

# THE FAUNA OF THE DERFEL LIMESTONE OF THE ARENIG DISTRICT, NORTH WALES

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The Derfel Limestone, a thin basal member of the Lower Bala of the Arenig-Bala district, north Wales, is exposed only in three localities but has yielded a rich fauna of brachiopods, trilobites, bryozoans and crinoids. A systematic study of the two former phyla shows that the brachiopods are represented by eighteen genera (one, *Salopia*, is described as new), including nine new species and subspecies, and the trilobites by nine genera. It has previously been believed that the fauna represented a Scoto-Appalachian intrusion into the independent Anglo-Welsh faunal province. But the brachiopods especially are not typical of contemporary Scottish or American sedentary benthos and are better described as a native association dominated by migrants from the east Baltic together with an association of clitambonitids, leptestiniids and productorthinids possibly of Russian origin.

### 1. HISTORICAL REVIEW

The age and affinities of the Derfel Limestone fauna have been matters of considerable interest since 1847, when a fossiliferous outcrop was found by Ramsay 'near Garn, 4 miles N.W. of Bala' (1866, p. 74). At that time no comment was made on its precise position within the described Ordovician succession of Bala, but in 1905 Fearnside (1905, p. 627) named the limestone and used it as a mappable unit at the most 6 ft. thick, intercalated between the underlying Upper Rhyolitic Ashes of Arenig and the succeeding Nant Hir Shales. The type locality is in the gorge of Nant Aber Derfel (grid reference 23/850395) just north of the railway viaduct about a mile and a quarter east of Arenig Station, Merionethshire. A few feet of fossiliferous, blue-black, pyritous mudstones are exposed in the west wall of the gorge, just north of outcrops of Rhyolitic Ashes. Exact relations are not revealed, but we follow Fearnside (1905, plate 41) in considering that the limestone must be at or near the base of the Nant Hir Shales. The faunal list given by Fearnside (1905, p. 627) was emended by Elles (1922, p. 145), who also discovered in the stream bed 'out on the moor, above the bridge', shales which yielded graptolites belonging to the *Nemagraptus gracilis* zone. Shales are now exposed in the stream about 600 yards south of the type locality, but we did not find graptolites. The junction between the Rhyolitic Ashes and the Nant Hir Shales is not exposed nearby, nor did we find any trace of the Derfel Limestone outcrop indicated hereabouts by Fearnside (1905, plate 41).

Fearnside mentioned (1905, p. 627) other localities, and we obtained a considerable

collection from that on the banks of the Afon Serw (grid reference 23/808435), half a mile south-west of the abandoned farmstead of Trawsnant and 3 miles north-north-west of Arenig Station. Here the fossils are contained in a few feet of silty mudstones, resting directly on the Rhyolitic Ashes, and passing up into Nant Hir Shales. In view of these relations it seems reasonable to assume that the Derfel Limestone at and near the type locality rests directly on the Upper Rhyolitic Ashes, and that the graptolitic shales discovered by Elles, and believed by her (1922, p. 144) to intervene between these ashes and the Derfel Limestone, represent a horizon above the limestone or, at most, laterally equivalent to it.

Finally, in 1933, Bancroft identified the fauna as being contemporary with that found in the Lower Harnage Shales of Shropshire. This correlation, presumably arising from his identification of the Derfel Limestone trinucleid as *Salterolithus harnagensis* (a specific determination that is open to question), should be regarded as provisional until more is known of the higher Costonian faunules.

## 2. NATURE AND ORIGIN OF THE FAUNA

Elles (1922, pp. 144–145) drew attention to the fact that the shelly fauna was ‘not of the type usually characteristic of the Welsh Llandeilian but approximates more closely to the fauna of the Scottish deposits of that age—more especially perhaps that of the Stinchar Limestone’ (p. 145). The brachiopod fauna as identified by her is certainly impressively comparable with that of the Stinchar Limestone (described by Reed 1917), and it is little wonder that since then many general discussions on the British Ordovician (e.g. Smith & George 1948, p. 36; Watts, in Evans & Stubblefield 1929, p. 71) have quoted this example of ‘Scottish—North Welsh affinity’. Our faunal list, compiled from previous as well as our large new collections, shows little similarity to faunal lists from contemporary Scottish deposits, and we do not consider that there was close affinity between Scottish and north Welsh faunas at that time. The brachiopods include a few indigenous species, subordinate to an association of exotic origin with an unknown source—possibly Russian—but approximately synchronous with the ‘*Pseudocrania planissima*’ invasion of the Baltic Province (Jaanusson 1945). The trilobites include mainly indigenous genera, together with forms that appear to be exotic, but are known in what may be called the North Atlantic province, i.e. ‘Baltoscandia’, Scotland, Ireland and the Appalachians.

The revised faunal list reads as follows:

### BRACHIOPODA

*Glossorthis* sp.

*Nicolella humilis* n.sp.

*Cyrtonotella* aff. *kukersiana* (Wysogorski), 1912.

*Dolerorthis tenuicostata* n.sp.

*Platystrophia precedens* McEwan, 1920, *major* n.subsp.

*Howellites* sp.

*Soudleyella* aff. *avelinei* Bancroft, 1928.

*Hordeleyella* sp.

*Salopia salteri* (Davidson), 1871, *gracilis* n. gen. et subsp.

*Cliftonia* (*Oxoplecia*) *mutabilis* n.sp.

*Kullervo* aff. *panderi* (Öpik), 1930.  
*Palaeostrophomena magnifica* n.sp.  
*Leptellina derfelensis* (Jones), 1928.  
*Sowerbyella* sp.  
*Plectodonta lenis* n.sp.  
 'Sowerbyella' *multiseptata* n.sp.  
*Sericoidea abdita* n.sp.  
*Leptaena* sp.  
*Kjaerina* sp.

## TRILOBITA

*Salterolithus* cf. *harnagensis* Bancroft, 1929.  
*Ampyx* ind.sp.  
*Harpes* (s.l.) ind.sp. A. Whittington, 1950.  
*Illaeus* (s.l.) ind.sp.  
*Ceraurina*? ind.sp.  
*Atractopyge* ind.sp.  
*Encrinurid*? ind.g.  
*Platylichas* ind.sp.  
*Odontopleurid* ind.g.  
 Calymenid? pygidium.

Bryozoa, a dendroid graptolite and pelmatozoan Echinoderma are also present.

Before attempting to analyze the origin and affinities of this fauna it may be noted that complications such as those described below are to be expected. Recent reviews like that of Stubblefield (1939) suggest that the pattern of relationship between the classical Ordovician Provinces, the Scandinavian, east Baltic, Anglo-Welsh, Bohemian and Scoto-Appalachian\* is assuming a complexity comparable with that existing between and within modern marine provinces, where the principal endemic faunas are not only distinct from one another but also consist of a number of independent and equally distinctive associations. Moreover, since such diversity is seen as a background to the stratigraphical succession the faunal sequence of any one area may be enlarged or modified by the introduction of associations from other habitats. Thus according to Jaanusson (1945) the Viru Series of the east Baltic, equivalent to  $C_{1\gamma}$  to  $E$  of Öpik (1930), was populated by eight distinct faunas which replaced one another so gradually that there was a considerable overlap between them; at horizons  $C_{11\alpha}$  and  $D_{1\alpha}$  as many as three faunas coexisted, though each seems to have contained sufficiently diverse elements to exploit fully most of the benthic ecological niches generally attributed to deposits like the Viru Series. Added to such complications, and in fact one of the prime factors contributing to them at the time of the Derfel Limestone deposition, is the effect of the *Nemagraptus gracilis* transgression, fully discussed with reference to Wales by Jones (1938), and now recognized elsewhere in

\* Scoto-Appalachian as distinct from Scoto-American to exclude the Cordilleran and Newfoundland successions of Canadian and Chazyan age which have yielded fossils not found in the Appalachian facies, but present in the Lower Ordovician of Russia and Europe (Ulrich & Cooper 1938; Ross 1951).

Europe and probably important in North America. This transgression resulted in a marked and widespread redistribution of facies belts which has so complicated the faunal successions even of well-known regions that the remarks made below should be regarded merely as surmises based on inadequate data.

Turning first to the brachiopods of the Derfel Limestone four chronological associations can be distinguished.

If 'indigenous' is taken as implying only that kindred stocks are found in abundance and diversity in the older successions of the same region (here the Welsh Llandeilo), and not necessarily the region of prototypic differentiation, then six genera found in the Derfel Limestone are native to the Anglo-Welsh region, viz. the dalmanellaceids *Soudleyella*, *Howellites* and *Horderleyella*, the sowerbyellinids *Sowerbyella* and *Plectodonta* and the triplesiid *Cliftonia* (*Oxoplecia*). *Horderleyella*, *Sowerbyella* and *Oxoplecia* are quite common in the Anglo-Welsh area, at least as far back as the Upper Llanvirn, while *Soudleyella* and *Howellites* are very closely related to *Resserella* s.s. and *Onniella* s.s. respectively, which are well represented in the Llandeilo (Williams 1953). *Plectodonta* has not yet been found in the Lower Ordovician of Britain, but the Derfel Limestone species is the earliest record of the genus from any succession anywhere, and since, apart from denticulation, it is very like contemporary *Sowerbyella* it may well have evolved within the Anglo-Welsh region.

The twelve remaining genera which so far have not been found in the British Lower Ordovician are regarded as exotic stocks.

Two of them, *Glossorthis* and *Platystrophia*, are found in the lowest horizons of the Uhaku Stage of the East Baltic (the Uhaku-Schichten of Jaanusson 1945, p. 216,  $C_{1\delta}$  of Öpik 1930, pp. 237–238) associated with such forms as *Clitambonites*, *Vellamo*, *Ēstlandia*, *Leptelloidea*, *Öpikina* and *Christiania*, which also occur in the underlying Tallina Stage, and can therefore be regarded as indigenous to that region whence they migrated to the Welsh area.

Six other stocks, *Kullervo*, *Leptaena*, the 'Sowerbyella' *quinquecostata* species group, *Palaeostrophomena*, *Cyrtonotella* and *Nicolella*, also occur for the first time in the upper part of the Uhaku Stage (the Püssi-Schichten of Jaanusson,  $C_{2\alpha}$  of Öpik) so that this association, henceforth referred to as the *Kullervo-Palaeostrophomena-Nicolella* association, may be regarded as previously foreign both to the east Baltic and the north Welsh regions. It is interesting to note that the influx of the *Kullervo-Palaeostrophomena-Nicolella* fauna into Estonia brought with it the earliest Baltic representatives of such Anglo-Welsh stocks as *Oxoplecia*, *Sowerbyella* and a *Soudleyella*-like form (*Dalmanella* sp. of Öpik 1930, pl. 6, fig. 73), suggesting that the ubiquitous *Kullervo-Palaeostrophomena-Nicolella* invasion was also accompanied by a limited exchange of native faunas.

Of the five remaining genera in the Derfel Limestone, four (*Dolerorthis*, *Salopia*, *Sericoidea* and *Kjaerina*) are at present unknown outside the Anglo-Welsh Province in deposits of *Nemagraptus gracilis* age. *Sericoidea* may have evolved within the Anglo-Welsh region but as yet remains undetected in the older successions, possibly because it is a small, pseudo-planktonic (?) sowerbyellinid seemingly restricted to a sulphurous mud facies usually inhospitable to shelly faunas. *Salopia* may have been derived from the drabovinids, a stock indigenous to Bohemia (Havliček 1950), though, as discussed below, there is some doubt as to its affinities. *Kjaerina* is undoubtedly related to *Actinomena* Öpik, the only exotic form unique to contemporary Baltic successions, and can be regarded as part of the *Kullervo-*

*Palaeostrophomena-Nicolella* association, as also must the Derfel Limestone *Dolerorthis* which bears no close relationship to any described stock of similar age in the east Baltic, Scotland, America or Bohemia.

The emigratory centre of the last newcomer to the Anglo-Welsh region, *Leptellina derfelensis* (Jones), is somewhat debatable. *Leptellina* Ulrich & Cooper is characteristically a Scoto-Appalachian Black River stock. But its authors also describe species of *Leptellina* from the Upper Pogonip Limestone of Nevada, and from Limestone no 2 of the Lévis Shale, and these occurrences are certainly the earliest yet known. On the other hand, *L. primula* (Barrande 1879) described by Havlíček (1952), as type for *Benignites* Havlíček, 1952, but regarded by the writer as congeneric with American and Scottish *Leptellina* is found in the Lower Llandeilo of Bohemia, and the pedicle valve of an undescribed leptestiid, possibly *Leptellina*, has also been found in the Lower Llandeilo of south Wales. The Derfel Limestone species then could well have been derived either from the European leptellinid stock or from the American one; provisionally it is considered as having been derived from the Bohemian source.

It will be seen that apart from *Leptellina* discussed above, the Derfel Limestone fauna includes no undoubted Bohemian or Appalachian indigenous stocks, although both these regions were invaded by representatives of the Anglo-Welsh native fauna (certain dalmanellids, *Sowerbyella*, *Oxoplecia*) during *Nemagraptus gracilis* times.

Apart from this rather small contribution from the Anglo-Welsh region the Bohemian fauna seems mainly to have been a specialized endemic one, for the commonest forms were certain dalmanellids, heterorthisids, draboviinids and the leptestiid *Aegiria* which does not occur in other European successions until post-*gracilis* times.

The Scoto-Appalachian fauna is also largely endemic (see Cooper & Cooper 1946). Superimposed upon an indigenous fauna, consisting especially of *Valcourea*, *Dinorthis*, *Hesperorthis*, *Glyptorthis* and *Mimella*, there is the Anglo-Welsh suite listed above,\* an East Baltic association including *Öpikina*, *Vellamo* and *Christiania* and along with representatives of the European *Kullervo-Palaeostrophomena-Nicolella* association (like *Nicolella agilera* Willard, 1928, *Cyrtonotella* sp. and *Palaeostrophomena*), a series of new stocks unknown also in the Estonian, Welsh or Bohemian successions (such as *Paurorthis*, *Ptychoglyptus*, *Pionodema* and *Bimuria*). It should be noted that a number of genera which first made their appearance in Europe in the *Nemagraptus gracilis* zone apparently did not reach the Scoto-Appalachian seas until early Trenton-Balclatchie times. These include *Platystrophia*, *Plectodonta*, *Leptaena* (Craighead and Appalachia), the harknessellid *Reuschella* (Oranda formation of Virginia and Craighead) and *Sericoidea* and *Dolerorthis* (Balclatchie).

The source of the *Kullervo-Palaeostrophomena-Nicolella* association is somewhat problematic, because it includes many stocks apparently confined to a particular region which may not belong with it. But judging from the dominance of the clitambonitoids, leptestiids and productorthisids, and the appearance of certain other genera like *Paurorthis*, it seems probable that much of it came from the Russian province where such stocks were prolific in the pre-*gracilis* successions.

\* A *Sowerbyella*-like form has been described by Ulrich & Cooper (1938, p. 186) from the Upper Pogonip Limestone of Nevada (? equivalent to the Llanvirn), and a similar species occurs in the Mystic Conglomerate of Quebec.

The trilobites from the Derfel Limestone are the only ones known from the early part of the Lower Bala of Wales. Trilobites from sandy mudstones overlying the Hoar Edge Grit at Horderley, Shropshire, were recently described by Bancroft (1949), and the list includes *Salterolithus smeathenensis*, '*Acidaspis*' *harnagensis*, *Proetidella fearnsidesi*, *Flexicalymene acantha*, *Diacalymene praecox*, *Phacopidina harnagensis* and *Nieszkowskia stubblefieldi*. The only genus in common, *Salterolithus*, is represented by quite different species in the two deposits. The incomplete calymenid (?) pygidium in the Derfel Limestone suggests that this family may be represented in both areas. Fearnside (1905, p. 627) recorded a phacopid from the Derfel Limestone, but this genus is not mentioned by Elles and we have found no specimens of this group. The differences between the Shropshire and Welsh faunas may reflect difference in facies, as well as some slight difference in age; evidently the early Bala trilobite fauna of the Anglo-Welsh area was more varied than has been realized.

