, 1953
Genus DINDYMENE Hawle and Corda, 1847

Type species. Dindymene fidericiaugusti Hawle and Corda, 1847.

Dindymene longicaudata Kielan, 1960

Plate 112, figs. 2–5

1973*a* *Dindymene longicaudata* Kielan; Price, tables 1, 2, 7.
1973*b* *Dindymene longicaudata* Kielan; Price, p. 538.

Holotype. Figured Kielan 1960, pl. 30, fig. 2; IG No. 2. II. 108, almost complete exoskeleton from *Staurocephalus clavifrons* Zone of Brzezinki, Poland.

Material. BM In54166a, b, internal and external moulds of distorted cranidium; In54161, 54164, GSM H.T. 913, internal moulds of incomplete pygidia, all from the basal Slade and Redhill Mudstones of Rudbaxton (locality 4); SM A77566a, b, internal and external moulds of pygidium from Sholeshook Limestone, locality 9e, Sholeshook.

Description. Cranidium in dorsal view broader (tr.) than long (sag.); strongly convex (tr. and sag.). Occipital ring broad and convex (sag. and exsag.), abaxially curving forwards around deep pits at ends of broad, shallow occipital furrow. Posterior borders adaxially strongly convex (exsag.), outwards gradually narrowing to genal angles but there broaden considerably and curve forwards; border furrows deep and slot-like adaxially. Axial furrows deep and broad posteriorly where converge forwards slightly. Within them a second apodemal pit, forward of the occipital pit, represents 1p lateral furrow. Short 1p lobe developed on median lobe between two

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EXPLANATION OF PLATE 111

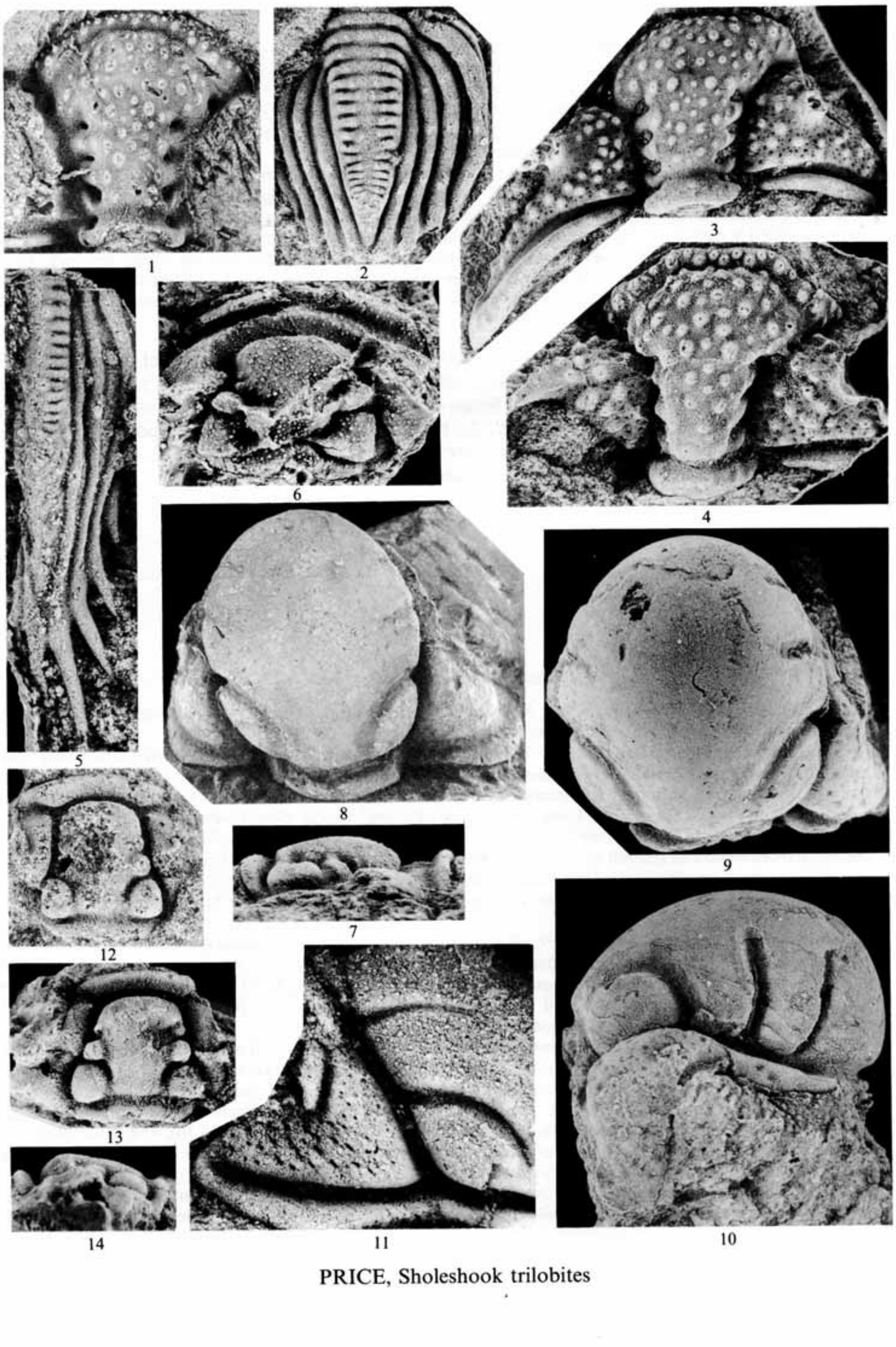
Figs. 1–4. *Atractopyge* aff. *scabra* Dean. 1, GSM 24546, internal mould of incomplete cranidium from Sholeshook Limestone of Sholeshook, dorsal view, ×2. 2, SM A31458, cast from external mould of incomplete pygidium, Sholeshook Limestone of Sholeshook, dorsal view, ×3. 3, SM A53005b, cast from external mould of cranidium from the high Sholeshook Limestone, locality 9h, Sholeshook, dorsal view, ×3. 4, GSM 24543, cast from external mould of cranidium from Sholeshook Limestone of Sholeshook, dorsal view, ×3; together with counterpart internal mould GSM 24545, original of Salter 1848, pl. 8, fig. 9, 9*b*.

Fig. 5. *Cybeloides* (*Paracybeloides*) *girvanensis* (Reed). BM It9251, cast from external mould of incomplete pygidium from high Sholeshook Limestone of Prendergast (locality 8c), dorsal view, ×6.

Figs. 6, 7. *Prionocheilus* cf. *obtusus* (McCoy). 6, SM A104837, distorted internal mould of cranidium from basal Sholeshook Limestone of Moldin (locality 25), near Llandowror, dorsal view, ×4. 7, SM A77943, internal mould of incomplete cranidium from high Sholeshook Limestone, locality 9h, Sholeshook, right lateral view, ×4; see also Pl. 110, fig. 1.

Figs. 8–11. *Pseudosphaerexochus juvenis* (Salter). 8, SM A31417, internal mould of cranidium from Sholeshook Limestone of Sholeshook railway cutting, dorsal view, ×2. 9, 10, SM A31432, internal mould of incomplete cranidium from the high Sholeshook Limestone of Prendergast, dorsal and right lateral views, ×2. 11, SM A77570, part of cast from external mould of partial cranidium from the high Sholeshook Limestone, locality 9b, Sholeshook, oblique view to show surface ornament, ×5.

Figs. 12–14. *Calymene* (s.l.) cf. *prolata* Ingham. 12, HM A9767, internal mould of incomplete cranidium from the low Sholeshook Limestone (locality 18b) of Craig-y-deilo quarry, Llandowror, dorsal view, ×2. 13, 14, GSM TJ. 843, internal mould of incomplete cranidium from about 24 m above the base of the Slade and Redhill Mudstones at Robeston Wathen (locality 10c), dorsal and left lateral views, ×3.



PRICE, Sholeshook trilobites

pits. Axial furrows narrow anteriorly as diverge round strongly convex (tr.) frontal lobe. Quadrant-shaped fixed cheeks strongly convex, dropping steeply to posterior parts of axial furrows and posterior border furrows and more gently anteriorly and laterally to broad, shallow border furrow. Base of right genal spine just visible on available cranidium curving gently anteriorly. Cast from external mould (Pl. 6, fig. 4) shows genal surfaces closely pitted and bearing scattered granules, glabella with even pattern of well-spaced small granules and scattered larger ones. Apically glabella bears prominent stout spine.

Triangular pygidial axis comprises eleven rings, first strongly convex (sag. and exsag.), those behind gradually less so. Ring furrows deepest towards abaxial ends, leaving, behind second ring, shallow mesial portions of about one-third axial width and narrow lateral borders; becoming fainter posteriorly so that rings behind fourth not clearly separated in mesial region. Three pairs of pleural ribs. First two continuous with first two axial rings then deflected posteriorly in smooth curves, separated from each other and from axis by strong furrows. Third segments pressed close to sides of axis, separated from it posteriorly by two short, shallow furrows meeting in acute-angled 'v'. Pleurae terminate as stout, free spines; tips of inner two form straight line transverse to axis, first terminate in front of this.

Discussion. The over-all similarity of the cranidium and the very close similarity of the pygidium to those of *D. longicaudata* described by Kielan (1960, p. 153, pl. 26, fig. 5; pl. 28, fig. 5; pl. 29, fig. 4; pl. 30, figs. 1-3; text-fig. 43) from the Ashgill Series of Poland, Bornholm, Scania, and Västergötland, leave little doubt as to the specific identity. As Kielan shows in her table 6 (opposite p. 148), the pygidia of known species of *Dindymene* are quite distinctive. Also distinctive of *D. longicaudata* are the stout glabellar spine and the forwardly directed genal spines.

EXPLANATION OF PLATE 112

Fig. 1. *Prionocheilus* cf. *obtusus* (McCoy), SM A77943, internal mould of incomplete cranidium from high Sholeshook Limestone, locality 9h, Sholeshook, dorsal view, ×4; see also Pl. 109, fig. 7.

Figs. 2-5. *Dindymene longicaudata* Kielan. 2-4, BM In54166a, b, internal mould of distorted cranidium from basal Slade and Redhill Mudstones of Rudbaxton quarry (locality 4) in left lateral and dorsal views and cast from partial external mould in left lateral view, all ×6. 5, SM A77566b, cast from external mould of pygidium from middle Sholeshook Limestone, locality 9e, Sholeshook, dorsal view, ×6.

