SOME EARLY ARENIG BRACHIOPODS AND TRILOBITES FROM WALES

BY

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SOME EARLY ARENIG BRACHIOPODS AND TRILOBITES FROM WALES

By DENIS EDWIN BEECHING BATES

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SYNOPSIS

Brachiopods and trilobites from the Lower Arenig Series of Ramsey Island, Carmarthen and Arenig are compared. *Lenorthis alata* (Sowerby), *Orthambonites* sp., *Monorthis menapiensis* (Hicks), *Neseuretus ramseyensis* Hicks, *Megalaspidella* (?) *murchisoniae* (Murchison) and *Megalaspidella* (?) *whittardi* sp. nov. are described, the last species being from the Shelve area.

I. INTRODUCTION AND ACKNOWLEDGMENTS

The lower Arenig (*D. extensus* zone) shelly faunas of South Wales were very early described, by Murchison (1839) from Carmarthen and from Ramsey Island by Hicks (1873). During collection by the writer of the Ramsey Island fauna it became evident that comparison was necessary with topotype material from Carmarthen, where the species *Spirifer alatus* Sowerby and *Ogygia murchisoniae* Murchison had been described in Murchison's Silurian System. It also became necessary to re-examine species of "*Ogygia*" from Dolgellau (*O. selwyni* Salter) and the Shelve region (Whittard 1964).

The writer wishes to acknowledge the help of a number of colleagues and friends in collecting material, especially Dr. A. S. G. Jones, who provided mountaineering assistance on the cliffs of Ramsey Island, Mr. K. Alpress, the owner of the island, and Mr. R. A. Straton, warden of the bird sanctuary at the time of collecting the material. I also wish to thank Professor H. B. Whittington and Professor Alwyn Williams for discussion on some of the trilobites and brachiopods. I am grateful

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Specimens whose numbers are prefixed by " BB." and " It." are in the British Museum, by " NMW." in the National Museum of Wales, by " LL." in the Manchester Museum, by " OUM." in the Oxford University Museum, by " SM.A." in the Sedgwick Museum, Cambridge, and by " GSM." in the Geological Survey Museum.

II. STRATIGRAPHY

In South-west Wales there appears to be a break everywhere at the base of the Ordovician, except possibly in the Carmarthen region (Crosfield & Skeat 1896); on Ramsey Island and in the St. David's region the basal Arenig sediments rest disconformably on Lingula Flags. At least the lower part of the *D. extensus* zone is represented everywhere by arenaceous sediments, followed by the graptolitic Tetragraptus shales. The shelly faunas are best seen today on Ramsey Island, though the succession crops out at Llanveran, Porth Gain and Abercastle on the mainland. At Tremanhire, near St. David's, Hicks (1873 : 41) described a yellow sandstone, not now exposed, containing a shelly fauna, in which the fossils are undistorted.

Pringle (1930), in his description of Ramsey Island, erected the succession:

Tetragraptus Shales	*D. extensus* & *D. hirundo*
Porth Gain Beds	Blue-grey sandy shales with orthids dominant, also lamellibranchs, trilobites, crinoids and asteroids (60 m.)
Abercastle Beds	Grey sandy shales with trilobites and few orthids (27 m.)

These divisions were made following Cox's divisions (1916) in the Abercastle region, mainly on palaeontological differences, though he noted a gradual decrease in grain size from the coarser Abercastle Beds to the chocolate-weathering *Tetragraptus* Shales.

The base of the Abercastle Beds, on the north-east tip of Ramsey Island, was believed by Pringle to be a fault, but Cox *et al.* (1930 : 422) considered the junction to be a disconformity with a thin conglomerate containing *Bolopora undosa* resting on cleaved shales at the top of the Lingula Flags. The succession as measured by the writer is given in Text-fig. 1. Collecting has shown that the palaeontological differences listed by Pringle cannot be used to separate the Abercastle and Porth Gain Beds, and accordingly these divisions should not be used for the beds on Ramsey Island, and the term Ogof Hên Formation is proposed for the strata between the base and the topmost shelly bed. While the writer agrees with Cox *et al.* (1930) that the base of the Arenig is probably marked by a disconformity, there is some shearing along that plane which precludes a categorical assertion of this. Sandy

shales lie above the plane, beneath which are cleaved mudstones without bedding planes, regarded as the topmost preserved beds of the Lingula Flags. About 30 cm. up from the plane a 2 cm. bed of coarse sandstone contains *Bolopora*-like masses (Pl. 1a); it was probably from this horizon that the *Bolopora* recorded by Cox *et al.* was collected. The lower part of the succession is marked by fine current bedded siltstone and sandstone bands, with some evidence of worm burrowing, load casting and convolute bedding (Pl. 1b).

The lowest shelly horizon is about 3 m. above the unconformity, and contains only *Orthambonites* sp. All the other elements in the fauna, with the exception of *Monorthis menapiae*, come in about 30 cm. higher up, where the coarser basal sandstones are succeeded by finer shales. *M. menapiae* is found only in the highest accessible shales, together with *Lenorthis alata* and possibly *Ramseyocrinus* (Bates 1968*b*). No specimens of *Uranaster* were found, and its range is therefore unknown.

At Carmarthen Murchison's type locality for *Spirifer alatus* and *Ogygia murchisoniae* is the old Roman Road at Pensarn, of which the lower 100 m. south-east from Capel y Babell (N.G.R. 41341920) are cut in soft grey shales. A new excavation, on the north-east side of the Roman Road at its lower end, 30 m. east of the Chapel, has furnished the material described here.

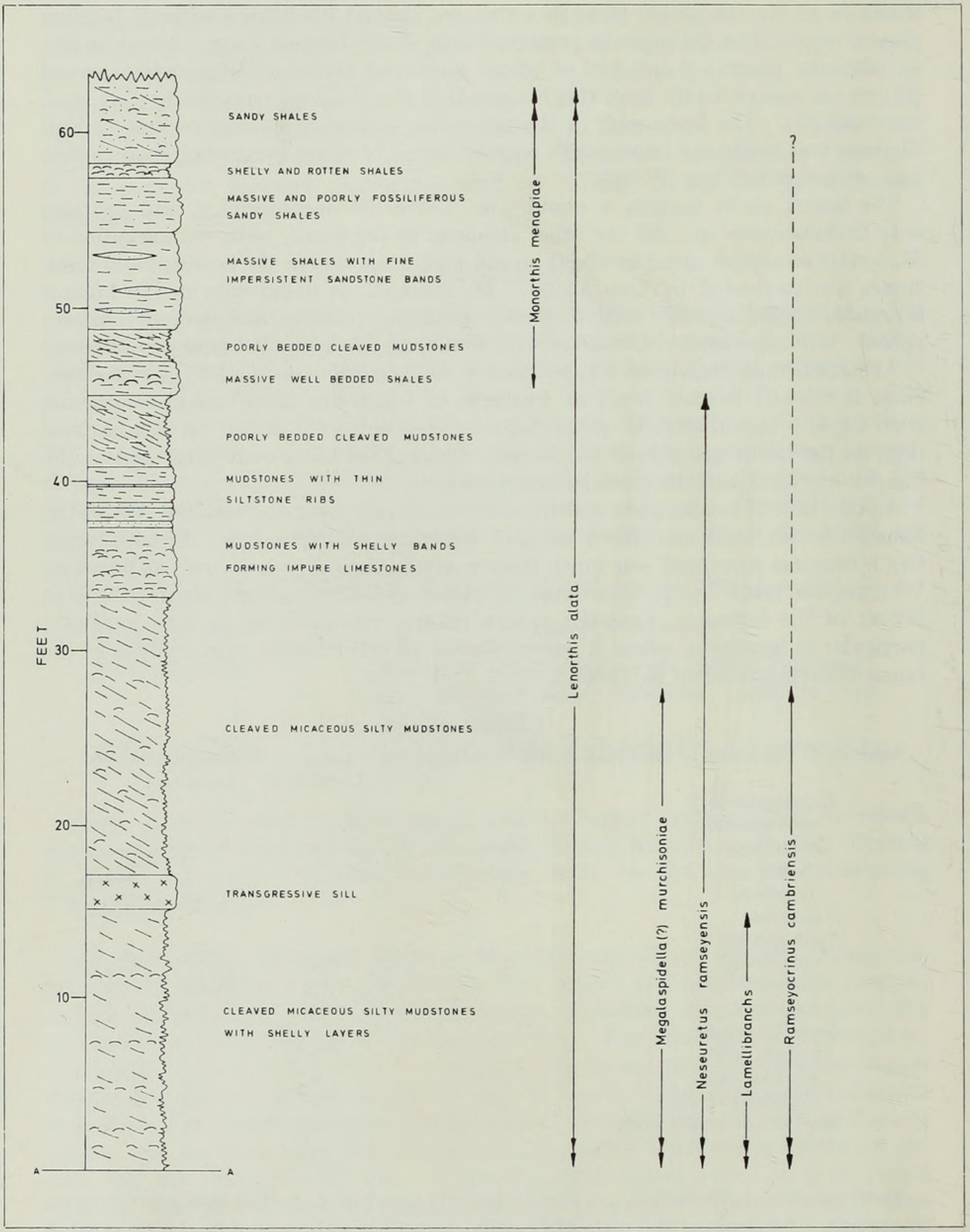
A collection of brachiopods and trilobites was made from the Henllan Ash of the Arenig District, from localities 2 and 4 of Whittington (1966 : 492). In both localities *Neseuretus parvifrons* was much more common than *N. murchisoni*, as noted by Whittington (1966 : 503), disarticulated pieces numbering about eight to one in favour of the former. *Lenorthis proava* (Salter) was common in both localities, particular in locality 4, where it out-numbered all other fossils. An analysis of the fauna collected is given in Table 1.

TABLE 1

Analysis of the fauna of the Henllan Ash from localities 2 and 4 of Whittington (1966).

	Locality 2	Locality 4
Megalaspidella(?) *murchisoniae*		
cranidium	7	3
thorax	0	1
pygidium	11	10
Neseuretus (both species)		
cranidium	16	0
thorax	7	0
pygidium	9	3
Lenorthis proava		
pedicle valve	9	13
brachial valve	6	15
conjoined valves	6	8
Inarticulate brachiopods	1	0
Orthocone nautiloid	3	3

Both species of *Neseuretus* are rare in locality 4, while *Lenorthis* is relatively more abundant. Analysis of the ratio of brachial to pedicle valves, and of the proportion


FEET
60
50
40
30
20
10
A
A
SANDY SHALES
SHELLY AND ROTTEN SHALES
MASSIVE AND POORLY FOSSILIFEROUS SANDY SHALES
MASSIVE SHALES WITH FINE IMPERSISTENT SANDSTONE BANDS
POORLY BEDDED CLEAVED MUDSTONES
MASSIVE WELL BEDDED SHALES
POORLY BEDDED CLEAVED MUDSTONES
MUDSTONES WITH THIN SILTSTONE RIBS
MUDSTONES WITH SHELLY BANDS FORMING IMPURE LIMESTONES
CLEAVED MICACEOUS SILTY MUDSTONES
TRANSGRESSIVE SILL
CLEAVED MICACEOUS SILTY MUDSTONES WITH SHELLY LAYERS
Monorthis menapiae
Lenorthis alata
Megalaspidella(?) murchisoniae
Neseuretus ramseyensis
Lamellibranchs
Ramseyocrinus cambriensis
?

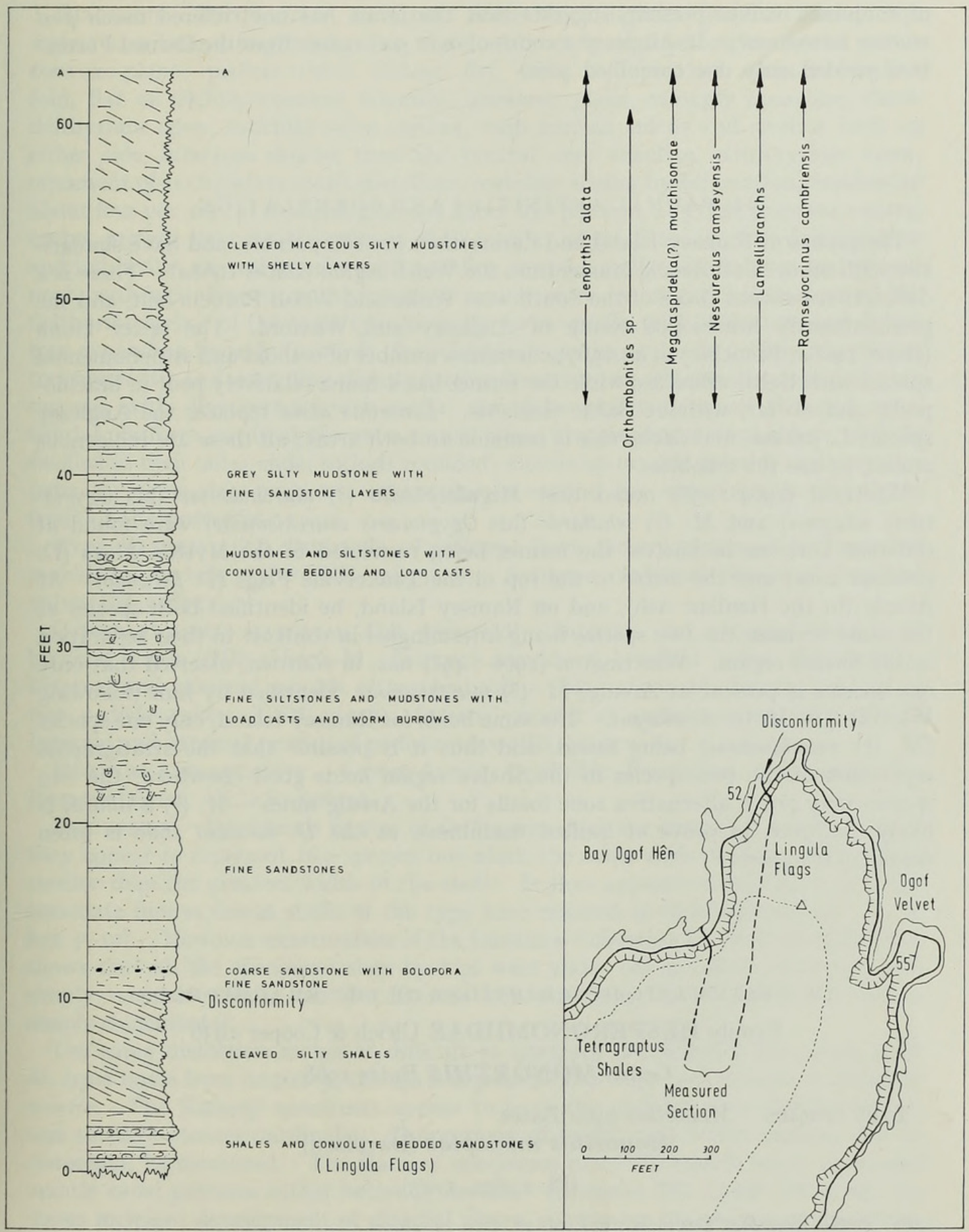


FIG. 1. Section through the Ogof Hên Formation strata at Bay Ogof Hên. Inset map shows the location of the section, at the north-east tip of Ramsey Island.

of conjoined valves present, suggests that the fauna has not suffered much *post mortem* movement. In Anglesey a count of over 500 valves from the Carmel Formation yielded only one conjoined pair.

III. FAUNAL AFFINITIES AND CORRELATION

The faunas of Ramsey Island and Carmarthen are comparable, and have similarities with other basal Arenig faunas from the Welsh region (Bates 1968*a*). There is a distinction between those of the South-west Wales and Welsh Borders belt, and the predominantly brachiopod fauna of Anglesey and Wexford. The latter fauna (Bates 1968*a*, Brenchley *et al.* 1967) contains a number of orthoid and strophomenoid species with Baltic affinities, while the former has a fauna relatively poor in brachiopods, and, so far, without Baltic elements. *Lenorthis alata* replaces the Anglesey species *L. proava*, and *Monorthis* is common to both areas; all these are indigenous stocks, as are the trilobites.