Trilobites from the Llandeilo of the Anglo-Welsh area include trinucleids, raphiophorids, asaphids, calymenids, cybelids, lichids and odontopleurids (Elles 1940; Williams 1953). All these stocks except asaphids are represented in the Derfel Limestone, where they may be regarded as indigenous elements of the fauna. The remaining elements, *Harpes* (s.l.), *Illaenus* (s.l.) and *Ceraurinella?*, may be regarded as exotic. They are widespread in the North Atlantic province at this time, so the direction from which they may have entered the Anglo-Welsh area is uncertain. This analysis of the Derfel Limestone fauna differs from that of Stubblefield (1939, p. 56), who regarded the trilobites other than *Salterolithus* as 'in general exotic' and as perhaps having come from a 'Scots-Irish source'. The Harnage fauna is also mainly indigenous, the exotic elements including *Proetidella*, *Phacopidina* and *Nieszkowskia*. Forms related to these three genera are widespread in the North Atlantic province at this time. The early Bala Anglo-Welsh trilobites thus include stocks common to the North Atlantic province, more than half of which were indigenous in the area at that time, and only one stock (*Salterolithus*) peculiar to the area.

### 3. SYSTEMATIC DESCRIPTION OF BRACHIOPODA

BY A. WILLIAMS

#### ORTHACEA Walcott & Schuchert, 1908

#### PLECTORTHIDAE Schuchert & Cooper, 1931

#### **Platystrophia precedens** McEwan, 1920 *major* n.subsp. (Figures 24 to 29, plate 38.)

*Orthis* (*Platystrophia*) *biforata* (Schlotheim) Elles, G. L., 1922, p. 145.

*Diagnosis.* A *Platystrophia* like *P. precedens* s.s. in its ornamentation but differing in being twice as large and having a relatively narrow sulcus.

*Dimensions:*

	length (mm)	width (mm)
Holotype:		
Internal and part of external mould of conjoined valves (A40946 <i>b</i> and <i>a</i> )	11 (est.)	18 (est.)
Paratypes:		
Internal mould of brachial valve (A40908)	13	23
External mould of pedicle valve (A40947)	14	21
Internal mould of pedicle valve (A40910)	14	18
External and internal mould of brachial valve (A40993 <i>a</i> and <i>b</i> )	6	12

*Exterior.* Semicircular, strongly biconvex shells with a deep sulcus in the pedicle valve (varying from 38 to 55 % the width of the valve, averaging 48 %) and corresponding high fold in the brachial valve; cardinal angle bluntly rectangular, interareas of pedicle and brachial valves apsacline and orthocline, delthyrium and notothyrium open; ornamentation consisting of fine, closely spaced tubercles and strong radiating costae with 2 in the sulcus, 3 on the fold (the median one arising as an intercalation between the two laterals) and 5 to 9 (generally 6 or 5) on each flank.

*Interior of pedicle valve.* Teeth small, simple, supported by a pair of subparallel, short dental lamellae continuous with a U-shaped ridge defining the anterior and antero-lateral limits of a long muscle scar (two-fifths the length of the shell), adductor scar long, median, linear, not extending to the anterior muscle boundary, diductor tracks impressed on the inner walls of the dental lamellae and floor of the valve.

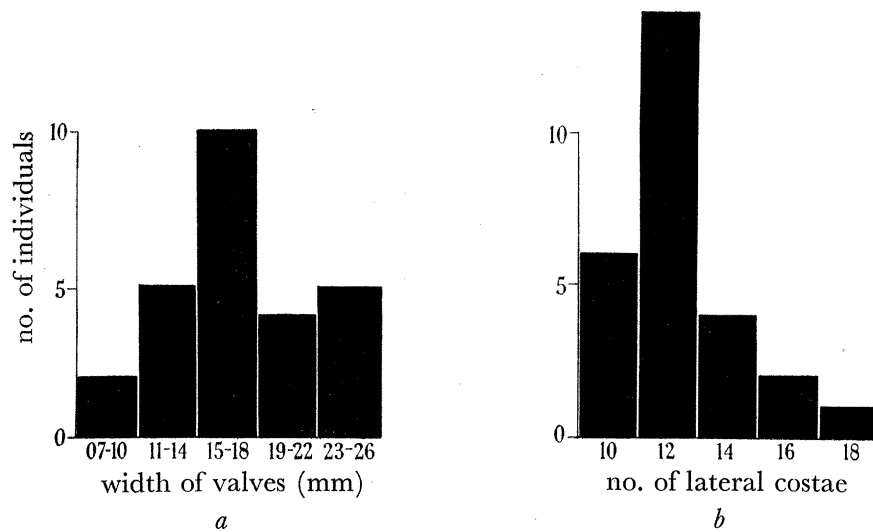


FIGURE 1. Histograms showing the range in width (a) and number of lateral costae (b) in 26 pedicle valves of *Platystrophia precedens major* n. subsp.

*Interior of brachial valve.* In young specimens cardinalia consist of a linear cardinal process and a pair of curved brachiophores strengthened laterally by a pair of fulcral plates and anteriorly by a pair of supporting plates convergent just anterior of the cardinal process; in adult specimens the brachiophore bases are usually embedded in a mass of secondary shell deposit masking the fulcral and supporting plates; adductor muscle scar quadripartite divided by a short sharp median septum and a pair of transverse ridges.

*Type horizon and locality.* Derfel Limestone; Pont Aberderfel.

*Discussion.* The *Platystrophia* from the Derfel Limestone belongs to the bicostate species group (see Schuchert & Cooper 1932, pp. 65-67) and appears to be closely related, especially in the unmodified nature of the costae on the fold and in the sulcus, to *P. dentata* (Pander) and *P. precedens* McEwan. *P. dentata* is somewhat smaller in adult stages of growth, but more significantly 8 or 9 costae ornament each lateral area of the shell, and although three specimens from the Derfel Limestone have a like number, by far the commonest forms are those with 5 or 6. *P. precedens* appears to be a rare species; it was founded on two adult specimens (McEwan 1920, p. 405), both of which have 5 lateral

costae and in this respect are conspecific with the North Welsh forms. Adults of the latter, however, are twice as large as *P. precedens* and have a relatively narrower sulcus, and on these differences are described as a new subspecies.

ORTHIDAE Woodward, 1852

ORTHINAE Schuchert & Cooper, 1931

**Glossorthis** sp. (Figures 12, 13, plate 38.)

*Orthis (Dalmanella) testudinaria* var. *gracilis* Reed *partim*, Elles, G. L., 1922, p. 145.

An incomplete mould of a pedicle valve (A40920) from the Derfel Limestone at Pont Aberderfel appears to belong to the genus *Glossorthis* Öpik, 1930. The valve is about 10mm long, convex, with a moderately long, curved, apsacline interarea and an open delthyrium and is ornamented, judging from the marginally impressed ribbing, by about 26 to 28 ribs either simple or branched; a fragment of the external mould shows that the external surface is also strongly lamellose and that parvicostellae are absent from the intercostate spaces. In the interior the teeth are simple, supported by short dental lamellae, the small triangular muscle scar is impressed on a low platform and consists of a relatively broad median adductor scar and a pair of narrow diductor scars not extending beyond the adductor; the vascula media are parallel, obscure and are separated by a low median ridge.

*Discussion.* There can be little doubt, especially when reference is made to the morphology of the muscle scar, that this specimen is an orthinid, but its identification as a representative of *Glossorthis* is based mainly on the absence of parvicostellae in the intercostate grooves, for the pseudospondylium of adult *Glossorthis* is not developed. However, the strength of the internal ribbing suggests that the specimen is an immature one, in which case the pseudospondylium, which is largely the result of secondary deposition, could well be no more than the low platform described above. Öpik (1930, p. 243, pl. IV, fig. 38) has figured an immature specimen of *Glossorthis linda* which shows a similar incipient development of the pseudospondylium and, indeed, on rib count and general shape the Derfel Limestone specimen could be included within that species.

**Cyrtonotella** aff. **kukersiana** (Wysogorski), 1912. (Figures 14 to 16, plate 38.)

*Dimensions:*

	length (mm)	width (mm)
External and internal mould of brachial valve (A40945 <i>a</i> and <i>b</i> )	7	9

*Exterior of brachial valve.* Semi-circular, plane with slight median sulcus, interarea very short, anacline, notothyrium open. Ornamentation concentrically lamellose and multicostellate with 10 primaries; primary 1 arising from primary 2 just anterior of the umbo, primaries 2 to 4 originating at the umbo; secondaries and tertiaries arising early so that 42 ribs are present at the margin.

*Interior of brachial valve.* Cardinal process, relatively massive, blunted posteriorly, erect and continuous with a short median septum, notothyrial platform absent; brachiophores short, widely divergent, sockets elongate, parallel with the hinge line and defined anteriorly by secondary shell deposition around the brachiophore bases.



*Discussion.* The specimen is probably an immature specimen of *Cyrtototella kukersiana*; dimensional proportions, the slight median sulcus, the ribbing pattern and cardinalia are all consistent with this comparison but until more material is obtained the specific identification must be regarded as provisional.

PRODUCTORTHINAE Schuchert & Cooper, 1931

**Nicolella humilis** n.sp. (Figures 7 to 11, plate 38.)

*Orthis (Nicolella) actoniae* (Sow.) Elles, G. L., 1922, p. 145.

*O. playfairi* Reed, *partim*, Elles, G. L., 1922, p. 145.

*O. alata* Sowerby, *partim*, Elles, G. L., 1922, p. 145.

*O. (Hebertella) crispa* M'Coy, *partim*, Elles, G. L., 1922, p. 145.

*Diagnosis.* Large plano-convex *Nicolella* with a very gently convex pedicle valve, ornamented by 18 to 20 costae sometimes giving rise to a small number of secondary costellae, muscle impressions obscure or absent.

<i>Dimensions:</i>	length (mm)	width (mm)
Holotype:		
External (incomplete) and internal mould of pedicle valve (A 40941 <i>a</i> and <i>b</i> )	15	20
Paratypes:		
Internal mould of brachial valve (G.S.C. 90386)	ca. 13	20
External mould of brachial valve (G.S.C. 85727)	15	20
External mould of brachial valve (A 40913)	6	13
External and internal mould of pedicle valve (A 40942 <i>a</i> and <i>b</i> )	17	20

*Exterior.* Semi-oval, slightly alate shells with a gently convex pedicle valve and a plane to slightly concave brachial valve; interarea of pedicle valve short, apsacline, of brachial valve very short, hypercline; delthyrium open, notothyrium closed by strongly arched chilidium. Ribbing essentially costate, usually with 18 to 20 costae in adult forms; in the brachial valve (reading to left or right of median line) primary 1 usually branches from primary 2 about 1 mm from the umbo, primaries 2 to 5 originate at the umbo and primaries 6 to 10 originate at the hinge line at increasing distances from the umbo, late internal secondaries (beyond 1 cm from the umbo) usually split off from primaries 2 to 5; a similar pattern is characteristic of the pedicle valve except that a median primary 1 develops in place of 2 submedian ones and the secondaries arise external to the parent ones.

*Interior of pedicle valve.* Teeth strong, dental lamellae very short, muscle scar usually absent except in gerontic specimens which display a strong pedicle callist and a suggestion of lozenge-shaped muscle scar extending anterior of the dental lamellae; intercostate grooves strongly impressed over most of the interiors of both valves.

*Interior of brachial valve.* Cardinal process long, thin, blade-like, extending ventrally and ankylosed posteriorly to the chilidium, sockets widely spaced, shallow, broad; brachiophores very small, muscle scars obscure.

*Type horizon and locality.* Derfel Limestone; paratypes G.S.C. 90386 and 85727 from Garn, the remainder from Pont Aberderfel.

*Discussion.* The description of *Orthis actoniae* J. de C. Sowerby (in Murchison 1839, p. 639) was originally based on an internal mould of a pedicle valve (G.S.M. Geol. Soc. Coll. 6883) from the 'Caradoc Sandstone, Acton Scott' and an internal mould of a

brachial valve (G.S.M. Geol. Soc. Coll. 6882) from the 'Caradoc Sandstone, Buiith'. The Acton Scott specimen is here chosen as lectotype; it is '*Nicolella actoniae*' as generally understood by palaeontologists, whereas the Buiith specimen belongs to the *Orthis calligramma* group of orthids. Fortunately, this discrimination does not materially alter Sowerby's original concept of the species, for he only referred to the profile of the brachial valve, and it so happens that in that respect *Orthis* and *Nicolella* are closely comparable.

Sowerby's diagnosis was later emended by Davidson (1871, pp. 252-254) to include all known occurrences of the stock which, in fact, ranged throughout the Upper Ordovician over most of Britain. As a result Davidson's concept of the species is roughly equivalent to the modern interpretation of the genus *Nicolella* and needs to be revised to allow for a more detailed discrimination between what may ultimately prove to be a number of species.

About 40 well-preserved *Nicolella* from the Gelli-Grin beds, apparently conspecific with *N. actoniae* s.s., have been examined, and essentially they confirm the substance of Sowerby's original description, viz. such forms possess highly convex pedicle valves and an ornament of 13 to 16, usually 14, costae which branch externally and internally towards the margin (especially primaries 2 to 5). Further, the muscle scars are well developed in *N. actoniae*, and the brachiophore bases in adult shells are usually encased in secondary shell deposit. The new species then differs from *N. actoniae* in the gently convex contour of the pedicle valve, the larger number of primary ribs and the lesser development of secondaries, and in the obscurity of muscle impressions and the general lack of secondary shell deposit in the interiors.

#### DOLERORTHIDAE Öpik, 1934

##### ***Dolerorthis tenuicostata* n.sp.** (Figures 17-23, plate 38.)

*Diagnosis.* Unequally biconvex dolerorthids usually with the pedicle valve more convex than the brachial and with a finely costellate ornamentation consisting of over 70 ribs at the margins of adult shells.

##### *Dimensions:*

	length (mm)	width (mm)
Holotype:		
External and internal moulds of pedicle valve (A40917a and b)	19	ca. 20
Paratypes:		
External and internal moulds of brachial valve (A40943a and b)	13	17
Internal mould of brachial valve (A40914)	16	21
Internal mould of pedicle valve (distorted) (A40944)	17	20

*Exterior.* Subquadrate to subcircular, gently and unequally biconvex, usually with the pedicle valve slightly more convex than the brachial and with the greatest width anterior to the hinge line, brachial valve with a gentle median sulcus; interarea of pedicle valve long, curved, apsacline, that of brachial valve short, straight, anacline, delthyrium and notothyrium open. Ornamentation finely lamellose and multicostellate with 16 primary costae radiating from the umbo and up to an additional 8 arising along the hinge line near the umbo; within a few millimetres of the umbo the primaries give rise to early secondary costellae (especially true of primaries 1, submedian, to 8), thereafter tertiary and later

secondary costellae appear (particularly in primary segments 2 to 5 inclusive), so that in shells which are about half adult size the margin bears about 50 ribs compared with over 70 in adult shells.

*Interior of pedicle valve.* Teeth strong simple, dental lamellae short, continued anteriorly as a pair of convergent ridges bounding a subrhomboidal muscle scar (one-third the length of the shell and one-fifth the width); adductor scar median, long, lanceolate divided by a median septum and separated from the diductor scars by a pair of fine ridges, diductor scars longer than adductor but not enclosing it, anteriorly separated by a low median ridge, pointed and passing into a pair of short, stout vascula media, obscure anteriorly. Postero-lateral areas bearing convolute impressions of genito-vascular systems, ribbing deeply impressed peripherally in the interiors of both valves.

*Interior of brachial valve.* Cardinal process simple, blade-like, brachiophores short, divergent with concave posterior surfaces adjacent to well-defined sockets and embedded in a prominent notothyrial platform passing anteriorly into a broad median ridge separating a pair of posteriorly impressed adductor scars; genito-vascular impressions convolute.

*Type horizon and locality.* Derfel Limestone; A40944 from Trawsant, the remainder from Pont Aberderfel.

*Discussion.* The new species belongs to a group of shells, predominantly Ordovician, which differ from *Dolerorthis* as originally defined by Schuchert & Cooper (1932, p. 88) only in the greater convexity of the pedicle valve as compared with the brachial one, a difference not, in the writer's estimation, meriting supraspecific recognition.

*Orthis (Plectorthis) duftonensis* Reed (1910, p. 295) also belongs to this group, and is closely related to the new species but differs in certain dimensions and especially in the ribbing pattern. Adult forms of *Dolerorthis duftonensis* are half as big again as those of *D. tenuicostata*, the ventral muscle scar is relatively longer (one-third the length of the shell as opposed to one-quarter) and the ribbing is much coarser, consisting of 40 to 45 primaries and early secondaries with no more than 6 to 8 late secondaries and tertiaries, a relationship attained by *D. tenuicostata* when immature so that fully grown adults of the latter despite their smaller size have very many more ribs (over 70 compared with about 50).

#### DALMANELLACEA Schuchert & Cooper, 1931

##### DALMANELLIDAE Schuchert, 1929

#### **Onniella (Soudleyella) cf. avelinei** Bancroft, 1928. (Figures 36 to 42, plate 38.)

*Orthis playfairi* Reed *partim*, Elles, G. L., 1922, p. 145.