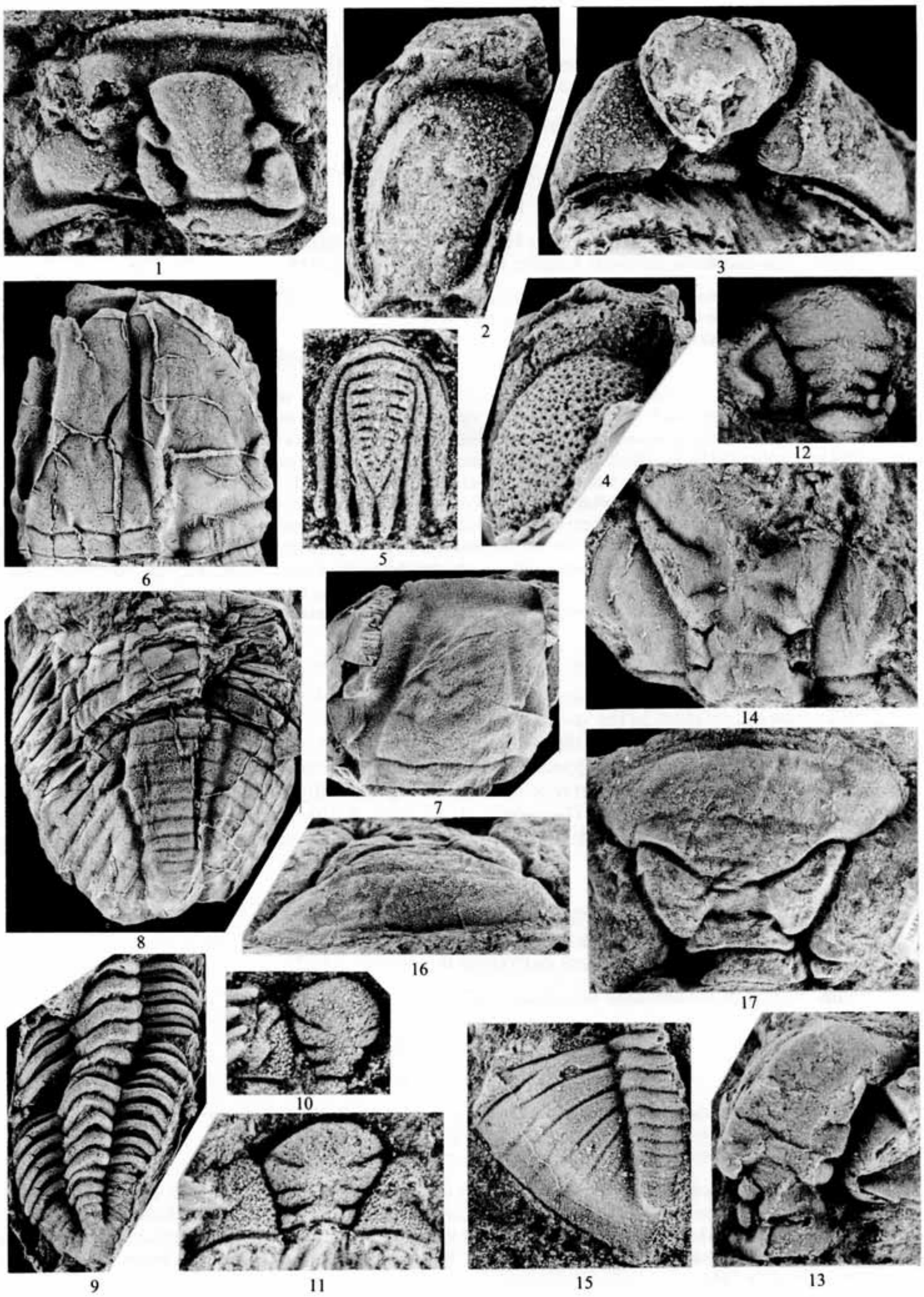
Figs. 6-8. *Brongniartella* cf. *marocana* Destombes. 6, SM A31174, internal mould of distorted, incomplete cephalon from Slade and Redhill Mudstones of Redhill quarry (locality 7), dorsal view, ×¾. 7, SM A104836, internal mould of cranidium showing traces of lateral glabellar furrows, same horizon and locality, dorsal view, ×1. 8, SM A31172, internal mould of pygidium and partial thorax, same horizon and locality, dorsal view, ×1.

Figs. 9-11. *Duftonia geniculata* Ingham? 9, GSM Pg. 134, cast from external mould of articulated thorax and pygidium from the high Sholeshook Limestone of Prendergast (locality 8b or 8c), dorsal view, ×3. 10, BM In54163b, cast from external mould of small, incomplete cranidium from basal Slade and Redhill Mudstones south-west of Knock (locality 3), dorsal view, ×8. 11, BM In54162b, cast from external mould of small, almost complete cranidium, same horizon and locality, dorsal view, ×8.

Figs. 12, 13. *Liocnemis recurvus* (Linnarsson). 12, SM A77634, internal mould of incomplete cranidium from basal Slade and Redhill Mudstones south-west of Knock (locality 3), dorsal view, ×8. 13, BM In54224a, internal mould of distorted incomplete cranidium from same horizon and locality, dorsal view, ×6.

Figs. 14, 15. *Calyptaulax planiformis* Dean. 14, SM A77518, internal mould of incomplete cranidium from the middle Sholeshook Limestone, locality 9e, Sholeshook, dorsal view, ×3. 15, GSM JM. 454, internal mould of incomplete pygidium from about 30 m above base of Slade and Redhill Mudstones at Cilrath Fawr, 3 km east-north-east of Robeston Wathen, dorsal view, ×4.

Figs. 16, 17. *Toxochasmops marri* (Reed), NMW.21.306.G.20a, internal mould of incomplete cranidium from the Sholeshook Limestone of Craig-y-deilo quarry, Llandowror, antero-dorsal oblique view and dorsal view, ×1½.



PRICE, Sholeshook trilobites

Family STAUROCEPHALIDAE Prantl and Přibyl, 1948
Genus STAUROCEPHALUS Barrande, 1846

Type species. Staurocephalus murchisoni Barrande, 1846.

Staurocephalus cf. *clavifrons* Angelin, 1854

Plate 110, fig. 18

1885 *Staurocephalus globiceps*, Portl.; Marr and Roberts, p. 481.
1973*a* *Staurocephalus clavifrons* Angelin; Price, tables 1-3, 7, p. 245.

Material, horizons, and localities. Not common but appears to range through Sholeshook Limestone Formation (see Table 1). Known also from basal Slade and Redhill Mudstones near Pelcomb Cross (locality 2) but not from elsewhere in that formation. Total of fifteen cranidia; thorax, pygidium, free-cheek, hypostoma, and rostral plate not yet known.

Description. Median lobe of glabella tapers slightly forwards bounded by very broad, deep axial furrows and indented laterally by large, shallow pits representing 1p and 2p lateral furrows of which 2p are distinctly larger. Pits representing 3p furrows small, shallow, and indistinct, situated near ends of broad, smooth furrow separating hemispherical frontal glabellar lobe from median lobe. Lateral glabellar lobes of sub-equal exsagittal length adaxially; basal lobes longer transversely, expanding (exsag.) slightly abaxially. Behind are small, deep, round apodemal pits at ends of occipital furrow; furrow straight and shallow mesially. Occipital ring mesially broad (sag. and exsag.), narrowing and curving forwards distally. Fixed cheeks strongly convex, standing higher than median lobe and dropping to axial furrows in steep, convex slopes; apically bearing prominent palpebral lobes surrounded by shallow furrows, their mid-lengths on the level of the 2p lateral lobes. Posterior border furrows narrow. Posterior borders narrow and strongly convex adaxially but broadening considerably towards genal angle. Cranidial surface tuberculated but no external moulds are available to show form of ornamentation in detail.

Discussion. On the basis of the cranidium alone the South Welsh form cannot be distinguished either from the holotype cranidium of *S. clavifrons* (Angelin 1854, pl. 24, fig. 8; Kielan 1957, pl. 4, fig. 1) or from other material referred to the species by Kielan (1957, p. 163) or subsequently by Whittington (1965, p. 53) or Dean (1971, p. 40). Following Ingham's remarks (1977, p. 89) on differences between the Polish specimens included in the species by Kielan and specimens from the Cystoid Limestone of the Cautley area and on the occurrence of a further potentially distinguishable form from the Swindale Limestone of Cross Fell (Ingham's pl. 19, figs. 8-10), it appears that *S. clavifrons* as previously recognized may be capable of further subdivision. The south Welsh form is therefore only compared with Angelin's species.

Family CALYMENIDAE Milne Edwards, 1840
Subfamily CALYMENINAE Milne Edwards, 1840
Genus CALYMENE Brongniart, 1822

Type species. Calymene blumenbachii Brongniart, 1822.

Calymene (s.l.) cf. *prolata* Ingham, 1977

Plate 111, figs. 12-14

1914 *Calymene blumenbachi* Brongn., var. *caractaci* Salter; Strahan *et al.* (*pars*), list p. 67.
1914 *Calymene* sp.; Strahan *et al.* (*pars*), table p. 70.
1973*a* *Diacalymene* cf. *marginata* Shirley; Price, p. 234.

Material, horizons, and localities. Three internal moulds of incomplete cranidia, GSM J.M. 396, GSM T.J. 483, and HM A9767, respectively from about 18 m above the base of the Slade and Redhill Mudstones at Cilrath-fawr, 2·25 km north-north-east of Narberth, about 24 m above the base of the same formation at Robeston Wathen (locality 10c), and from a low horizon in the Sholeshook Limestone of Craig-y-deilo quarry, Llandowror (locality 18b).

Discussion. The available cranidia show a bell-shaped glabella with very prominent, convex (tr. and exsag.) 1p lateral lobes, relatively large, rounded and convex 2p lobes with genal buttresses opposite and small 3p lobes. The frontal lobe occupies just less than one-third the pre-occipital glabellar length, is twice to 2½ times as wide as long, broadly rounded frontally, and extends well beyond the fixed cheeks which are angulated antero-mesially. The pre-glabellar area is strongly upturned, unridged and roll-like in cross-section, longer (exsag.) opposite the axial furrows, and separated from the frontal lobe by a deep, slot-like furrow. These characteristics are shared with *C. prolata* Ingham (1977, pp. 102–103, pl. 22, figs. 11–17) from Zone 3 of the Cautley Mudstones of northern England but the south Welsh specimens appear to differ slightly from the illustrated cranidia of *C. prolata* in possessing basal lateral lobes which are more quadrate in outline and in having rather less obviously bifurcating 1p lateral furrows.

Subfamily FLEXICALYMENINAE Siveter, 1977
Genus FLEXICALYMENE Shirley, 1936

Type species. Calymene blumenbachii var. *caractaci* Salter, 1865.

Flexicalymene cavei Price, 1974

1973*a* *Flexicalymene* sp. nov.; Price, tables 1–4.
1974 *Flexicalymene cavei* Price, pp. 852–856, pl. 114, figs. 1–15.

Holotype. Figured Price 1974, pl. 114, figs. 1, 2; SM A57050, internal mould of cranidium from the basal Sholeshook Limestone of Moldin (locality 25), near Llandowror.

Horizons and localities as in Table 1. Not known from Slade and Redhill Mudstones other than where ranges up from underlying Sholeshook Limestone at localities 8a and 15.

Discussion. The form has been fully described elsewhere (Price 1974). Siveter (1977, p. 355) has referred to the similarity between *F. cavei* and *F. declinata* (Hawle and Corda 1847) from the Králův Dvůr Formation of Bohemia. This similarity is not apparent from Barrande's figures (1852, pl. 43, figs. 53–58) but Dr. Siveter has kindly supplied the author with photographs of Bohemian specimens of *F. declinata*, including the lectotype (selected Marek *in* Horný and Bastl 1970, p. 114). Though these show that the two forms are closely related, there do appear to be differences. The glabella of the Bohemian form is relatively rather broader (tr.) and shorter (sag.), with the frontal lobe, in particular, shorter (sag. and exsag.) and less broadly rounded anteriorly. The 3p lateral glabellar lobes appear longer (tr.) and separated from the frontal lobe by more strongly developed 3p furrows, and the 1p lateral furrows curve adaxially at their inner ends to give the median lobe a distinctive, postero-laterally convex outline not seen in South Welsh specimens. In addition, to judge from Barrande's figures (1852, pl. 43, figs. 57, 58), the hypostoma may lack the prominent maculae seen on that of *F. cavei* (Price 1974, pl. 114, fig. 8).