Whittard (1964 : 236) noted that *Megalaspidella* (?) *murchisoniae* (his *Ogygiocaris selwynii*) and *M.* (?) *whittardi* (his *Ogygiocaris murchisoniae*) were found at different horizons in Shelve, the former being restricted to the Mytton Flags (*D. extensus* zone) and the latter to the top of the Tankerville Flags (*D. hirundo*). At Arenig (in the Henllan Ash), and on Ramsey Island, he identified both species at the same horizon, the two species being intermingled in contrast to their separation in the Shelve region. Whittington (1966 : 498) has, in contrast, asserted that only one species is present at Arenig, *M.* (?) *murchisoniae*, identified by him (following Whittard) as *M.* (?) cf. *selwyni*. The same holds for Ramsey Island, only one species (*M.* (?) *murchisoniae*) being found, and thus it is possible that the stratigraphic separation of the two species in the Shelve region holds good elsewhere; the two species may prove alternative zone fossils for the Arenig series. *M.* (?) *whittardi* is likely, however, to prove of limited usefulness, as the *D. hirundo* zone is often devoid of trilobites.

IV. SYSTEMATIC DESCRIPTIONS OF THE BRACHIOPODS

Family **HESPERONOMIIDAE** Ulrich & Cooper 1936

Genus ***MONORTHIS*** Bates 1968

TYPE SPECIES. *Monorthis typis* Bates
Monorthis menapiae (Davidson)

(Pl. 2, figs. 1–13).

1868 *Orthis menapiae* Davidon : 314, pl. 16, figs. 24–28.
1869 *Orthis menapiae* Davidson : 228, pl. 33, figs. 8–12.

DIAGNOSIS. Subquadrate biconvex *Monorthis*, slightly indented anteriorly, widest at a long, straight hingeline, alate, with acute cardinal angles, lateral profile convexo-plane; pedicle valve almost flat, with well marked carinate median fold, flat or slightly concave laterally, interarea plane, strongly apsacline, short, delthyrium open; brachial valve convex, with median sulcus and swollen folds on either side, interarea shorter than the ventral one, anacline, notothyrium open; ornament of both valves multi-costellate, costellae arising by bifurcation, numbering about four per mm. at shell margins and about five per mm. at 5 mm. from the ventral umbo, growth lines visible only at shell margin where they are crowded together and imbricate; ventral interior with receding dental lamellae, teeth blunt and prominent, with well defined crural fossettes, muscle scars extending a little beyond the delthyrial cavity, of the same type as in *Hesperonomiella*, with adductors and diductors expanding linearly forwards, the adductors quadrangular in outline, the diductors crescentic and extending slightly further forwards; mantle canal system probably saccate, with divergent *vascula media*; dorsal interior with small elevated notothyrial platform, cardinal process a simple ridge, brachiophores stout ridges, slightly swollen at their outer ends; sockets rounded; muscle scars with anterior and posterior pairs the same size, both sets subcircular in outline, the anterior pair directly in front of the posterior.

TYPE MATERIAL (All distorted). Lectotype (here chosen): Internal and external moulds of pedicle valve (BB.31873a–b). Syntype: Internal mould of brachial valve (BB.31874).

OTHER FIGURED MATERIAL (All distorted). Internal and external moulds of brachial valve (BB.31897a–b); Internal mould of brachial valve (BB.31898); Internal and external moulds of brachial valve (BB.31899a–b); Internal mould of two pedicle valves (GSM.11938); Internal mould of pedicle valve (BB.31902); Internal and external moulds of pedicle valve (BB.31901a–b).

HORIZON AND LOCALITY. Lower Arenig, Ogof Hên Formation, Bay Ogof Hên, Ramsey Island. N.G.R. 708252.

DISCUSSION. Davidson's figures of *Orthis menapiae* are somewhat misleading, as they appear to represent two species, one alate, the other with the hinge line a little shorter than the greatest width of the shell. It thus appears at first sight that the non-alate figures are of shells of the type here referred to *Orthambonites* sp. (Pl. 5, figs. 7–12). However examination of the Davidson Collection in the British Museum shows that all the specimens seen by him were alate; his non-alate drawings were simply reconstructions, and the likeness between them and *Orthambonites* sp. is simply coincidental.

The same distortion makes it difficult to compare the Ramsey specimens with *M. typis* Bates from Anglesey, though it is possible that they are referable to different species. The Ramsey specimens appear to have the pedicle valve slightly flatter, and to have stouter cardinalia. Proportions of length and width cannot, due to distortion, be measured. The Ramsey specimens have the muscle scars, teeth and mantle canal patterns rather better preserved. Specimen BB.31898 (Pl. 2, fig. 12) shows incipient development of chilidial plates, confirming the placing of this genus in the Hesperonomiidae.

Family **ORTHIDAE** Woodward 1852

Genus ***LENORTHIS*** Andreeva 1955

TYPE SPECIES. *Lenorthis girardi* Andreeva.

Lenorthis alata (J. de C. Sowerby)

(Pl. 2, fig. 14; Pl. 3, figs. 1–7; Pl. 4, figs. 1–10; Pl. 5, figs. 1–6)

1839 *Spirifer alatus* J. de C. Sowerby in Murchison : pl. 22, fig. 7.
1849 *Orthis alata* (J. de C. Sowerby); Salter in Murchison : 55, fig. 15, pl. 5, fig. 6.
1868 *Orthis carausii* Davidson : 315, pl. 16, fig. 23.
1869 *Orthis alata* (J. de C. Sowerby); Davidson : 232, pl. 33, figs. 17–21.
1869 *Orthis carausii* Davidson; Davidson : 229, pl. 33, figs. 1–7.
non 1883 *Orthis carausii* Davidson; Davidson : 182, pl. 14, figs. 21–26.
1911 *Orthis carausii* Davidson; Matley : 78.

DIAGNOSIS. Sub-semicircular ventro-biconvex *Lenorthis* two-thirds as long as wide (in large specimens), approximately one quarter as deep as wide, the pedicle valve being at least twice as deep as the brachial valve; widest at the hinge line, with alate cardinal angles becoming less accentuated with growth, anterior margin not indented; anterior commisure slightly sulcate; delthyrium and notothyrium open; pedicle valve convex but with concave or flattened portions adjacent to the cardinal angles, interarea slightly concave, apsacline, about one-sixth the length of the valve; brachial valve gently convex with a shallow median sulcus and concave flanks to the folds becoming flat towards the cardinal angles, interarea anacline, curved and half the length of the ventral one; ornament on both valves of approximately 40 rounded costae and equal rounded interspaces, strong in the median portion of the valves but becoming fine and crowded towards the hinge lines, with a wavelength of 0·7 mm. at 5 mm. from the dorsal umbo, the pedicle valve bearing a median costa and the brachial valve 4 costae in the sulcus; fine parvicostellae and growth lines present; ventral interior with blunt pyramidal teeth, the posterior faces parallel to the interarea and apparently bearing a central ridge aligned parallel to the edge of the delthyrium: dental lamellae vertical, receding; muscle scars approximately twice as long as the delthyrium and extending one-third the length and one-fifth the width of the pedicle valve, approximately pentagonal in outline with the adductor tracks extending linearly forward and not enclosed by the diductor tracks, the latter extending slightly further forwards than the adductor tracks and with their anterior margins running obiliquely forwards from the dental lamellae making an angle of about 50° with the hinge line; grooves present in the sides of the dental lamellae between the diductor tracks and the margin of the delthyrium; *vascula media* extend from the anterior ends of the diductor tracks and diverge at the same angle; margin of valve deeply crenulate; dorsal interior with socket ridges diverging at just under 90° from each other, short, blade-like on their postero-ventral edges, rounded at their ends, bearing faint curved striae on their outer faces; sockets excavated below the hinge line, split by a subdued median ridge whose growth forms a ridge in the interarea, outside the socket ridge, aligned on the umbo; cardinal process a simple ridge, thickened on its antero-ventral edge, flanked by low accessory ridges; notothyrial

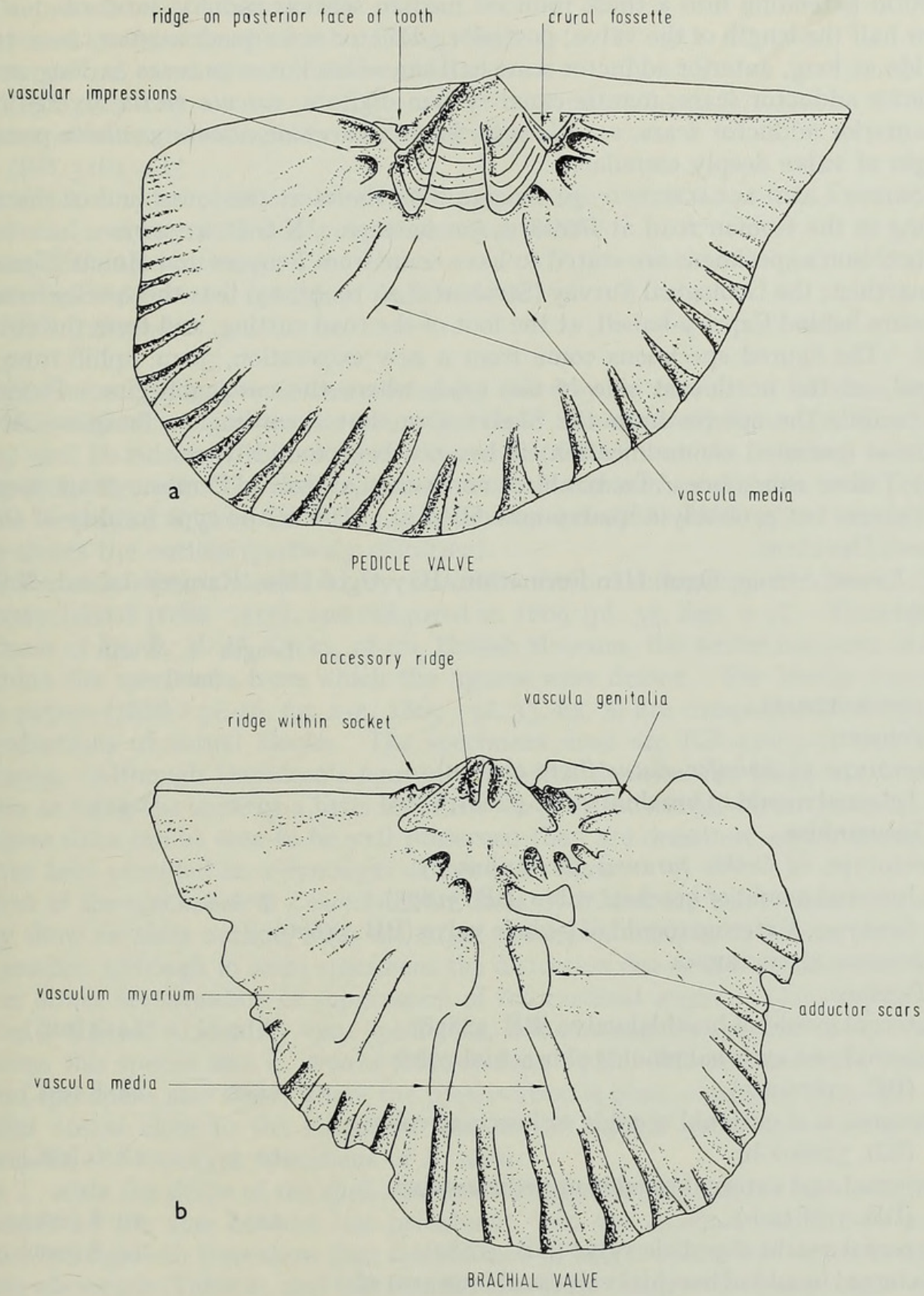


FIG. 2a. Sketch of ventral interior of *Lenorthis alata* (Sowerby), based on specimen BB.31881a (Pl. 4, fig. 2).

FIG. 2b. Sketch of dorsal interior of *Lenorthis alata* (Sowerby), based on specimen BB.31879a (Pl. 4, fig. 1).

platform extending into a thick rounded median septum running forwards for just under half the length of the valve; posterior adductor scars quadrangular, over twice as wide as long, anterior adductor scars half the width but over twice as long as the posterior adductor scars; mantle canal system digitate, *vascula media* diverge from the anterior adductor scars, *vascula myaria* and traces of *vascula genitalia* present; margin of valve deeply crenulate.

Horizons and localities. (a) Friable blue shales at the lower end of the road cutting in the Roman road at Pensarn, Carmarthen. N.G.R. 41341920.

Murchison's specimens are stated to have come from Pensarn and Mount Pleasant, Carmarthen; the Geological Survey (Strahan *et al.* 1909 : 15) lists the species from an exposure behind Capel-y-babell, at the foot of the road cutting, and from the cutting itself. The figured specimens come from a new excavation, 30 m. uphill from the Chapel, on the north-east side of the road, where the cutting begins. Davidson also records the species from the Shelve area, but according to Professor Alwyn Williams (personal communication) it has not been found there.

(b) Yellow sandstones, Tremanhire, north-east of Solva, Pembs.; exact locality not known, but probably a quarry now filled in. This is the type locality of *Orthis carausii* Davidson.

(c) Lower Arenig, Ogof Hên Formation, Bay Ogof Hên, Ramsey Island. N.G.R. 708252.

	Length (mm)	Width
Type material.		
(a) Pensarn		
Lectotype of *Spirifer alatus* (here chosen):		
Internal mould of brachial valve (GSM. 6868)	9·1	24·5
(b) Tremanhire		
Lectotype of *Orthis carausii* (here chosen):		
Internal mould of brachial valve (BB.31875)	7·1	—
Syntype: External mould of pedicle valve (BB.31876)	—	—
Additional material		
(a) Pensarn.		
Internal mould of brachial valve (BB.31878)	8·4	14·4 (est.)
Internal and external moulds of brachial valve (BB.31879 a-b)	14·1	18·8 (est.)
Internal and external moulds of brachial valve (BB.31880a-b)	10·5	18·6 (est.)
Internal and external moulds of pedicle valve (BB.31881a-b)	12·3	19·8 (est.)
Internal mould of pedicle valve (BB.31882)	—	14·8 (est.)
External mould of brachial valve and interarea of pedicle valve (BB.31883)	—	—
External mould of brachial valve (BB.31884)	—	20·6 (est.)
External mould of brachial valve (BB.31885)	—	22·4
External mould of pedicle valve (BB.31886)	11·9	16·2 (est.)

(b) Ramsey Island (All distorted)		
Internal mould of brachial valve (BB.31887)	—	—
Internal and external moulds of brachial valve (BB.31890a-b)	—	—
Internal and external moulds of brachial valve (BB.31893a-b)	—	—
Internal mould of pedicle valve (NMW.29.308.G397)	—	—
Internal and external moulds of pedicle valve (NMW 29.308.G400 & G249)	—	—
Internal and external moulds of pedicle valve (BB.31891a-b)	—	—

Discussion. The species was erected by Sowerby on account of its alate shape, and was originally placed in the genus *Spirifer*. Subsequently Salter (in Murchison 1849) and Davidson (1869) recognized it as an *Orthis*, but the interiors were not adequately figured. The only specimen from Murchison's collection now present in the Geological Survey Collection is here refigured (GSM.6868, pl. 2, fig. 14), but only shows the outline (probably distorted).

Orthis carausii was described by Davidson from Tremanhire, St. David's and Ramsey Island (1868 : 315), and refigured in 1869 (pl. 33, figs. 1–7). Through the kindness of Dr. L. R. M. Cocks, of the British Museum, the writer has been able to examine the specimens from which the figures were drawn. The blocks drawn in both papers (1868 : pl. 16, fig. 23c; 1869 : pl. 33, fig. 5) are composite drawings, not reproductions of actual blocks. The specimens used are BB.31875–7, and block B.13055. Although Davidson's figures, and texts, describe the hinge-width of the valves as being the same or a little less than the greatest width, where the specimens on these slabs can be seen to be well preserved they are definitely alate; the species is thus here accepted as a synonym of *Lenorthis alata*.