*O. (Hebertella) crispa* M'Coy *partim*, Elles, G. L., 1922, p. 145.

*O. (Dalmanella) testudinaria* var. *gracilis* Reed *partim*, Elles, G. L., 1922, p. 145.

#### *Specimens described:*

	length (mm)	width (mm)
External and internal moulds of pedicle valve (A40956 <i>a</i> and <i>b</i> )	8	10
External mould of pedicle valve (A40960)	8	9
Internal mould of pedicle valve (A40921)	10	—
External mould of brachial valve (A40957)	6	9
Internal mould of brachial valve (A40958)	9	11
External and internal moulds of pedicle valve (A40959 <i>a</i> and <i>b</i> )	9	11

*Exterior.* Subcircular, unequally and gently biconvex shells with a short hinge line and a median sulcus in the lesser convex brachial valve. Interareas of pedicle and brachial valves apsacline-anacline, that of the former longer and curved; delthyrium and notothyrium open, cardinal process projecting slightly above the hinge line. Ribbing system costellate with up to 42 ribs in adult shells; in brachial valve sectors I and II narrow, each usually with one secondary internal costella, sectors III and IV wide with 4 or 5 secondaries and tertiaries mainly internal in origin, sectors V, VI and VII narrow, sometimes with external secondaries (especially V); shell substance punctate.

*Interior of pedicle valve.* Teeth simple, large, dental lamellae short, muscle scar subcordate about one-third the length of shell with a relatively broad median adductor track shorter than the laterally adjacent diductor scars but not enclosed anteriorly by them. Pallial sinus pattern, when impressed, consisting of a pair of divergent vascular media and convolute genito-vascular impressions postero-laterally.

*Interior of brachial valve.* Cardinal process stout with a bilobed posterior face, notothyrial platform well developed extending anteriorly as a short median ridge; brachiophores short, stout, consisting of ankylosed fulcral and supporting plates, sockets widely divergent; adductor scars small, divided by a median ridge and faintly developed transverse ridges into four subequal impressions.

*Type horizon and locality.* Derfel Limestone; from Pont Aberderfel.

*Discussion.* The Derfel Limestone *Soudleyellas* agree very closely with *S. avelinei* Bancroft (1928), except that adults are 2 to 3 mm larger than those described by Bancroft. This affinity is well expressed in ornament, particularly with regard to the relative positions of the following ribs:  $3 \bar{a} \bar{l} \bar{a}$   $3 a^\circ$  (L),  $3 \bar{c}$   $3 a^\circ$  (L), and  $4 \bar{b}$   $4 b^\circ$  (M) (compare Bancroft's table, 1945, p. 189). Ribs  $2 a^\circ$  and  $4 \bar{a} 1^\circ$  are not developed in the *Soudleyella* examined, nor, apparently, do they appear in *S. avelinei*.

### **Resserella (Howellites) sp.** (Figures 31 to 35, plate 38).

Two specimens (an external and internal mould of a brachial valve (A40961 *a* and *b*) and an internal mould of a pedicle valve (A40919)) have been collected from the Derfel Limestone at Pont Aberderfel and appear to belong to the species group *Resserella* (*Howellites*). The ribbing system is significantly comparable— $3 \bar{a} \bar{l} \bar{a} \bar{l}$   $3 a^\circ$ ,  $4 \bar{b}$   $4 b^\circ$ ,  $3 \bar{a} \bar{l} \bar{a}$   $2 \bar{a} \bar{l}$ ,  $4 \bar{a} \bar{l} \bar{a}$   $4 \bar{a} \bar{l}^\circ$  and  $4 \bar{b} \bar{l}$   $4 \bar{a} \bar{l}^\circ$ —and so are dimensions and internal characters, except that a pseudopolypalmate vascular system is not impressed on the interior of the pedicle valve, the fulcral and supporting plates are discrete not ankylosed, so that the brachiophore bases are small and the brachial valve is less convex than usual. None of these characters needs be diagnostic, and since the morphological variation is unknown the writer hesitates to compare them with previously described species or to consider the differences significant enough for systematic recognition.

## HETERORTHIDAE Schuchert & Cooper, 1931

### **Horderleyella?** sp. (Figure 30, plate 38.)

*Orthis* (*Dalmanella*) *testudinaria* var. *gracilis* Reed *partim*, Elles, G. L., 1922, p. 145.

An internal cast of a pedicle valve (A40922), 9 mm long and with an estimated width of 13 mm, appears to be the cast of a harknessellinid, in which case the relatively small

size of the muscle scar suggests it to be a *Orderleyella*, although it does not agree closely with any described species of that genus.

LINOPORELLIDAE Schuchert & Cooper, 1931

**Salopia** n.gen.

*Diagnosis.* Unequally biconvex linoporellids with a very long curved interarea in the pedicle valve, ornamentation finely multicostellate without intercostellate pores; cardinalia consisting of a thin, simple cardinal process continuous with a strong, long, median septum, blade-like brachiophores with squared ends, ankylosed laterally to fulcral plates defining the sockets and anteriorly to a pair of socket-supporting plates which converge on to the median septum to form a cruralium; musculature of pedicle valve occupying the inner sides of the dental lamellae as well as the umbonal floor of the valve, adductor scar broad, median, diductors slightly longer but not enclosing the adductor; shell substance punctate.

*Type species.* *Orthis salteri* Davidson, 1871 (from Horderley, Salop).

*Discussion.* The coarsely punctate nature of the shell of *Salopia* has been revealed both in finely preserved moulds and also in shell fragments occasionally found adhering to moulds of *S. salteri gracilis* n.subsp. from the Derfel Limestone. The development of a distinct cruralium in the brachial valve suggests that the stock is related to the hitherto monotypic family Linoporellidae, but whether it truly belongs here as a precursor of *Linoporella* or is an aberrant derivative from the Dalmanellidae remains to be seen, for only in the possession of a cruralium does it resemble *Linoporella*. In other characteristics it differs markedly, and especially noteworthy are the excessively long interarea of the pedicle valve, the absence of intercostellate pores and the different shape of the ventral muscle scars attributable partly at least to the encroachment of the diductors onto the dental lamellae.

In 1950 Havlíček (p. 115) described a number of Ordovician genera and species from Bohemia as constituting a subfamilial group, the Draboviinae Havlíček, which is supposedly related to the dalmanellaceid schizophoriids except for the dalmanellid-like arrangement of the ventral muscle scar and the parallel or convergent arrangement of the plates supporting the brachiophores. *Salopia* could be included within his subfamily and would bear comparison with *Giraldiella*, the only 'draboviinid' with convergent supporting plates, though it is generically distinct in many other external and internal features. The writer, however, is not satisfied with Havlíček's systematic treatment of the draboviinids.

The name *Giraldiella* was given to a group of shells of Upper Llandovery age referred to as *Orthis protensa* J. de C. Sowerby (Williams 1951, p. 91). At that time the stock was described as a plectorthid, for the disposition of the cardinalia was typical of that family and no traces of punctuation were found on the moulds, though admittedly the genus differed from all other plectorthids in possessing a short triangular ventral muscle scar, usually undifferentiated but occasionally showing a broad, median adductor track, in all not unlike that of an unspecialized draboviinid. Recently, through the kindness of Dr Nancy Kirk, the writer obtained specimens of *Giraldiella* with adherent shell substance, thin sections of which appear to confirm the original opinion that the stock is impunctate. The draboviinids described by Havlíček, including a Caradocian *Giraldiella*, *G. partita*

(p. 125), appear all to be moulds, a mode of preservation not likely to show punctuation unless it is particularly coarse. Consequently it is assumed either that Havličěk is correct in associating *Giraldiella* with the other draboviinids but incorrect in assigning the group to the dalmanellaceids, or that *Giraldiella* does not belong within the Draboviinae which is truly a punctate dalmanellaceid group. Of the two interpretations the latter is probably the correct one, but until these doubts are dissipated it seems best to assign *Salopia* to the Linoporellidae.

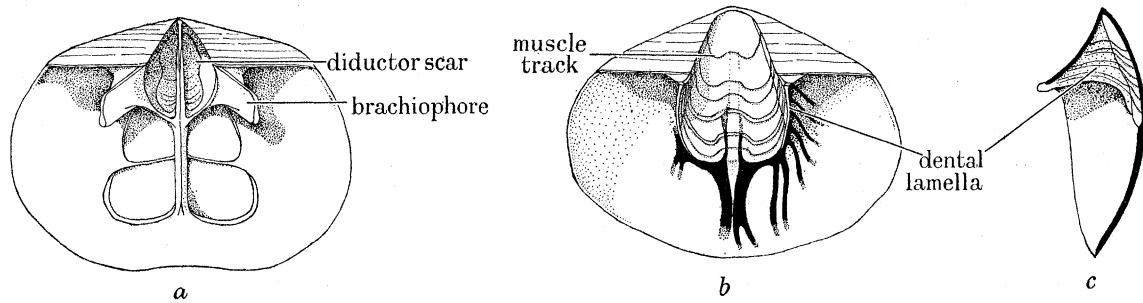


FIGURE 2. *Salopia salteri* (Davidson) n.gen. *a*. The interior of the brachial valve showing the disposition of the cardinalia (magn.  $\times 3$ ). *b*, *c*. Dorsal and median views of the interior of the pedicle valve showing especially the disposition of the dental lamellae (magn.  $\times 3$ ).

***Salopia salteri* (Davidson) *gracilis* n.subsp.** (Figures 47 to 51, plate 38.)

*Dimensions:*

	length (mm)	width (mm)
<b>Holotype:</b>		
Internal and part of external mould of brachial valve (A40934 <i>b</i> and <i>a</i> )	—	11
<b>Paratypes:</b>		
Internal and part of external mould of conjoined valves (A40970 <i>b</i> and <i>a</i> )	7	7
Internal mould of brachial valve (distorted) (A40971)	8	7
Internal mould of distorted brachial valve (A40972)	14	9
External and internal mould of pedicle valve (A40973 <i>a</i> and <i>b</i> )	9	11
External mould of pedicle valve (A40974)	11	10
Internal mould of pedicle valve (A40975)	12	13

*Exterior.* Subcircular, unequally biconvex shells with a gently convex brachial valve and a strongly convex pedicle valve with a long curved apsacline interarea; delthyrium and notothyrium open; ornamentation finely multicostellate with about 70 ribs crenulating the margins of adult shells; shell substance punctate.

*Interior of pedicle valve.* Teeth simple, massive, dental lamellae high, parallel and long, extending for about one-quarter the length of the valve; musculature impressed in adult forms, restricted except anteriorly by the dental lamellae but not extending in front of them, adductor scar broad, median undivided, diductor scars appearing narrow on the floor of the valve but encroaching laterally on to the inner surfaces of the dental lamellae and almost completely covering them. Faint convolutions of the genito-vascular system impressed postero-laterally.

*Interior of brachial valve.* Cardinal process simple, thin, diductor scars limited to notothyrial floor; brachiophores thin, divergent, blade-like with squared ends, supported laterally by a pair of concave fulcral plates defining deep sockets, and anteriorly by a pair

of long supporting plates convergent on to a long median septum to form a cruralium; adductor muscle scars, when impressed, a pair of elongate depressions separated by the median septum.

*Type localities and horizon.* The Derfel Limestone: A40934*a* and *b*, A40973*a* and *b*, A40975 from Pont Aberderfel, the remainder from Trawsnant.

*Discussion.* The Derfel Limestone forms exhibit some noteworthy differences in proportions when compared with specimens of *S. salteri* from Hazler Hill, Shropshire.

	cardinalia % of valve length	width of ventral muscle scar as % of length	width of ventral muscle scar as % of shell width	length of interarea as % of valve length
<i>S. salteri gracilis</i> (10 specimens)	20	70	23	27
<i>S. salteri</i> (Hazler Hill) (5 specimens)	30	100	34	50
		(4 specimens)	(4 specimens)	(3 specimens)

How significant these differences are remains to be seen. *S. salteri gracilis* undoubtedly possesses a shorter interarea, a feature which may well govern the proportionate development of dental lamellae, muscle scars and possibly even the cardinalia. The variability of growth of the interarea in such an unusual form as *Salopia* may be conditioned by ecological factors like the nature of the bottom (contrast the pebbly sandstone facies of Hazler Hill with the calcareous mud facies of Derfel), in which event the differences are better described as subspecific.

TRIPLESACEA Cooper, 1944

**Cliftonia (Oxoplecia) mutabilis** n.sp. (Figures 52 to 55, plate 38.)

*Orthis (Hebertella) crispa* M'Coy *partim* Elles, G. L., 1922, p. 145.

*Triplesia craigensis* Reed Elles, G. L., 1922, p. 145.

*Cliftonia andersoni* Reed *partim* Elles, G. L., 1922, p. 145.

*Diagnosis.* Slightly asymmetrical *Oxoplecia* which developed a costate ornamentation only in post-neanic stages of growth.

*Dimensions:*

	length (mm)	width (mm)
Holotype:		
External and internal mould of brachial valve (A40948 <i>a</i> and <i>b</i> )	13	14
Paratype:		
External and internal mould of pedicle valve (A40949 <i>a</i> and <i>b</i> )	15	over 16
Internal mould of pedicle valve (distorted) (A40950)	18	14
Internal mould of pedicle valve (A40940)	ca. 15	ca. 20
Internal mould of brachial valve (A40938)	over 13	19

*Exterior.* Subcircular to transversely quadrate in outline (immature specimens tend to the former with a length over 80 % the width, adult specimens are usually more transverse with the length less than 70 % the width), slightly asymmetrical, unequally biconvex with a strongly globose brachial valve and a gently convex pedicle valve, a relationship accentuated by the development of a broad, flat-topped dorsal fold (35 to 43 % the width

of the shell at the anterior margin) and a complementary ventral sulcus. Shell surface distantly lamellose, and costate, with 6 to 12 (usually 9) costae on the fold and a variable number (in excess of 9) on the flanks; costate condition limited to the later stages of growth especially on the flanks, so that the immature specimens (less than 14 mm wide) bear only marginal costae and much of the surface is without radial ornamentation. Interarea of pedicle valve short, curved apsacline, that of brachial valve linear; pedicle foramen apical, pseudodeltidium entire with median fold.

*Interior of pedicle valve.* Teeth simple, fairly massive, dental lamellae short, divergent; muscle scars not impressed, but in A40940 presumably narrow rather long with a median lanceolate adductor scar enclosed by narrow diductors.

*Interior of brachial valve.* Socket ridges short, curved, stout, cardinal process long, curved, bifurcating near the base; fold bearing a faint capillate median ridge extending for about one-third the length of shell, adductor scars faintly impressed on either side of the fold, quadripartite.

*Type localities and horizon.* Derfel Limestone; A40950 from Trawsnant, the remainder from Pont Aberderfel.

*Discussion.* The new species compares closely with *Cliftonia (Oxoplecia) dorsata* (Hisinger), 1837, in dimensions and rib counts, except that the former possesses a more convex brachial valve, a less convex pedicle valve and usually a rib or two fewer on the fold. More significant than these differences is the limitation of rib development to postneanic growth stages; in *C. dorsata* costae develop at least in early neanic stages of growth.

#### CLITAMBONACEA Schuchert, 1929

##### KULLERVOIDAE Öpik, 1934

#### **Kullervo** aff. **panderi** (Öpik), 1930. (Figures 56 to 62, plate 39.)

*Orthis alata* Sowerby *partim* Elles, G. L., 1922, p. 145.

*Cliftonia andersoni* Reed *partim* Elles, G. L., 1922, p. 145.

#### *Dimensions:*

	length (mm)	width (mm)
Internal mould of pedicle valve (A40951)	12	14
External and internal moulds of brachial valve (A40952 <i>a</i> and <i>b</i> )	9	14
External and internal moulds of pedicle valve (A40953 <i>a</i> and <i>b</i> )	—	—
Internal mould of pedicle valve (A40954)	3	7
Internal mould of pedicle valve (A40955)	10	10

*Exterior.* Unequally biconvex shells with a gently convex, semicircular brachial valve possessing a short anacline interarea and a deep pedicle valve with a long slightly curved apsacline interarea up to one-half the length of the shell; notothyrium covered by a convex chilidium, delthyrium by a pseudodeltidium (absent in young specimens), foramen apical. Ornamentation costellate (with about 16 costae at or near the umbo and a further 40 secondary and tertiary costellae at the margins of adult shells) and concentrically lamellose, both so sharply developed as to give the shell a reticulate appearance.