Subfamily PHAROSTOMATINAE Hupé, 1953
Genus PRIONOCHEILUS Rouault, 1847

Type species. Prionocheilus verneuili Rouault, 1847.

Remarks. Both Siveter (1977, pp. 339, 393) and Ingham (1977, p. 103) have recently reviewed the difficulties surrounding the choice between *Pharostoma* Hawle and Corda and its senior synonym *Prionocheilus*. The balance of recent usage appears to be in favour of *Prionocheilus*.

Prionocheilus cf. *obtusus* (McCoy, 1846)

Plate 111, figs. 6–7; Plate 112, fig. 1

1973*a* *Pharostoma* cf. *obtusum* (M'Coy); Price, tables 1–4.

Material, horizons, and localities. Ten partial or incomplete cranidia from the following horizons and localities: the basal Sholeshook Limestone at Moldin (locality 25) and in the Mylet road section (24a); the low Sholeshook Limestone of Craig-y-deilo quarry (18c); the railway cutting, locality 9e and locality 9h at Sholeshook; the Sholeshook Limestone at Lan-y-gaer (16b); and the highest Sholeshook Limestone at Prendergast (locality 8b).

Discussion. Cranidia from the Sholeshook Limestone are similar in over-all form and proportions and in most details of morphology to the holotype of *P. obtusus* (McCoy) redescribed by Whittington (1965, pp. 55–56, pl. 16, figs. 1–3, 6) from the Chair of Kildare Limestone and refigured, together with topotype cranidia by Dean (1971, pl. 18, figs. 6, 8, 10, 12, 13, 15). They appear to differ, however, in that the basal lateral glabellar lobes in several Sholeshook specimens are distinctly sub-quadrate in outline (e.g. Pl. 112, fig. 1) and in that small 3p lateral glabellar lobes are clearly visible in most Sholeshook specimens. In the outline of the 1p lateral glabellar lobes the South Welsh specimens resemble *P. cautleyensis* Ingham (1977, pp. 104–105, pl. 22, figs. 19–23) from the Cautleyan Stage of the Cautley Mudstones, but that form has relatively much wider (tr.) 1p lateral lobes, a narrower (tr.) frontal glabellar lobe, more strongly developed subsidiary lobes between the 1p and 2p lateral lobes, and a mesially very short (sag. and exsag.) pre-glabellar field. The pre-glabellar field in the Sholeshook specimens appears to be of similar length and convexity to that of *P. obtusus*.

Family HOMALONOTIDAE Chapman, 1890
Genus BRONGNIARTELLA Reed, 1918

Type species. Homalonotus bisulcatus McCoy, 1851.

Brongniartella cf. *marocana* Destombes, 1966

Plate 112, figs. 6–8

1885 *Homalonotus*?; Marr and Roberts, p. 480.
1885 *Homalonotus bisulcatus*, Salt.; Marr and Roberts, p. 482.
1914 *Homalonotus rudis*? Salt.; Strahan *et al.*, table p. 74.
1973*a* *Brongniartella* sp.; Price, pp. 229–230, 242, tables 1, 2.

Material, horizons, and localities. One partial pygidium from the highest Sholeshook Limestone of Prendergast (locality 8b); 1 pygidium from the basal Slade and Redhill Mudstones of Prendergast (8a); 1 partial pygidium, 2 pygidia with partial thoraxes, 2 incomplete cranidia, and 1 incomplete cephalon all from the Slade and Redhill Mudstones of Redhill quarry (locality 7); all internal moulds. ?Other fragmental material from localities 7, 8a, b, c, and 9d.

Description. Cephalon sub-semicircular. Weakly convex glabella trapezoid in outline, its lateral margins gently convex posteriorly and concave near the mid-length; width (tr.) just in front of occipital furrow slightly less than pre-occipital length and twice width at anterior margin. One specimen (Pl. 112, fig. 7) faintly shows lateral glabellar furrows; 1p furrows commence abaxially at one-third pre-occipital glabellar length and curve inwards for about one-quarter of glabellar width at that level, 2p furrows commence abaxially at half pre-occipital length and curve sigmoidally inwards and back, 3p furrows very faint. Occipital furrow narrow but distinct, sinuous, curved forward mesially and abaxially. Occipital ring occupies one-seventh glabellar length (sag.). Axial furrows shallow, very broad posteriorly but narrow forwards. Anterior border furrow broad and shallow, anterior border only weakly convex (sag. and exsag.). Gently convex (tr.) anterior portions of fixed cheeks each about half anterior width of glabella. Short (exsag.) palpebral lobes on level of cranidial mid-length. Posterior border furrows broad and shallow, borders flat (exsag.), broader (exsag.) than occipital ring. Free cheeks with indistinct borders and border furrows.

Thoracic axis occupies over one-third total width, defined by shallow axial furrows; rings separated from half-rings by broad, strong, articulating furrows. Pleurae bear deeply incised, curved pleural furrows. Pygidium sub-parabolic, moderately convex (tr.). Axis anteriorly occupying less than one-third total width, defined by broad, deep axial furrows and tapering gradually to a well-defined, bluntly rounded distal end which almost(?) reaches posterior margin. Axis composed of nine broad, flat axial rings and narrow articulating half-ring. Pleurae show seven abaxially broadening ribs and outwardly and backwardly curving inter-rib furrows which do not reach lateral margins.

Discussion. B. marocana Destombes (1966, p. 34, pl. 1, figs. 1–8) from the Upper Ktaoua Formation of the Moroccan Anti-Atlas is closely similar to the south Welsh form in glabellar shape and agrees in showing faint lateral glabellar furrows and in the posteriorly broad axial furrows and the position of the palpebral lobes. The pygidium is similar in over-all form but the axial furrows, ring furrows, and pleural furrows are weaker than in the south Welsh material and the axis is less well developed posteriorly. In this latter respect the South Welsh pygidia are closer to those of the form from Zone 5 of the Rawtheyan Stage of the Cautley Mudstones referred with question by Ingham (1977, p. 109, pl. 24, figs. 1–4) to *B. robusta* (Lesperance) in which the axial tip is slightly swollen. Neither that species, however, nor the type material of *B. robusta* (Lesperance 1968, p. 822, pl. 106, figs. 8–13) from the 'Upper Ashgill' part of the Whitehead Formation of Percé, Quebec, show any sign of glabellar furrows and both forms are said to have only eight rings on the pygidial axis. In *B. platynotus* (Dalman) from the late Ashgill of Poland, Sweden, and Czechoslovakia (Kielan 1960, p. 116, pl. 19, figs. 1–3) the glabella narrows more sharply anteriorly than in the south Welsh form and the eyes are much further forward. As Ingham has noted (1977, p. 110), *B. marocana* is more closely related to forms such as *B. sedgwicki* (Salter) and *B. robusta* than it is to *B. platynotus*.

Family DALMANITIDAE Vogdes, 1890
Subfamily DALMANITINAE Destombes, 1972
Genus DUFTONIA Dean, 1959

Type species. Duftonia lacunosa Dean, 1959.

Duftonia geniculata Ingham, 1977?

Plate 112, figs. 9–11

1973*a* *Duftonia* cf. *lacunosa* Dean; Price, tables 2, 7.
?1977 *Duftonia geniculata* Ingham, p. 114, pl. 26, figs. 12–19; text-fig. 28*b*.

Holotype. Figured Ingham 1977, pl. 26, figs. 12, 13; HM A5540a, b, internal and external moulds of damaged cranidium from the mid-Rawtheyan Swindale Limestone of Cross Fell.

Material, horizons, and localities. BM In54162a, b, 54163a, b, internal and external moulds of incomplete cranidia, In54164, internal mould of pygidium, all from basal Slade and Redhill Mudstones near Pelcomb, 4 km north-west of Haverfordwest (locality 3); GSM Pg. 133, 134, internal and external moulds of articulated thorax and pygidium and Pg. 123, internal mould of pygidium, from the high Sholeshook Limestone of Prendergast (locality 8b or 8c).

Description. Two available cranidia small and poorly preserved. Both show a rather weakly developed geniculation in the course of the 3p lateral glabellar furrows. Outer margins of 3p lateral lobes not independently convex and postero-laterally do not project further into axial furrows than antero-lateral corners of 2p lobes. Palpebral lobes relatively short (exsag.), extend back to level opposite anterior parts of 2p lateral lobes. Preservation too poor to show glabellar ornamentation. Thorax of eleven segments, tapering gradually posteriorly. Axis strongly convex, occupies over one-third total width (tr.) anteriorly. On cast of external mould (Pl. 112, fig. 9) axial rings sub-rectangular in dorsal outline, arched forward mesially and again curving gently forwards and slightly broadening (exsag.) abaxially. Articulating furrows broad and shallow mesially but drop abaxially into deep apodemal slots. On internal moulds these slots separate prominent, rounded axial lobes. Axial furrows narrow and rather weak. Pleurae flat-lying over inner portions but strongly deflected ventrally at fulcrum; divided by strong pleural furrows into broad posterior and narrow anterior convex pleural bands; becoming much flatter towards broad, rounded abaxial extremities. Thoracic surface appears to be finely granulated. Pygidial axis with four well-defined rings anteriorly and indications of two more behind. Axial furrows die out at less than two-thirds pygidial length from anterior margin. Pleurae crossed by three broad pleural ribs divided by strong pleural furrows and defined by broad interpleural furrows which extend further laterally, though neither set reaches the lateral margins.

Discussion. The small size and poor preservation of the south Welsh cranidia preclude complete comparison, but in all their visible features they appear close to those of *D. geniculata* as described by

Ingham (1977) from the mid-Rawtheyan Swindale Limestone of Cross Fell and from Zones 5 and 6 of the Cautley Mudstones, as do the south Welsh pygidia. No thorax is known for *D. geniculata*.

Family PTERYGOMETOPIDAE Reed, 1905*b*
Subfamily PTERYGOMETOPINAE Reed, 1905*b*
Genus LIOCNEMIS Kielan, 1960

Type species. Phacops recurvus Linnarsson, 1869.

Liocnemis recurvus (Linnarsson, 1869)

Plate 112, figs. 12, 13; Plate 113, fig. 16

1869 *Phacops recurvus* Linnarsson; p. 59, pl. 1, figs. 1, 2.
1885 *Phacops Brongniarti*, Portl.; Marr and Roberts (*pars*), p. 481 (lowest two faunal lists).
1960 *Liocnemis recurvus* (Linnarsson); Kielan, pp. 121–123, pl. 9, figs. 11, 12; pl. 21, figs. 8–11; pl. 22, figs. 1, 2; text-fig. 32.
1973*a* *Liocnemis* cf. *recurvus* (Linnarsson); Price, table 7.

Type specimens. The original specimens figured by Linnarsson (1869) have not been located (see Kielan 1960, p. 123).

Material, horizons, and localities. BM In54220a, b, 54224a, b, internal and external moulds of distorted, incomplete cranidia; SM A31543, 31544, 31546, 77634, 77935, internal moulds of incomplete cranidia, mostly distorted, and SM A77627, internal mould of pygidium; all from the basal Slade and Redhill Mudstones near Pelcomb (localities 2, 3) 4 km north-west of Haverfordwest. SM A31545, the fragmentary external mould of a cranidium from the same horizon at Clarbeston Road Station (locality 6b) may also belong here.

Discussion. Kielan (1960) has provided a full description of this species which does not require repetition. Distortion of the south Welsh cranidia makes it difficult to establish the exact proportional length of the frontal glabellar lobe which on most specimens is strongly bent-down; it does appear, however, to be slightly longer than the rest of the glabella as in the Swedish and Polish material of *L. recurvus* figured by Kielan (1960).