Most of the specimens of *Lenorthis* from Ramsey Island can be referred to *L. alata*. They show an alate outline, with the larger specimens tending to be less alate than the smaller, although in some specimens the distortion due to the cleavage has resulted in either accentuation or suppression of the cardinal angles. Their suppression makes it difficult to identify some specimens, and accounts for some of the confusion between this species and *L. proava* (Matley 1912 : 78). Rib-counts of the Ramsey Island specimens also show, where the preservation is good, counts of up to 40, with smaller costae close to the hingeline, and similar muscle scars and mantle canal impressions to topotype specimens of *L. alata*.

In *L. alata* the shape of the shell changes with growth, the outline becoming more quadrate as the alae become less prominent, and the cardinal angles less acute. Statistics of growth lines show that the increase in length relative to width is significantly allometric (Table 2), and this is easily seen from the growth lines in some valves (e.g. Pl. 3, fig. 1).

Muscle scars are well developed and distinctive in both valves. In the pedicle valve the diductor scars are partly impressed on the sides of the dental lamellae, and their anteromedian corners project forwards farther than the adductor scars.

Beneath the margins of the delthyrium and above the diductor tracks are two grooves expanding forwards, either the tracks left by the crural fossettes, or the tracks of pedicle adjustor muscles. In the brachial valve the posterior adductor scars are larger than the anterior scars, wider than long, and with anterior and posterior margins which are both concave inwards towards the centre of the scar.

The teeth and sockets are unusual in the development of double sockets, the outer of which apparently interlocks with a ridge on the tooth, and the inner, which is bounded medianly by the socket ridge, with the inner edge of the tooth (Text-fig. 2). The median partition of the socket leaves a ridge on the inter-area marking its track, diverging slightly anteriorly from the boundary of the notothyrium. This complication in the dentition does not seem to be common, though it may be present in *Lenorthis subconvexus* (Cooper) (Cooper 1956 : pl. 34, fig. 22). A similar ridge is indicated at least in the right hand socket of the specimen illustrated by Cooper, and its track across the interarea is visible. The teeth of *L. alata* may also bear ridges.

The mantle canal system is partially indicated by scars in both valves. The ventral *vascula media* diverge from the anterior ends of the diductor scars, but are only faintly indicated, as are the proximal ends of the *vascula genitalia*, beneath the sockets. It cannot, however, be determined whether the canal system is saccate or digitate, though the system is generally saccate within the *Orthinae*. Traces of the dorsal canal system are more extensive, and elements of the system described by Öpik (1934), figured in Moore (1965, fig. 134), can be recognized in specimen BB.31879 (Pl. 4, fig. 1). The *vascula media* diverge anteriorly from the anterior adductor scars, and are roughly parallel to the *vascula myaria* which originate at the anterolateral corners of the posterior adductor scars. Between the posterior adductor scars and the notothyrial platform the median ridge thickens to twice its anterior width, while small branches from it may represent the transmyarian apophyses of Öpik. Beneath the ends of the socket ridges is a group of three radiating ridges, probably part of the digitate *vascula genitalia*.

TABLE 2

Statistics of length (l) and width (w) of 15 pedicle valves (A) and 30 brachial valves (B) of *Lenorthis alata* (J. de C. Sowerby) from Pensarn, Carmarthen.

	A	B
$\bar{l}$	7·807	7·018
var. l	10·543	9·285
$\overline{\log_e l}$	1·9640	1·8390
var. $\log_e$l	0·1862	0·3016
$\bar{w}$	14·013	14·993
var. w	13·952	27·990
$\overline{\log_e w}$	2·5922	2·6229
var. $\log_e$w	0·0831	0·2032
r_e	0·9092	0·9087
α	1·498	1·219
var. α	0·01296	0·008628
$\log_e\beta$	1·4364	1·1135
var. $\log_e\beta$	0·01645	0·01459

The values of α and β refer to the equation $\log_e w = \log_e\beta + \alpha \log_e l$.

Genus *ORTHAMBONITES* Pander 1830

TYPE SPECIES. *Orthambonites transversa* Pander 1830.

Orthambonites sp.

(Pl. 5, figs. 7–12)

DIAGNOSIS. Sub-semicircular *Orthambonites*, as wide as long(?), width at hinge line less than width of shell, biconvex; pedicle valve with the greater convexity, with rounded median fold, interarea apsacline, curved, delthyrium open; brachial valve with a rounded median sulcus, interarea anacline, shorter than the ventral one, notothyrium open; ornament on both valves multicostellate with the costellae increasing by bifurcation and numbering about three per mm. at 5 mm. from the dorsal umbo; ventral interior with diverging dental lamellae descending vertically to the floor of the valve, teeth not seen, muscle scars extending beyond the lamellae, with crescentic diductors not enclosing triangular adductors and extending farther than them; dorsal interior with simple cardinal process on a raised notothyrial platform, socket ridges short, bladelike, thickened on their outer sides in front of the sockets, supported by bases which converge to the sides of rounded median ridge, sockets mainly excavated in hinge line, muscle scars quadripartite, with anterior pair slightly larger than the posterior pair.

HORIZON AND LOCALITY. Ogof Hên Shales, Bay Ogof Hên, Ramsey Island. N.G.R. 708252.

FIGURED SPECIMENS:—(All distorted). Internal mould of brachial valve (LL.3182); Internal mould of brachial valve (LL.3184); Internal mould of brachial valve (NMW.29.308.G360); Internal mould of brachial valve (NMW.29.308.G31); Internal mould of pedicle valve (BB.30900).

DISCUSSION. Externally the species is very similar to *Nanorthis* Ulrich & Cooper, though this genus has a rudimentary cardinal process and a poorly developed notothyrial platform. *Nothorthis* Ulrich & Cooper is similar but more transverse, and has a rudimentary cardinal process and a well developed notothyrial platorm. The closest species are from the Upper Pogonip of Nevada, *Orthambonites bifurcatus* Cooper, and *Orthambonites eucharis* (Ulrich & Cooper). Differences are few; in particular the distinctions between the two American species seem very finely drawn, and are mainly in the shape of the costellae. The Welsh species does not have a median ridge anterior to the ventral muscle scars, and the brachial valve may be more convex.

V. SYSTEMATIC DESCRIPTIONS OF THE TRILOBITES

Family **ASAPHIDAE** Burmeister 1843

DISCUSSION. The most recent subdivision of the large family Asaphidae is that of Jaanusson (in Moore 1959), where seven subfamilies are recognized, on a variety of criteria.

In the Asaphinae the glabella has a pair of oblique furrows, which gives it a

distinctive shape; the occipital ring is not constricted medianly, the hypostome is deeply notched, and the glabellar tubercle is far back. Of these characters, the first is confined to this subfamily. The Promegalaspidinae are unique in that the eighth thoracic segment is developed as macropleurae; also they have the occipital ring without a median constriction, the hypostome is notched, the glabellar tubercle is situated forward from the occipital ring by at least the length (sag.) of the ring. The Symphysurinae have a glabellar tubercle which is situated very far forwards, between the centres of the eyes; the occipital ring may be longest (sag.) medianly, and the hypostome appears to have a rounded posterior margin. The Thysanopyginae have a spinose pygidial border, together with a rounded posterior border to the hypostome, and a glabellar tubercle which is situated far back.

Thus these four subfamilies are distinct from each other, and the rest of the Asaphidae, in at least one character in each subfamily: oblique glabellar furrows, macropleurae, a glabellar tubercle placed very far forwards, and a spinose pygidium. All these characters are lacking in the other three subfamilies, the Isotelinae (groups A and B), Niobinae, and Ogygiocaridinae. The distinctions between these groups are less clear in the *Treatise*. The glabellar tubercle occupies a similar position in all four, the hypostomes all have triangular anterior wings, and the pygidium is rounded or bears a median spine.

Differences occur chiefly in the form of the occipital ring, and the posterior margin of the hypostome. The occipital ring in the Ogygiocaridinae and in group B of the Isotelinae is restricted medianly where seen, and has a posterior band corresponding to the articulating half ring of the first thoracic segment (Henningsmoen (1960 : 210). The posterior margin of the hypostome is strongly concave to deeply notched in the Niobinae; otherwise it is rounded, straight or pointed.

Consideration of these points suggests that Group A of the Isotelinae can be conveniently joined with the Niobinae, as comprising a subfamily with a notched or concave hypostome, and with an unrestricted occipital ring where seen (Isotelinae Angelin 1854). Group B and the Ogygiocaridinae can also be united, as comprising forms with an entire hypostome, and an occipital ring restricted where seen (Ogygiocaridinae Raymond 1937). The two groups are, however, probably closely related, and may have diverged in the Tremadoc from an ancestral form such as *Niobella*, with a rounded posterior margin to the hypostome, and an almost smooth glabella, in which the occipital ring was not restricted medianly. From this root stock the Isotelinae diverged, with progressively greater emargination of the hypostome, as in the sequences *Niobella—Niobe, Protopresbynileus—Presbynileus, Isoteloides—Isotelus—Homoteloides*. The glabella remained smooth, and all traces of the occipital ring vanished. There is also a tendency for the glabella to be parallel-sided in the early forms, and to expand in front of the eyes in later genera.

In the Ogygiocaridinae the hypostome remained rounded, or pointed, and the glabella in many of the later genera, became furrowed, and expanded forwards. The occipital ring was constricted medianly, with a well developed posterior band.

Some genera are difficult to place in this scheme. *Pseudogygites* seems, from its glabella, to be a member of the Ogygiocaridinae, but is thought by Jaanusson (in Moore 1959 : *O*343) to have a notched hypostome. *Megistaspis*, with an unrestricted

occipital ring and notched hypostome, is here put in the Isotelinae, while its subgenera *Megistaspidella* and *Ekeraspis* are assigned to the Ogygiocaridinae.

Stratigraphically the Isotelinae range from the Tremadoc to the upper Ordovician, while the Ogygiocaridinae became extinct during the middle Ordovician (in a broad sense). The two subfamilies also have different geographical distributions. The Ogygiocaridinae are found in Europe and South America, and appear not to have penetrated North America. On the other hand the Isotelinae are not found in South America, but are common in North America, particularly in the Upper Ordovician.

Subfamily **OGYGIOCARIDINAE** Raymond 1937

DIAGNOSIS. Glabella tapering forwards, parallel sided or expanding in front of eyes; glabellar tubercle situated far back, well behind level of eyes; occipital ring where recognizable constricted medianly usually with a posterior band developed; hypostome with triangular anterior wings, posterior margin rounded to pointed (faintly concave in some species of *Asaphellus*); pygidium with rounded posterior margin or with median spine.

Genus ***MEGALASPIDELLA*** Kobayashi 1937

TYPE SPECIES *Megalaspidella kayseri* Kobayashi 1937.

Megalaspidella (?) ***murchisoniae*** (Murchison)

(Pl. 6, figs. 1–6; Pl. 7, figs. 1–9; Pl. 8, figs. 1, 2, 5).

1839 *Ogygia Murchisoniae* Murchison : 664, pl. 25, figs. 3a, 3b.
1852 *Asaphus Selwynii* Salter : 57.
1873 *Niobe menapiensis* Hicks : 46, pl. 4, figs. 1–9.
1873 *Niobe solvensis* Hicks : 47, pl. 4, figs. 10–16.
1896 *Ogygia marginata* Crosfield & Skeat : 538–539, pl. 26, figs. 13–26.
1906 *Ogygia marginata* Crosfield & Skeat; Evans : 603, 606, 608.
1907 *Ogygia marginata* Crosfield & Skeat; Strahan *et al.* : 10, 14–15.
1931 *Ogygia marginata* Crosfield & Skeat; Reed : 461.
1964 *Ogygiocaris selwynii* (Salter); Whittard : 232–238, pl. 34, figs. 7–13, pl. 35, figs. 1–10, pl. 36, figs. 1–7, pl. 37, figs. 1–11 (see also for earlier references).
1964 *Ogygiocaris murchisoniae* (Murchison); Whittard : 238–241, pl. 38, figs. 5–11 (see also for earlier references).
1964 *Ogygiocaris marginata* (Crosfield & Skeat); Whittard : 237, 241, pl. 36, figs. 8–10.
1966 *Ogygiocaris*? cf. *selwyni* (Salter); Whittington : 496–499, pl. 2, figs. 7–12, pl. 3, pl. 4, fig. 16.
1968a *Ogygiocaris selwynii* (Salter); Bates: 179–180, pl. 12, figs. 1, 2, 5, 6.

DIAGNOSIS. A species of *Megalaspidella*(?) with the anterior branches of the facial sutures diverging at about 100–120°; the glabella expanding slightly in front of the eyes and encroaching onto the anterior border; with or without hypostomal pits; pygidium with seven to nine axial rings and six to eight pleural furrows.

TYPE HORIZON AND LOCALITY. *Tetragraptus* Beds, Arenig Series, Roman Road, Pensarn, Carmarthen. N.G.R. 413192.

TYPE MATERIAL. (distorted). Holotype: Internal and external moulds of dorsal carapace. (GSM.18988 and counterpart).

OTHER MATERIAL.

(a). Pensarn, Carmarthen.

Internal and external moulds of cranidium (It.5805a-b); Internal and external moulds of carapace (It.5806a-b); Internal mould of hypostome (It.5807); Internal mould of pygidium (It.5808); Internal and external moulds of pygidium (It.5809a-b).

(b). Glan Pibwr, Carmarthen.

Internal mould of cranidium (SM.A.3118).

(c). Ramsey Island.

Internal mould of cranidium (OUM.B6); Internal mould of cranidium (It.5810); Internal mould of cranidium (SM.A.45141); External mould of dorsal carapace (NMW.29.308.G275); Internal mould of dorsal carapace (NMW.29.308.G219); Internal mould of hypostome (OUM.B183); Internal mould of pygidium (NMW.29.308.G28); Internal mould of pygidium (NMW.29.308.G422); Internal and external moulds of pygidium (It.5811a-b).

DESCRIPTION. Cephalon about twice as wide as long, semicircular in outline, with probably a slight change in curvature medianly. Glabella twice as long as wide, with a semicircular anterior margin and probably a slight constriction at half its length (sag.), opposite the eyes; gently convex, with a domed anterior portion. Glabella furrows if present very weakly impressed. Axial furrows weakly impressed, with shallow hypostomal pits. Fixigenae divided into two by constriction at the level of the palpebral lobes; posterior portion sub-triangular, palpebral lobes semicircular, close to glabella. Anterior border narrow medianly, possibly with a dorsally raised ridge on the midline. Occipital ring not well seen; delimited by a posterior band which is marked off by a curved furrow, convex forwards, and by very faint traces of the occipital furrow, inclined inwards and backwards from the axial furrows, commencing from in front of the posterior border furrows. Glabellar turbercle immediately in front of the occipital ring. Facial suture crosses the posterior border about midway between the axial furrow and the genal angle, inclined forwards and outwards from the margin of the cephalon, but curving immediately round to cross the posterior border furrow running directly forwards, and then describing a sigmoidal curve to the eyes. Anterior branches curve outwards and describe a similar sigmoidal curve, diverging from each other at more than 90°. The angle of divergence of the facial sutures is greatest where the sense of curvature of the suture changes from concave outwards to concave inwards. It is measured between tangents drawn to the sutures at these points. After crossing the inner margin of the anterior border the anterior branches curve round steadily to converge towards the margin, meeting it with a slight acumination at the midline, or possibly following the margin for a short distance on either side of the midline. The median suture may not therefore appear dorsally but this is difficult to verify. Librigenae large, provided with long genal spines. Lateral border broad and concave dorsally, defined by a wide shallow furrow which extends onto the fixigenae and meets the axial furrow at the hypostomal pit. Posterior border wide, defined by a furrow

broader than the border itself, deepest on the fixigenae, widening and becoming shallow laterally before it fades out against the lateral border. Dorsal surface of cephalon apparently without terrace lines, but doublure of librigenae with well defined lines extending along the genal spine.