*Interior of pedicle valve.* Teeth simple, supported by the posterior faces of a wide, deep spondylium simplex supported medianly by a variably developed septum (usually low,



broad and short) and, postero-laterally, by a pair of short ridges; hemisyrix broad, as long as spondylium, defined laterally by a pair of low, thin ridges inclined towards the median line.

*Interior of brachial valve.* Cardinal process simple, ankylosed to the chilidium, socket ridges widely divergent, embedded in a strongly developed notothyrial platform passing anteriorly into a short thick median septum. Adductor scars deeply impressed on either side of the median septum consisting of two pairs of broad lanceolate impressions surrounded by slightly raised margins with the apices pointing postero-medianly, the inner posterior pair being the larger.

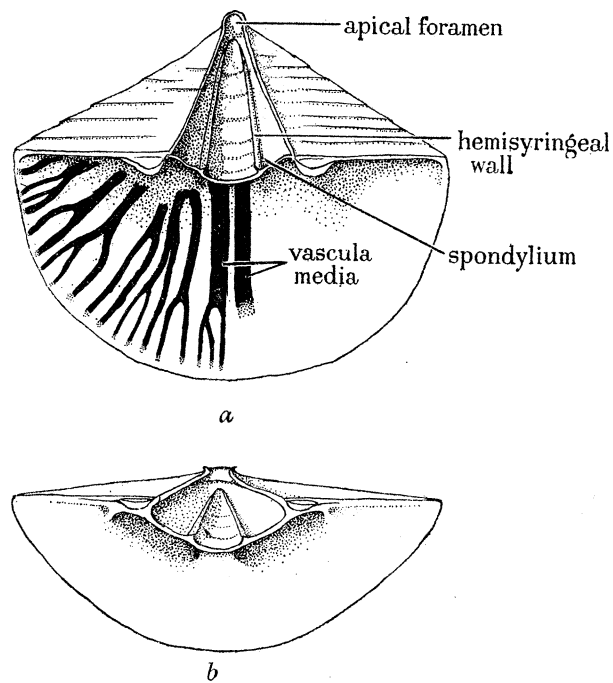


FIGURE 3. Dorsal (a) and antero-dorsal (b) views of the interior of the pedicle valve of *Kullervo* aff. *panderi* Öpik to show especially the disposition of the spondylium simplex, the hemisyrix and the vascular system somewhat stylized; the pseudodeltidium has been omitted (magn.  $\times 4$ ).

*Localities and horizon.* Derfel Limestone; A40951 from Trawsnant, the remainder from Pont Aberderfel.

*Discussion.* All clitambonitoids from the Derfel Limestone appear to be conspecific with *Kullervo panderi* (Öpik), 1930 in every feature except the hemisyrix, which is better developed in the Baltic specimens, a distinction probably without systematic significance.

In the description reference has been made to a spondylium simplex in contradiction to Öpik's description of the *Kullervo* spondylium as a degenerate spondylium triplex (Öpik 1934, p. 28). In one specimen only (A40951) are there any indications of the rudimentary 'subspondylial septa'; their absence in other specimens, particularly the immature ones, suggests that such 'septa' are the products of mantle deposition in the late adult stages of growth and are probably not homologous with the lateral septa of the true spondylium triplex.

## PLECTAMBONITACEA Cooper &amp; Williams, 1952

## LEPTESTIIDAE Williams, 1953

## LEPTESTIINAE Öpik, 1933

**Palaeostrophomena magnifica** n.sp. (Figures 64 to 70, plate 39.)

*Rafinesquina subarachnoidea* Reed (?) *partim* Elles, G. L., 1922, p. 145.

*Leptaena rhomboidalis* Wilckens *partim* Elles, G. L., 1922, p. 145.

*Diagnosis.* Large, subquadrate, gently biconvex to almost biplanate *Palaeostrophomena* with long, deeply impressed, usually narrowly parallel diductor scars in the pedicle valve.

<i>Dimensions:</i>	length (mm)	width (mm)
Holotype:		
Internal mould of pedicle valve (A40615)	20	ca. 26
Paratypes:		
Internal mould of pedicle valve (A40614)	ca. 24	ca. 33
External mould of pedicle valve (A40966)	17	—
Internal mould of part of brachial valve (A40967)	—	—
Partly weathered exterior of pedicle valve (A40968)	27	25
Internal mould of cardinalia of brachial valve (A40969)	—	—

*Exterior.* Large, subquadrate, gently biconvex to almost biplanate shells with the pedicle valve slightly more convex than the brachial, ornamented by delicate radiating parvicostellae separated into narrow regular sectors, each containing up to 8 parvicostellae, by accentuated sharp costellae numbering about 36 at the periphery. Interarea of pedicle valve long, apsacline, that of brachial valve shorter but still pronounced, anacline; pseudodeltidium small, narrow, apical; chilidium strong, wide, highly convex.

*Interior of pedicle valve.* Teeth small, nodular buttressed medianly by a pair of accessory teeth, dental lamellae absent; adductor scars narrow elongate, median, flanked laterally by narrow parallel or slightly divergent diductor scars twice as long as adductors and separated anteriorly by a low elevated area; genital areas large, coarsely pitted and striated. Vascular system complex, polypalmate; vascula media bisecting the diductor scars and branching just anterior to the scars, each to give rise to about 10 vascula terminalia; 3 main vascula genitalia emerge lateral of the genital areas.

*Interior of brachial valve.* Cardinal process tricusate, due presumably to the fusion of the chilidial plates with the median process, erect massive, protruding ventrally and fused with a strong, long, median septum; accessory sockets well defined lying between short divergent socket ridges and the cardinal process base; primary sockets elongate, lateral of the socket ridges; adductor scars elongate, impressed, bisected by the median septum, anterior boundaries septate, with 4 divergent ridges on either side of the median septum; genital area coarsely striate, vascula media broad, divergent anteriorly, rest of vascular pattern unknown.

*Type localities and horizon.* Derfel Limestone; A40967, A40968 from Trawsnant, the remainder from Pont Aberderfel.

*Discussion.* The new species differs from *Palaeostrophomena concava* (Schmidt), 1858 in its larger size, its subquadrate, plano-convex to biplanate outline compared with the semi-circular alate, resupinate outline of *P. concava* and also in the much greater length of the diductor scars.

Among strophomenoids generally the distinction between resupinate and concavo-convex forms is usually considered fundamental, which difference together with the length and disposition of the diductor scars suggests that the Derfel Limestone specimens are not congeneric with *Palaeostrophomena*. But *P. concava*, the type species, is a rare fossil, and although the types are resupinate (see Öpik 1933, p. 24), one of the few extant topotypes (figure 63, plate 39) has a negligible marginal deflexion in the pedicle valve, so that

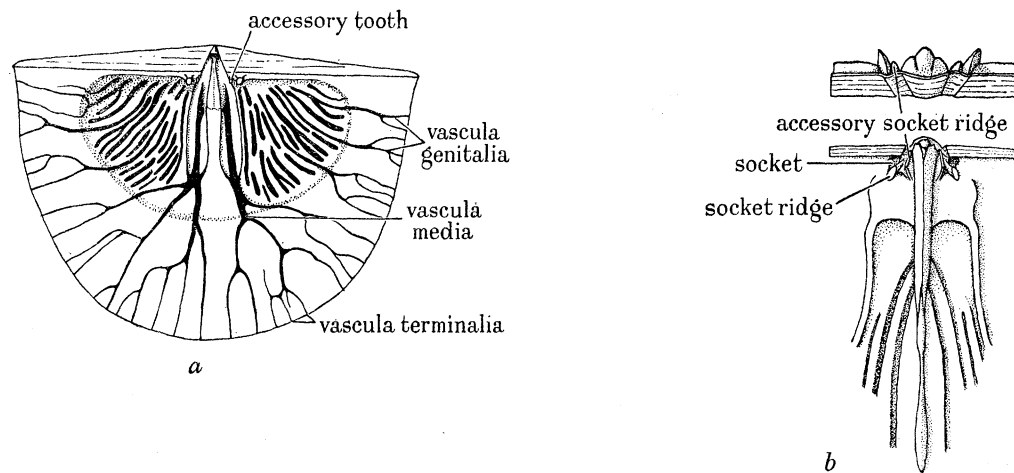


FIGURE 4. *Palaeostrophomena magnifica* n.sp. *a.* The interior of the pedicle valve illustrating the occurrence of the accessory teeth and a complex vascular system (magn.  $\times 2$ ). *b.* The postero-median interior of a compressed brachial valve (A40967), with a posterior view of the cardinalia above (magn.  $\times 6$ ), showing the disposition of the cardinalia and the septa associated with the muscle scars (magn.  $\times 3$ ).

biplanate shells like those of *P. magnifica* were probably also members of a *concava* population. The disposition of the diductors appears to have been equally variable. In *P. magnifica* they are usually narrowly parallel, but in one specimen (A40614) they are widely spaced. Öpik (1933, pl. 2) has illustrated a somewhat similar variation in *P. concava*, and it would appear that in this stock size, shell shape and the length of the diductor scars have a greater taxonomic importance than resupination and diductor disposition.

#### **Leptellina derfelensis** (Jones), 1928. (Figures 71 to 73, plate 39.)

This species is adequately described by O. T. Jones (1928, pp. 477-481) as *Leptelloidea derfelensis*. Since that time a number of *Leptelloidea*-like genera have been described, and the species is more precisely assigned to *Leptellina* Ulrich & Cooper.

In 1952 Havličěk described two new subgenera of leptestiids, *Benignites* (*Benignites*) and *B. (Leptestiina)*, the latter to include *L. derfelensis*. The difference between these two groups is nothing more than the configuration of the lophophore platform which, in the writer's opinion, is not sufficiently fundamental to necessitate generic recognition; in any case *B. (Benignites)* is certainly a synonym of *Leptellina*.

## SOWERBYELLINAE Öpik, 1930

*Sowerbyella* Jones, 1928

The *Sowerbyella* 'quinquecostata' group constitute a homogeneous species suite so different from other sowerbyellinids as only to be provisionally referred to *Sowerbyella*, an opinion already expressed by Jones (1928, p. 398), who, in fact, also described their most distinctive features. The new species described below is typical of the stock and is the earliest representative yet described from the British Ordovician.

***Sowerbyella multiseptata* n.sp.** (Figures 74 to 78, plate 39.)

*Diagnosis.* *Sowerbyella* lacking parvicostellae and possessing, in addition to the three primary costae, only two lateral secondary ones; ventral muscle scar very long, divergent; pseudocrenulation along the hinge line absent.

*Dimensions:*

	length (mm)	width (mm)
Holotype:		
Internal mould of brachial valve (A40976)	5	9
Paratypes:		
External mould of brachial valve with portion of internal mould of conjoined valves (A40977 <i>a</i> and <i>b</i> )		distorted
Exterior of pedicle valve (A40978)	—	10
Internal mould of pedicle valve (A40979)	7	14
Internal mould of pedicle valve (G.S.C. 85727 <i>a</i> )	6	10
External mould of brachial valve (A40980)	5	—

*Exterior.* Semi-elliptical, concavo-convex shells; interarea of pedicle valve short, apsacline, pseudodeltidium small apical; interarea of brachial valve very short, anacline, cardinal process and chilidial plates massive protruding into the delthyrium and sometimes covered umbonally by a short chilidium; shell surface faintly and impersistently rugate postero-laterally, ribbing consisting of 3 strong, accentuated primary costae, a median and two lateral ones subtending an angle of 90° at the umbo and dividing the shell surface into 4 approximately equal sectors each of the 2 lateral ones bearing a short secondary costa arising more than halfway from the umbo.

*Interior of pedicle valve.* Teeth simple, short and wide; pseudodeltidium buttressed by a small node passing anteriorly into a narrowly elliptical median ridge containing a shallow lanceolate depression, adductor scars small, oval, impressed on either side of the median ridge; diductor scars divergent, extending for over half the length of the shell contained laterally by equally long ridges and bearing a pair of intramuscular ridges which may represent the posterior impressions of the vascula myaria.

*Interior of brachial valve.* Cardinal process simple, protruding ventrally without the support of a median ridge and ankylosed laterally to a pair of widely divergent chilidial plates which in turn are fused with a pair of widely splayed short socket ridges; septa associated with the musculature-lophophore area high and blade-like and arranged in a distinctive pattern with a median one separating a pair of divergent U-shaped septal loops, within each of which is an oblique and medianly disposed septum.

*Type localities and horizon.* Derfel Limestone; A40977, A40979 from Trawsnant, G.S.M. 85727a from Garn, the rest from Pont Aberderfel.

*Discussion.* The new species bears a close resemblance to *S. quinquecostata* (Jones 1928 non M'Coy) from the Shoalhook Limestone, having a similar range of size and shell curvature but can be distinguished by its lack of parvicostellate ornamentation and internally by the absence of pseudocrenulation and the larger size of the ventral muscle scar, with the development of an apical node and a low median ridge separating the diductor scars.

**Sowerbyella** sp. (Figure 82, plate 39.)

O. T. Jones (1928, p. 420) has compared an external mould of a sowerbyellinid brachial valve from the Derfel Limestone with the Llandeilo species *Sowerbyella antiqua* Jones. Only one specimen has been collected since, an external mould of a pedicle valve with the postero-median part of the mould of the dorsal interior adhering to it (A40985). The material is too poor to warrant description, but at least it confirms Jones's opinion, for the strong submedian septa so characteristic of the dorsal interior of the *S. sericea*-*S. antiqua* species group are well developed.

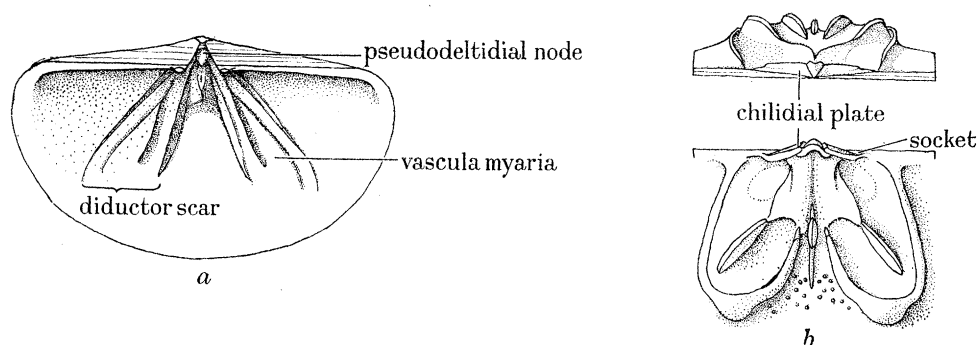


FIGURE 5. *Sowerbyella multiseptata* n.sp. a. The interior of the pedicle valve showing the disposition of the muscle scars (magn.  $\times 5$ ). b. The cardinalia and the septate muscle-lophophore platform of the brachial valve with a posterior view above (magn.  $\times 5$ ).

**Plectodonta lenis** n.sp. (Figures 79 to 81, plate 39.)

*Rafinesquina subarachnoidea* Reed (?) *partim* Elles, G. L., 1922, p. 145.

*Diagnosis.* Gently concavo-convex *Plectodonta* with 4 or 5 denticles along the hinge line; septa of the muscle and lophophore platform not strongly developed.

<i>Dimensions:</i>	length (mm)	width (mm)
Holotype:		
External and internal mould of distorted brachial valve (A40981 a and b)	16	12
Paratypes:		
Internal mould of distorted pedicle valve (A40982)	13	19
External moulds of brachial and pedicle valves (A40983)	12	18
External mould of pedicle valve (A40984)	11	17

*Exterior.* Large, gently concavo-convex semicircular shells lacking pronounced ears; interareas of pedicle and brachial valves moderately long, apsacline and anacline respectively, pseudodeltidium small, chilidium usually developed to cover the umbonal

parts of the cardinal process and chilidial plates; unequally parvicostellate with about 5 per millimetre and with 23 to 26 accentuated ribs, about 15 of them primary, at the margin; faintly and impermissibly rugate at the hinge-line.

*Interior of pedicle valve.* Denticular plates wide, bearing 4 or 5 denticles, dental lamellae absent; muscle scar small, about one-fifth the length of the shell, bisected by a low median septum thickening posteriorly and bounded laterally and anteriorly by two pairs of ridges, the lateral pair diverging from the delthyrial floor, the anterior pair as bifurcations from the anterior end of the median septum; adductors insignificant, impressed postero-medially, diductors divergent, subrhomboidal bisected by a pair of strong vascula myaria.