Genus CALYPTAULAX Cooper, 1930

Type species. Calyptaulax glabella Cooper, 1930.

Calyptaulax planiformis Dean, 1962

Plate 112, figs. 14, 15

1885 *Phacops Brongniarti*, Portl.; Marr and Roberts (*pars*), pp. 480, 482.
1962 *Calyptaulax* planiformis Dean, p. 98, pl. 13, figs. 1–5.
1973*a* *Calyptaulax planiformis* Dean; Price, p. 233, tables 1–4.
1975 *Calyptaulax* sp.; Cocks and Price, list p. 705, pl. 81, fig. 6.

Holotype. Figured Dean 1962, pl. 13, fig. 4, BM In50138, internal mould of cranidium from the Pusgillian Stage, Swindale Beck, Cross Fell.

Horizons and localities. As in Table 1. Appears also to range through the Slade and Redhill Mudstone Formation.

Discussion. C. norvegicus Størmer (1945, p. 417, pl. 4, figs. 2, 3) from the Gagnum Shale of Hadeland is closely similar to *C. planiformis*. Dr. A. Owen informs me that in Størmer's illustration the holotype cranidium was tilted forward slightly thus foreshortening the frontal lobe. There thus appear to be no important differences in cranidial proportions between the two forms and the main distinction rests on the pygidial differences referred to by Dean (1962, p. 99). In this respect south Welsh pygidia are like the holotype and paratype pygidia of *C. planiformis*, with a relatively long axis and at least the first three interpleural furrows reaching the pygidial margin (Pl. 6, fig. 15). The form described by Whittington (1962, p. 12, pl. 2, figs. 17, 18; pl. 3, figs. 15, 16) as *C.* aff. *norvegicus* from the Rhiwlas Limestone of North Wales differs from the south Welsh form in that the 3p lateral glabellar lobes are narrower (tr.) anteriorly and the 3p furrows strongly geniculated and here also, as in the pygidium of *C. norvegicus* figured by Størmer, the pygidial border appears to be smooth. It may be of significance that both Whittington and Størmer refer in their descriptions to circular or sub-circular 1p lateral glabellar lobes whereas in the south Welsh specimens, and apparently in those figured by Dean (1962, pl. 13, figs. 1–3), the outline is distinctly sub-quadrilateral and angular. The validity of the differences referred to here between *C. planiformis* and *C. norvegicus* must remain uncertain until more material of the latter is illustrated. For the present the South Welsh specimens are best referred to *C. planiformis*.

Family LICHIDAE Hawle and Corda, 1847
Subfamily HOMOLICHINAE Phleger, 1936
Genus PLATYLICHAS Gürich, 1901

Type species. Lichas margaritifera Nieszkowski, 1857.

Platylichas noctua sp. nov.

Plate 113, figs. 1–9; Plate 114, fig. 7.

1848 *Lichas laxatus*, McCoy; Salter (*pars*), p. 340, pl. 8, figs. 4, 4*a* (*non* 5, 6).
1866 *Lichas laxatus*, M'Coy; Salter (*pars*), p. 324, pl. 19, fig. 1 (*non* 2, 3).
1885 *Lichas laxatus*, M'Coy; Marr and Roberts, lists pp. 480, 481.
1909 *Lichas laxatus* McCoy; Strahan *et al.*, table p. 58.
1914 *Lichas laxatus* McCoy; Strahan *et al.*, table p. 63.
1973*a* *Platylichas* cf. *laxatus* M'Coy; Price, tables 1–4, 7, list p. 242.

Holotype. (Pl. 113, figs. 4–6), GSM 19475, internal mould of incomplete cranidium (?together with GSM 19479, original of Salter 1848, pl. 8, fig. 4), Sholeshook Limestone of Sholeshook.

Diagnosis. Species of *Platylichas* with very wide (tr.), D-shaped composite glabellar lobes, narrow median lobe between and relatively wide (tr.) and short frontal lobe; palpebral lobes occupy up to four-fifths length (exsag.) of composite lobes; hypostoma with anterior lobe of median body coarsely granulated and lateral borders bearing a few raised ridges; pygidial border spines long, only gradually tapering, first two with convex outer margins.

Horizons and localities. In addition to occurrences shown in Table 1, known also from Slade and Redhill Mudstones of Redhill Quarry (locality 7) and basal Slade and Redhill Mudstones near Pelcomb (locality 3) and Rudbaxton (4).

Description. Width (tr.) of cranidium greatest posteriorly where about twice sagittal length. Glabella also widest posteriorly, width across frontal lobe being only three-quarters that at occipital ring. Latter broadest (sag. and exsag.) mesially, narrowing and curving forwards behind ovoid occipital lobes. Median lobe narrowest just behind mid-length of composite lobes, occupying one-sixth glabellar width at that level. Composite lobes occupy just over two-fifths cranidial length, very wide (tr.) and prominent, separated from rest of glabellar by deep, strongly curved longitudinal furrows; stand slightly above median lobe (Pl. 113, fig. 5), most of their surface horizontal but dropping steeply antero-laterally in front of anterior ends of palpebral furrows. Frontal lobe $2\frac{1}{2}$–3 times as wide (tr.) as long (sag.), broadly rounded frontally, occupying about one-quarter of cranidial length (sag.) and dropping steeply anteriorly (Pl. 113, fig. 6) to strong pre-glabellar furrow and broad, flat anterior border. Border narrows laterally where crossed at low angle by anterior branches of facial sutures (Pl. 113, fig. 4). Shallow axial furrows diverge forwards at about 55°. Palpebral lobes broad, prominent, and strongly curved, three-quarters to four-fifths length of composite glabellar lobes and standing on same level. Separated from rest of fixed cheeks by poorly defined palpebral furrows which at their mid-lengths are exsagittally in line with abaxial ends of occipital ring. Fixed cheeks moderately convex (exsag.) behind palpebral lobes, separated by deep furrows from occipital lobes. Anterior branches of facial sutures at first diverge and then converge forwards sub-linearly; posterior branches curve sigmoidally out and back to cross posterior border at angle of about 50°. Cranidial surface ornamented with granules of two sizes (Pl. 113, fig. 8), the larger about 0·15 mm and evenly distributed, the space between filled by the smaller. Occipital ring bears prominent median tubercle near posterior margin.

Hypostoma (Pl. 113, figs. 2, 3; Pl. 114, fig. 7) sub-quadrate, broadest on level of posterior border furrow. Median body moderately convex (tr.), divided by short but strong median furrows. Anterior lobe large, rounded. Posterior lobe short (sag. and exsag.), about two-thirds width (tr.) of anterior lobe. Anterior border narrow. Small anterior wings sub-triangular, directed dorsally. Lateral notches broad (exsag.), shallow in side view. Lateral and posterior border furrows deep, posterior border broad and moderately convex (sag. and exsag.); posterior margin bifurcate with broad (tr.), shallow median notch. Anterior lobe of median body evenly covered with large (0·03 mm) granules and lateral borders bear a few raised, anastomosing lines running sub-parallel to lateral margins.

Thorax (Pl. 113, fig. 9) incompletely known. Axis broad (tr.), tapering back only gradually, with broad (sag. and exsag.), sub-rectangular axial rings. Axial furrows narrow but deep. Pleurae become narrower (exsag.) abaxially and are deflected posteriorly at fulcrum as long, backwardly directed pleural spines. Pleural furrows commence at axial furrows near anterior margin of each segment then curve gently outwards and towards mid-line.

Axis of pygidium moderately convex (tr.), tapering only gradually back. Four narrow and convex (sag. and exsag.) axial rings are separated by ring furrows which gradually shallow posteriorly until fourth is only developed laterally and does not reach axial furrows. Behind it posterior portion of axis is more convex (tr.) and drops steeply in line with anterior ends of third interpleural furrows. Post-axial ridge at first narrows posteriorly more rapidly than axis but then expands again towards posterior border furrow. Axial furrows broad and deep. Pleural lobes crossed by pleural and interpleural furrows of equal prominence; three pleural ribs. First two developed into border spines which are long, taper only gradually, and curve backwards and inwards with evenly convex lateral margins. Gently convex border and shallow border furrow only clearly developed behind posterior band of second pleural rib (Pl. 113, fig. 7). Third pair of backwardly directed, broad-based border spines set close together behind axis. Doublure of thorax and pygidium broad, with widely spaced terrace-lines. External surface of both granulated in same manner as cranidium though on smaller specimens the granulation is relatively coarser.

Discussion. In common with many other upper Ordovician species of *Platylichas*, the Sholeshook form was long identified with *P. laxatus* (McCoy 1846, p. 51, pl. 4, fig. 9), a species erected on the basis of a partial cranidium from strata at Ballygarvan Bridge, New Ross, Eire, the exact age of which is uncertain. Dean (1963, pl. 43, fig. 10) refigured this holotype and a more complete topotype

EXPLANATION OF PLATE 113

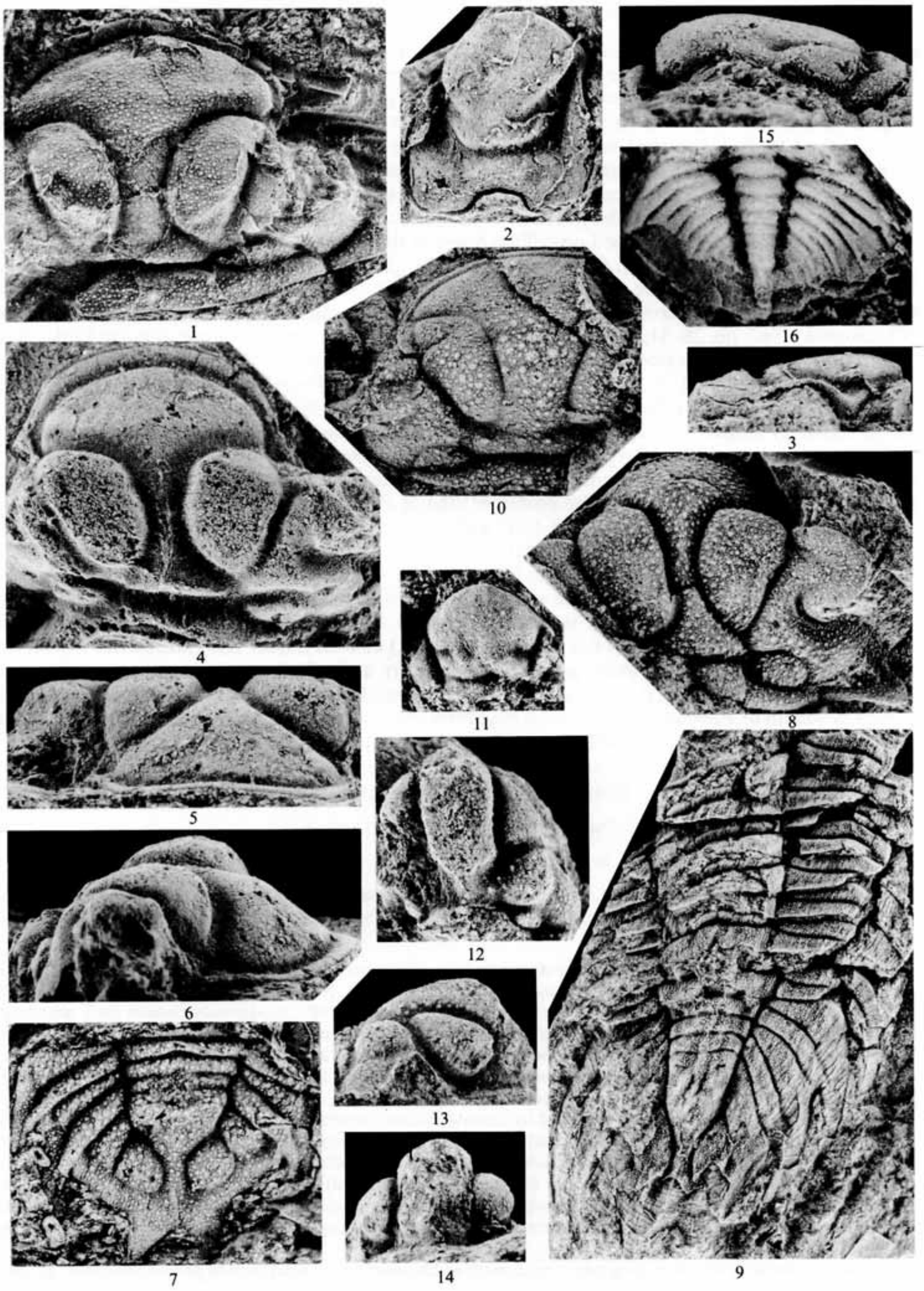
Figs. 1–9. *Platylichas noctua* sp. nov. 1, SM A31531, testate, incomplete cranidium from the Sholeshook Limestone of Sholeshook railway cutting, dorsal view, ×4. 2, 3, SM A104839, internal mould of hypostoma from the basal Sholeshook Limestone of Moldin (locality 25) near Llandowror, ventral and right lateral views, ×4. 4–6, GSM 19475, internal mould of incomplete cranidium, HOLOTYPE (?together with GSM 19479, original of Salter 1848, pl. 8, fig. 4), Sholeshook Limestone of Sholeshook, dorsal, anterior, and antero-lateral oblique views, ×4. 7, SM A31513, cast from external mould of incomplete pygidium from high Sholeshook Limestone of Prendergast, dorsal view, ×6. 8, GSM 19479, cast from external mould of incomplete cranidium (?together with GSM 19475, original of Salter 1848, pl. 8, fig. 4), Sholeshook Limestone of Sholeshook, oblique view, ×4. 9, SM A31530, testate internal mould of incomplete articulated thorax and pygidium from Sholeshook Limestone of Sholeshook railway cutting, dorsal view, ×1½.