Hypostome known from poorly-preserved and incomplete specimen. Median body longer than wide. Anterior lobe much larger than posterior one, gently convex, defined by lateral furrows extending inwards towards the maculae, which are linked by a shallow median groove. Posterior lobe sickle-shaped, with indistinct maculae. Posterior border narrow medianly, rounded, with possibly a slight median point. Anterior wings small, triangular. Ornament of terrace lines parallel to the posterior border, but concave forwards across the median body and anterior wings to cross the anterior margin and become confluent with the terrace lines on the doublure of the librigenae.

Thoracic segments not well preserved, axis narrower than pleurae, convex, tapering only slightly backwards; pleurae with pleural furrows developed as broad concavities, ending in blunt spines.

Pygidium approximately as long as wide, with the posterior margin either semicircular or slightly acuminate medianly. Axis evenly tapering, of about eight axial rings and a semicircular terminal piece. Axial furrows broad and well defined. Pleurae with about six faint pleural furrows. Border broad, concave dorsally with a ridge on its inner margin, having a steep inner face. Doublure convex ventrally, with an evenly curved inner margin lying directly beneath the inner edge of the border, and bearing terrace lines parallel to its margin.

Discussion. Whittard (1964 : 238) redescribed *Ogygiocaris murchisoniae* (Murchison), mainly from specimens collected in the Shelve area, but asserted that the holotype of the species, from Pensarn, Carmarthen, differed from *O. selwynii* in having anterior facial sutures diverging at about 45°, a frontal glabellar lobe which stops short of the anterior border, and in having no hypostomal pits. In addition a topotype pygidium had at least eight axial rings and five pleural pairs.

The writer has collected topotype material from Pensarn, and has re-examined the holotype; it is here claimed that *O. murchisoniae* is a synonym of *O. selwynii* as understood by Whittard. In the holotype of *O. murchisoniae*, especially in the external mould (Whittard 1964 : pl. 38, fig. 6), the anterior branches of the facial sutures diverge at about 95° (as the specimen is laterally compressed this must be an underestimate). The glabella also encroaches on the anterior border, reducing its width by at least half. Hypostomal pits have not been seen in any of the specimens, with the possible exception of It.5805 (Pl. 6, fig. 4).

The topotype pygidium figured by Whittard (1964 : pl. 38, fig. 7) as having at least eight axial rings and five pleural pairs is badly crushed and distorted. Specimen It.5806 (Pl. 6, figs. 1–2) has seven axial rings and a terminal piece, and about six pleural furrows.

The Pensarn specimens, therefore, differ significantly from *O. selwynii* of the Shelve region only in the apparent absence of hypostomal pits, and are probably conspecific with that species. The holotype of *O. selwynii* (SM.A.44425, Whittard

1964 : 236, pl. 37, fig. 1) from Hengwrt-uchaf, near Dolgellau, is, as Whittard states, poorly preserved, and shows possibly five or six axial rings followed by a relatively long terminal piece, and six or seven pleural furrows. It is possible that there may have been seven or eight axial rings present. Thus it appears probable that *O. selwynii* from its type locality is conspecific with *O. murchisoniae*, and as the earlier described species, the latter must take precedence.

The specimens identified by Whittard from the Shelve region as belonging to *O. murchisoniae* (1964 : 238–241, pl. 37, figs. 12–13, pl. 38, figs. 1–4) do, however, differ significantly from *O. murchisoniae* from Pensarn and *O. selwynii* from Shelve; they are here referred to a new species, *Megalaspidella*(?) *whittardi*.

Hicks (1873 : 46–47) described two species from the basal Arenig beds of Ramsey Island, *Niobe menapiensis* and *N. solvensis*. On re-examination of the type material, Whittard (1964 : 240) put both species into *O. murchisoniae* and considered them to be sexual dimorphs. Whittard refigured two cranidia of *N. menapiensis* (1964 : pl. 38, figs. 9–10). The original of fig. 9 (OUM.B6) is here refigured (Pl. 7, fig. 1) after further excavation from the matrix; the eye is further back than in *M.*(?) *whittardi*, the anterior branches of the facial sutures diverge at about 90° (the specimen is laterally compressed and this is therefore an underestimate), and there appear to be no hypostomal pits. The original of Whittard's fig. 10 (GSM.10174) is axially compressed, but still shows facial sutures which are widely divergent, and a glabella which encroaches on the anterior border. The writer has not seen any cranidia from Ramsey Island in which the anterior branches of the facial sutures diverge at less than 60°, and this is in axially compressed specimens; all the material from Ramsey Island is here identified as *O. murchisoniae*. Specimen SM.A.45141 (quoted by Whittard in error as SM.A.45142) is here refigured; it was identified by Whittard (1964 : 236) as a definite *O. selwynii* from Ramsey Island.

Whittard claimed that the pygidia from Ramsey Island showed a sexual dimorphism, one form being relatively longer than the other. It is difficult to check this, as the pygidia are all distorted, and their proportions may have been greatly altered. Distortion and compression also make it difficult to count the axial rings and pleural furrows on the pygidia, as these features are but faintly impressed even in well preserved specimens. A maximum of nine axial rings and a terminal piece has been observed (in NMW.29.308.G422; Pl. 8, fig. 2) and seven pleural furrows (in NMW.29.308.G148; Pl. 7, fig. 4); eight and six respectively are average figures for both measurements.

Ogygia marginata Crosfield & Skeat is here identified as a synonym of *M*(?) *murchisoniae*. Whittard recognized it as a valid species (1964 : 237, 241) in which the divergence of the anterior branches of the facial sutures is 100°, hypostomal pits occur, and the pygidium has nine axial rings and nine pleural furrows. It is thus only slightly different from *M*(?) *murchisoniae*.

The generic position of "*Ogygia*" *murchisoniae* is in some doubt (Whittington 1966 : 499). Of the genera assigned to the Asaphidae, five are close:— *Hoekaspis* Kobayashi, *Megalaspidella* Kobayashi, *Ogygiocaris* Angelin, *Ogyginus* Raymond, and *Ogygiocarella* Harrington & Leanza.

The facial sutures in "*O*" *murchisoniae* are definitely intramarginal or isoteliform

(NMW.29.308.G219; Pl. 7, fig. 7); this excludes *Ogygiocarella* and *Ogyginus*, but, as Whittard says (1964 : 232), the differences between the two types of suture are very slight, and there may not be any fundamental difference between them. Variations can be seen in the Ramsey Island specimens: in some the anterior portions are almost straight, meeting in a blunt point (It.5810; Pl. 7, fig. 3), but in others (NMW.29.308.G219; Pl. 7, fig. 7) there appears to be an even curve, which is tangential to the margin on the midline.

The glabella shows a slight expansion in front of the eyes, and a slight taper from the posterior margin to the eyes. This shape is characteristic of all the genera, with the exception of *Megalaspidella*, in which the glabella tapers evenly forwards. Glabella furrows are almost obsolete in the British species, as they are in *Megalaspidella*, and almost so in *Hoekaspis*. *Ogygiocarella*, and to a lesser extent *Ogyginus* and *Ogygiocaris*, have furrows developed.

The occipital ring is also used as a diagnostic feature. In all these genera, it is poorly developed, or not differentiated, and consists of a band, limited posteriorly against a lenticular or spindle-shaped area (the posterior band of Henningsmoen, 1960 : 210) which overlies the articulating half-ring of the first thoracic segment. The occipital ring is restricted medianly where seen in all the genera, and is defined in front by a pair of faint furrows, commencing just in front of the posterior border furrows, and running inwards and backwards, but fading out before reaching the midline. The glabellar tubercle is just in front of a line joining the two posterior border furrows. In *Megalaspidella* the occipital ring is not differentiated by these furrows, but it is faintly developed in one species of *Hoekaspis*. In the other genera it is clearly developed.

The hypostomes of the genera offer no clear cut differences between them. All have rounded or slightly acuminate posterior margins.

The pygidia of the genera are stated to differ in the following features: the number of axial rings and pleural furrows, the presence or absence of interpleural furrows, the width of the border, and the nature of the inner margin of the doublure. Whittard regarded pygidial differences of less than generic importance (1964 : 231). *Ogygiocaris*, as restricted by Henningsmoen (1960 : 216) has a scalloped margin to the pygidial doublure; all the species described by him are of middle Ordovician age (Llanvirn). Of Whittard's species from Shelve, *O. seavilli* (Whittard 1964 : 241) has a margin of this type, and is of Llanvirn age: it appears to be the only species referable to *Ogygiocaris* on these criteria from outside the Oslo region.

Thus *Hoekaspis* is close, in its glabella, facial suture and pygidium. It does, however, differ in that the librigenae have a convex border, and that the occipital furrows are better developed. *Megalaspidella* also is close, but has the glabella tapering forwards, has no glabellar furrows (as preserved), and has the anterior branches of the facial sutures diverging at a small angle (cf. "*Ogygia*" *whittardi*). Whittington (1966 : 499) compared the material from Arenig with *Megalaspidella*, pointing out that the chief differences were in the shape of the glabella and the course of the facial suture.

A generic assignation of these species is thus very difficult to make. An obvious course would be to erect a new genus for their reception, but this the writer hesitates

to do: some of the differences between existing genera seem finely enough drawn. Stratigraphically *Megalaspidella* is closest to the British species.

Megalaspidella(?) *whittardi* sp. nov.

1964 *Ogygiocaris murchisoniae* Whittard : 238–241, pl. 37, figs. 12–13; pl. 38, figs. 1–4 (non 5–11).

Diagnosis. A species of *Megalaspidella*(?) with the anterior branches of the facial sutures diverging at about 40°; the glabella parallel sided without a definite expansion anteriorly; the frontal lobe of the glabella stopping short of the anterior border; without hypostomal pits; the pygidium having nine to ten axial rings and six pleural furrows.

Type specimens. Holotype: internal mould of cranidium (GSM.85363, Whittard 1964 : pl. 38 fig. 3). Paratypes: internal mould of cephalon and thorax (Wattison Coll. W. 25); internal mould of partial cephalon and thorax (GSM.85364); internal mould of thorax and pygidium (GSM.85365); external mould of cranidium, thorax and pygidium (GSM.85362); external mould of pygidium (GSM.85366).

Type horizon and locality. Upper Arenig, *D. hirundo* zone, Tankerville Fags, Bergam Quarry, 330 yds. east-north-east of the Tankerville Mine, Shelve, Shrops.

Discussion. The species was described fully, and the type specimens figured, by Whittard (see synonymy above). Reasons for erecting this species are given in the discussion of *M.*(?) *murchisoniae* (p. 20).

Family **HOMALONOTIDAE** Chapman 1890

Genus ***NESEURETUS*** Hicks 1873

1873 *Neseuretus* Hicks : 44.
1898 *Synhomalonotus* Pompeckj : 240.
1925 *Neseuretus* Vogdes : 106.
1960 *Neseuretus* Whittard : 138–141.
1966 *Neseuretus* Whittington : 499–500.

Type species. *Neseuretus ramseyensis* Hicks 1873.

Discussion. *Neseuretus* has generally been treated as a synonym of *Synhomalonotus* Pompeckj, but Whittard (1960 : 138) showed that it takes precedence over the latter. He designated *Calymene parvifrons* as the type species, as he identified the first of Hicks's species, *N. ramseyensis* (Hicks 1873 : 44) as being conspecific with that species. However it is here claimed that *N. ramseyensis* is specifically distinct from *N. parvifrons*, and thus it should become the type species, as selected by Vogdes (1925 : 106).

Neseuretus ramseyensis Hicks

(Pl. 8, figs. 3, 4, 6–12; Pl. 9, figs. 1–3, 6).

1873 *Neseuretus ramseyensis* Hicks : 44–45, pl. 3, figs. 7–10, 16–22.
1873 *Neseuretus quadratus* Hicks : 45, Pl. 3, figs. 11, 13, 23–26, non fig. 12.
1873 *Neseuretus recurvatus* Hicks : 45, pl. 3, figs. 5–6.
1873 *Neseuretus? elongatus* Hicks : 45, pl. 3, figs. 1–3.
1873 *Neseuretus elongatus* var. *obesus* Hicks : pl. 3, fig. 4.
?1900 *Neseuretus recurvatus?* Hicks; Reed : 305, pl. 12, fig. 4.
?1900 *Neseuretus quadratus?* Hicks; Reed : 305–306, pl. 12, fig. 6. (quoted in error as fig. 5.).
?1900 *Neseuretus* sp. Reed : 306, pl. 12, fig. 5 (quoted in error as fig. 6).
1911 *Calymene tristani* (*Neseuretus ramseyensis*) Pringle : 558.
1918 *Calymene* (*Neseuretus? elongatus*) sp. Reed : 319.
1930 *Calymene* (*Neseuretus? elongatus*) sp. Pringle : 9.
1930 *Calymene tristani* Brongniart; Pringle : 12.
?1960 *Neseuretus grandior* Whittard : 141–142, pl. 20, figs. 1–2.
1960 *Neseuretus paryifrons* (Salter); Whittard : 145–146.
1960 *Neseuretus murchisoni* (Salter); Whittard : 148–150, pl. 21, figs. 1–2, *non* pl. 20, figs. 6–15.

Diagnosis. A species of *Neseuretus* with probably a thin upturned anterior brim and border furrow, bearing canals on the border which may spread onto the preglabellar area; a distinct furrow in front of the glabella, indistinct glabellar furrows and well defined semicircular alae; the pygidium bearing eight to nine axial rings and a semicircular terminal piece, and eight pleural furrows, with faint interpleural furrows present towards the lateral borders.

Type horizon and locality. Lower Arenig, Ogof Hên Formation, Bay Ogof Hên, Ramsey Island. N.G.R. 708252.

Type material. Lectotype (selected by Whittard 1960 : pl. 21, fig. 1): GSM. 10166 (Hicks 1873 : pl. 3, fig. 10), cranidium. Syntypes are cranidium SM.A.45277 (Hicks 1873 : pl. 3, fig. 9; Whittard 1960 : pl. 21, fig. 2); cranidium SM.A.45276.

Other figured material. Cranidium (OUM.B9) (Hicks 1873 : pl. 3, fig. 12, syntype of *N. quadratus*); cranidium (It.5812); cranidium (It.5813); cephalon and thorax (NMW.29.308.G240a-b); pygidium (NMW.29.308.G168); pygidium (NMW. 29.308.G211); cranidia (SM.A.16732–3) (Hicks 1873 : 45, pl. 3, figs. 2–3, syntypes of *N.? elongatus*); dorsal carapace (L.10172) (Hicks 1873 : 45, pl. 3, fig. 1, syntype of *N.? elongatus*).

Description. Cranidium roughly trapezoidal in outline, original proportions not known. Glabellar outline nearly trapezoidal, with anteriorly convergent lateral margins and frontal margin slightly curved forwards; convexity variable (due to distortion), but longitudinally with a steep anterior profile. Two pairs of glabellar furrows commonly preserved; the posterior pair (1p) steeply inclined backwards from the axial furrow; second pair (2p) less steeply inclined, less deep, and not extending so far across the glabella. Faint median longitudinal ridge occasionally developed, and indications of subcircular muscle scars on the second glabellar lobes (2p) faintly preserved. Axial furrows well marked; hypostomal pits present at the

antero-lateral corners of the glabella, preglabellar furrow well marked. Preglabellar area appreciably less than the length (sag.) of the glabella, inflated (probably due to distortion), marked off by the curving back of the anterior border furrows to the front of the glabella, with a variably accentuated marginal furrow and border. Border upturned, and sharply deflected downwards to define a thin brim as in *N. murchisoni* (Whittard 1960 : 149). Canal system present on the brim, occasionally also on the preglabellar area. Fixigenae about equal to half width of glabella at the level of the eyes. Paraglabellar areas faintly outlined, semicircular in outline and about the same size as the basal glabellar lobes. Occipital furrow well marked, flexed forward medianly; posterior border furrow broad (exsag.); occipital ring convex, widest medianly; posterior borders widening laterally. Facial suture gonatoparian, posterior branch sigmoidally curved; palpebral lobe crescentic in outline, probably spanning the interval between the centres of the 2p and 3p glabellar lobes, but distortion makes this very difficult to check; anterior branch extending slightly inwards to the anterior border.