*Interior of brachial valve.* Cardinal process simple, flanked by a pair of chilidial plates which pass antero-laterally into a pair of short socket ridges parallel to the hinge line, cardinalia constituting one fused unit supported by a well-developed notothyrial platform passing anteriorly into a slender low median septum extending about half the length of the shell; muscle and lophophore platform not greatly accentuated, submedian septa about the same length as the median septum, intramuscular septa weak, faintly discernible anteriorly.

*Type locality and horizon.* Derfel Limestone; Trawsnant.

*Discussion.* The new species is allied to a group typified by *Plectodonta conspicua* (Reed) and presumably *P. rhombica* (M'Coy), both which species, however, are twice as large and very much more concavo-convex, a condition accentuated by the development of a median carination in the pedicle valve of the former species. Nothing is known of the interiors of *P. rhombica*, but *P. conspicua* has a stronger and proportionately larger muscle area in the pedicle valve and the muscle-lophophore area is well developed and typically plectodontid with a high blade-like median septum (accommodated by the carina of the pedicle valve) and four distinct lateral septa.

### **Sericoidea abdita** n.sp. (Figures 83 to 85, plate 39.)

*Diagnosis.* *Sericoidea* with up to three pairs of strong lateral septules and a long sharp median septum all extending into the anterior half of the valve; muscle platform obscure.

<i>Dimensions:</i>	length (mm)	width (mm)
<i>Holotype:</i>		
Internal mould of pedicle valve (A40988)	3	6
<i>Paratypes:</i>		
Internal mould of pedicle valve (A40986)	2.5	5.5
Internal mould of pedicle valve (A40987)	1	2
External mould of brachial valve bearing casts of internal mould (A40989)	2	—
External mould of brachial valve bearing casts of internal mould (A40990)	3	ca. 6

*Pedicle valve.* The youngest pedicle valve (A40987) is ornamented by 5 strong primary costae with 31 finer costellae intercalated between them. The costae do not extend to the umbo which is occupied by a subcircular hump ornamented by concentric growth lines and bearing a narrow median depression; this is interpreted as the protegulum. Internal moulds in excess of 5 mm wide (e.g. A40988) bear the impressions of a small bilobed to cordate muscle scar with a narrow median indentation; ribbing is strongly impressed, and

at the periphery there are over 80 fine costellae and about 12 coarse secondaries and primaries, averaging about 15 ribs per mm.

*Brachial valve.* The smallest brachial valve examined (A40989) displays postero-medially a semicircular elevated ridge representing the cardinalia and disposed in an arc about three-fifths the length of the shell from the umbo, a long, sharp, elevated median septum and 2 pairs of short lateral septules scarcely bigger than tubercles. A slightly larger specimen (A40990) also bears a symmetrical array of septules, but in this specimen the median septum is broader and longer and has coalesced posteriorly with an indistinct anchor-shaped eminence, an incipient notothyrial platform, and an extra pair of lateral septules as well as 6 pustules, scattered sporadically anterior to the septule arc, make their appearance.

*Type locality and horizon.* Derfel Limestone; Pont Aberderfel.

*Discussion.* The pedicle valve of these sowerbyellinids recalls *S. restricta* (Hadding) (see Lindström 1953, p. 135) both in general morphology and ontogenetic development. In the brachial valve there is a considerable similarity, but in *S. restricta* the septules are very much smaller and limited to the posterior third of the valve where they are associated with a small but well defined muscle platform.

#### STROPHOMENIDAE King, 1846

##### **Leptaena** sp. (Figures 86 to 90, plate 39.)

*Leptaena rhomboidalis* Wilckens *partim* Elles, G. L., 1922, p. 145.  
*Stropheodonta corrugatella* (Davidson) Elles, G. L., 1922, p. 145.

##### *Dimensions:*

	length (mm)	width (mm)
External and internal mould of distorted pedicle valve (A 40962 <i>a</i> and <i>b</i> )	28	24
Part of internal mould of pedicle valve (A40613)	—	30
Part of external mould of brachial valve (A40617)	—	—
Part of internal mould of brachial valve (A40963)	—	—

A small number of *Leptaena* moulds has been obtained from the Derfel Limestone exposures at Trawsant (A40962*a* and *b*) and especially Pont Aberderfel, the source of the rest of the figured material. Their close relationship to later members of the genus is shown by their internal morphology. The large oval ventral muscle scar is contained by a raised ridge and consists of a lanceolate adductor scar completely enclosed by the somewhat flabellate diductors. The interior of the brachial valve is equally typical of the genus, although the raised rim of the visceral disk is only incipiently developed. The cardinal process lobes are slender with roughened posterior surfaces in part covered by a conspicuous chilidium; the socket ridges are denticulate, divergent and short; the notothyrial platform and the short median septum (which bifurcates anteriorly into a pair of curved ridges) together form an anchor-shaped structure forming the posterior and median limits to the adductor scars.

The unequally parvicostellate ornamentation, however, reveals that these specimens belong to a distinctive species group which, so far as the writer is aware, is essentially characteristic of the Ordovician. In this respect the Welsh specimens are closely allied to the Baltic species, *L. trigonalis* Schmidt, 1908, for they have three strong primary costae

differentiated at the umbo and in all about 10 accentuated ribs concentrated in the median sector of the shell, and a like number of rugae (about 10) on the disk. The specimens are too distorted to permit a more detailed comparison, although they appear to be smaller and probably did not have the characteristic shape of *L. trigonalis*.

**Kjaerina** sp. (Figures 91 to 93, plate 39.)

*Dimensions:*

	length (mm)	width (mm)
External and internal mould of pedicle valve (A40964 <i>a</i> and <i>b</i> )	29	17
External mould of brachial valve (A40965)	ca. 26	ca. 26

*Description.* Three moulds of a species of *Kjaerina* Bancroft, 1929 have been collected from the Derfel limestone outcrop at Trawsnant. Dimensions are deceptive for the specimens are distorted, but the forms undoubtedly possessed very gently concavo-convex shells ornamented by unequally developed parvicostellae with at least 50 accentuated ribs at the margin which divide the shell surface into narrow sectors each containing 4 to 7 fine parvicostellae. The interior of the pedicle valve is characteristically kjaerinid. The pseudo-deltidium is small, the teeth simple, supported by short divergent dental lamellae which anteriorly are fused with a pair of low parallel ridges laterally restricting a small narrow pentagonal muscle scar differentiated into a median, relatively broad, adductor track not enclosed by the diductors. A pair of vaguely defined vascula media emerge anterior of the muscle scar.

*Discussion.* This *Kjaerina* differs from all other described species of the genus in that the ornamentation does not include a coarse and prominent median rib (or bundle of ribs). The difference is probably specifically significant, but until more and better preserved material is obtained and a more precise morphological study made, systematic recognition is not desirable.

#### 4. SYSTEMATIC DESCRIPTION OF TRILOBITA

BY H. B. WHITTINGTON

All the trilobites listed in the introduction are described below, with the exception of *Harpes* (s.l.) ind.sp. A (Whittington 1950, p. 30, pl. 5, fig. 3). The terminology follows that previously employed (Whittington 1953, p. 648, etc.).

Family TRINUCLEIDAE Emmrich, 1844

Genus **Salterolithus** Bancroft, 1929

**Salterolithus** cf. **harnagensis** Bancroft, 1929. (Figures 94–96, 100, 101, plate 40, figure 6.)

*Material.* A40585–7 from Aberderfel, referred to *Trinucleus* sp. by Elles 1922, p. 145; A40993–A40995 from Trawsnant.

*Discussion.* The description of *Salterolithus harnagensis* (Bancroft 1929, pp. 79–81, pl. 1, figs. 1, 2) from Cressage, Shropshire, fits approximately the incomplete cephalons from the Derfel Limestone, and Bancroft (1933) first recognized the latter as *S. harnagensis*. Certain differences from the Cressage specimens are evident: (1) there are about 24 pits in  $E_2$  on



each side (not 28–30), about 22 in  $E_1$  and  $I_1$ , not 24; (2) there is no strong concentric ridge between  $I_1$  and  $I_2$ ; (3) Bancroft states that additional pits in  $E_2$  (as compared to  $E_1$ ) may be present in any region, and this is true of the Derfel specimens. In the same sentence (Bancroft 1929, p. 79) it is stated that 'all pits in posterior region of  $E_1$  represented in  $E_2$ '. This appears to be contradictory, and does not apply to the Derfel material.

*Ulricholithus* Bancroft, 1949 (= *Ulricholithus* Bancroft, 1933, *nomen nudum*) was erected as a subgenus of *Salterolithus*, and the description of the type species (1949, pp. 296–297, fig. 14, pl. 9) includes a somewhat unsatisfactory illustration of a specimen from the Welshpool area. The latter appears to be quite like the Derfel Limestone specimens, in number and arrangement of pits in the fringe, the outward deflexion postero-laterally of  $E_1$  and  $I_1$ , the low radial ridges between pits of  $E_1$  laterally, and presence of a 'pseudo-girder' or

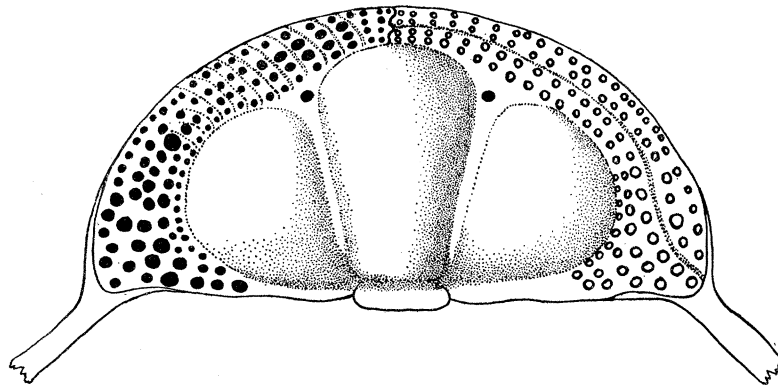


FIGURE 6. *Salterolithus* cf. *harnagensis* Bancroft 1929. (magn. ca.  $\times 8$ .) Reconstruction of cephalon based on originals of figures 94 to 96, 100, plate 40. The upper lamella of the fringe, with pits shown by black circles, is shown on left side of the mid-line (broken edge indicated) and the lower lamella, the pits shown by open circles, on the right. Position of girder indicated by stippling. Anterior pits (black circles) lie at anterior end of axial furrow, adjacent to inner margin of fringe.

strong ridge on the ventral surface of the fringe between  $I_1$  and  $I_2$  (pl. 3, fig. 96) about which the lower lamella is flexed. It seems clear that the Derfel Limestone, Shropshire, and Welshpool specimens are similar to each other and of early Bala age. Further, they are distinguished from typical *Salterolithus* by the absence of the third external row of pits, and from the stratigraphically younger *Broeggerolithus* by the intercalation of pits in  $E_2$  (as compared to  $E_1$ ) in all regions. In 1935 Bancroft wrote of a line of descent from *Salterolithus* to *Ulricholithus* to *Broeggerolithus*, and this view appears reasonable. The posthumous paper (Bancroft 1949, p. 295) indicates that this view was later modified, but the evidence on which this was done remains unpublished.

#### Family RAPHIOPHORIDAE Angelin, 1854

#### Genus *Ampyx* Dalman, 1827

*Ampyx* ind.sp. (Figure 97, plate 40.)

*Material.* Counterpart moulds of a pygidium and portion of external mould of pygidium, A40996, from Aberderfel.

*Description.* Pygidium of width 2.1 cm, length 1.5 cm, maximum width of axis 0.54 cm and tapering back to reach posterior margin. Articulating furrow distinct, first four axial rings faintly indicated by furrows in median part of axis. Pleural regions with characteristic first pleural furrow, running out in curve concave forwards. Border bent steeply down, with fine terrace lines sub-parallel to margin.

This pygidium is typical of *Ampyx*, and the genus was recorded from Garn by Ramsay (1866, p. 74).

Family ILLAENIDAE Hawle & Corda, 1847

**Illaeus** (s.l.) ind.sp. (Figures 98, 99, 103–105, 108, plate 40.)

*Material.* Internal mould of cranidium, A40583, of pygidium, A40580, from Aberderfel. Several moulds of cranidia (A40997, A40998) and one incomplete pygidium (A40999) from Trawsnant. The Aberderfel specimens were identified by Elles (1922, p. 145) as *I. cf. balclatchiensis*, Reed.

*Description.* Cranidium with deep axial furrows at posterior margin extending forwards between one-third and one-half the length, the anterior portion curving slightly outwards before disappearing. Distance between axial furrows little more than one-third distance between palpebral lobes at that level. Palpebral lobes small, situated far back. Posterior branch of suture straight, running diagonally outwards to margin. Anterior branch running forwards and slightly outwards to margin.

Pygidium with axis less than one-third total width, defined by broad shallow furrows which reach back about half the length. Outline of pleural regions curved antero-laterally, apparently lacking abrupt angulation of anterior margin.

*Discussion.* The crushed and distorted nature of the material precludes any attempt to make detailed comparisons between the Derfel and other species, though the cranidium appears to be like certain Craighead Limestone specimens described by Reed (1904, pl. 10, figs. 1, 1a; 1935, pl. 3, figs. 5, 5a).

Family CHEIRURIDAE Hawle & Corda, 1847

**Ceraurinella?** ind.sp. (Figures 102, 107, 111, plate 40.)

*Material.* Two incomplete cranidia, internal moulds, from Aberderfel, A40577, A40578, recorded by Elles (1922, p. 145) as '*Cybele rugosa* (Portlock)'; A41000, from Trawsnant, distorted external mould of half of cranidium.

*Description.* Glabella convex, outline sub-parallel sided, rounded anteriorly. Median lobe of width more than half that of glabella, gently convex. Occipital ring longest sagittally, occipital furrow deepest laterally. Three pairs of glabellar furrows, anterior the longest, running inwards and slightly backwards. Median and posterior furrows transversely directed, deep. The three pairs of glabellar lobes with independent convexity, the anterior the largest, posterior smallest. Broad axial furrow, deep anterior pit. Fixed cheek of width greater than that of glabella, eye lobe situated opposite anterior lateral lobe and far out, strong eye ridge runs in to reach axial furrow opposite anterior glabellar furrow. Posterior branch of facial suture runs out sub-parallel to posterior border, and curves to cut lateral border in front of genal angle. Deep posterior border furrow and convex

posterior border, latter becoming longer (exs.) outwards. Uncertain whether or not genal spine present. Tubercular ornament on glabella. Fixed cheek tuberculate with scattered pits.

*Discussion.* The cranidium of this species recalls that of cheirurinids of *Ceraurinella* type (Whittington & Evitt 1954, pl. 10), though the eye lobe appears to be situated rather far outwards and forwards. Trilobites of this type have not previously been recorded from the early Lower Bala of the Anglo-Welsh area. They are characteristic of the Middle Ordovician of the Appalachian region of North America, and are present in the Baltic and Scandinavia.

Family ENCRINURIDAE Angelin, 1854

Genus *Atractopyge* Hawle & Corda, 1847

*Atractopyge* ind.sp. (Figures 106, 109, 110, plate 40.)

*Material.* An incomplete cranidium, A40575, referred to *Cybele verrucosa* (Dalman) by Elles 1922, p. 145, two incomplete pygidia, A40576, 40579a and b, referred to *Cybele rugosa* (Portlock) by Elles, 1922, p. 145. All from Aberderfel.

*Description.* Glabella quite strongly convex, expanding forwards to anterior lobe, which slopes vertically. Shallow axial furrow ends in a deep anterior pit. Three short glabellar furrows, deepest at the inner end. Glabellar lobes without convexity independent from that of median lobe. Only inner part of convex fixed cheek preserved. Anterior border short at mid-line, convex shallow preglabellar furrow. Coarse tubercles scattered on glabella, some paired, conspicuous pair on fronto-median lobe; fine granules between tubercles. Fixed cheek with pits and scattered coarse tubercles.

Axis of pygidium convex, tapering to well-defined tip, first ring a complete, raised ridge, at least 12 more rings present, defined laterally but absent in the medial axial area. Pleural regions composed of 4 pairs of pleurae, each with a free spinose tip. The posterior portion of each pleura is a strong ridge, ending in the pleural spine. Each ridge curves outwards and successively more strongly backwards, so that the fourth runs sub-parallel to the axis, and the ridge runs out into a spine beside the tip of the axis. The pleural ridges are continuous with the axial rings, and between the first and second is a low additional ridge, presumably belonging to the anterior band of the second pleura.

*Discussion.* The fragmentary specimens here regarded as belonging to one species are like the *verrucosa* type of cybelid, i.e. *Atractopyge*. This group appears to be represented in the Balclatchie beds of Scotland by *A. michelli* (Reed 1914, pp. 42-44, pl. 7, figure 7) as well as in Scandinavia.