Figs. 10, 11. *Platylichas angulatus* Warburg? 10, BM It9261, cast from external mould of incomplete cranidium from the Sholeshook Limestone horizon at Robeston Wathen, flattened, dorsal view, ×5. 11, BM It9263, internal mould of incomplete hypostoma, same horizon and locality, ventral view, ×4.

Figs. 12–14. *Trochurus* sp. indet., GSM Pg. 291, internal mould of poorly preserved, incomplete cranidium from the Sholeshook Limestone, 'middle section' of Sholeshook railway cutting, dorsal, right lateral, and anterior views, ×5.

Fig. 15. *Glaphurella* cf. *harknessi* (Reed), GSM Pg. 299, internal mould of cranidium from same horizon and locality as original of figs. 12–14, left lateral view, ×4. See also Pl. 114, figs. 17, 18.

Fig. 16. *Liocnemis recurvus* (Linnarsson), SM A77627, internal mould of pygidium from the basal Slade and Redhill Mudstones south-west of Knock (locality 3), dorsal view, ×8.



PRICE, Sholeshook trilobites

cranidium was figured by Tripp (1958, pl. 84, fig. 4). *P. laxatus* differs from *P. noctua* in having narrower (tr.) composite glabellar lobes with a relatively wider median lobe between; the median lobe is narrowest further posteriorly and expands much more gradually anteriorly into a relatively longer (sag. and exsag.) and narrower (tr.) frontal lobe. Dean (1963, pp. 235–237, pl. 43, figs. 1, 2, 5, 8, 11, 12) also assigned to *P. laxatus* material from the Actonian Stage of south Shropshire. The cranidia appear to be similar to the Irish specimens; the hypostoma differs from that of *P. noctua* in that the maximum width is attained further anteriorly, across the shoulders, and is comparable to that on the level of the anterior wings, also the posterior lobe of the central body is smaller.

P. nodulosus (McCoy) from the Longvillian Stage of the Bala area (Whittington 1962, pp. 25–28, pl. 6, figs. 12, 13; pl. 7, figs. 1–14, 19; 1968, pp. 100–101, pl. 31, figs. 5, 6, 8–11, 14) differs in having a broader median glabellar lobe with the posterior part inflated as a distinct ring, in having shorter palpebral lobes and in having a much wider (sag. and exsag.) anterior border. In *P. glenos* Whittington (1962, pp. 28–31, pl. 7, figs. 15, 16; pl. 8) from the Rhiwlas Limestone of north Wales and the Chair of Kildare Limestone of eastern Ireland (Dean 1974, pp. 81–83, pl. 33, fig. 12; pl. 36, figs. 3–5, 7, 9–11; pl. 37, figs. 1–3, 5, 7, 10; pl. 38, figs. 3, 4, 7, 11, 12) the palpebral lobes are long as in *P. noctua* but the composite lobes are less wide and tend to be posteriorly pointed in outline, the frontal lobe is relatively longer (sag. and exsag.), less broad, and with a more strongly convex anterior margin and the median lobe does not expand so rapidly near its posterior margin. The hypostoma is much more finely granulated and carries many more anastomosing ridges on the lateral borders (Whittington 1962, pl. 8, fig. 10), the posterior lobe of the central body is narrower (tr.) and the posterior border more strongly convex (sag. and exsag.). The pygidial border spines are shorter, much more slender, and have concave lateral margins. The hypostoma of *P. crescenticus* (Reed, 1935, pp. 29–31, pl. 3, figs. 13–16) from the upper Drummuck Group of Girvan is similar to that of *P. glenos* in having a finer granulation and more anastomosing ridges than that of *P. noctua*; in addition the posterior lobe of the median body is relatively smaller and separated by less prominent median furrows and the posterior margin has a far narrower (tr.) median notch. The glabella has a broader median lobe which expands more gradually posteriorly and relatively narrower composite and frontal lobes. If Tripp (1958, p. 579) is correct in considering *P. vicinus* (Reed, 1935, p. 33, pl. 3, fig. 12) to be a synonym of *P. crescenticus* then the pygidium of the latter form differs from that of *P. noctua* in having shorter border spines with less strongly curved outer margins.

Platylichas angulatus Warburg, 1925?

Plate 113, figs. 10–11; Plate 114, fig. 6

1973*a* *Platylichas* sp. ?nov.; Price, list p. 233.

Material. BM It9261, 9262, 9263, SM A77810, respectively external mould of incomplete, flattened cranidium and internal moulds of three incomplete hypostomata from the Sholeshook Limestone horizon at Robeston Wathen.

Description. Glabella equally wide (tr.) across frontal lobe and occipital ring. Latter broadest (sag. and exsag.) mesially, behind ovoid occipital lobes narrows and curves forwards. Median lobe broad (tr.), narrowest just behind mid-length of palpebral lobes, expanding forwards at about 40°; moderately convex (tr.), standing slightly higher than composite lobes; posterior portion developed as distinct convex (sag. and exsag.) ring almost twice as wide as narrowest part of median lobe and separated by broad shallow furrow. Composite lobes large, sub-triangular, moderately convex (tr.). Strongly curved longitudinal furrows become shallow and indistinct antero-mesially and postero-mesially. Frontal lobe short and wide, sharply angulate laterally, with only moderately convex anterior margin; separated by narrow, distinct furrow from narrow, convex (sag. and exsag.) anterior border. Axial furrows deep and broad posteriorly. Palpebral lobes broad (tr.), strongly curved, about half-length (exsag.) of composite glabellar lobes and situated opposite posterior halves of these. Surface of cranidium with exception of anterior border ornamented with variably sized, irregularly spaced granules, the largest, on the median lobe and posterior two-thirds of composite lobes, very prominent, attaining *c.* 0·03 mm; granulation markedly finer anteriorly and antero-laterally. Occipital ring bears small, posteriorly placed median tubercle.

Hypostoma broader (tr.) than long (sag.); maximum width attained at about level of posterior border furrow;

anterior margin bluntly pointed. Median body sub-pentagonal in outline, only gently convex, divided by short (tr.) but broad and deep middle furrows. Anterior lobe about twice as broad (tr.) as long (sag.), broadest at about mid-length, anterior margin bluntly pointed, lateral margins straight and posteriorly convergent. Posterior lobe short (sag. and exsag.). Anterior border absent. Anterior wings small. Lateral notch shallow (tr.). Lateral borders broaden posteriorly until about level of posterior border furrow. Lateral border furrows deep, sub-linear, posteriorly convergent; posterior border furrow shallower, transverse. Posterior border bifurcate with broad median notch.

Discussion. P. angulatus was described by Warburg (1925, p. 286, pl. 7, figs. 28–30) on the basis of two cranidia from the Boda Limestone of Kallholn, Dalarne, Sweden. Her original figures are too small to permit close comparison with other forms. More recently Dean (1974, p. 83, pl. 37, figs. 4, 6, 8, 9; pl. 38, figs. 1, 6) referred two cranidia from the Chair of Kildare Limestone to Warburg's species. Although very similar in over-all form, these two cranidia show some differences from the south Welsh specimen. The median glabellar lobe does not narrow so markedly, the transverse posterior portion is relatively longer (sag. and exsag.) and less wide (tr.) and apparently less well separated from the anterior part and the granulation on the median and composite lobes is less coarse than on the south Welsh specimen. Hypostomata have not been described for either the Boda Limestone or the Chair of Kildare Limestone form. More certain identification of the south Welsh form must await redescription of *P. angulatus* from Boda Limestone material.

Subfamily CERATARGINAE Tripp, 1957
Genus TROCHURUS Beyrich, 1845

Type species. Trochurus speciosus Beyrich, 1845.

Trochurus sp. indet.

Plate 113, figs. 12–14

1914 *Lichas bulbiceps* Reed ?Phillips MS.; Strahan *et al.*, table p. 63.
1973*a* *Trochurus* sp. indet.; Price, table 2.

Material. GSM Pg. 291, internal mould of incomplete cranidium from the middle section of Sholeshook railway cutting.

Discussion. The poorly preserved, incomplete cranidium is similar in over-all form to the holotype cranidium of *T. toernquisti* (Gürich) figured by Warburg (1925, pl. 7, figs. 1, 2) from the Boda Limestone of Boda, Dalarne, Sweden, but differs in that the 1p glabellar lobes appear to be relatively longer (exsag.) and the bullar lobes narrower (tr.) and more triangular in dorsal view. Both Warburg (1925, p. 259) and Dean (1974, pp. 87–88, pl. 35, figs. 2, 3, 5, 8, 11) referred specimens from the Chair of Kildare Limestone of eastern Ireland to *T. toernquisti.* To judge from the Irish specimens figured by Dean, the Sholeshook form has both the median glabellar lobe and the bullar lobes relatively longer (sag. and exsag.) and narrower (tr.).

Family ODONTOPLEURIDAE Burmeister, 1843
Subfamily MIRASPIDINAE R. & E. Richter, 1917
Genus WHITTINGTONIA Prantl and Přibyl, 1949

Type species. Acidaspis bispinosa McCoy, 1846.