Thorax of thirteen segments, axis approximately one third the total width. Articulating furrow deepening distally (cf. *N. parvifrons*, Whittington 1966 : 502, pl. 5, fig. 2). Pleural furrows deep and narrow broadening distally; tip rounded, with a broad facet. Apodemes prominent pits on internal mould.

Pygidium oval in outline, broader than long. Axis tapers uniformly to a semicircular terminal piece which does not reach the posterior margin. Articulating half-ring and furrow followed by eight to nine axial rings. Axial furrows converge uniformly to the last axial ring, then become almost parallel for a short distance before curving round the terminal piece. Pleural regions divided by seven to eight pleural furrows, including the anterior border furrow, all of which curve forwards slightly at the margin. Occasionally faint interpleural furrows present distally (seen on internal moulds). Doublure narrow and convex ventrally.

Discussion. When Hicks erected *Neseuretus*, from Ramsey Island and Tremanhire, he described the pygidium as having eight to ten axial rings, as this was characteristic of all the species included by him (Hicks 1873 : 44, pl. 3). Whittard (1960) re-examined Hick's types, redefined *Neseuretus*, and referred *N. quadratus*, *N. elongatus obesus*, *N. ramseyensis* and *N. recurvatus* to *N. murchisoni* (Salter). *N.? elongatus* he identified as *N. parvifrons* (M'Coy). Whittard stated that he did not study the pygidia in detail (1960 : 139), as the species of *Neseuretus* are mainly defined on the cephala.

An accurate description of the Ramsey Island specimens is difficult, particularly in terms of relative proportions, as the specimens are all distorted, and this distortion has affected the preservation of the glabellar furrows, the anterior furrow, and the palpebral lobes. The cranidia found are mostly similar to *N. murchisoni*, in that an anterior border furrow is present, with a thin and forwardly projecting border in front. The glabella is trapezoidal in outline, though the amount of taper cannot be directly compared with either *N. murchisoni* or *N. parvifrons*, due to the distortion. Two pairs of glabellar furrows are present, and are similar in attitude to those in both *N. murchisoni* and *N. parvifrons*; the third pair, which is very faint in both

those species, may be present but obliterated. The facial sutures converge anterior to the eyes, and the palpebral lobes extend from the level of the 2p glabellar lobes to the presumed level of the 3p lobes, but again this is only an estimation. In general the width of the fixigenae (tr.) at the level of the eyes is less than or equal to half the width of the glabella.

The preglabellar furrow is deeper than in either *N. parvifrons* or *N. murchisoni*, though it is in many specimens accentuated by distortion. It is also probable that the glabellar furrows were less accentuated than in those species, as even in specimens where other transverse furrows have been deepened with the distortion they still remain faint.

In several specimens (e.g. It.5813, Pl. 8, fig. 10) the internal moulds have a peculiar pattern of furrows on the glabella, representing original ridges on the ventral surface of the carapace, though the glabellar furrows cannot be fully made out. Two longitudinal furrows in the anterior half of the glabella enclose a lenticular area, while the rear half, apparently on the 2p glabellar lobes, is marked by two furrows with circular outlines, parts of which may be made by the glabellar furrows. The paired appearance of these furrows suggests that they are an original feature, perhaps accentuated by the compression and distortion of the fossil, although the glabellar furrows have apparently been obliterated. Whittard (1960 : 148) has described similar features in *N. murchisoni*, in the form of a faint median glabellar ridge, and in oval or nearly circular depressed areas on the second lobes. The latter he suggested were muscle scars.

A few *Neseuretus* cranidia from Ramsey Island have been found without the anterior border furrow, including the types of *N.? elongatus* (Hicks 1873 : 45–46, pl. 3, figs. 1–3; Whittard 1960 : 145). These Whittard referred to *N. parvifrons*, though in other respects they cannot be separated from specimens bearing an anterior furrow, and referred to *N. ramseyensis*. No pygidia referable to *N. parvifrons* have been found.

The pygidia referred to *N. parvifrons* and *N. murchisoni* both have a small number of axial rings and pleural furrows. *N. parvifrons* (Whittington 1966 : 502, pl. 4, fig. 9) has five axial rings, followed by a terminal piece which is distended in front, and parallel-sided where it runs down the steep posterior slope. Six pleural furrows are present, with interpleural furrows abaxially. In *N. murchisoni* (Whittard 1960 : 149, pl. 20, fig. 9) there are four or possibly five axial rings, followed by a tapering terminal piece which reaches the posterior border. Four or five pleural furrows are present, without interpleural furrows. All the well preserved pygidia from Ramsey Island have eight to nine axial rings, followed by a semi-circular terminal piece, which does not reach the posterior border, which is formed medianly by the confluence of the pleural fields. Seven to eight pleural furrows are present, with occasional faint interpleural furrows.

Of Whittard's other species, only *N. grandior* (1960 : 141, pl. 20, figs. 1, 2) is comparable, the pygidium having ten axial rings and a terminal piece, and eight to nine pleural furrows. Whittard states that it is much larger than the pygidia of either *N. parvifrons* or *N. murchisoni*, but some of the pygidia collected from Ramsey Island approach it in size.

Neseuretus murchisoni (Salter)

Pl. 9, figs. 8, 11)

1966 *Neseuretus murchisoni* (Salter); Whittington : 503, pl. 4, figs. 14, 15, 17–19.

MATERIAL. External mould of cranidium (It.5820a-b).

HORIZON AND LOCALITY. Henllan Ash, at and above the south end of the highest wall of Moel Llyfnant, Arenig (Whittington 1966 : 492, locality 2). N.G.R. 812357.

DISCUSSION. A well preserved cranidium of *N. murchisoni* is figured for comparison with *N. parvifrons* and *N. ramseyensis*. The anterior border is a rounded rim, upturned and forwardly projecting, and apparently bearing pits. The glabella has a faint median ridge, extending from the level of the 1p to the 3p glabellar furrows, widening forwards and having the outline of an exclamation mark.

Neseuretus parvifrons (McCoy)

(Pl. 9, figs. 4, 5, 7, 9, 10, 12–16)

1966 *Neseuretus parvifrons* (McCoy); Whittington : 500–503, pl. 4, figs. 1–13; pl. 5, figs. 1–10.

MATERIAL: External mould of cranidium (It.5816); External mould of enrolled carapace (It.5817); Internal mould of carapace (It.5818); Internal and external mould of pygidium (It.5819a-b).

HORIZON AND LOCALITY. Henllan Ash, at and above the south end of the highest wall on Moel Llyfnant, Arenig (Whittington 1966 : 492, locality 2). N.G.R. 812357.

DISCUSSION. Some new material, collected by the writer, is here figured for comparison with that illustrated by Whittington (1966 : 500–503, pl. 4, figs. 1–13; pl. 5, figs. 1–10), chiefly to show the nature of the external ornament. The larger pits present on the anterior margin of the cranidium are each surrounded by a raised rim, forming an incipient tubercle. Similar pits are present around the posterior margin of the pygidium, particularly over the midline. The internal openings of the pits, which are really canals through the carapace, can be seen on the internal cast of the pygidium (Pl. 9, fig. 13). The anterior portion of the rostral plate, and the ventral facing surfaces of the librigenae, have a distinct tuberculate appearance, well preserved in specimen It.5818 (Pl. 9, figs. 4, 10, 14). This specimen has been excavated to show the hypostome (cf. Whittington 1966 : pl. 5, figs. 5, 6, 8, 10). The relationship of the main body of the hypostome to the anterior wings and the subtrapezoidal anterior extension is not clear, as the hypostome may be fractured at this point, and the anterior wings are missing. The anterior plate is almost rectangular in outline, wider than long, with its antero-lateral corners produced into horns, which project ventrally. These horns may have interlocked with the pygidium during enrolment, or simply formed part of the suture with the rostral plate.

The enrolled specimen (Pl. 9, figs. 15, 16) shows that the pygidium probably tucked beneath the doublure of the cephalon, exposing the main part of the doublure, i.e. that part with the tubercular ornament.

Two small specimens, probably referable to *Neseuretus parvifrons* have been

collected from Murchison's Locality at Pensarn, Carmarthen. The more complete of the two (It.5815) includes the cephalon and possibly 13 thoracic segments, but the anterior border is missing. The other specimen, a cranidium (It.5814), includes the preglabellar area and anterior border, which is not apparently marked by a marginal furrow, but is abruptly deflected ventrally. Unfortunately the specimen is crushed and the furrow may have been suppressed. The fixed cheeks in both specimens are narrow (trans.): their width at the level of the eyes being half that of the glabella at the same level. The palpebral lobes run from opposite the centre of the 2p glabellar lobes to almost the front of the glabella. The specimens are thus probably referable to *N. parvifrons*, as the anterior border furrow is apparently lacking. They differ from *N. monensis* (Shirley) in the position of the palpebral lobes.

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PLATE 1

a. Disconformity between the Lingula Flags and Ogof Hên Formation at Bay Ogof Hên, Ramsey Island.

b. Slumped and current bedded sandstones, siltstones and shales near the base of the Ogof Hên Formation, Bay Ogof Hên, Ramsey Island.


Bolopora Horizon
Disconformity
1'3"
Cleaved Shales
Lingula Flags
a.

b.

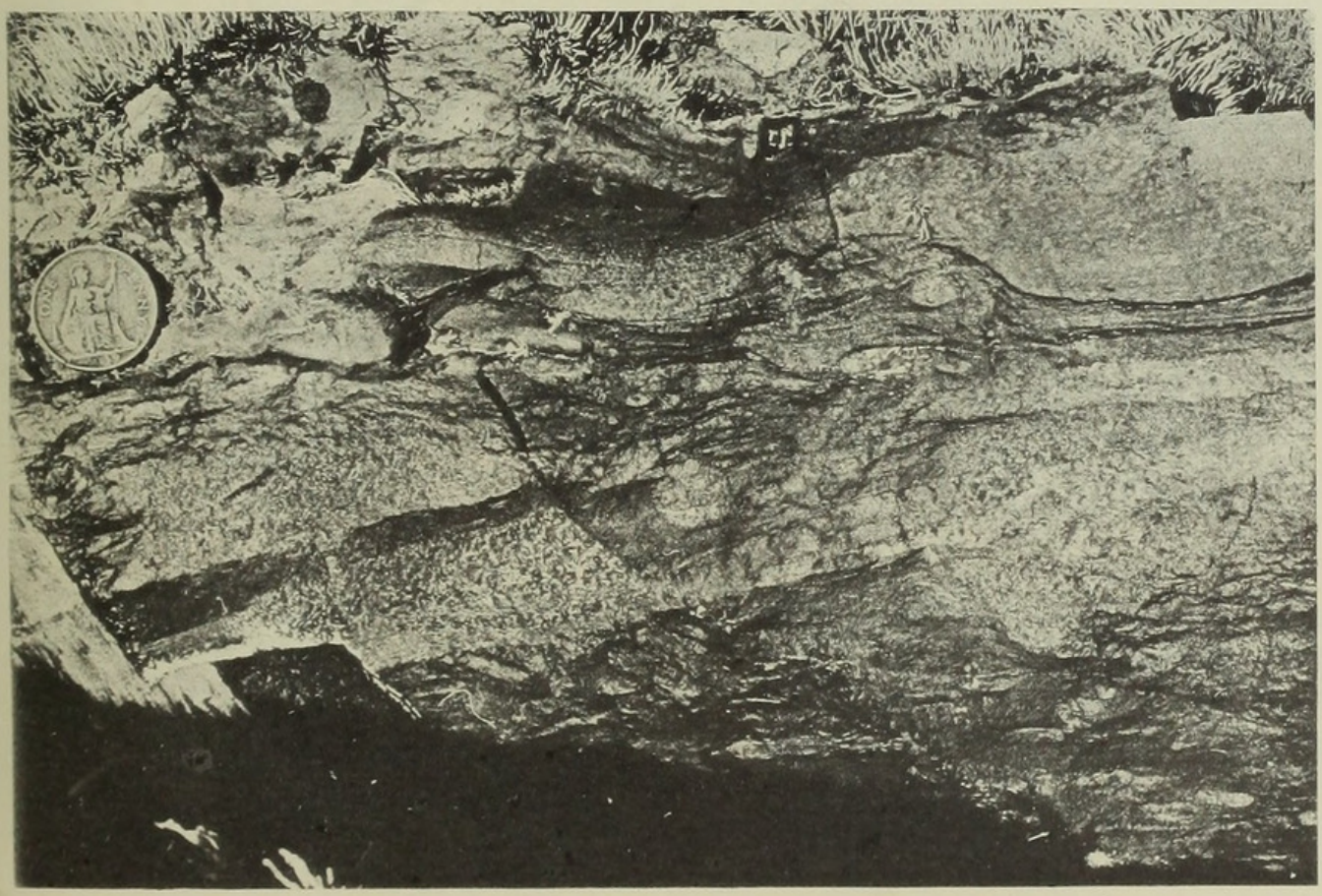


PLATE 2

Monorthis menapiensis (Davidson)

Lower Arenig, Ogof Hên Formation, Bay Ogof Hên, Ramsey Island.

FIGS. 1–3. BB.31873 a-b. Lectotype. Internal mould of pedicle valve, latex cast of interior, latex cast of exterior. Figured Davidson 1869: pl. 33, figs. 12, 12a. × 2·8.

FIGS. 4–5. BB.31874. Syntype. Latex cast of dorsal interior, internal mould, cardinalia. Figured Davidson 1869, pl. 33, figs. 11, 11a. × 2·8, × 4·6.

FIG. 6. BB.30902a. Latex cast of ventral interior. × 2·8.

FIG. 7. GSM.11938. Latex cast of ventral interior. × 3·4.

FIG. 8. BB.30897a. Latex cast of dorsal interior. × 3·5.

FIGS. 9–10. BB.30901. Latex cast of ventral exterior and interior. × 3·3.

FIG. 11. BB.31899a. Latex cast of dorsal interior. × 3·3.

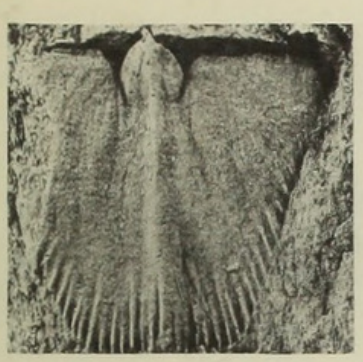
FIG. 12. BB.31898. Latex cast of dorsal interior. × 3·3.

FIG. 13. GSM.11938. Latex cast of ventral interior. × 2·9.

Lenorthis alata (Sowerby)

Lower Arenig Shales, Pensarn, Carmarthen.

FIG. 14. GSM.6868. Lectotype. Internal mould of brachial valve. Figured by Murchison 1839 pl. 22, fig. 7. × 2·5.