*Encrinurid?* ind.gen. (Figure 112, plate 40.)

*Material.* Fragment of external mould of anterior portion of glabella, on A40931, from Aberderfel.

*Discussion.* This fragment is moderately convex, apparently not crushed, and the ornament is well preserved. Two lateral glabellar lobes, with gentle independent convexity, are preserved on the left side, the furrows defining them deep, directed inwards and backwards. Rounded tubercles, with intervening fine granulation, are scattered over

lateral and fronto-median lobes. In the centre of the anterior lobe is a pair of prominent tubercles separated by a conspicuous pit. Such a pit is seen in some encrinurids, and is one character distinguishing this fragment from that here referred to *Atractopyge* (figure 106, plate 40). This glabella fragment might be regarded as belonging to the same species as the three specimens here referred to *Ceraurinella*? (figures 102, 107, 111, plate 40), but differences in preservation render comparison difficult. A median pit in the anterior glabellar lobe would be unusual in a cheirurid of *Ceraurinella* type, but both a shallow median furrow running in from the preglabellar furrow, and shallow paired pits, have been observed in closely related forms.

Family LICHIDAE Hawle & Corda, 1847

Genus *Platylichas* Gürich, 1901

*Platylichas* ind.sp. (Figures 113 to 118, plate 40.)

*Material.* Two fragments of cranidia and a pygidium, internal and external moulds respectively from Aberderfel, A40571, A40573, A40574, referred to *Lichas laxatus* M'Coy by Elles 1922, p. 145; A41010, A41011, moulds of pygidia from Trawsnant; A41012 incomplete external mould of hypostome, from Aberderfel.

*Description.* Glabella with fronto-median lobe expanding greatly forwards; composite lateral lobes well defined by a deep furrow on the inner side, this furrow curving out posteriorly to meet the shallow axial furrow. This junction appears to lie a short distance in front of the occipital furrow, and a transversely elongated occipital lobe appears to be present outside and behind the junction. Narrow, flat anterior border. External surface of glabella tuberculate.

Middle body of hypostome convex, length (sag.) about equal to maximum width, latter across anterior lobe; middle furrow deep, extending inwards diagonally to about one-third width. Anterior border present only antero-laterally, where it is narrow (exs.) and poorly defined. Lateral border narrow beside anterior lobe of middle body, widening rapidly posteriorly and merging with broad, flat posterior border. Middle body of hypostome tuberculate, lateral border with terrace lines which diverge and die out postero-laterally.

Axis of pygidium tapering gradually back to prominent tip, axial furrows continuing for short distance beyond axis, then diverging and dying out. First two axial rings present, third less distinctly marked. Pleural regions with three pairs of interpleural grooves, the third pair commencing beyond half the length of the axis. First two pairs of pleural furrows deep, diagonally directed and curving back at extremities. Tips of first two pairs of pleurae free, pointed; apparently tips of third pleurae free and defined by small median notch in posterior margin. No border furrow. Doublure broad, posteriorly reaching in close to tip of axis, terrace lines sub-parallel to margin.

*Discussion.* The form of the glabella and apparent presence of occipital lobes lead me to place this species in *Platylichas*, following Warburg (1939). The pygidium and hypostome are like those of species placed in this genus by Warburg. Lichids are not commonly recorded in the Anglo-Welsh area until the Longvillian Stage of the Lower Bala, though a Llandeilo species was described by Wyatt-Edgell (1866), and one is also recorded from the Hoar Edge Grit.

## Family ODONTOPLEURIDAE Burmeister, 1843

**Gen. indet.** (Figure 119, plate 40.)

*Discussion.* The incomplete thorax (5 or 6 segments represented) and pygidium, preserved as an internal mould, from Aberderfel (A40584), is that of an odontopleurid and was referred to *Acidaspis hystrix* Wyville Thomson by Elles (1922, p. 145). The pleurae with two transverse ridges separated by a furrow which is slightly diagonal. The posterior ridge is much the strongest, and is continuous with the backwardly directed pleural spine. The margin of the pygidium bears 6 pairs of spines, there being 4 small pairs inside the much larger second pair, each of which is connected by a prominent ridge to the first axial ring. In front of this ridge is a furrow and lower ridge, like those seen on the anterior part of the thoracic pleurae. This arrangement of pygidial border spines is unlike that of '*Acidaspis*' *hystrix* (Reed 1906, pp. 116-117, pl. 16, figs. 3-5). In '*A*'. *harnagensis* Bancroft (1949, pp. 301-303, pl. 10, figs. 21, 22) there are 7 pairs of pygidial border spines, the fifth much the largest, and connected by a ridge to the first axial ring. Thus the Derfel specimen does not seem to represent this species either.

**Calymenid? pygidium.** (Figure 120, plate 40.)

*Discussion.* This incomplete pygidium, together with part of a thoracic segment, is preserved as an external mould A41013, and is from Aber Derfel. Axis convex, first three rings defined, tip rounded and well marked. Pleural regions with four deep, curving pleural furrows and three shallow interpleural grooves. The appearance is suggestive of a calymenid.

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## DESCRIPTION OF PLATES 38 TO 40

Numbers prefixed by A refer to specimens deposited in the Sedgwick Museum, Cambridge, those prefixed by G.S.M. to specimens in the Geological Survey and Museum, London.

## PLATE 38

FIGURES 7 to 11 (magn.  $\times 1.5$ ). *Nicolella humilis* n.sp.

7, 11. Latex casts of external moulds of brachial valves; G.S.C. 85727, A 40913.

8. Latex cast of internal mould of brachial valve, G.S.C. 90386.

9, 10. Internal mould and latex cast of pedicle valve, holotype A 40941 *b*.

FIGURES 12, 13. *Glossorthis* sp.

12, 13. Internal and external moulds of pedicle valve, A 40920 *a* and *b* (magn.  $\times 2$ ,  $\times 3$ , resp.).

FIGURES 14 to 16 (magn.  $\times 2$ ). *Cyrtonotella* aff. *kukersiana* (Wysogorski).

14, 15. Internal mould and latex cast of brachial valve, A 40945 *b*.

16. Latex cast of external mould of brachial valve, A 40945 *a*.

FIGURES 17 to 23 (magn.  $\times 1.5$ ). *Dolerorthis tenuicostata* n.sp.

17. Latex cast of external mould of brachial valve, A 40943 *a*.

18. Latex cast of external mould of pedicle valve, holotype A 40917 *b*.

19, 20. Internal mould and latex cast of brachial valve, A 40943 *a*.

21, 22. Internal mould and latex cast of pedicle valve, A 40944.

23. Internal mould of pedicle valve, holotype A 40971 *a*.

FIGURES 24 to 29. *Platystrophia precedens* McEwan *major* n.subsp.

24, 25. Latex cast of external mould of brachial valve, A 40993 (magn.  $\times 3$ ,  $\times 6$ , resp.).

26, 27. Internal mould and latex cast of pedicle valve, A 40910 (magn.  $\times 1.5$ ).

28, 29. Internal mould and latex cast of brachial valve, A 40908 (magn.  $\times 1.5$ ).

FIGURE 30 (magn.  $\times 1.5$ ). *Horderleyella* sp. Internal mould of pedicle valve, A 40922.

FIGURES 31 to 35 (magn.  $\times 2$ ). *Howellites* sp.

31, 32. Internal mould and latex cast of brachial valve, A 40961 *b*.

33, 34. Internal mould and latex cast of pedicle valve, A 40919.

35. Latex cast of external mould of brachial valve, A 40961.

FIGURES 36 to 42 (magn.  $\times 2$ ). *Soudleyella* cf. *avelinei* (Bancroft).

36. Latex cast of external mould of pedicle valve A 40960.

37. Latex cast of external mould of brachial valve, A 40957.

38. Internal mould of gerontic pedicle valve A 40921.

39, 40. Internal mould and latex cast of pedicle valve, A 40959 *b*.

41, 42. Internal mould and latex cast of brachial valve, A 40958.

FIGURES 43 to 46 (magn.  $\times 2$ ). *Salopia salteri* (Davidson) n.gen.

43, 44. Posterior and ventral views of internal mould of pedicle valve, G.S.M. 11229, figured by Davidson 1871 (pl. XXXVI, figs. 31 to 32) as *Orthis salteri*, from Horderley, Salop.

45, 46. Internal mould and latex cast of brachial valve (A 29134) from the Neptunian Dyke of Hazler Hill, near Church Stretton, Salop.

FIGURES 47 to 51 (magn.  $\times 2$ ). *Salopia salteri* (Davidson) *gracilis* n.gen. et subsp.

47. Internal mould of pedicle valve A 40973 *b*.

48. Latex cast of external mould of pedicle valve A 40974.

49. Internal mould of pedicle valve A 40975.

50. Internal mould of brachial valve holotype A 40934 *b*.

51. Latex cast of internal mould of brachial valve, A 40971.

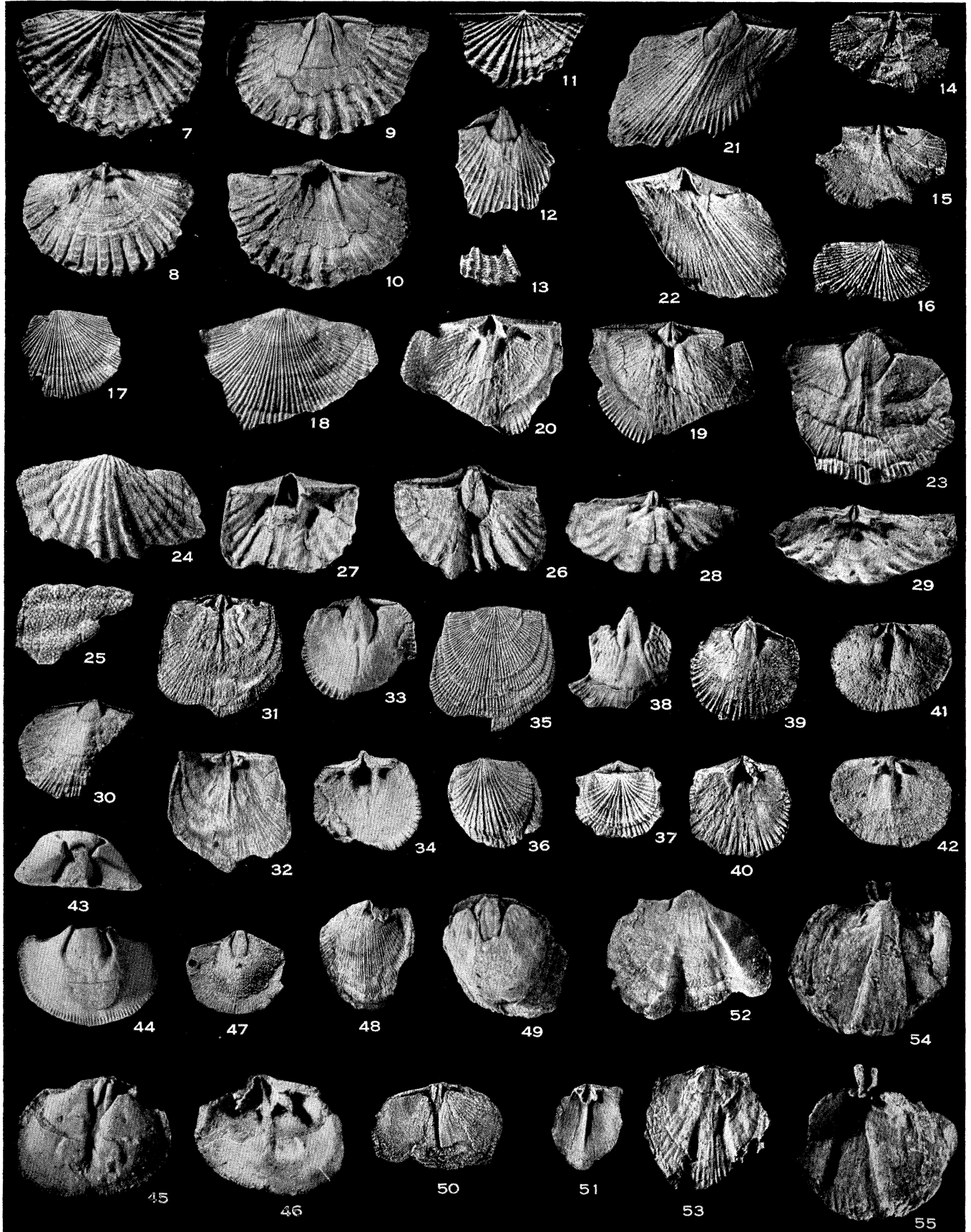
FIGURES 52 to 55. *Cliftonia* (*Oxoplecia*) *mutabilis* n.sp.

52. Internal mould of pedicle valve, A 40940 (magn.  $\times 1.5$ ).

53. Internal mould of pedicle valve, A 40949 *b* (magn.  $\times 1.5$ ).

54, 55. Internal mould and latex cast of brachial valve, holotype A 40948 *b* (magn.  $\times 2$ ).





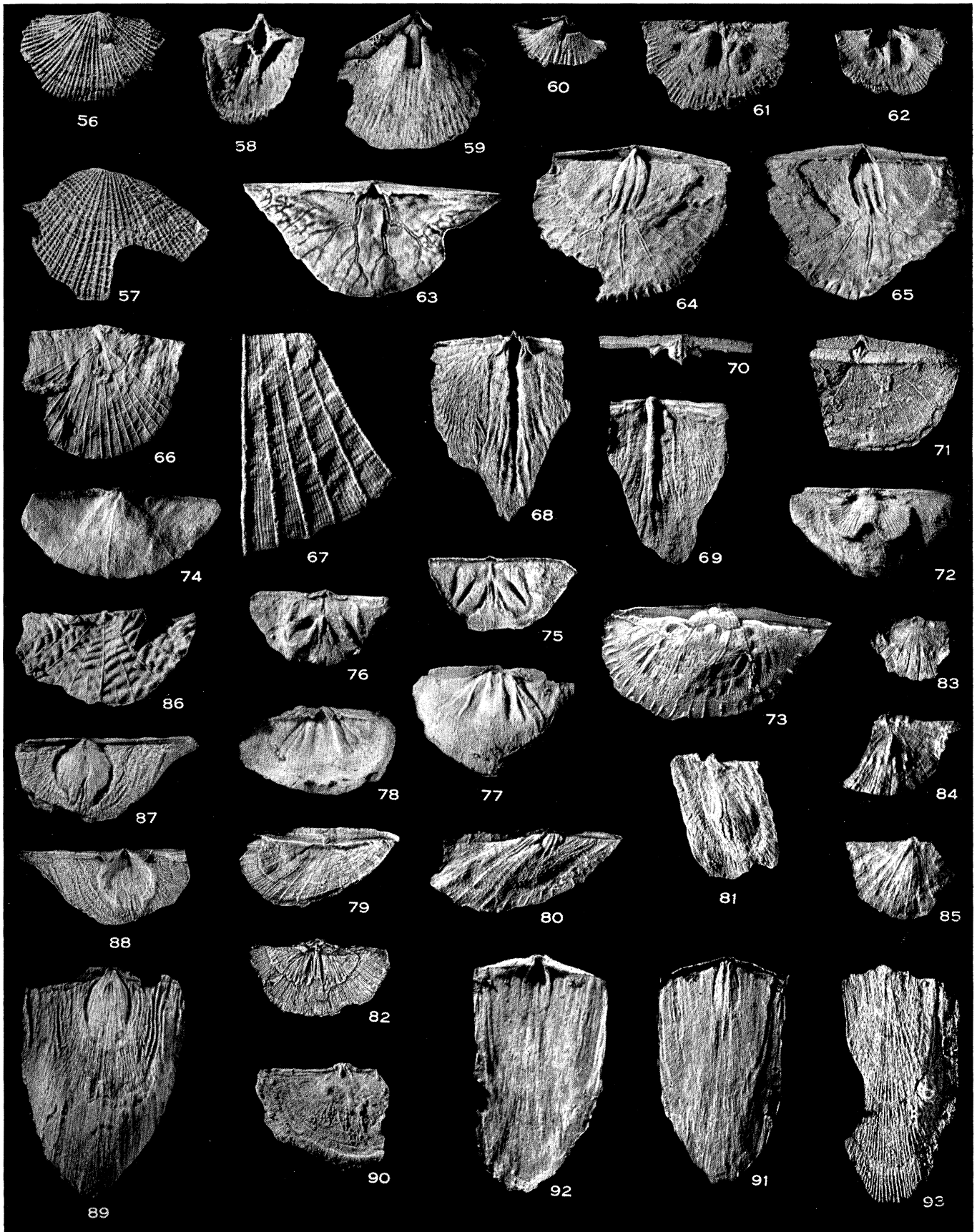


PLATE 39

FIGURES 56 to 62. *Kullervo* aff. *panderi* Öpik.