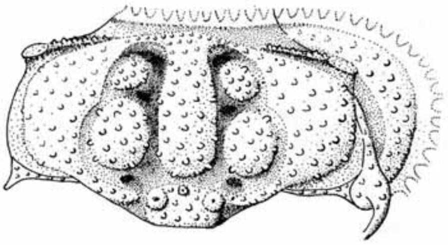
Whittingtonia whittingtoni Kielan, 1960

Plate 114, figs. 1–3

1960 *Whittingtonia whittingtoni* Kielan, pp. 109–111, pl. 16, fig. 5; pl. 18, figs. 1–4; text-fig. 28.
1965 *Whittingtonia* cf. *whittingtoni* Kielan; Whittington, pp. 34–35, pl. 9, figs. 11–17.
1968 *Whittingtonia whittingtoni* Kielan; Whittington, p. 100, pl. 31, figs. 1–3.
1973*a* *Whittingtonia whittingtoni* Kielan; Price, p. 245, table 7.
1973*b* *Whittingtonia whittingtoni* Kielan; Price, p. 538.

Material. In54227, internal mould of almost complete, slightly distorted cephalon, basal Slade and Redhill Mudstones, road-section at crossways south-west of Knock (locality 3), 4 km north-west of Haverfordwest; SM A31364, internal mould of incomplete cephalon, same horizon near Pelcomb Cross (locality 2), 4 km west-north-west of Haverfordwest.

Discussion. The prominent, strongly convex (tr. and sag.) fronto-median glabellar lobe is similar in both dorsal and anterior views to those of specimens figured by Kielan (see synonomy) from the upper Ordovician of Poland and by Whittington from the Rhiwlas Limestone of north Wales, particularly to the latter. In lateral profile this lobe on one specimen (Pl. 114, fig. 3) appears to be rather more convex and to overhang the anterior border less, but these differences may well be due to distortion. Abaxially the median lobe drops steeply to broad, deep axial furrows which contain only weakly developed 1p and 2p lateral lobes; in this respect the cephala are more like those described by Whittington (1965, p. 34). In all other features, the short, stout occipital spines, the elongated (tr.) occipital node, the large eyes, the broad, deep palpebral furrows and prominent eye-ridges, the form



TEXT-FIG. 1. *Proceratocephala* cf. *terribilis* (Reed, 1914); reconstruction of cephalon approximately ×6·5, based largely on original of Plate 114, fig. 4. Details of spinose margin to anterior and lateral border (dotted) hypothetical.

EXPLANATION OF PLATE 114

Figs. 1–3. *Whittingtonia whittingtoni* Kielan, BM In54227, internal mould of almost complete, slightly distorted cephalon from the basal Slade and Redhill Mudstones south-west of Knock (locality 3), dorsal, anterior, and right lateral views, ×10.

Figs. 4, 5. *Proceratocephala* cf. *terribilis* (Reed). 4, GSM Pg. 487, internal mould of almost complete cephalon from the high Sholeshook Limestone of locality 9h, Sholeshook, dorsal view, ×6. 5, SM A77582a, testate, incomplete cranidium from the basal Sholeshook Limestone of the Pentre-howell road section (locality 17), Llandowror, dorsal view, ×6.

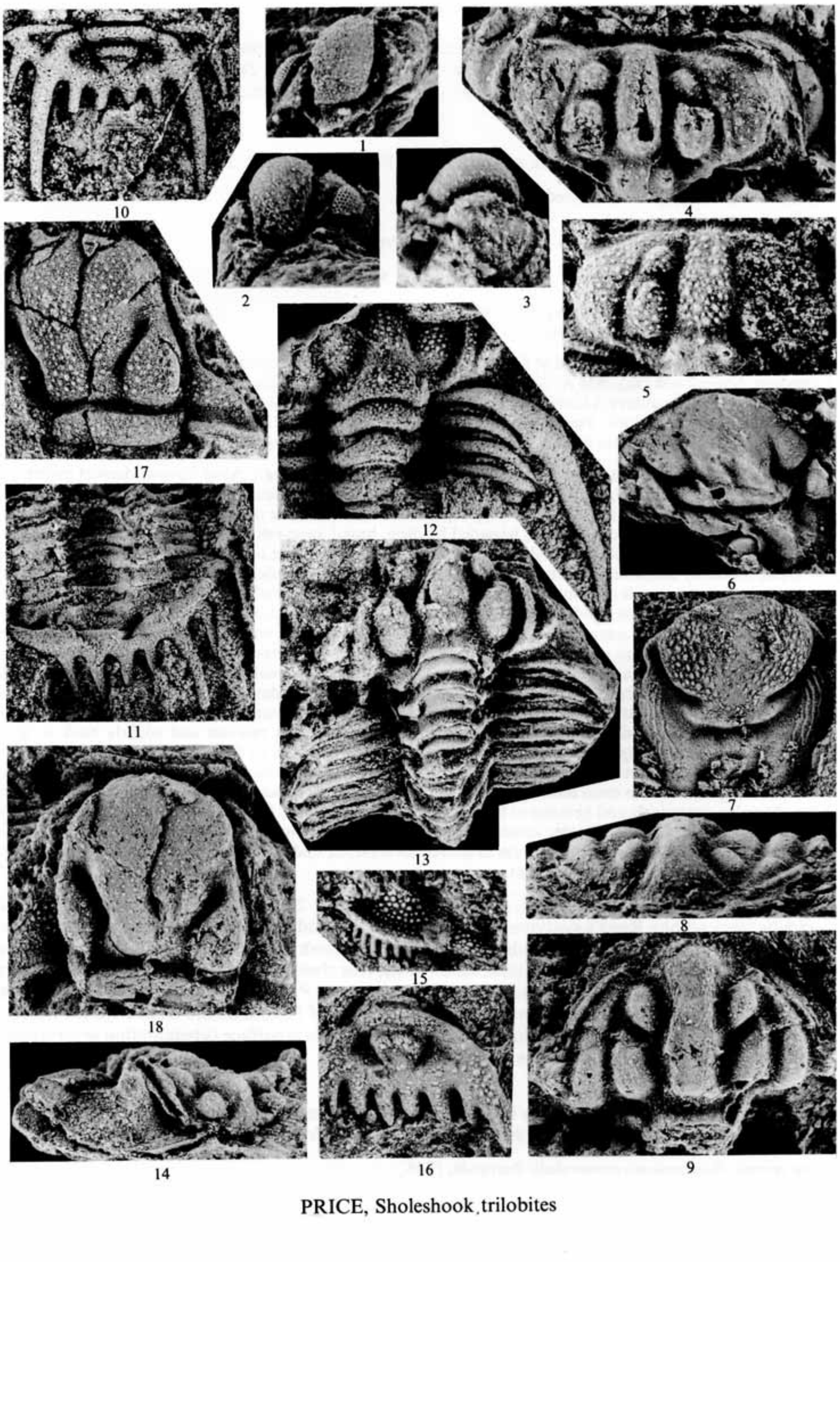
Fig. 6. *Platylichas angulatus* Warburg?, BM It9262, internal mould of incomplete hypostoma from the Sholeshook Limestone horizon at Robeston Wathen, ventral view, ×4.

Fig. 7. *Platylichas noctua* sp. nov., SM A31537b, cast from external mould of hypostoma, Sholeshook Limestone of Sholeshook railway cutting, ventral view, ×4.

Figs. 8–15. *Primaspis llandowrorensis* sp. nov. 8, 9, HM A9633, internal mould of incomplete cranidium from the high Sholeshook Limestone of Lan-y-gaer (locality 16a), near Llandowror, anterior and dorsal views, ×4. 10, NMW.21.306.G.17, external mould of pygidium from the Slade and Redhill Mudstones of Old Pale, near Llandowror, dorsal view, ×5. 11–14. GSM 21053/5213, HOLOTYPE, cast from internal mould of posterior part of thorax and pygidium with ventral mould of pygidial doublure, cast from partial external mould of cephalon and thorax and internal mould (including counterpart to above) of incomplete articulated exoskeleton (enrolled) from Sholeshook Limestone of Craig-y-deilo quarry, Llandowror, figs. 11–13 dorsal views, fig. 14 antero-lateral oblique, all ×4. 15, BM It9266b, cast from external mould of left free cheek from the Sholeshook Limestone horizon at Robeston Wathen, dorsal view, ×8.

Fig. 16. *Primaspis* sp. indet., SM A77514b, cast from external mould of incomplete pygidium from the highest Sholeshook Limestone of Prendergast (locality 8b), dorsal view, ×5.

Figs. 17, 18. *Glaphurella* cf. *harknessi* (Reed), GSM Pg. 296/299, cast from partial external mould of cranidium in dorsal view and counterpart internal mould of cranidium in dorsal view, Sholeshook Limestone, 'middle section' of Sholeshook railway cutting, both ×4; see also Pl. 113, fig. 15.



PRICE, Sholeshook trilobites

of the cheeks and surface ornamentation, the specimens resemble closely the material described by both Kielan and Whittington. Kielan (1960, p. 111), Bruton (1966, p. 28), and Dean (1974, p. 94) have discussed the differences between *W. whittingtoni* and the type species, *W. bispinosa*, from the Chair of Kildare Limestone.

Genus PROCERATOCEPHALA Prantl and Přibyl, 1949

Type species. Acidaspis terribilis Reed, 1914.

Proceratocephala cf. *terribilis* (Reed, 1914)

Plate 114, figs. 4, 5; text-fig. 1

1914 *Acidaspis* sp.; Strahan *et al.*, table p. 63.
1973*a* *Proceratocephala* cf. *terribilis* (Reed); Price, tables 1–4.

Material, horizons, and localities. GSM Pg. 487, internal mould of almost complete cephalon, high Sholeshook Limestone, Sholeshook (9h); HM A9702, A9704, internal moulds of cranidia, low Sholeshook Limestone, track south of Craig-y-deilo quarry, Llandowror (18d); SM A77582a, b, A77754a, b, counterpart moulds of cranidia, basal Sholeshook Limestone, Pentre-howell road section (17); SM A77989, internal mould of incomplete cranidium 9½–10 m above base of Sholeshook Limestone in Mylet road section (24a).

Description. Cranidium elliptical in outline, twice as broad (tr.) as long (sag.). Axial furrows deepest posteriorly where strongly divergent, broad and distinct over most of length but only faintly developed forward of 2p lateral lobes. Glabella broadest (tr.) at mid-level of 1p lateral lobes. Median lobe roughly semi-cylindrical, narrowing slightly anteriorly; strongly convex (tr.), bounded by deep, broad longitudinal furrows. Large 1p lateral lobes ovoid, strongly convex. 2p lobes of similar form but only half length (exsag.) of basal lobes; separated from them by broad, adaxially deepening 1p lateral furrows. Small 3p lateral lobes fused to median lobe to form narrow (sag. and exsag.), transverse anterior section. Occipital furrow broad, mesially shallow; ring very broad, bearing large, paired occipital spines, small median tubercle near anterior margin. Longitudinal furrows contain shallow apodemal pits where they merge with the 1p and 2p lateral furrows and with the longitudinal furrows. Fixed cheeks strongly convex and steeply declined postero-laterally; antero-mesially not distinctly separated from transverse anterior section of antero-median lobe, posteriorly only weakly separated from occipital ring. Posterior border furrow broad, curving strongly forwards abaxially; border narrow adaxially, broadening and curving gently forwards distally. Anterior border furrow broad; border narrow (sag. and exsag.) but form not clearly seen. Antero-laterally on cranidium narrow (exsag.) eye-ridges run out and slightly back to small palpebral lobes situated opposite 2p lateral furrows. Posterior branches of facial sutures run back in gently sigmoidal curves, the anterior sections concave adaxially. Anterior branches abaxially run close to eye-ridges before curving forwards to cross anterior border at low angle. Free cheeks crescentic. Strongly convex sutural ridges broaden posteriorly and give rise to broad-based librigenal spines. Broad furrows, anteriorly convergent with anterior border furrow, separate sutural ridges from remaining convex portions of cheeks. Lateral borders broad (tr.) and spinose but number and size of spines not clear. Cranidial surface ornamented with prominent, closely spaced tubercles of *c.* 0·15–0·2 mm.