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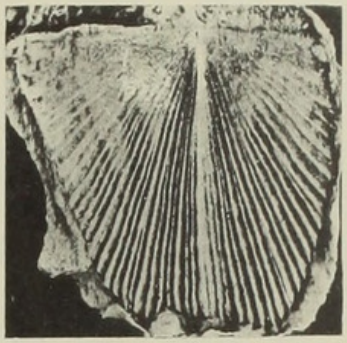

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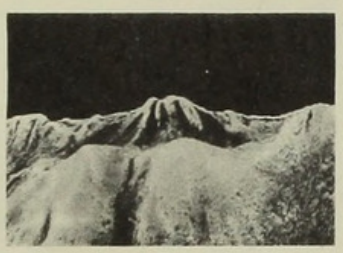

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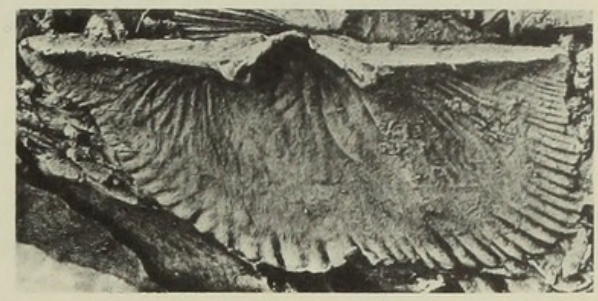

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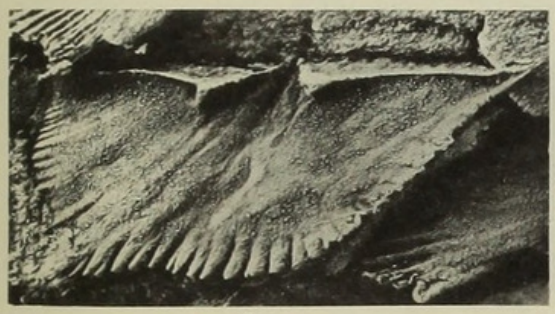

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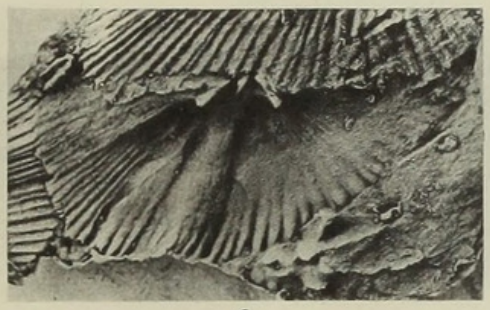

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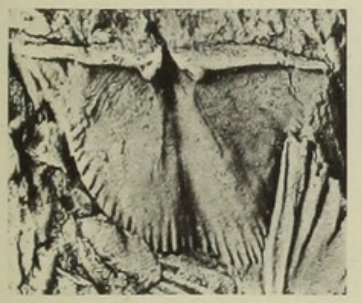

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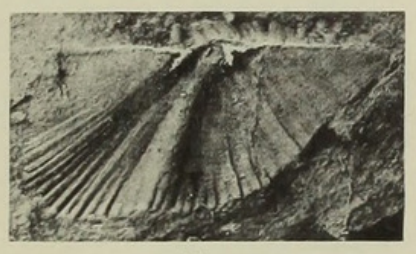

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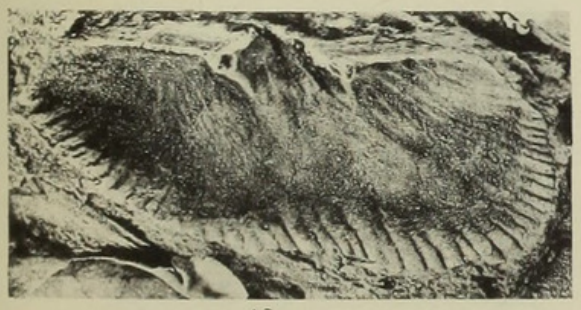

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PLATE 3

Lenorthis alata (Sowerby)

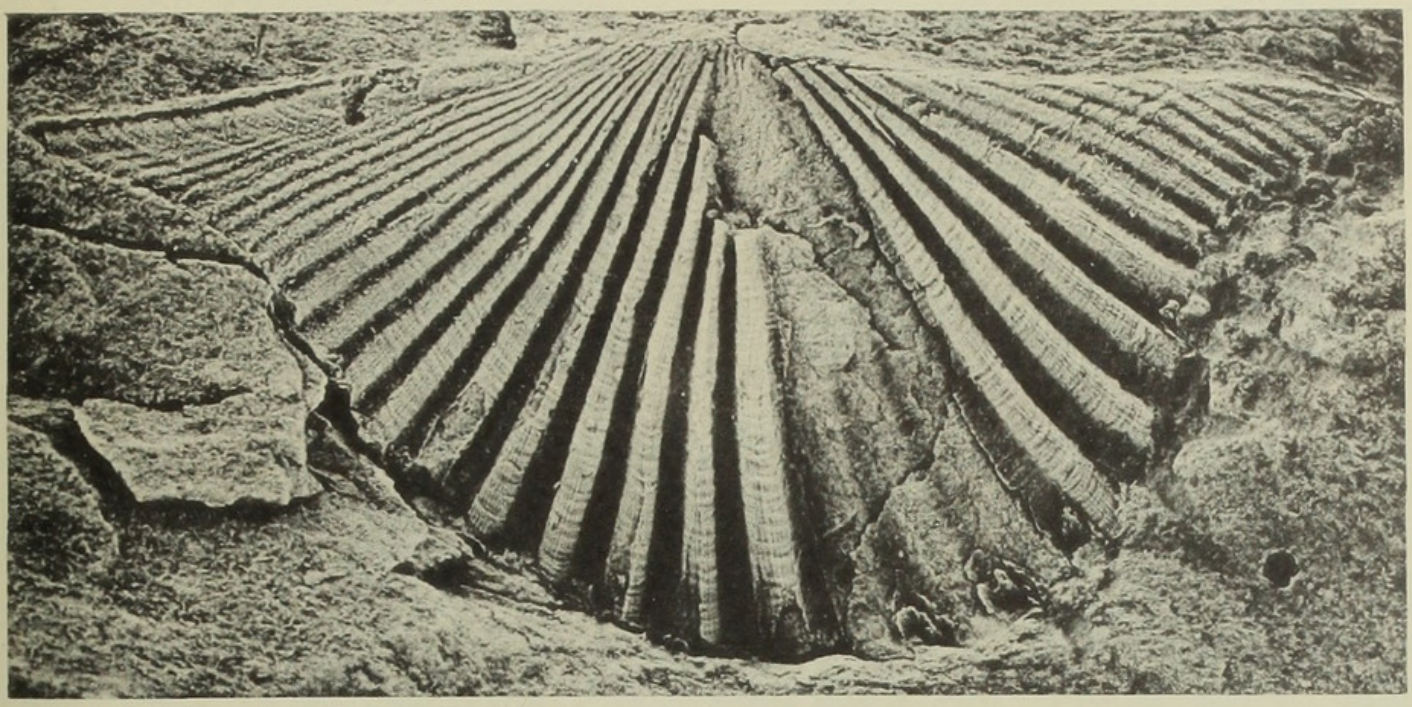
Lower Arenig Shales, Pensarn, Carmarthen.

FIG. 1. BB.31885. External mould of brachial valve. × 6·2.

FIGS. 2, 4, 6. BB.31880. Latex cast of dorsal interior, postero-ventral view of cardinalia, latex cast of exterior. × 3·0, × 13·0, × 2·4.

FIG. 3. BB.31882. Latex cast of ventral interior. × 3·0.

FIGS. 5, 7. BB.31883. Latex cast of conjoined valves, posterior and dorsal views. × 2·5.



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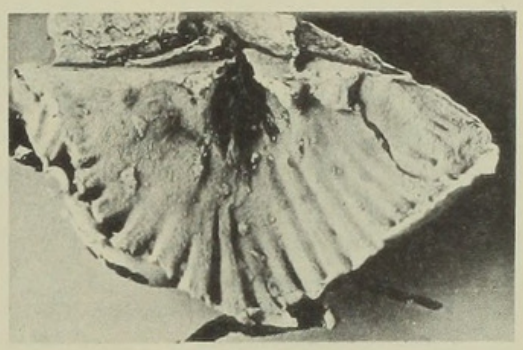

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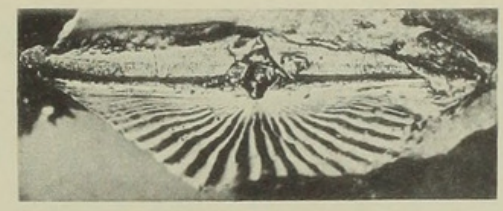

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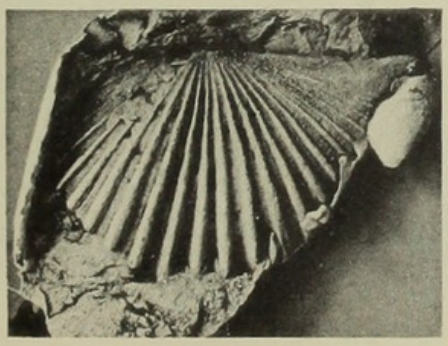

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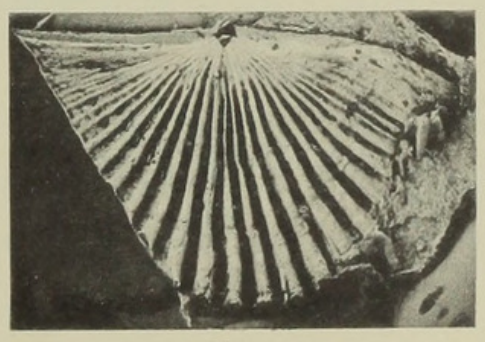

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PLATE 4

Lenorthis alata (Sowerby)

Lower Arenig Shales, Pensarn, Carmarthen.

FIGS. 1, 3. BB.31879a. Latex cast of dorsal interior, postero-ventral view of cardinalia. × 2·5, × 15·0.

FIG. 2. BB.31881a. Latex cast of ventral interior. × 2·5.

FIG. 4. BB.31878. Latex cast of dorsal interior. × 3·1.

FIG. 7. BB.31886. Latex cast of ventral exterior. × 2·3.

Lower Arenig Sandstone, Tremanhire, Solva.

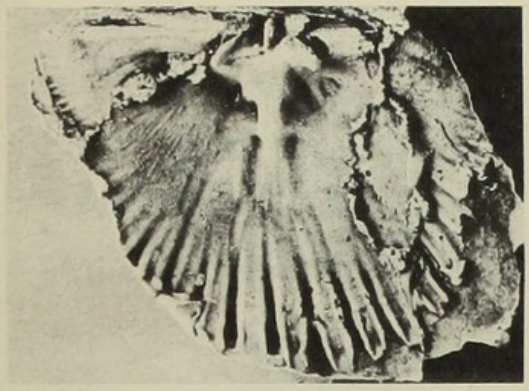
FIG. 5. BB.31875. Lectotype of *Orthis carausii* Davidson. Internal mould of brachial valve. Figured Davidson 1869 pl. 33, fig. 5, specimen at left side of block. × 2 8.

FIG. 6. BB.31876. Syntype of *Orthis carausii* Davidson. Latex cast of ventral exterior. Figured Davidson 1869. pl. 33, fig. 3. × 2·8.

Lower Arenig, Ogof Hên Formation, Bay Ogof Hên, Ramsey Island.

FIG. 8. BB.31893a. Latex cast of dorsal interior. × 3·8.

FIGS. 9, 10. BB.31887. Latex cast of dorsal interior, postero-ventral view of cardinalia. × 2·5, × 5·5.



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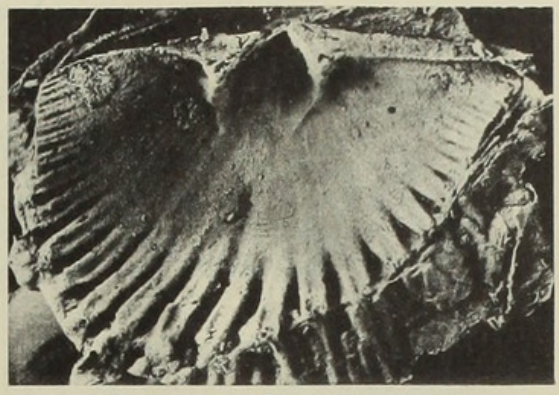

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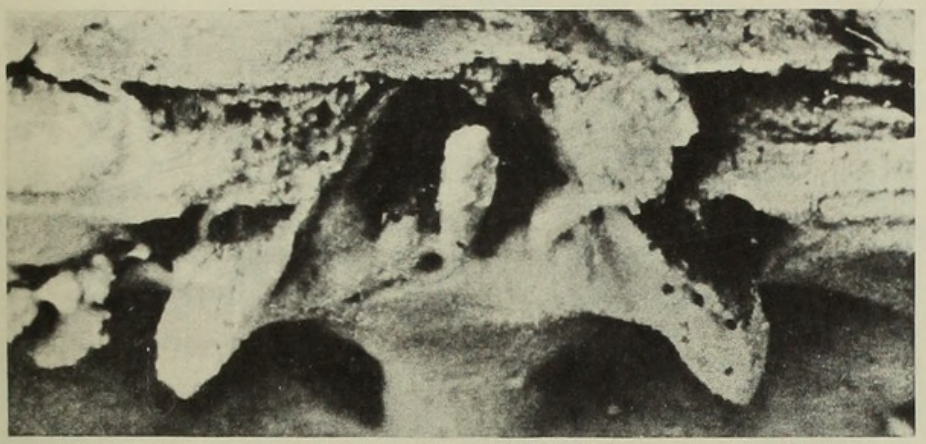

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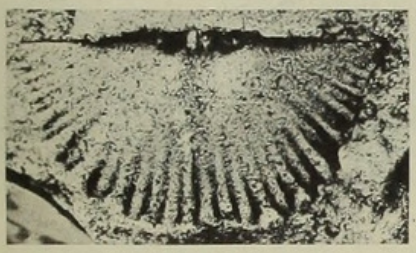

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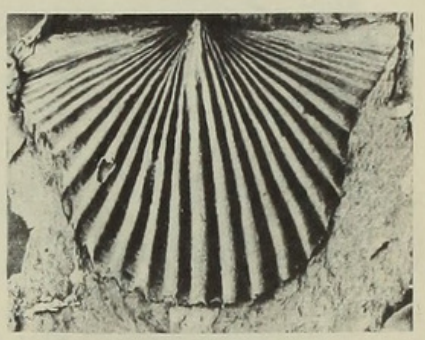

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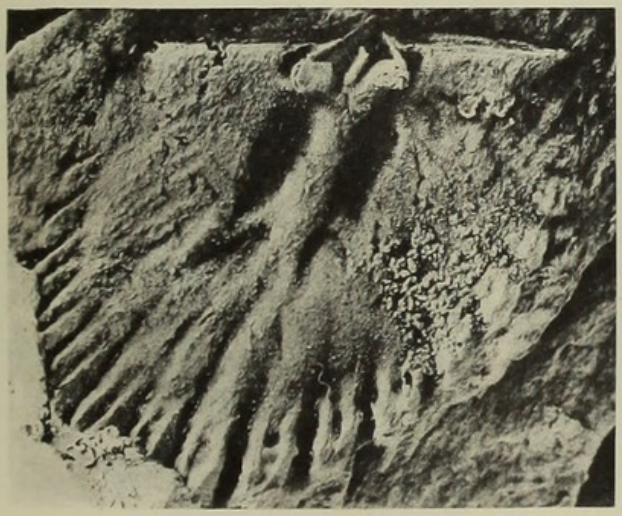

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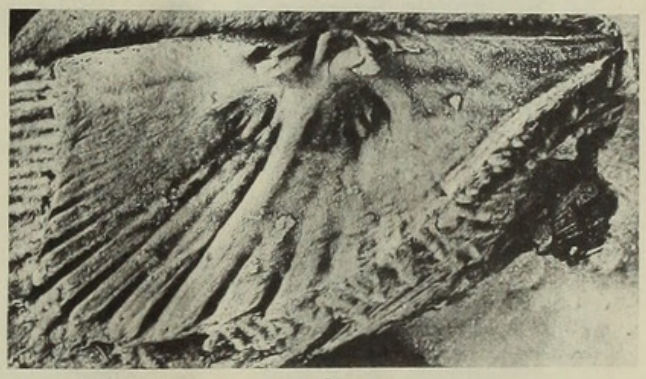

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PLATE 5

Lenorthis alata (Sowerby)

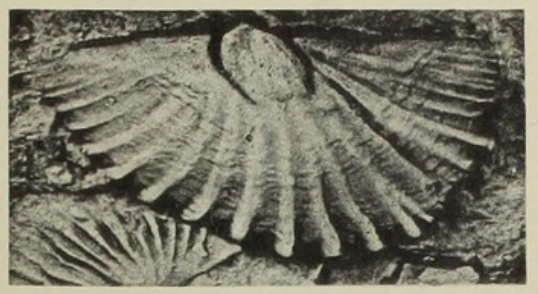
Lower Arenig, Ogof Hên Formation, Bay Ogof Hên, Ramsey Island.