- 56. Latex cast of external mould of brachial valve, A 40952a (magn.  $\times 2$ ).
- 57. Latex cast of external mould of pedicle valve, A 40953a (magn.  $\times 3$ ).
- 58. Latex cast of internal mould of pedicle valve, A 40951 (magn.  $\times 2$ ).
- 59. Internal mould of pedicle valve, A 40954 (magn.  $\times 2$ ).
- 60. Internal mould of pedicle valve, A 40954 (magn.  $\times 2$ ).
- 61, 62. Internal mould and latex cast of brachial valve, A 40952b (magn.  $\times 2$ ,  $\times 1.5$ , resp.).

FIGURE 63 (magn.  $\times 1.5$ ). *Palaeostrophomena concava* Schmidt. Interior of pedicle valve (Riksmuseum, Stockholm Br. 68796) from the Uhaku Stage of Estonia.

FIGURES 64 to 70. *Palaeostrophomena magnifica* n.sp.

- 64, 65. Internal mould and latex cast of pedicle valve, holotype, A 40615 (magn.  $\times 1.5$ ).
- 66, 67. Latex cast of external mould of pedicle valve, A 40966 (magn.  $\times 1.5$ ,  $\times 5$ , resp.).
- 68, 69. Internal mould and latex cast of brachial valve, A 40967 (magn.  $\times 2$ ).
- 70. Posterior view of latex cast of cardinalia, A 40969 (magn.  $\times 3$ ).

FIGURES 71 to 73 (magn.  $\times 3$ ). *Leptellina derfelensis* (Jones).

- 71. Latex cast of external mould of brachial valve and interarea of pedicle valve, A 40991.
- 72. Latex cast of internal mould of brachial valve, A 40992.
- 73. Internal mould of pedicle valve, A 16671 (figured by Jones 1928, pl. 25, fig. 3).

FIGURES 74 to 78. *Sowerbyella multiseptata* n.sp.

- 74. Exterior of pedicle valve, A 40978 (magn.  $\times 3.5$ ).
- 75, 76. Internal mould and latex cast of brachial valve, holotype A 40976 (magn.  $\times 3$ ).
- 77, 78. Internal mould and latex cast of pedicle valve, G.S.M. 85727a (magn.  $\times 3$ ).

FIGURES 79 to 81 (magn.  $\times 1.5$ ). *Plectodonta lenis* n.sp.

- 79. Latex cast of external mould of brachial valve and interarea of pedicle valve, A 40983a.
- 80. Internal mould of pedicle valve, A 40982.
- 81. Latex cast of internal mould of brachial valve, holotype, A 40981b.

FIGURE 82 (magn.  $\times 2$ ). *Sowerbyella* sp. External mould of pedicle valve with the postero-median portion of the internal moulds of conjoined valves (dorsal view), A 40985.

FIGURES 83 to 85 (magn.  $\times 4$  approx.). *Sericoidea abdita* n.sp.

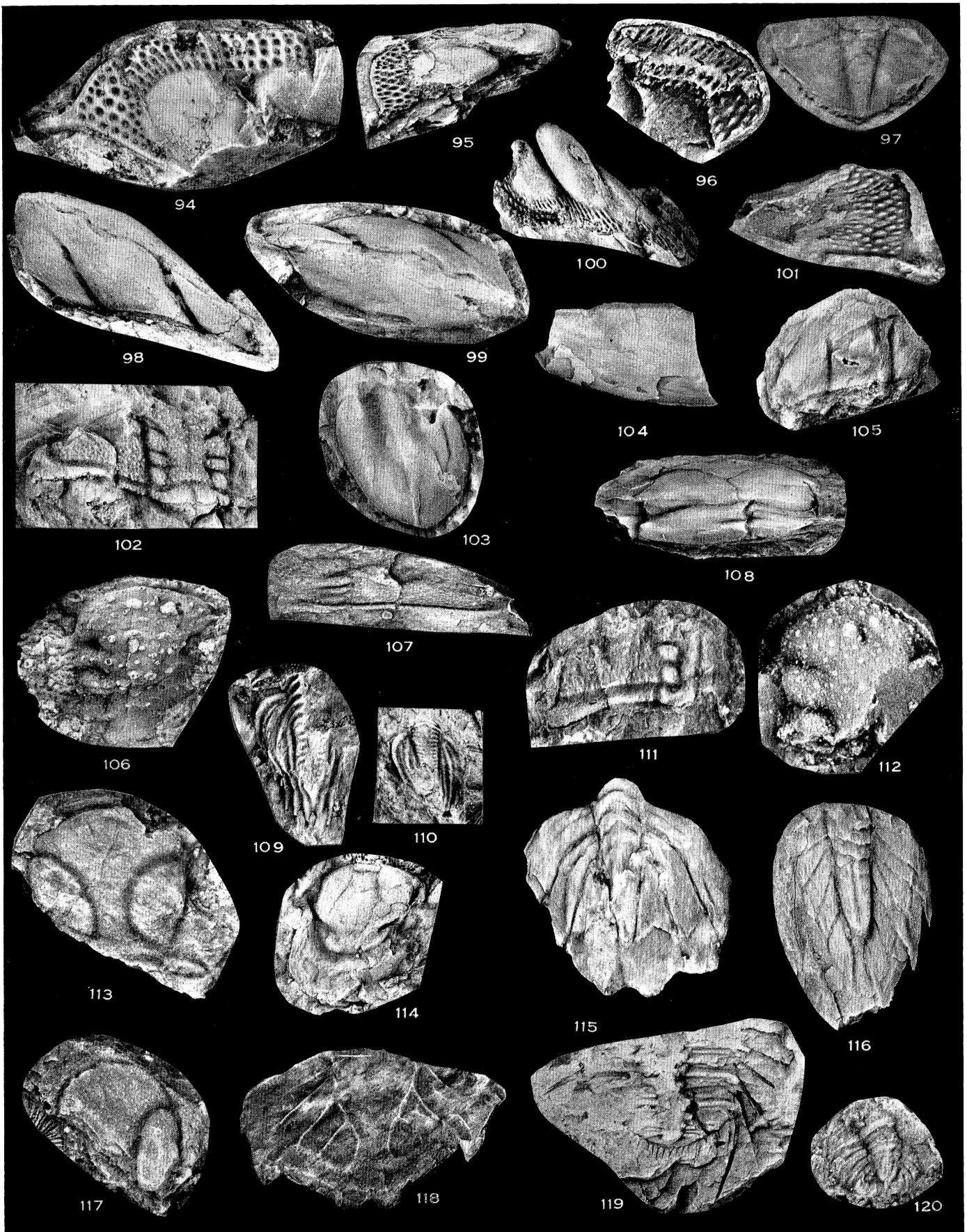
- 83, 84. External moulds of brachial valves bearing casts of internal moulds, A 40989 and A 40990 respectively.
- 85. Internal mould of pedicle valve, holotype A 40988.

FIGURES 86 to 90. *Leptaena* sp.

- 86. Latex cast of external mould of brachial valve, A 40617 (magn.  $\times 3$ ).
- 87, 88. Internal mould and latex cast of muscle area of pedicle valve, A 40613 (magn.  $\times 1.5$ ).
- 89. Internal mould of pedicle valve, A 40962b (magn.  $\times 1.5$ ).
- 90. Latex cast of internal mould of brachial valve, A 40963 (magn.  $\times 2$ ).

FIGURES 91 to 93 (magn.  $\times 1.5$ ). *Kjaerina* sp.

- 91, 92. Internal mould and latex cast of pedicle valve, A 40964b.
- 93. Latex cast of external mould of pedicle valve, A 40964a.



## PLATE 40

FIGURES 94 to 96, 100, 101. *Salterolithus* cf. *harnagensis* Bancroft, 1929.

94. Part of left half of cephalon, external view, showing upper lamella of fringe, A 40585 (magn.  $\times 3$ ).  
95, 100. Distorted cephalon, dorsal and anterior views, upper lamella of fringe on left side, external mould of lower lamella on right, A 40993 (magn.  $\times 2$ ).  
101. External mould of fringe and cheek lobe of left side, internal view, showing reticulated ornament on cheek lobe, A 40994 (magn.  $\times 3$ ).  
96. Portion of left side of cephalon, external mould, with cast of fringe attached showing external surface of lower lamella, A 40995 (magn.  $\times 3$ ).

FIGURE 97, *Ampyx* ind.sp. Internal mould of pygidium, A 40996,  $\times 1.5$ .

FIGURES 98, 99, 103 to 105, 108. *Iliaenus* (s.l.) ind.sp.

- 98, 99. Distorted cranidium, internal mould, dorsal and anterior views, palpebral lobe and branches of suture on right side, A 40997 (magn.  $\times 2$ ).  
103. Distorted pygidium, internal mould, A 40580 (magn.  $\times 2$ ).  
104. Incomplete distorted pygidium, internal mould, A 40999 (magn.  $\times 1.5$ ).  
105. Incomplete cranidium, internal mould, A 40583 (magn.  $\times 3$ ).  
108. Crushed cranidium, internal mould, antero-dorsal view, palpebral lobe and branches of suture on right side, A 40998 (magn.  $\times 1$ ).

FIGURES 102, 107, 111. *Ceraurinella?* ind.sp.

102. Incomplete cranidium, internal mould, A 40578 (magn.  $\times 3$ ).  
107. Rubber cast of distorted external mould of incomplete cranidium, A 41000 (magn.  $\times 2$ ).  
111. Part of cranidium, internal mould, showing genal angle, A 40577 (magn.  $\times 4$ ).

FIGURES 106, 109, 110 *Atractopyge* ind.sp.

106. Rubber cast of external mould of glabella and part of left free cheek, A 40575 (magn.  $\times 3$ ).  
109. Incomplete pygidium, internal mould, A 40576 (magn.  $\times 3$ ).  
110. Incomplete pygidium, internal mould, A 40579a (magn.  $\times 2$ ).

FIGURE 112 (magn.  $\times 6$ ). Encrinurid? ind. gen. Rubber cast of external mould of anterior portion of glabella, on A 40931.

FIGURES 113 to 118. *Platylichas* ind.sp.

113. Internal mould of part of glabella, A 40573 (magn.  $\times 3$ ).  
114. Rubber cast of external mould of hypostome, A 41012 (magn.  $\times 3$ ).  
115. Internal mould of pygidium, A 41010 (magn.  $\times 1.5$ ).  
116. Internal mould of pygidium, A 41011 (magn.  $\times 2$ ).  
117. Internal mould of part of glabella, A 40571 (magn.  $\times 3$ ).  
118. External mould of pygidium, A 40574 (magn.  $\times 4$ ).

FIGURE 119 (magn.  $\times 2.5$ ). Odontopleurid ind. gen. Internal mould of part of thorax and pygidium, A 40584.

FIGURE 120 (magn.  $\times 2$ ). Calymenid? Rubber cast of external mould, A 41013.

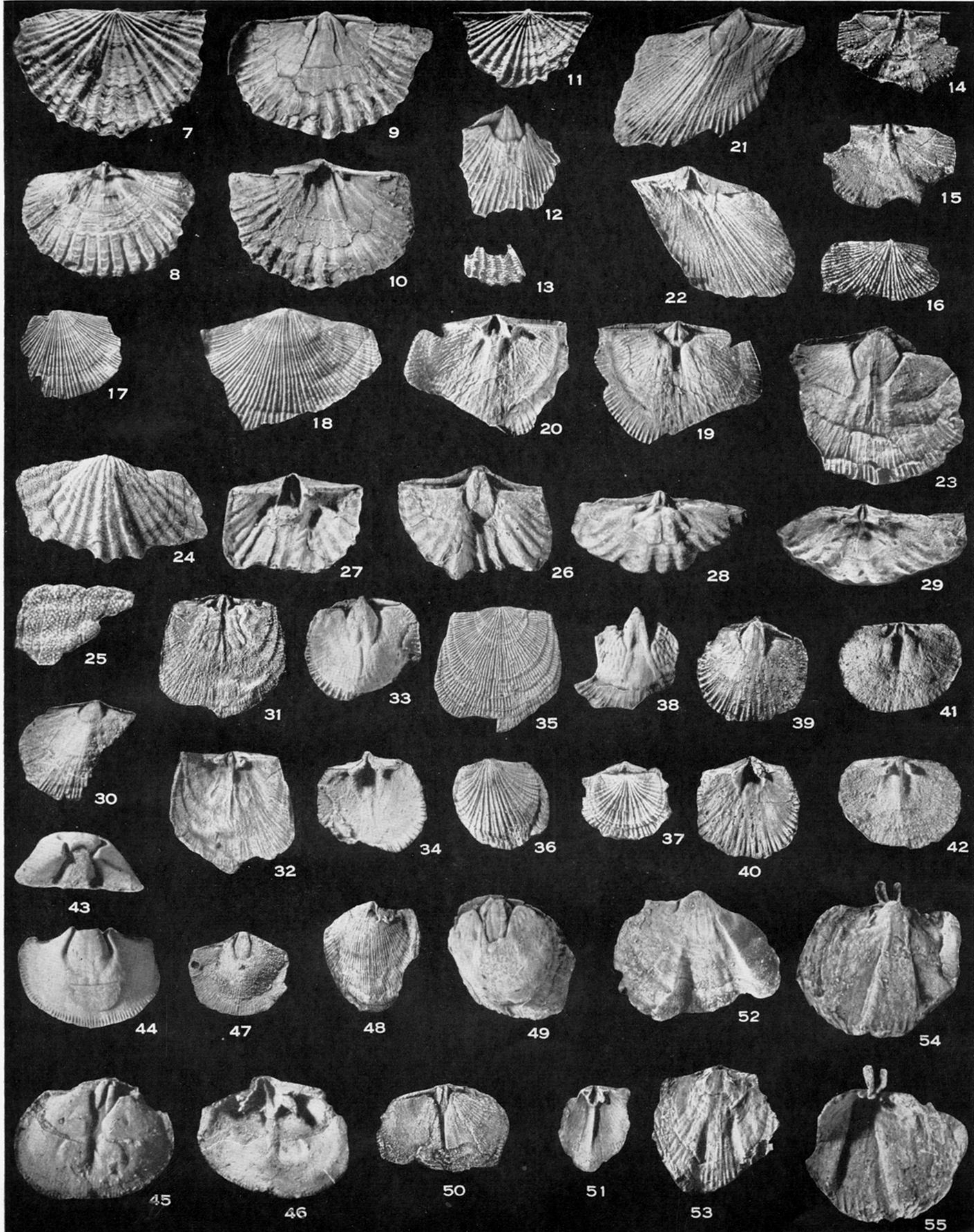


PLATE 38

FIGURES 7 to 11 (magn.  $\times 1.5$ ). *Nicolella humilis* n.sp.

7, 11. Latex casts of external moulds of brachial valves; G.S.C. 85727, A40913.

8. Latex cast of internal mould of brachial valve, G.S.C. 90386.

9, 10. Internal mould and latex cast of pedicle valve, holotype A40941*b*.

FIGURES 12, 13. *Glossorthis* sp.

12, 13. Internal and external moulds of pedicle valve, A40920*a* and *b* (magn.  $\times 2$ ,  $\times 3$ , resp.).

FIGURES 14 to 16 (magn.  $\times 2$ ). *Cyrtotella* aff. *kukersiana* (Wysogorski).

14, 15. Internal mould and latex cast of brachial valve, A40945*b*.

16. Latex cast of external mould of brachial valve, A40945*a*.

FIGURES 17 to 23 (magn.  $\times 1.5$ ). *Dolerorthis tenuicostata* n.sp.

17. Latex cast of external mould of brachial valve, A40943*a*.

18. Latex cast of external mould of pedicle valve, holotype A40917*b*.

19, 20. Internal mould and latex cast of brachial valve, A40943*a*.

21, 22. Internal mould and latex cast of pedicle valve, A40944.

23. Internal mould of pedicle valve, holotype A40971*a*.

FIGURES 24 to 29. *Platystrophia precedens* McEwan *major* n.subsp.

24, 25. Latex cast of external mould of brachial valve, A40993 (magn.  $\times 3$ ,  $\times 6$ , resp.).

26, 27. Internal mould and latex cast of pedicle valve, A40910 (magn.  $\times 1.5$ ).

28, 29. Internal mould and latex cast of brachial valve, A40908 (magn.  $\times 1.5$ ).

FIGURE 30 (magn.  $\times 1.5$ ). *Horderleyella* sp. Internal mould of pedicle valve, A40922.