Discussion. Whittington (1956, p. 515, pl. 59, fig. 13; pl. 60, figs. 2, 3, 5, 6, 10) selected a lectotype for *P. terribilis* from among Reed's syntypes and redescribed this and other material from the Rawtheyan Starfish Bed of Girvan. In cranidial characters the south Welsh specimens do not significantly differ from this material though the poor preservation of the free cheeks and the present lack of other parts of the exoskeleton preclude a full comparison. The subspecies *P. terribilis bituberculata* Kielan (1960, p. 107, pl. 3, fig. 3; pl. 16, fig. 1) from the upper Ordovician of Poland differs from both the Scottish and south Welsh specimens in showing in addition to the general surface tuberculation several much larger, regularly positioned tubercles on the cranidium.

Subfamily ODONTOPLEURINAE Burmeister, 1843
Genus PRIMASPIS R. and E. Richter, 1917

Type species. Odontopleura primordialis Barrande, 1846.

Primaspis llandowrorensis sp. nov.

Plate 114, figs. 8–15

1973*a* *Primaspis* aff. *semievoluta* (Reed); Price, list p. 233, table 2.

Holotype. GSM 5213, 21053 (Pl. 8, figs. 11–13), internal and external moulds of incomplete articulated exoskeleton from Craig-y-deilo quarry, Llandowror.

Paratypes. NMW 21.306.G17, external mould of pygidium and NMW 21.306.G18, internal mould of free cheek, both from Slade and Redhill Mudstones of Coed Old Pale, near Llandowror; HM A9633, internal mould of cranidium, high Sholeshook Limestone, Lan-y-gaer (locality 16a); BM It9264, 9265, 9266a, b, internal mould of partial cranidium, external mould of incomplete pygidium, and counterpart moulds of free-cheek, from Sholeshook Limestone of Robeston Wathen; SM A77994, poor internal mould of free cheek from 9½–10 m above base of Sholeshook Limestone in Mylet Road section (locality 24a), Llandowror. This comprises all available material.

Diagnosis. *Primaspis* with relatively narrow (tr.) median glabellar lobe, small, poorly differentiated 3p lateral lobes, centrally (not posteriorly) positioned occipital tubercle and stout genal spines, particularly broad where they join the posterior borders; pygidium with only one pair of anterior secondary border spines and outermost posterior pair of secondary spines not fused with bases of major spines; sculpture of small, well-spaced granules.

Description. Cranidium broadest posteriorly where width about 2½ times sagittal length. Glabella broadest at mid-level of 1p lateral lobes; width here about equal to pre-occipital length. Occipital ring strongly convex (tr.), broad and sub-parallel sided mesially with prominent centrally positioned median tubercle, narrows sharply behind posterior ends of 1p lateral furrows and then curves forward to form prominent occipital lobes. Occipital furrow broad and prominent. Large 1p lateral lobes ovoid, 1½ times as long (exsag.) as wide (tr.), strongly convex; long axes diverge forward at *c*. 25°. 2p lobes about two-thirds length of 1p, of similar form and orientation. 1p and 2p lateral furrows prominent, curving in and strongly back completely separating 1p and 2p lobes from median lobe; 1p furrow deeper than 2p. 3p lateral lobes very small, with only slight independent convexity; oriented antero-laterally and defined anteriorly by broad but short and shallow 3p furrows. Median lobe strongly convex (tr.), narrowest (tr.) at mid-level of 2p lateral lobes, widest at about three-quarters length of 1p lobes. Frontal lobe about as wide (tr.) as posterior part of median lobe, roughly semicircular, dropping steeply to broad anterior border furrow. Anterior border narrow (sag. and exsag.) and upturned (Pl. 114, fig. 9). Axial furrows broad and deep posteriorly. Elongated triangular strips of fixed cheeks lie outside axial furrows, broadening and becoming more strongly convex posteriorly. Antero-laterally to these strips, separated by strong furrows, narrow convex eye-ridges run back to palpebral lobes situated opposite posterior halves of 1p lateral lobes. Anterior branches of facial sutures curve forwards and adaxially, gradually diverging from eye-ridges; posterior branches curve out and gradually back. Convex posterior borders narrow adaxially, broadening rapidly outwards. Free cheeks crescentic; at inner posterior corners bear eyes on stout, elongated stalks (Pl. 114, fig. 14); extended postero-laterally as long, stout, broad-based librigenal spines. Lateral border furrow broad; narrow, convex border appears to bear about thirteen slender border spines, longest posteriorly. Cephalic surface ornamented with prominent, well-spaced granules of up to 0·175 mm.

Hypostoma unknown. Thorax of ten segments. Axis strongly convex, occupying less than one-third total width anteriorly. Axial rings convex (sag. and exsag.), broadest mesially, abaxially narrowing then curving forwards to form axial lobes. Articulating furrows broad and shallow mesially, outwards forming deep apodemal slots. Axial furrows shallow. Pleurae comprise broad, strongly convex posterior bands separated by narrow, distinct pleural furrows from lower, narrow, convex anterior bands which bear a row of about six regularly spaced, small tubercles. Inner portions of pleurae horizontal but at fulcrum deflected ventrally and posteriorly; posterior bands have prominent fulcral expansions (Pl. 114, fig. 13). Axial rings and posterior pleural bands with similar ornament to that of cephalon.

Pygidium, discounting border spines, sub-triangular, about three times as wide (tr.) as long (sag.). Axis occupies one-third total width anteriorly, tapers back rapidly. First axial ring strongly convex longitudinally, moderately so transversely, clearly defined; second ring about two-thirds as wide (tr.), lower, less convex (sag. and exsag.), followed by low triangular terminal portion fused to convex posterior border. Convex pleural ridge curves out and strongly back and swells slightly as it approaches posterior border; pleural areas between it the axis and the borders depressed. Border spines long, gradually tapering. Between the major spines are four secondary posterior spines of which the outermost are not fused with the bases of the major spines; only one pair of anterior secondary spines is present. Ornament of well-spaced granules poorly preserved.

Discussion. In cephalic features *P. llandowrorensis* sp. nov. shows much over-all similarity to *P. bucculenta* McNamara (1979*a*, p. 86, pl. 12, figs. 10–19) from Cautleyan Zone 3 in the southern Lake District. In that form, however, the fixigenae are much broader (tr.) posteriorly, the librigenal spines appear shorter and more rapidly tapering and the librigenal denticles are shorter. Like *P. bucculenta* the south Welsh form differs from *P. evoluta* (Tornquist) from the upper Ordovician of Sweden (see Bruton 1966, p. 4, pl. 1, figs. 1–9; pl. 4, fig. 9; text-fig. 2*a*) and north Wales (Whittington 1968, p. 98, pl. 30, figs. 25–30) in having a relatively narrower median glabellar lobe, larger 2p lateral lobes, smaller, less prominent and less anteriorly divergent 3p lobes, a greater number of librigenal border spines, and a central occipital tubercle.

In pygidial characters *P. llandowrorensis* differs from both these forms in lacking the fusion between an outermost (third) pair of posterior secondary border spines and the bases of the macrospines. It lacks the second anterior secondary border spines of *P. evoluta* and in over-all form is relatively longer (sag.) and less broad (tr.). *P. bucculenta*, like *P. llandowrorensis*, has only one anterior secondary spine but the macrospines in *P. llandowrorensis* are much longer, narrower-based, and less strongly curved. The anterior secondary spines appear longer also and the pygidial tuberculation is much finer. The lack of the fused border spines together with the presence of only one pair of anterior secondary spines appear to distinguish the pygidium of *P. llandowrorensis* from that of any other known species of the genus.

Primaspis sp. indet.

Plate 114, fig. 16

1973*a* *Primaspis* cf. *evoluta* (Tornquist); Price, tables 1, 2.

Material. Single specimen, SM A77514a, b, internal and external moulds of incomplete pygidium from the highest Sholeshook Limestone of Prendergast Place (locality 8b), Haverfordwest.

Description. Axis strongly convex; anteriorly with well-developed articulating ring separated by broad furrow. First axial ring strongly convex (sag. and exsag.); second lower and less wide (tr.), bearing pair of large but ill-defined tubercles and followed by a low, rapidly tapering (tr.) terminal portion fused with the convex posterior border. Strongly convex pleural ridge curved outwards and posteriorly. Between ridge, axis, and posterior border pleural areas depressed. Posteriorly there are six secondary spines of which the outermost are small and fused with the swollen bases of the major spines. All the spines but particularly the major spines, the posterior border, the pleural ridge, and the first axial ring are ornamented with prominent granules.

Discussion. In over-all form and proportions and in the character of the ornamentation the incomplete Prendergast pygidium resembles the corresponding portions of the pygidia of both *P. evoluta* (cf. Bruton 1966, pl. 1, figs. 6–7; pl. 4, fig. 9; text-fig. 2*a*) and *P. bucculenta* (cf. McNamara 1979*a*, pl. 12, figs. 16, 18, 19). The border spines are relatively shorter and stouter than those of *P. bestorpensis* Bruton (1966, pp. 7–9, pl. 2, figs. 1, 2, 5–6; text-fig. 2*b*) from the Bestorp Limestone (basal Harju Series) of Västergötland, and the depressed pleural areas lack the coarse granulation seen in that form. In the absence of the antero-lateral parts of the pygidium further comparisons are not possible.

?Family GLAPHURIDAE Hupé, 1953
Genus GLAPHURELLA Dean, 1971

Type species. Cyphaspis ? Harknessi Reed, 1896.

Glaphurella cf. *harknessi* (Reed, 1896)

Plate 114, figs. 17, 18

1905*a* *Cyphaspis* cf. *Harknessi*, Reed; Reed, p. 98.
1914 *Proetus harknessi* Reed; Strahan *et al.*, table p. 64.
1973*a* *Glaphurella* cf. *harknessi* (Reed); Price, tables 1, 2.

Material, horizons, and localities. SM A104833, internal mould of partial cranidium, Sholeshook Limestone, Sholeshook; GSM Pg. 296, 299, internal and external moulds of cranidium, middle section of Sholeshook railway cutting; GSM Pg. 280, internal mould of flattened partial cranidium, same horizon and locality; SM A77948, internal mould of partial cranidium, locality 9e, Sholeshook; SM A30940, internal mould of incomplete cranidium, basal Slade and Redhill Mudstones south-west of Knock (locality 3).

Discussion. Dean (1971, p. 44, pl. 22, figs. 3–10, 12, 13; pl. 23, fig. 1) redescribed the holotype cranidium of *G. harknessi* from the Keisley Limestone of Cross Fell together with better-preserved specimens from the Chair of Kildare Limestone of eastern Ireland. The south Welsh specimens are similar in general form and in details of ornamentation but appear to have glabellae which are consistently relatively longer (sag.) and less wide (tr.) than in the cranidia figured by Dean and which do not drop so steeply anteriorly. Also, although the 2p lateral glabellar furrows are just visible on internal moulds of some of the south Welsh cranidia, none of them show any signs of glabellar lobation anterior to these. Such differences may simply be the effects of distortion and poor preservation but until better specimens are available the south Welsh form is probably best only compared with *G. harknessi*.