FIGS. 1, 2. BB.31891. Internal mould of pedicle valve, latex cast of exterior. × 2·5.
FIGS. 3, 5. NMW.29.308.G400. Latex cast of ventral interior. × 2·5, × 5·5.
FIG. 4. BB.31890b. Latex cast of dorsal exterior. × 3·6.
FIG. 6. NMW.29.308.G397. Internal mould of pedicle valve. ×3·5.

Orthambonites sp.

Lower Arenig, Ogof Hên Formation, Bay Ogof Hên, Ramsey Island.

FIGS. 7, 8. NMW.29.308.G31. Latex cast of dorsal interior, ventral and anterior views. × 3·3, ×4·1.
FIG. 9. BB.30900. Internal mould of pedicle valve. × 3·3.
FIG. 10. LL.3182. Latex cast of dorsal interior. × 3·3
FIG. 11. LL.3184. Latex cast of dorsal interior. × 4·4.
FIG. 12. NMW.29.308.G360. Latex cast of dorsal interior. × 3·3.



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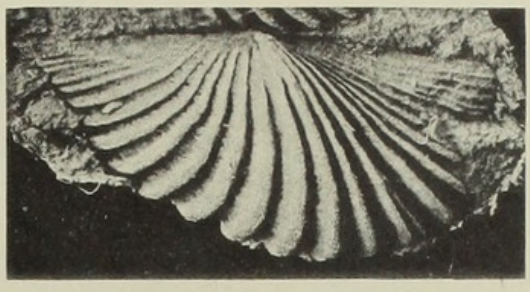

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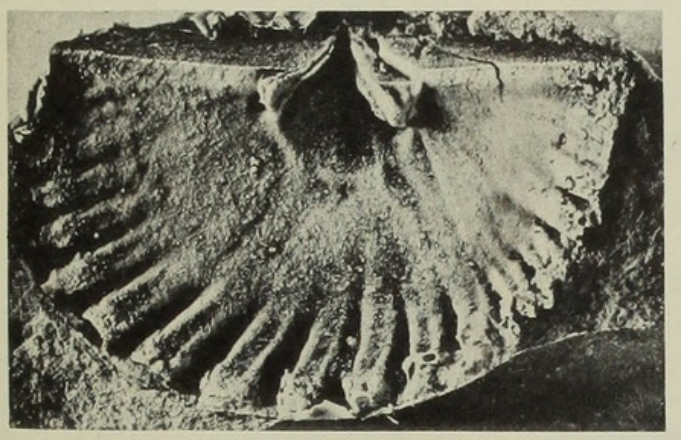

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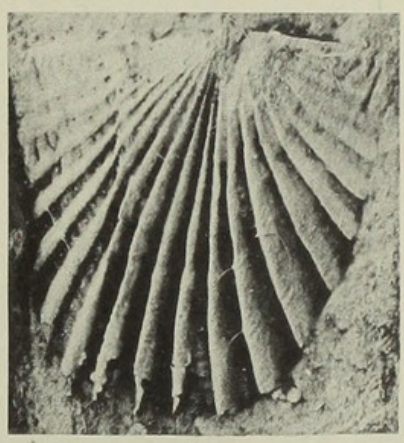

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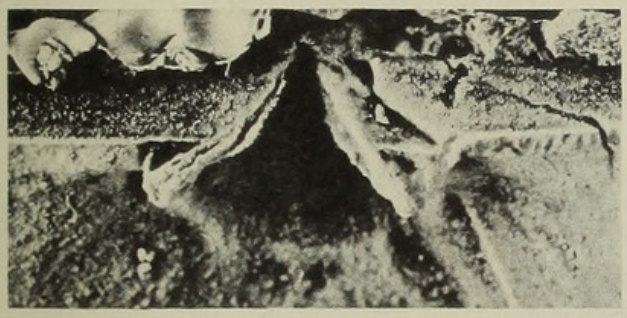

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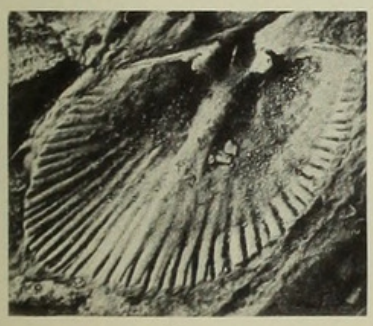

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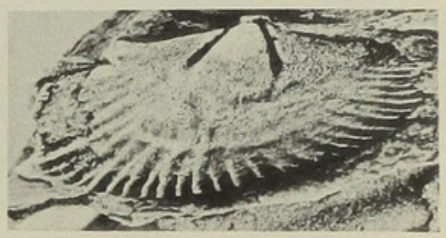

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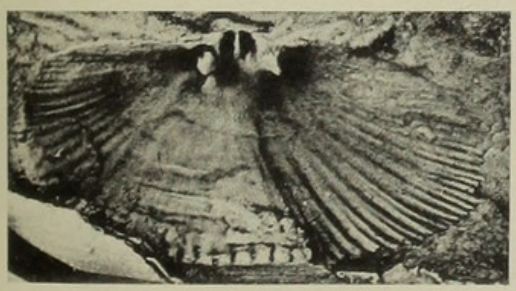

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PLATE 6

Megalaspidella*(?) *murchisoniae (Murchison)

Lower Arenig Shales, Pensarn, Carmarthen.

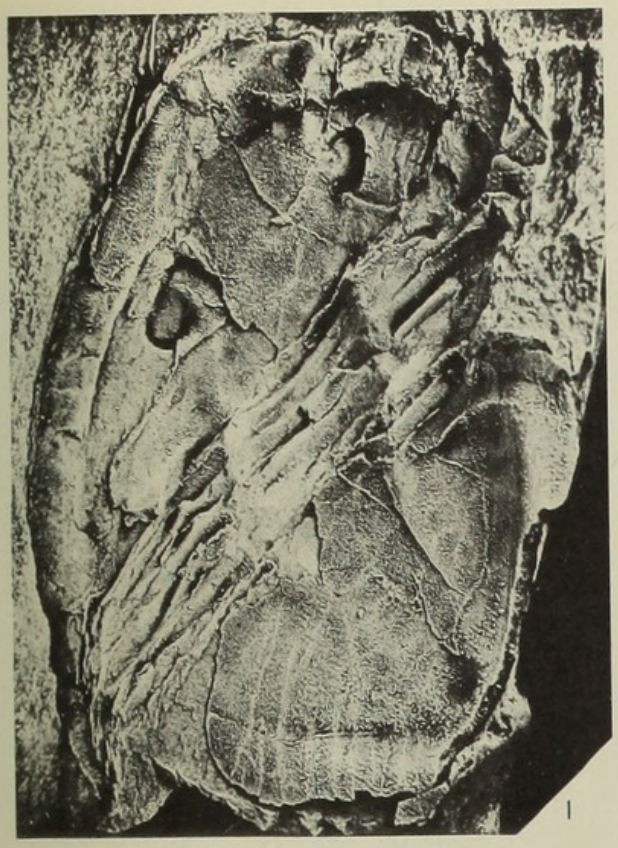
FIGS. 1, 2. It.5806 a-b. Dorsal carapace, internal and external moulds. × 1·8.

FIG. 3. GSM.18988. Holotype. Internal mould. Figured Murchison 1839, pl. 25, fig. 3. × 1·3.

FIG. 4. It.5805a. Cranidium. × 1·6.

FIG. 5. It.5809b. Latex cast of dorsal surface of pygidium. × 2·0.

FIG. 6. It.5808. Internal mould of pygidium. × 2·6.



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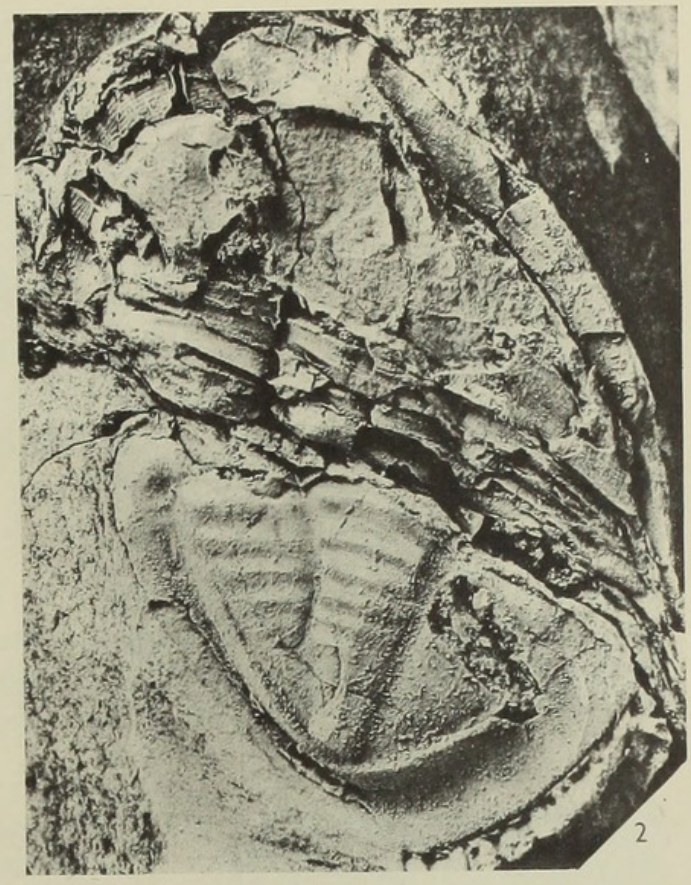

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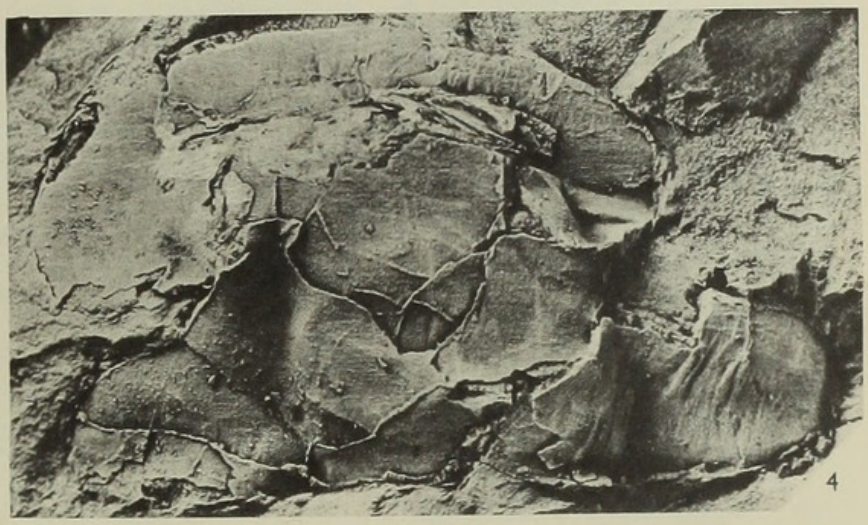

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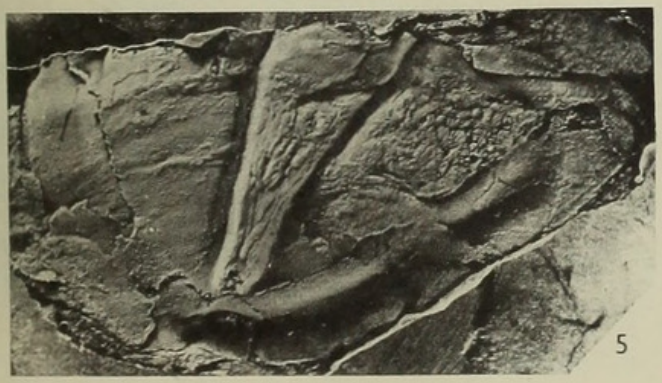

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PLATE 7

Megalaspidella*(?) *murchisoniae (Murchison)

Lower Arenig, Ogof Hên Formation, Bay Ogof Hên, Ramsey Island.

FIG. 1. OUM.B6. Syntype of *Niobe menapiensis* Hicks. Ventral mould of cranidium. Figured Hicks 1873, pl. 4, fig. 3. × 1·4.

FIG. 2. OUM.B183. Internal mould of hypostome. × 1·3.

FIG. 3. It.5810. Internal mould of cranidium. × 1·2.

FIG. 4. NMW.29.308.G148. Internal mould of pygidium. × 1·3.

FIG. 5. SMA.45141. Internal mould of cranidium. Identified by Whittard 1964 p. 236 as *Ogygiocaris selwynii* (specimen no. quoted in error as SMA.45142). × 1·3.

FIG. 7. NMW.29.308.G219. Internal mould of dorsal carapace. × 1·4.

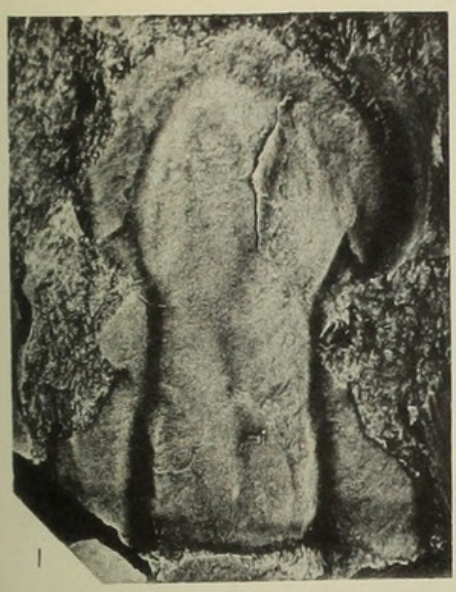
FIG. 8. NMW.29.308.G.275. Internal mould of dorsal carapace. × 1·4.

Lower Arenig Shales, Pensarn, Carmarthen.

FIG. 6. Internal mould of hypostome. × 3·6.

Lower Arenig Shales, Glan Pibwr, Carmarthen.