FIGURES 31 to 35 (magn.  $\times 2$ ). *Howellites* sp.

31, 32. Internal mould and latex cast of brachial valve, A40961*b*.

33, 34. Internal mould and latex cast of pedicle valve, A40919.

35. Latex cast of external mould of brachial valve, A40961.

FIGURES 36 to 42 (magn.  $\times 2$ ). *Soudleyella* cf. *avelinei* (Bancroft).

36. Latex cast of external mould of pedicle valve A40960.

37. Latex cast of external mould of brachial valve, A40957.

38. Internal mould of gerontic pedicle valve A40921.

39, 40. Internal mould and latex cast of pedicle valve, A40959*b*.

41, 42. Internal mould and latex cast of brachial valve, A40958.

FIGURES 43 to 46 (magn.  $\times 2$ ). *Salopia salteri* (Davidson) n.gen.

43, 44. Posterior and ventral views of internal mould of pedicle valve, G.S.M. 11229, figured by Davidson 1871 (pl. XXXVI, figs. 31 to 32) as *Orthis salteri*, from Horderley, Salop.

45, 46. Internal mould and latex cast of brachial valve (A29134) from the Neptunian Dyke of Hazler Hill, near Church Stretton, Salop.

FIGURES 47 to 51 (magn.  $\times 2$ ). *Salopia salteri* (Davidson) *gracilis* n.gen. et subsp.

47. Internal mould of pedicle valve A40973*b*.

48. Latex cast of external mould of pedicle valve A40974.

49. Internal mould of pedicle valve A40975.

50. Internal mould of brachial valve holotype A40934*b*.

51. Latex cast of internal mould of brachial valve, A40971.

FIGURES 52 to 55. *Cliftonia* (*Oxoplecia*) *mutabilis* n.sp.

52. Internal mould of pedicle valve, A40940 (magn.  $\times 1.5$ ).

53. Internal mould of pedicle valve, A40949*b* (magn.  $\times 1.5$ ).

54, 55. Internal mould and latex cast of brachial valve, holotype A40948*b* (magn.  $\times 2$ ).

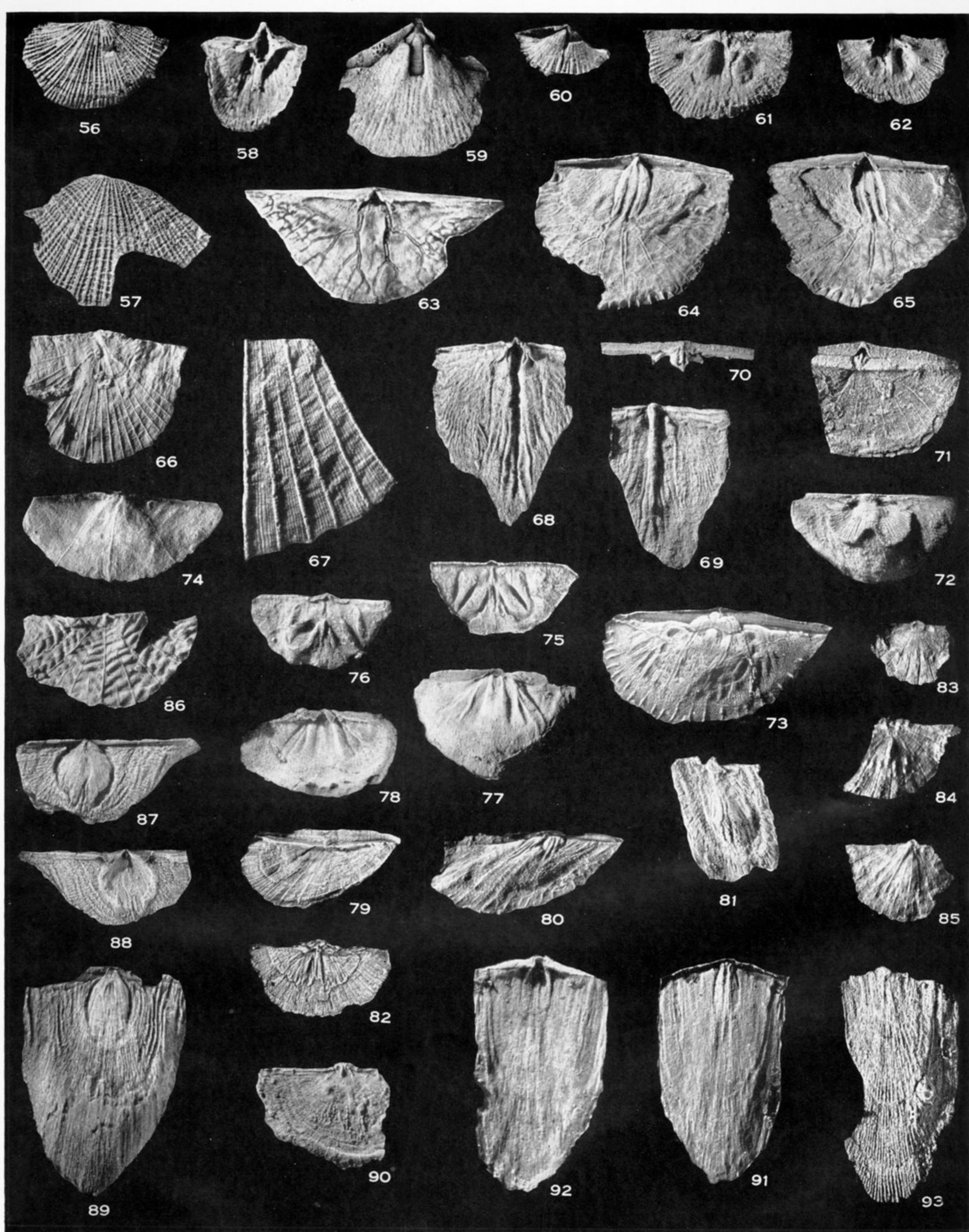


PLATE 39

FIGURES 56 to 62. *Kullervo* aff. *panderi* Öpik.

56. Latex cast of external mould of brachial valve, A40952a (magn.  $\times 2$ ).  
 57. Latex cast of external mould of pedicle valve, A40953a (magn.  $\times 3$ ).  
 58. Latex cast of internal mould of pedicle valve, A40951 (magn.  $\times 2$ ).  
 59. Internal mould of pedicle valve, A40954 (magn.  $\times 2$ ).  
 60. Internal mould of pedicle valve, A40954 (magn.  $\times 2$ ).  
 61, 62. Internal mould and latex cast of brachial valve, A40952b (magn.  $\times 2$ ,  $\times 1.5$ , resp.).

FIGURE 63 (magn.  $\times 1.5$ ). *Palaeostrophomena concava* Schmidt. Interior of pedicle valve (Riksmuseum, Stockholm Br. 68796) from the Uhaku Stage of Estonia.

FIGURES 64 to 70. *Palaeostrophomena magnifica* n.sp.

- 64, 65. Internal mould and latex cast of pedicle valve, holotype, A40615 (magn.  $\times 1.5$ ).  
 66, 67. Latex cast of external mould of pedicle valve, A40966 (magn.  $\times 1.5$ ,  $\times 5$ , resp.).  
 68, 69. Internal mould and latex cast of brachial valve, A40967 (magn.  $\times 2$ ).  
 70. Posterior view of latex cast of cardinalia, A40969 (magn.  $\times 3$ ).

FIGURES 71 to 73 (magn.  $\times 3$ ). *Leptellina derfelensis* (Jones).

71. Latex cast of external mould of brachial valve and interarea of pedicle valve, A40991.  
 72. Latex cast of internal mould of brachial valve, A40992.  
 73. Internal mould of pedicle valve, A16671 (figured by Jones 1928, pl. 25, fig. 3).

FIGURES 74 to 78. *Sowerbyella multiseptata* n.sp.

74. Exterior of pedicle valve, A40978 (magn.  $\times 3.5$ ).  
 75, 76. Internal mould and latex cast of brachial valve, holotype A40976 (magn.  $\times 3$ ).  
 77, 78. Internal mould and latex cast of pedicle valve, G.S.M. 85727a (magn.  $\times 3$ ).

FIGURES 79 to 81 (magn.  $\times 1.5$ ). *Plectodonta lenis* n.sp.

79. Latex cast of external mould of brachial valve and interarea of pedicle valve, A40983a.  
 80. Internal mould of pedicle valve, A40982.  
 81. Latex cast of internal mould of brachial valve, holotype, A40981b.

FIGURE 82 (magn.  $\times 2$ ). *Sowerbyella* sp. External mould of pedicle valve with the postero-median portion of the internal moulds of conjoined valves (dorsal view), A40985.

FIGURES 83 to 85 (magn.  $\times 4$  approx.). *Sericoidea abdita* n.sp.

- 83, 84. External moulds of brachial valves bearing casts of internal moulds, A40989 and A40990 respectively.  
 85. Internal mould of pedicle valve, holotype A40988.

FIGURES 86 to 90. *Leptaena* sp.

86. Latex cast of external mould of brachial valve, A40617 (magn.  $\times 3$ ).  
 87, 88. Internal mould and latex cast of muscle area of pedicle valve, A40613 (magn.  $\times 1.5$ ).  
 89. Internal mould of pedicle valve, A40962b (magn.  $\times 1.5$ ).  
 90. Latex cast of internal mould of brachial valve, A40963 (magn.  $\times 2$ ).

FIGURES 91 to 93 (magn.  $\times 1.5$ ). *Kjaerina* sp.

- 91, 92. Internal mould and latex cast of pedicle valve, A40964b.  
 93. Latex cast of external mould of pedicle valve, A40964a.

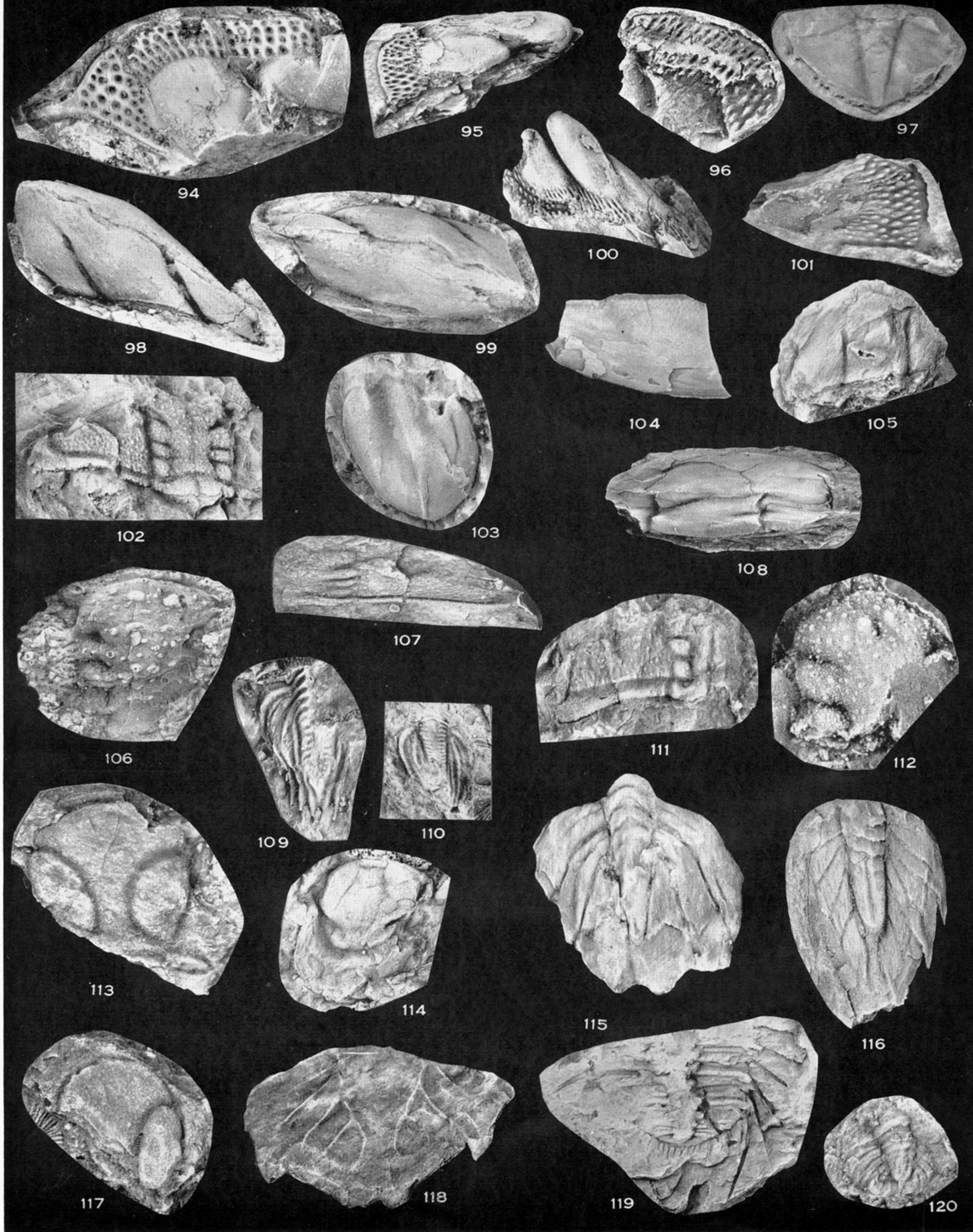


PLATE 40

FIGURES 94 to 96, 100, 101. *Salterolithus* cf. *harnagensis* Bancroft, 1929.

94. Part of left half of cephalon, external view, showing upper lamella of fringe, A 40585 (magn.  $\times 3$ ).

95, 100. Distorted cephalon, dorsal and anterior views, upper lamella of fringe on left side, external mould of lower lamella on right, A 40993 (magn.  $\times 2$ ).

101. External mould of fringe and cheek lobe of left side, internal view, showing reticulated ornament on cheek lobe, A 40994 (magn.  $\times 3$ ).

96. Portion of left side of cephalon, external mould, with cast of fringe attached showing external surface of lower lamella, A 40995 (magn.  $\times 3$ ).

FIGURE 97, *Ampyx* ind.sp. Internal mould of pygidium, A 40996,  $\times 1.5$ .

FIGURES 98, 99, 103 to 105, 108. *Iliaenus* (s.l.) ind.sp.

98, 99. Distorted cranidium, internal mould, dorsal and anterior views, palpebral lobe and branches of suture on right side, A 40997 (magn.  $\times 2$ ).

103. Distorted pygidium, internal mould, A 40580 (magn.  $\times 2$ ).

104. Incomplete distorted pygidium, internal mould, A 40999 (magn.  $\times 1.5$ ).

105. Incomplete cranidium, internal mould, A 40583 (magn.  $\times 3$ ).

108. Crushed cranidium, internal mould, antero-dorsal view, palpebral lobe and branches of suture on right side, A 40998 (magn.  $\times 1$ ).

FIGURES 102, 107, 111. *Ceraurinella?* ind.sp.

102. Incomplete cranidium, internal mould, A 40578 (magn.  $\times 3$ ).

107. Rubber cast of distorted external mould of incomplete cranidium, A 41000 (magn.  $\times 2$ ).

111. Part of cranidium, internal mould, showing genal angle, A 40577 (magn.  $\times 4$ ).

FIGURES 106, 109, 110 *Atractopyge* ind.sp.

106. Rubber cast of external mould of glabella and part of left free cheek, A 40575 (magn.  $\times 3$ ).

109. Incomplete pygidium, internal mould, A 40576 (magn.  $\times 3$ ).

110. Incomplete pygidium, internal mould, A 40579a (magn.  $\times 2$ ).

FIGURE 112 (magn.  $\times 6$ ). Encrinurid? ind. gen. Rubber cast of external mould of anterior portion of glabella, on A 40931.

FIGURES 113 to 118. *Platylichas* ind.sp.

113. Internal mould of part of glabella, A 40573 (magn.  $\times 3$ ).

114. Rubber cast of external mould of hypostome, A 41012 (magn.  $\times 3$ ).

115. Internal mould of pygidium, A 41010 (magn.  $\times 1.5$ ).

116. Internal mould of pygidium, A 41011 (magn.  $\times 2$ ).

117. Internal mould of part of glabella, A 40571 (magn.  $\times 3$ ).

118. External mould of pygidium, A 40574 (magn.  $\times 4$ ).

FIGURE 119 (magn.  $\times 2.5$ ). Odontopleurid ind. gen. Internal mould of part of thorax and pygidium, A 40584.

FIGURE 120 (magn.  $\times 2$ ). Calymenid? Rubber cast of external mould, A 41013.