RANGES, ABUNDANCES, AND FAUNAL COMPARISONS

The known ranges or restricted occurrences of trilobite species within the three developments of the Sholeshook Limestone Formation, together with indications of their relative abundance, are given in Table 1. The five categories in the list of abundances are based primarily on the relative numbers of specimens in the author's collections and in other recent collections from the formation where an attempt has been made to retain all potentially identifiable material (e.g. S. F. Morris collection BM, J. K. Ingham collection HM)—though some of the forms listed as rare are known only from old collections. Each of these categories is a generalization for the formation as a whole or for those parts of it in which the particular taxon occurs; it has not been possible to sample in a sufficiently controlled way throughout all developments of the Sholeshook Limestone to give a more rigorous quantitative assessment of the abundance of each form or to chart variations in abundance at different horizons. In comparing the Sholeshook trilobites with other Ashgill trilobite faunas it is most useful to deal with comparisons at specific level separately from those at generic level. This is because the specific composition of the fauna is the basis for assessing the precise age and correlation of the formation while differences from other Ashgill faunas in generic composition probably relate to factors other than age relationships.

The age and correlation of the Sholeshook Limestone have been extensively discussed elsewhere (Price 1973*a*, *b*, 1980) and it is now considered that the formation ranges from high Cautleyan Zone 1 to Rawtheyan Zone 5. This conclusion is based on comparisons of the vertical distribution of trilobite species in the formation with the stratigraphical ranges of identical or closely allied species in the type Ashgill succession at Cautley (Ingham 1966, 1972–7). A precise correlation between the two successions is possible because they have large numbers of species in common. Several species of *Tretaspis* from Sholeshook and species of *Illaenus*, *Stenopareia*, *Pseudosphaerexochus*, *Calymene* (s.l.), *Flexicalymene*, *Kloucekia*, *Duftonia*, and *Toxochasmops* are all considered to be conspecific and species of *Atractopyge*, *Lonchodomas*, and *Hadromeros* very probably conspecific with forms of Cautleyan or lowest Rawtheyan age at Cautley.

Accepting this correlation, the occurrence in low to middle horizons of the Sholeshook Limestone of a few species occurring elsewhere in Rawtheyan horizons extends their stratigraphical ranges (Price 1973*a*, *b*). This argument was initially made with reference to elements of the '*Phillipsinella parabola*—*Staurocephalus clavifrons* fauna' where there is some confirmatory evidence for pre-Rawtheyan occurrences from other sections (Price 1973*b*) but it has been recently extended to apply also to other forms such as *Prionocheilus* cf. *obtusus* and *Glaphurella* cf. *harknessi* (Price 1980). Thus certain species in the Sholeshook trilobite fauna appear to be long-ranging and are common to younger faunas such as those of the Rhiwlas Limestone of north Wales (Whittington 1962–1968) and the Chair of Kildare Limestone of eastern Ireland (Dean 1971–1978). They are, however, relatively few in number and when such faunas are fully compared with the Sholeshook fauna the difference in age is reflected in the presence of different species of, for example, *Illaenus*, *Tretaspis*, *Lonchodomas*, *Pseudosphaerexochus*, and *Platylichas*; over-all the number of species in common is much smaller than in the case of the Cautleyan fauna of the Cautley Mudstones referred to earlier.

Nearly all the genera present in the faunas so far discussed and in other Ashgill trilobite faunas are known to range through the Cautleyan and Rawtheyan Stages. Most of them are known to be geographically wide ranging. It can reasonably be argued therefore that where these faunas differ in generic composition it is largely as a result of differences in palaeoenvironmental factors. Although the environmental significance of Ashgill trilobite faunas is as yet only poorly understood, there do appear to be at least two reasonably clear associations between facies and fauna which can be referred to here and used as a basis for comparison with the Sholeshook fauna.

The first of these associations relates to the faunas of light-coloured, relatively pure, biosparite limestone developments often considered to be, at least in part, of 'reef' facies. These are here taken to be relatively shallow-water accumulations probably representing shelf-edge or near shelf-edge environments. Examples are the Boda Limestone of Sweden, the Chair of Kildare Limestone of eastern Ireland, and the Keisley Limestone of northern England all usually considered to be Rawtheyan in age, at least partially. These formations have trilobite faunas represented almost entirely by disarticulated remains. Broadly their faunas appear to be characterized by the importance in them of illaenids, cheirurids, and lichids (illaenid-cheirurid community type of Fortey, 1975). To a much greater extent than in the Sholeshook fauna these groups are both numerically predominant and generically diverse. When an over-all comparison is made the Sholeshook fauna does have a number of genera in common (cf. Dean 1978, table p. 111) such as *Atractopyge*, *Hadromeros*, *Pseudosphaerexochus*, *Platylichas*, *Illaenus*, *Stenopareia*, *Panderia*, *Prionocheilus*, and the rarer forms *Trochurus*, *Sphaerocoryphe*, and *Glaphurella*. This is as far as the similarity can be taken, however, for many other forms apparently characteristic of the pure limestone association are not represented at Sholeshook—*Sphaerexochus*, *Holotrachelus*, *Stenoblepharum*, *Decoroproetus*, *Dicranopeltis*, *Toernquistia*, and isocolids are notable examples. Similarly the pure limestone faunas themselves completely lack the following Sholeshook genera: *Calyptaulax*, *Kloucekia*, *Duftonia*, *Liocnemis*, *Lonchodomas*, *Raphiophorus*, *Flexicalymene*, *Brongniartella*, *Opsimasaphus*, *Encrinuroides*, *Dindymene*, *Amphitryon*, *Dionide*, and *Nankinolithus*. Chasmopines are also completely absent from them and though *Tretaspis* may be present it is usually very rare.

Many of the Sholeshook genera listed above as being absent from the pure limestone association appear to be more characteristic of a second distinct association. This relates to certain mudstone sequences here taken to represent deeper-water, low-energy environments probably considerably down-slope from the platform edge. Good examples are the mudstones of the '*Staurocephalus clavifrons* Zone' of Poland and the Králův Dvůr Formation of Bohemia (Kielan 1960; Havlicek and Vaněk 1966); in Wales the Ashgill mudstones of Grugan and Llanystwmdwy in the Lleyn Peninsula (Matley 1938; Harper 1956) appear to be of similar type. Their faunas usually contain a significant proportion of complete or almost complete articulated exoskeletons. Among trilobites which appear to be important and characteristic elements of such faunas are several genera which occur at Sholeshook: *Liocnemis*, *Lonchodomas*, *Raphiophorus*, *Opsimasaphus*, *Dindymene*, *Amphitryon*, *Dionide*, and *Nankinolithus*. With the exception of *Nankinolithus* these genera are among the rarer elements of the Sholeshook fauna and even *Nankinolithus* is only abundant at Sholeshook within a very restricted vertical range. At Crugan *Duftonia* occurs in association with the genera listed above. *Kloucekia*, *Flexicalymene*, and *Brongniartella* may also be less ubiquitous members of this mudstone association. The Polish and Bohemian mudstone faunas also contain many elements, possibly representing genera preferring even deeper water conditions—perhaps in foot-of-slope and basinal environments, not known from Sholeshook (though present elsewhere in Wales in the mudstones of the Abercwmeiddaw Group of the Corris–Ddinas Mawddwy area; P. M. Magor and J. K. Ingham coll.). These include *Novaspis*, several cyclopygid genera and telephinids.

On general sedimentological and stratigraphical evidence the Sholeshook Limestone probably represents an environment in the middle to upper part of the slope between platform edge and basin where deposition took place under relatively high energy conditions (skeletal material largely disarticulated, often broken) and was dominantly clastic but with some carbonate content. In this sense it would represent an environment intermediate between that represented by low-energy, deeper-water mudstones on the one hand and by shallow-water carbonate accumulations on the other. It is suggested that this 'intermediate' nature of the environment may be reflected in the variety of genera in the trilobite fauna which embraces both forms more common in deeper-water mudstones and forms occurring in pure limestones.

A few Sholeshook forms—*Calyptaulax*, *Encrinuroides*, and *Toxochasmops* (in fact chasmopines in general)—do not appear to be usual members of either the pure limestone or the mudstone associations and may be restricted to faunas of an 'intermediate' nature related to shallower-clastic and impure carbonate sequences. Another characteristic of such faunas is an abundance of *Tretaspis*; the genus becomes rare, as mentioned earlier, in pure limestone faunas and appears to be progressively replaced in deeper environments by first *Nankinolithus* and then *Novaspis*. Ultimately it may prove possible to characterize 'intermediate' faunas more fully as a separate third association though clearly this would overlap with both the carbonate and mudstone associations.

Overlap of this kind might prove useful, however, in permitting within a broad 'intermediate' association some distinction between faunas of deeper and shallower water affinities. For instance, when the Sholeshook trilobites are compared with those from the Cautleyan Stage of the Cautley area (Ingham 1966, 1970–1977) one major difference is the absence of those Sholeshook genera listed as being characteristic of the deeper-water mudstone association—*Liocnemis*, *Raphiophorus*, *Opsimasaphus*, *Dindymene*, *Amphitryon*, *Dionide*, and *Nankinolithus* (*Lonchodomas* is an exception). *Duftonia*, *Kloucekia*, *Brongniartella* and *Flexicalymene* are also absent. In view of what has been said in earlier sections these differences would suggest that the Cautleyan rocks at Cautley were deposited under shallower water conditions than was the Sholeshook Limestone. This suggested difference in environment might also relate to other faunal differences. For example, the Sholeshook genus *Flexicalymene* is replaced at Cautley by species of *Calymene* (s.l.) ('*Diacalymene*') and *Gravicalymene*, and *Harpidella* is replaced by *Otarion*. The odontopleurids at Cautley are represented by *Acidaspis* in addition to *Primaspis*, and *Decoroproetus* is common.

Similar differences are seen when the Sholeshook fauna is compared with that of the Birdshill Limestone, probably of Pusgillian–low Cautleyan age, of the Llandeilo area. Here again the *Harpidella* of the Sholeshook fauna is replaced by *Otarion*, the *Flexicalymene* is replaced by *Gravicalymene*, and both *Acidaspis* and *Decoroproetus* are present. The Birdshill Limestone is a light-coloured, relatively pure limestone, coarse grained, sparry, and largely bioclastic; all of these characters suggest a relatively shallow-water origin. The fauna, however, differs from that of the Cautleyan Stage at Cautley, probably as a reflection of its closer affinity with the pure carbonate association outlined earlier, in that species of *Platylichas* are important elements, *Holotrachelus* may also be present and *Tretaspis* is very rare (information based on collections from Birdshill Limestone in BM). The Rhiwlas Limestone of north Wales is faunally more like the Sholeshook Limestone in containing a number of genera like *Amphitryon*, *Dindymene*, *Opsimasaphus*, *Lonchodomas*, *Raphiophorus*, and *Cyclopyge* associated with deeper mudstone environments as well as forms like *Encrinuroides*, *Platylichas*, *Prionocheilus*, *Sphaerocoryphe*, and *Ulugtella* (last named noted by Dean 1978, p. 113). Like the Sholeshook Limestone it may represent an environment towards the deeper part of the 'intermediate' (broadly mid-slope) range.

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Typescript received 12 September 1979
Revised typescript received 1 March 1980