FIG. 9. SM.A.3118. Syntype of *Ogygia marginata* Crosfield & Skeat. Internal mould of cranidium. Figured Crosfield & Skeat 1896 pl. 26, fig. 26. × 1·0.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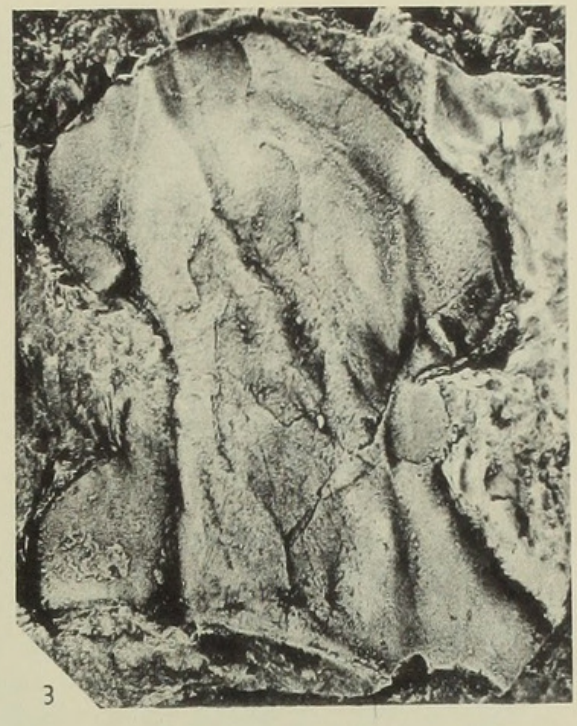
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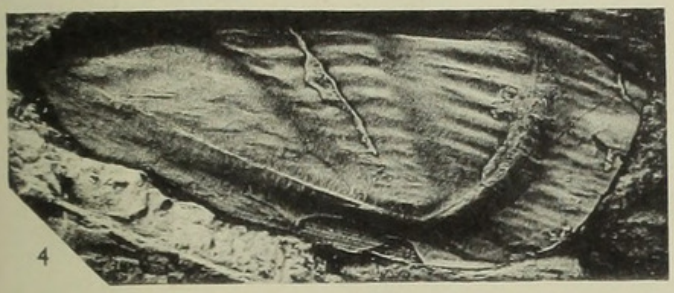
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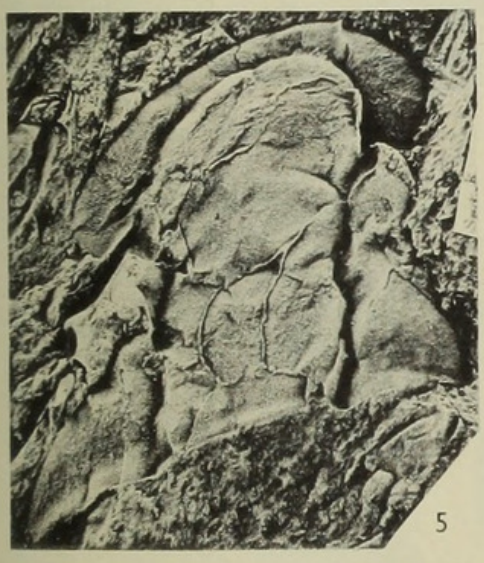
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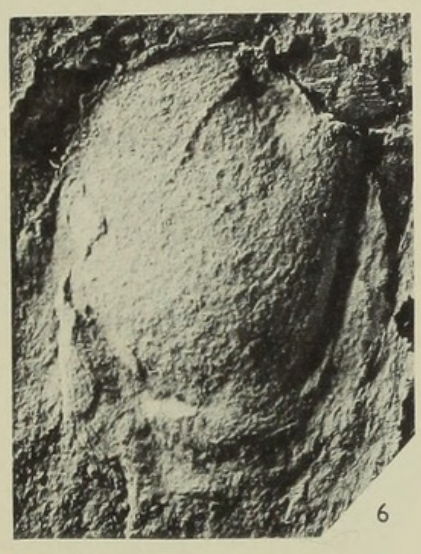
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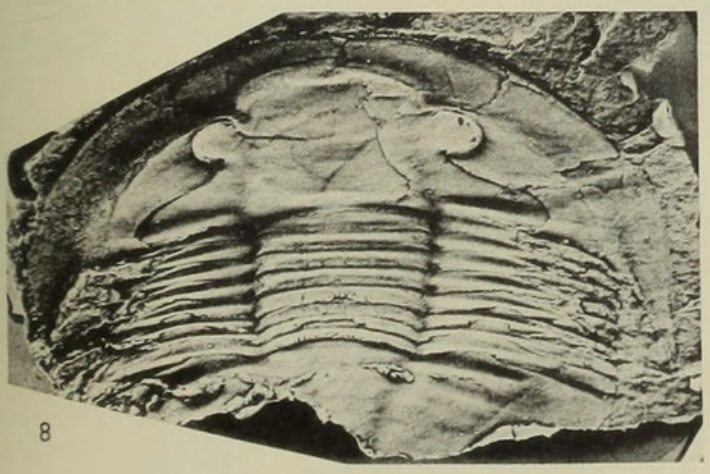
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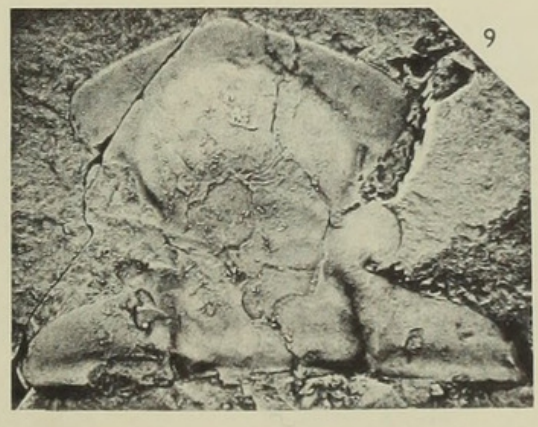
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PLATE 8

Megalaspidella*(?) *murchisoniae (Murchison)

Lower Arenig, Ogof Hên Formation, Bay Ogof Hên, Ramsey Island.

FIG. 1. It . 5811b. Latex cast of external surface of pygidium. × 1·9.

FIG. 2. NMW.29.308.G422. Internal mould of pygidium. × 1·4.

FIG. 5. NMW.29.308.G28. Internal mould of pygidium. × 0·8.

Neseuretus ramseyensis Hicks

Lower Arenig, Ogof Hên Formation, Bay Ogof Hên, Ramsey Island.

FIGS. 3, 4. It.5812. Internal mould of cranidium, lateral and dorsal views. × 3·9. × 3·0.

FIG. 6. OUM.B9. Syntype of *Neseuretus quadratus* Hicks. Internal mould of cranidium. Figured Hicks 1873 pl. 3, fig. 12. × 1·3.

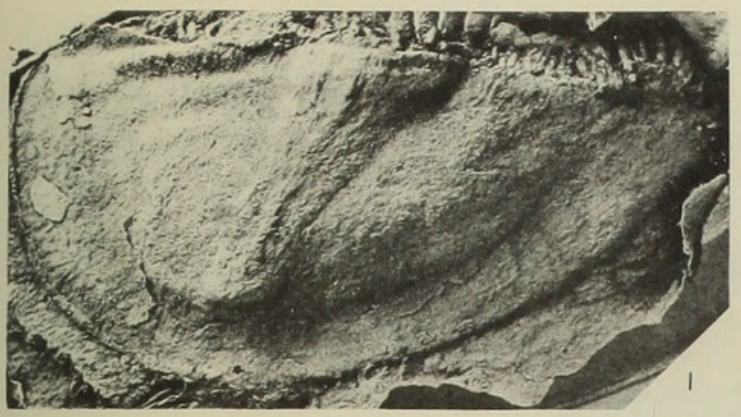
FIGS. 7, 11. OUM.B11. Internal mould of cranidium. × 2·4.

FIG. 8. SM.A.16733. Syntype of *Neseuretus elongatus* Hicks. Internal mould of cranidium. Figured Hicks 1873 pl. 3, fig. 3. × 3·8.

FIGS. 9, 11. SM.A.16732. Syntype of *Neseuretus elongatus* Hicks. Internal mould of cranidium, lateral and dorsal views. Figured Hicks 1873, pl. 3, fig. 2. × 3·8.

FIG. 10. It.5813. Internal mould of cranidium. × 1·3.

FIG. 12. OUM.B186. Internal (dorsal) mould of hypostome. × 2·5.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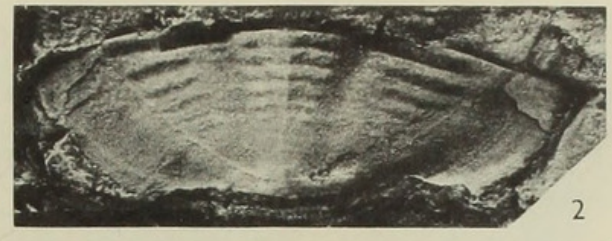
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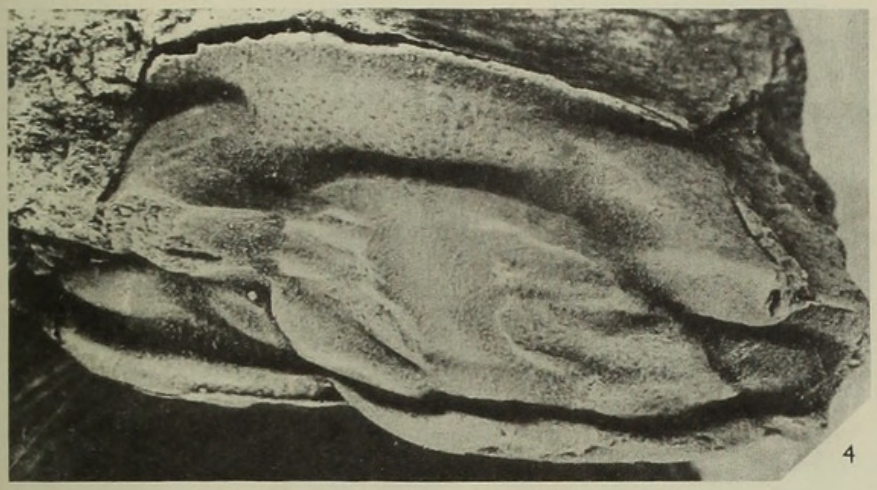
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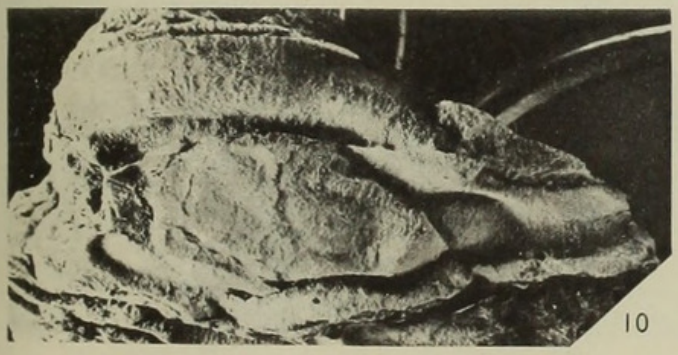
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PLATE 9

Neseuretus ramseyensis Hicks.

Lower Arenig, Ogof Hên Formation, Bay Ogof Hên, Ramsey Island.

FIG. 1. NMW.29·308.G211. Internal mould of pygidium. × 1·7.

FIGS. 2, 3. NMW.29.308.G168. Internal mould of pygidium, dorsal and lateral views. × 2·4.

FIG. 6. SM.A.16734. Internal mould of pygidium. Figured Hicks 1873 pl. 3, fig. 19. × 1·4.

Neseuretus parvifrons (McCoy)

Lower Arenig, Henllan Ash, Moel Llyfnant, Arenig.

FIGS. 4, 10, 14. It.5818. Latex cast of internal mould of carapace, with hypostome in place; ventral view, hypostome, rostral plate and doublure of librigenae. × 2·3, × 3·5, × 5·8.

FIGS. 5, 7. It.5816. Latex cast of external mould of cranidium, dorsal and anterior views. × 2·9, × 9·7.

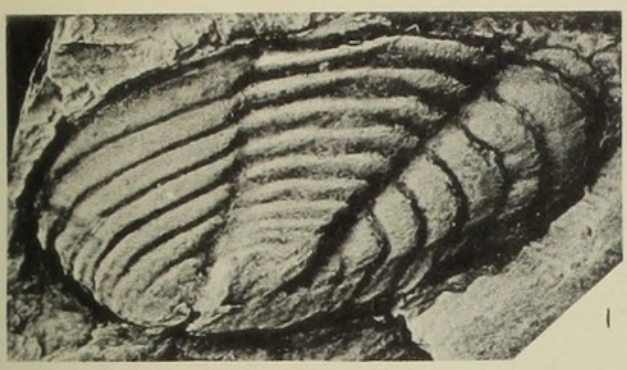
FIGS. 9, 12, 13. It.5819. Latex cast of external mould of pygidium, dorsal and posterior views, and latex cast of ventral surface of pygidium, internal view to show the openings of the canals. × 4·7, × 11·0, × 11·0.

FIGS. 15, 16. It.5817. Latex cast of enrolled carapace, lateral and dorsal views. × 2·3.

Neseuretus murchisoni (Salter)

Lower Arenig, Henllan Ash, Moel Llyfnant, Arenig.

FIGS. 8, 11. It.5820b. Latex cast of external mould of cranidium, dorsal and lateral views. × 3·0.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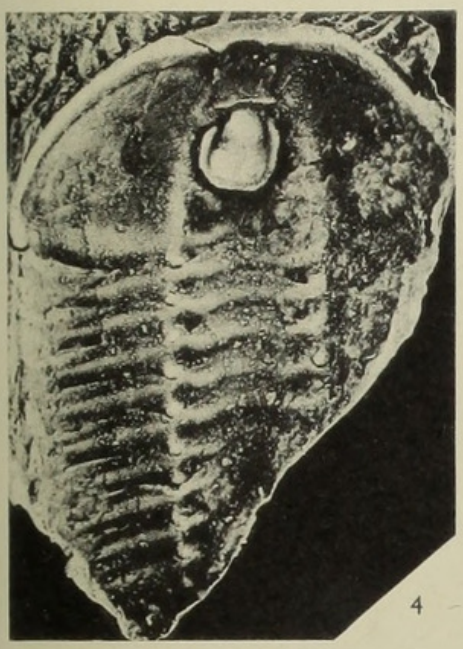
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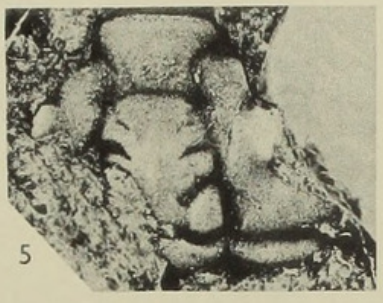
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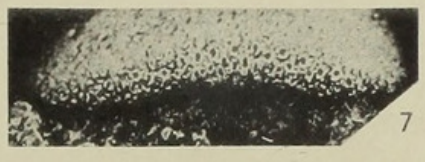
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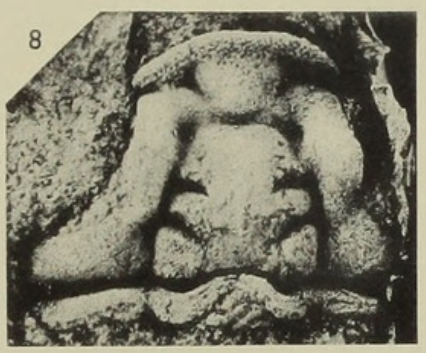
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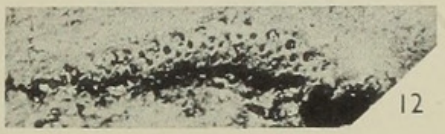
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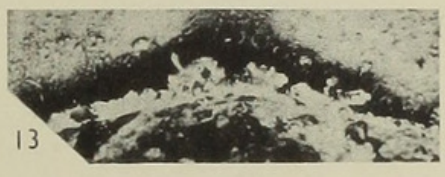
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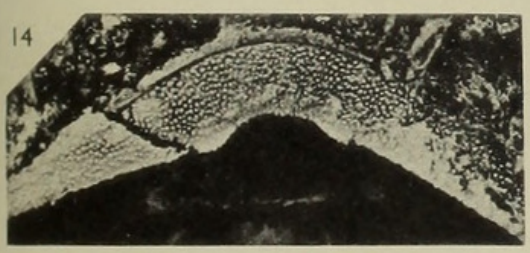
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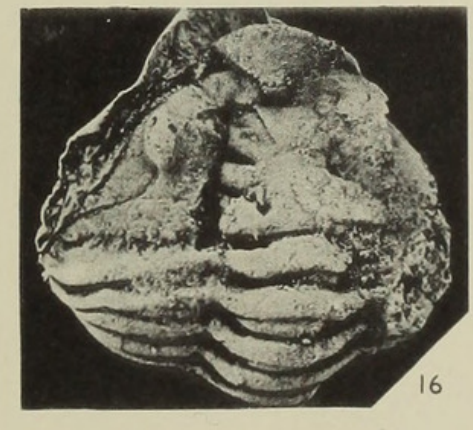
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